



MONTENEGRO

PODGORICA CAPITAL CITY

VODOVOD I KANALIZACIJA PODGORICA D.O.O.



Co-financed by:



Podgorica Capital City

BMZ Project ID 2020 84 366

KfW Procurement No. 505 731

CONTRACT AGREEMENT FOR

Components 1, 2 and 3: Works for Construction of a Wastewater Treatment Plant, Sewage Sludge Treatment Plant and Sewage Sludge Incineration Plant for the City of Podgorica

May 2022

Volume II of V

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1. Specifications

a) Scope of Supply of Plant and Installation Services by the Contractor

Bidding Documents for the Construction of the Wastewater Treatment Plant, Sewage Sludge Treatment Plant and Sewage Sludge Incineration Plant for the City of Podgorica

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

1. Specifications

- a) Project Description and Scope of Supply of Plant and Installations
by the Contractor

Content of Volume 3:

Section VII: Employer's Requirements

1. Specifications

- a) Project Description and Scope of Supply of Plant and Installation Services by the Contractor
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- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
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Section VII – Employer's Requirements

1. Specifications

a) Project Description and Scope of Supply of Plant and Installations by the Contractor

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List of Acronyms

A2O	Anaerobic, Anoxic & Oxic (activated sludge process)	MNE	Montenegro
CHP	Combined Heat and Power	PE	Population Equivalent
COD	Chemical Oxygen Demand	PEA	Project Executing Agency
DBO	Design Build Operate	PIU	Project Implementing Unit
DIN	Deutsche Industrienorm (German Standard)	SCADA	Supervisory Control and Data Acquisition
DN	Nominal Diameter	SHPP	Small Hydro-Power Plant
DNP	Defects Notification Period	SSIP	Sewage Sludge Incineration Plant
d.o.o.	Drustvo sa ogranicenom odgovornoscu (private limited liability company)	SSTP	Sewage Sludge Treatment Plant
EU	European Union	UV	Ultra-violet
FGT	Flue Gas Treatment	VIK	Vodovod i Kanalizacija (Water and Sewerage Company)
IEC	International Electrotechnical Commission	WBIF	Western Balkans Investment Frameworks
KAP	Kombinat aluminijuma Podgorica (Podgorica Aluminium Company)	WWTP	Wastewater Treatment Plant
KfW	KfW Entwicklungsbank		

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the **decimal comma** is used and the dot is used as **thousand separator**.

1. INTRODUCTION

In 2017 KfW Entwicklungsbank (KfW) appraised the Project "Wastewater Collection and Treatment Podgorica" which aims at the improvement of the sewerage situation in the Capital City of Podgorica, through extension of the sewer network and construction of a new municipal wastewater treatment plant.

The water supply and sewerage service provision company Vodovod i kanalizacija (ViK) Podgorica d.o.o. shall act as the Project Executing Agency (PEA) and be responsible for the implementation of the project in close cooperation of the Municipality of Podgorica, which will be the recipient of the funds and owner of the facilities. ViK Podgorica and the Capital City of Podgorica established a Project Implementation Unit (PIU) for the purpose of project implementation.

The project comprises several components. The present Bidding Documents refer to the construction of the new wastewater treatment plant (WWTP) including a sewage sludge treatment plant (SSTP), a sewage sludge incineration plant (SSIP) (Components 1, 2 and 3 of the project) and common facilities.

Remark:

In the present document the term Wastewater Treatment Plant (WWTP) is used to describe both the whole plant, including the wastewater treatment facilities, the sewage sludge treatment facilities, the sludge incineration plant and the general facilities as, in special cases, only the wastewater treatment facilities.

2. PROJECT BACKGROUND

The existing wastewater treatment plant of the city of Podgorica is 40 years old and technically outdated and critically overloaded. The plant cannot provide for a state-of-the art wastewater treatment with regard to both its design capacity and its treatment efficiency, especially considering removal of nutrients. The capacity of the plant is 55.000 PE, while the current wastewater flow and pollution load collected by the existing sewer network and transferred to the plant exceeds 100.000 PE, i.e. a close to or even more than 100 % overload. This results in the necessity to discharge partly treated and also untreated raw wastewater directly to the River Moraca and in a significant impact on the water quality of River Moraca and the downstream sensitive Skadar Lake.

In addition, the existing plant is meanwhile located within the urban extension area of Podgorica city and directly surrounded with housing and commercial areas, which are not compatible with an industrial facility of the type of a wastewater treatment plant.

Finally, existing badly designed and poorly maintained on-site sanitation facilities in unsewered areas of the city of Podgorica, installed in highly permeable underground, are a constant threat for the quality of the underground water resources.

The above picture of the existing situation emphasises the necessity to urgently improve the sanitation situation in Podgorica through:

- Construction of state-of-the-art new wastewater treatment plant providing the required treatment efficiency to adequately protect the environment;
- Extension of the sewer network in unsewered areas, allowing to remove defective on-site sanitation facilities;
- Improve the condition and maintenance of on-site sanitation facilities in areas which will remain unsewered at mid or long-term.

Both the Capital City of Podgorica and the water and sanitation company (Vodovod i kanalizacija, ViK) have recognised since many years the improvement of the sanitation and wastewater treatment situation in Podgorica as a priority for the enhancement of the living condition of the population and the economic development of the city and have taken first crucial steps for its realisation, notably:

- The preparation of three feasibility studies in 2004 and 2011 and finally in 2017 with support from external development agencies;
- The identification and reservation in urban development documents of the required site for a new WWTP;
- The assessment of existing wastewater treatment technologies and identification of the most suitable technological wastewater and sludge processes;
- The development and implementation of a long-term concept for the development of the sewer network and transfer to the site of the new WWTP.

The present project aims at the implementation of the project on the basis of the approved Feasibility Study 2017. It is conceived as an integrated project including not only the construction of the new WWTP but also necessary measures for the adequate and sustainable future operation and management of the treatment plant and sewerage system. The project encompasses following main components:

- Construction of the new wastewater treatment plant for the city of Podgorica including sewage sludge treatment and incineration (Components 1, 2 and 3);
- Construction of the main collector from the site of the existing to the site of the new WWTP (Component 4), including a pipe bridge over River Moraca (Component 5);
- Extension and densification of the secondary sewer network (Component 6);
- Development of measures for the separation of internal networks, reduction of the discharged pollution load and pre-treatment of effluents discharged to the public sewer by the 13.jul-Plantaže winery (Component 7);
- Preparation of detailed design and tender documentation for extensions of main collectors in currently unsewered areas (Component 8).

Purpose of the present Bidding Documents is the construction of the new wastewater treatment plant (WWTP), including sewage sludge treatment plant (SSTP), sewage sludge incineration plant (SSIP) (Components 1, 2 and 3 of the project) and common facilities.

3. PROJECT OBJECTIVE

The main objective of the Works is the environmentally sound, efficient, reliable and economic treatment and disposal of wastewater and wastewater treatment by-products generated within the wastewater collection catchment area of the city of Podgorica. The project principally aims at the reduction of the pollution of the Moraca River and Skadar Lake, the reduction of health risks and the improvement of the living conditions of the population of the Capital City of Podgorica. In addition, the project shall support Montenegro in its objectives to implement technical and environmental standards of the European Union (EU) in the water sector.

Above indicated objectives shall be achieved with the construction and commissioning of a new Wastewater Treatment Plant (WWTP), including a Sewage Sludge Treatment Plant (SSTP) and a Sewage Sludge Incineration Plant (SSIP) for the city of Podgorica.

The specific objective of this Tender Dossier is to deliver to the Employer a fully functional, tested and operating WWTP including management of the operation of the Wastewater and Sewage Sludge Treatment plants (WWTP and SSTP) for two (02) years and management of the operation of the Sewage Sludge Incineration Plant (SSIP) for a period of three (03) years in accordance to the Employer's Requirements.

Based on the information given in the Bidding Documents, the Contractor shall design, build, commission and operate a Wastewater Treatment Plant in accordance with the Employer's Requirements. The scope of works includes all necessary activities (such as design,

construction, testing, operation, handover, training etc.) pertaining to the successful completion of the Contract as detailed in the Bidding Documents.

4. BENEFICIARY, PROJECT EXECUTING AGENCY AND OPERATING COMPANY

The main beneficiary of the project is the capital City of Podgorica and its population and economic, politic and touristic stakeholders. The Project Executing Agency (PEA) is the Vodovod i kanalizacija (ViK) Podgorica d.o.o. who will act in close cooperation with the Capital City of Podgorica and operate the new facilities.

The Capital City of Podgorica is the recipient of the external funding for the project and will act as the Employer for the works and supplies to be carried out under the project.

For the purpose of the project implementation, ViK Podgorica established a Project Implementing Unit (PIU) together with Podgorica Capital City to coordinate all project activities on behalf of the PEA.

ViK Podgorica will be the future operator of the plant after successful completion of the Defects Notification Period and the two years operation period by the Contractor. For the sewage sludge incineration plant it is foreseen that the Contractor will provide operation and management services for a minimum period of three years before the plant will be handed over to ViK Podgorica.

The operation period by the Contractor shall be used to provide training and further education to ViK operational staff in the operation, maintenance and management of the plant.

The project is funded by the Federal Republic of Germany through several credits from KfW Entwicklungsbank, by the European Union through a grant from the Western Balkans Investment Frameworks (WBIF) and a local contribution from the Government of Montenegro / City of Podgorica.

5. PROJECT AREA

The project area encompasses the whole of Podgorica Capital City and the whole urban area which may be possibly connected in future to the new WWTP, including future sewer network extensions areas (see Figure 1 below).

Podgorica is the Capital City of Montenegro and is situated in the southern part of the country in the Zeta plain close to the Skadar Lake. The municipality counted a total population of 187.085 inhabitants (30 % of total Montenegrin population) during the last census in 2011 with 152.602 inhabitants (82 % of the Municipality population) living in Podgorica City (Project Area).

The estimated population of the project area is about 164.000 inhabitants in 2018. It is anticipated to increase to close to 200.000 inhabitants in 2045, design horizon of the present project. The city (Project Area) covers an area of 108 km².

6. LOCATION OF THE WORKS

The Site of the Works for the construction of the WWTP is located south-west of the city of Podgorica, between the KAP Aluminium Factory and the River Moraca. The location of the site downstream of Podgorica, allows to drain by gravity almost the whole sewered area up to the site of the WWTP, with minimised need for intermediate pumping of sewage within the sewer network.

The project area and the site of the WWTP are shown in Figure 1.

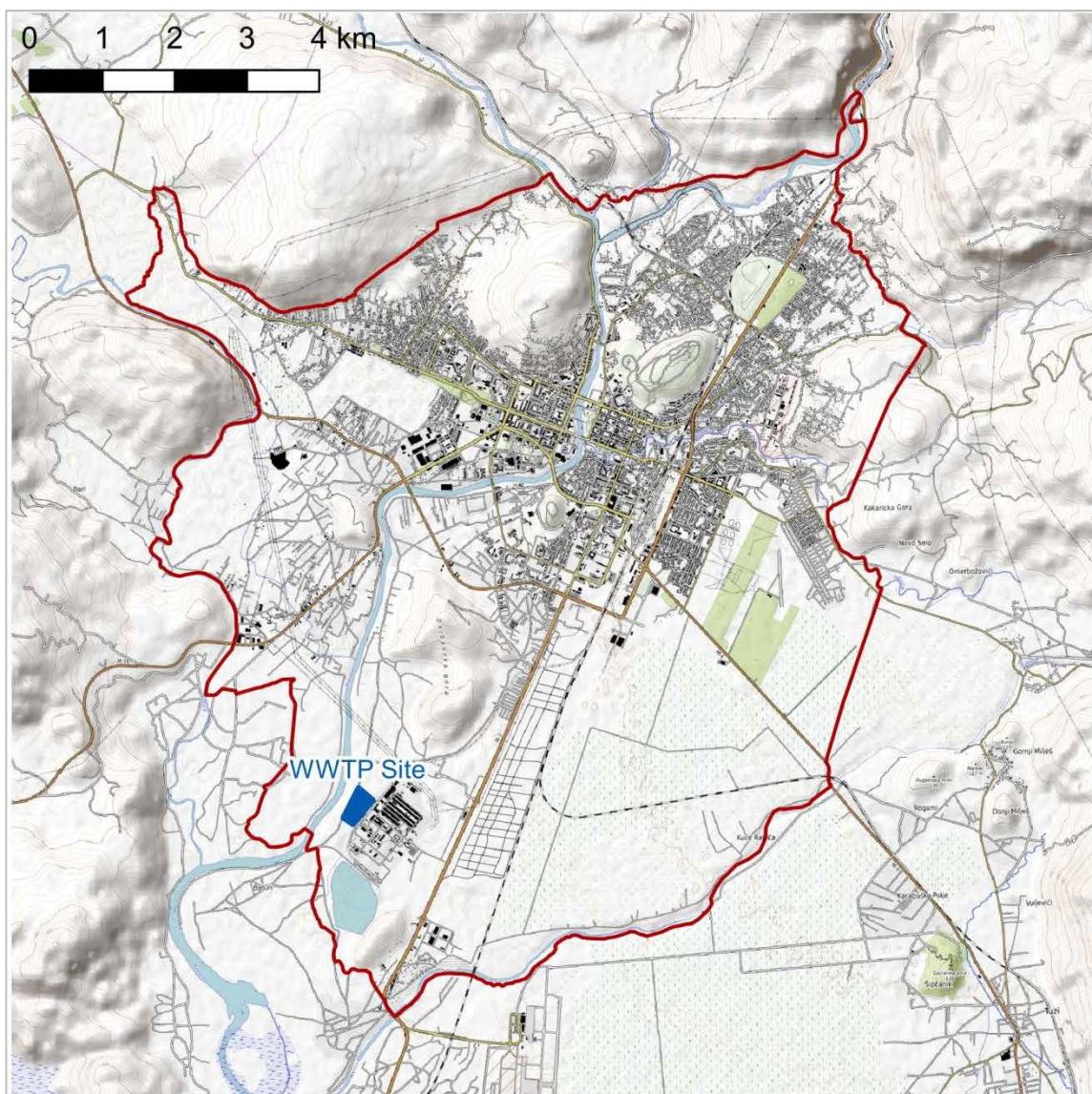


Figure 1: Wastewater collection catchment area and location of the site of the new WWTP

7. SCOPE OF WORKS AND SUPPLY OF PLANT AND INSTALLATION AND OPERATION SERVICES BY THE CONTRACTOR

The scope of works comprises following Sections:

Section A:

- Wastewater treatment plant (WWTP) for the treatment of the municipal and industrial wastewater generated in Podgorica by use of activated sludge process with tertiary treatment for nitrogen and phosphorus removal as well as UV-disinfection and all ancillaries;
- Sewage sludge treatment plant (SSTP) with anaerobic digestion including biogas recovery and reuse for production of electrical power and heat by use of CHP units and sludge dewatering with centrifuges and all ancillaries;
- Small Hydro-Power Plant (SHPP) to recover electrical energy from the discharge of treated wastewater into the receiving water;
- Common facilities including administration building, workshop and storage building, control room and SCADA system, transformer station, emergency generator, internal roads and pathways, fence and landscaping.

Section B:

- Sewage sludge incineration plant (SSIP) with pre-dryer, fluidised bed incinerator, flue gas cleaning by use of electrostatic precipitator, bicarbonate dosing and fabric filter and all ancillaries;

Section C

- 24 months technical operation management of above Section A works after taking over and 36 months technical operation management of above Section B works after taking over.

The plant shall be designed for the planning horizon **2045** and shall have a treatment capacity of approximately **230,000 p.e.** (13,800 kg BOD₅/d; 49,000 m³/d).

Works will be implemented in the municipality of Podgorica in the area of Dajbabe and Botum in the southern part of the city.

The construction period is: 30 months for the Section A works and 36 months for the Section B works.

The scope of works, supply and services to be provided by the Contractor include all activities to be carried out by the contractor for the delivery to the Employer of a fully functional wastewater treatment plant in accordance the Employer's Requirements; including commissioning, testing, operating and provision of training of the Employer's staff for the appropriate operation, management and maintenance of the plant.

7.1. Scope of Works and Supply

The Wastewater Treatment Plant is conceived as a complete and self-contained facility for the complete treatment of wastewater and sewage sludge, including sewage sludge incineration and comprise of the following main sub-components which are described in more detailed below:

Section A:

- Wastewater Treatment Plant (WWTP);
- Sewage Sludge Treatment Plant (SSTP);
- Small Hydro-Power Plant (SHPP);
- Common facilities.

Section B:

- Sewage Sludge Incineration Plant (SSIP);

Utmost care is to be brought in the design of the WWTP, SSTP and SSIP in compliance with applicable Montenegrin and European legislation, especially with regard to environmental protection, health and safety and avoidance of any kind of nuisances as well as security and flexibility of operation.

7.1.1. Wastewater Treatment Plant (WWTP)

The wastewater treatment process consists in an activated sludge treatment, using the A2/O process technology, with specific treatment for nitrogen (nitrification and denitrification) and phosphorous (enhanced biological and chemical phosphorous precipitation) removal, as well as final disinfection by UV radiations.

The wastewater treatment line comprises following main treatment steps and facilities:

- Inlet works including:
 - Inlet chamber of the DN 1.300 mm main collector;
 - Grit trap;
 - Manual coarse screen (20 cm);
 - Emergency overflow and by-pass;
- Preliminary treatment and pumping station, including:
 - Septage receiving station;
 - Automated coarse (20 mm bar space) screen with screenings washing and dewatering units;
 - Sewage lifting station;
 - Automated fine (6 mm bar space) screen with screenings washing and dewatering units;

- Combined aerated grit and grease removal tanks with grit washing and classification unit and transfer of the separated fat and grease to the sludge digesters;
 - Biofilter for the treatment of the foul air from the pre-treatment facility (screen and pumping station building);
- Primary sedimentation tanks;
- Biological (secondary) treatment, including:
 - 2 mandatory lines of aeration tanks (+ 1 optional line) with respective anoxic and anaerobic zones for nitrification, denitrification and bio-P elimination;
 - Blower station;
 - Final sedimentation;
- Tertiary treatment for the disinfection of the treated effluent, including:
 - Microscreens (disc filters);
 - UV disinfection;
- Discharge pipe of the treated effluent to Moraca River connected to the small hydro-power plant installed at the outlet of the pipe to Moraca River.

7.1.2. Sewage Sludge Treatment Plant (SSTP)

Sewage sludge produced from the wastewater treatment and extracted from the primary and final sedimentation tanks will be treated in anaerobic digesters to decompose the organic matter and produce biogas. Biogas will be used in the plant for the production of heat and electrical power through the use of Combined Heat and Power (CHP) equipment. The remaining sludge will be dewatered and further incinerated in the sludge incineration plant (see below). The sewage sludge treatment line comprises following main treatment steps and facilities:

- Primary (primary sedimentation) sludge storage and thickening, including:
 - Primary sludge storage tank;
 - Primary sludge thickening by use of centrifuges;
 - Polymer preparation and dosing station;
- Excess (biological or secondary) sludge storage and thickening, including:
 - Excess sludge storage tank;
 - Excess sludge thickening by use of centrifuges;
 - Polymer preparation and dosing station;
- Sludge digestion including:
 - Thickened raw sludge storage tank;
 - 1 mandatory sewage sludge digester (+ 1 optional);
 - Digested sludge storage;
- Biogas storage and reuse, including:

- Gas storage tank;
- Combined Heat and Power (CHP) facilities for the production of electrical power for the operation of the plant and heat for the heating of the digesters from the biogas;
- Flare stack for burning of excess gas;
- Sludge dewatering including:
 - Sludge dewatering centrifuges;
 - Polymer preparation and dosing station;
 - Supernatant storage tank and recycling pumping station;
- Biofilter for the treatment of the foul air from the sewage sludge treatment building.

7.1.3. Small Hydro-Power Plant (SHPP)

To take advantage of the fall height between the outlet of the WWTP and the water level of Moraca River, it is planned to install a small hydro-power plant (SHPP) at the outlet of the discharge pipe of treated effluents to the Moraca River to produce electrical energy.

It is anticipated that the electrical power produced by the SHPP will allow covering min 5 % of the total power demand of the WWTP.

7.1.4. Common Facilities

Common facilities of the plant include following main structures:

- Power supply main station including transformers, emergency generators and medium voltage switchgear;
- Administration building with control room including SCADA system, conference room and laboratory;
- Workshop and storage building;
- Guard house;
- Electronic truck weighing bridge at the inlet to the plant;
- Process, firefighting and irrigation water production and distribution system.

7.1.5. Sewage Sludge Incineration Plant (SSIP)

Digested and dewatered sewage sludge will finally be incinerated in a Sewage Sludge Incineration Plant (SSIP) which will be part of the wastewater treatment plant. The SSIP includes following main facilities:

- Concrete bunker for storage of dewatered sludge and reception of external sludge;
- Sludge drying system (contact dryer or belt dryer);

- Fluidised bed sewage sludge incinerator with reuse of flue gas heat for sludge drying;
- Electrostatic precipitator for flue gas cleaning and flue gas treatment;
- Ash and Flue Gas Treatment Residues storage silos.

7.1.6. Optional Works

Following components of the works and their appurtenances are optional items and will be ordered and included in the contract depending on the availability of the respective funding:

- i. Wastewater tertiary treatment including disc filters and UV disinfection;
- ii. Small hydro-power plant;
- iii. One additional line of aeration tank including civil works and equipment;
- iv. One additional sludgedigester (one of the two units) including civil works and equipment.

7.2. Scope of Contractor's Services

Services to be provided by the contractor in the scope of the contract shall include but will not be limited to the following:

- Design services including preliminary and detailed design of the WWTP in accordance to the applicable local regulations on construction of structures;
- Support to the Employer for obtaining all required permits and approvals as required by local regulations;
- Commissioning and testing of the plant and all sub-components in accordance to the Employer's Requirements;
- Submission of full documentation including as-built drawings of the plant and operational manuals of all components of the plant;
- Provision of on-the-job training and advanced training to the Employer's staff for the adequate operation, maintenance and management of the plant;

Section C:

- Provision of technical operation management services for Section A Works for a period of two (02) years starting from the successful completion of tests on completion;
- Provision of technical operation management services for Section B Works for a period of three (03) years starting from the successful completion of tests on completion.

The above indicated technical operation management periods may be optionally extended by up to one additional year on the Employer's request and on conditions to be agreed between the Employer and the Contractor.

The Contractor is in general responsible for providing all necessary services and support to the Employer for the completion and commissioning of the complete wastewater treatment plant in accordance to the Employer's Requirements and in compliance with applicable international and local regulations.

8. PROVISIONAL TIME SCHEDULE

The figure on the following page gives the provisional time schedule for the implementation of the project, considering the following:

- The completion period (time for completion) for all works under the contract, including design, construction, commissioning and testing is thirty (30) months for Section A (WWTP, SSTP, SHPP and Common Facilities) and thirty-six (36) months for Section B (SSIP);
- The Defects Notification Period shall be twelve (12) months from the issuance of the Taking-Over Certificate for Section A Works and twenty-four (24) months for Section B Works;
- Section C (Technical Operation Management of Section A Works and Section B Works after the related Taking Over): The duration of Section C services under the responsibility of the Contractor shall be:
 - two (2) years, for the section A Works;
 - three (3) years for the Section B Works.

The times and sequences of the various activities depicted in the following table and provisional time schedule are for information only. The times and sequences may be varied by the Contractor after Commencement Date to suit his own proposals for carrying out the works within the time target, subject to the approval of the Engineer. In accordance with the FIDIC Clause 8.3 the Contractor shall submit his own detailed work programme.

The following shall be taken into account:

- Time for Completion of Section A Works: 30 months;
- Time for completion of Section B Works: 36 months;
- DNP for Section A Works: 12 months;
- DNP for Section B Works: 24 months;
- Duration of Section C Services:
 - for Section A Works: 24 months;
 - for Section B Works: 36 months;
- Time for submission of draft Preliminary Design (complete document), from commencement date: 60 days;
- Time for obtaining the building permit, from date of submission of complete documentation: 60 days;

Section VII – Employer's Requirements - Project Description and Scope of Supply

- Time for obtaining the approval of Preliminary Design or Detailed Design by the External Revision Committee (mandatory for project implementation), from date of submission of complete documentation: 60 days;
- Latest date for awarding parts or all Optional Works without impacting the Time for Completion of Section A:
 - Wastewater tertiary treatment: ... 18 months (540 days) from commencement date;
 - Small hydro-power plant:..... 18 months (540 days) from commencement date;
 - Third aeration tank: 12 months (360 days) from commencement date;
 - Second sludge digester:..... 12 months (360 days) from commencement date;

Section VII – Employer's Requirements - Project Description and Scope of Supply

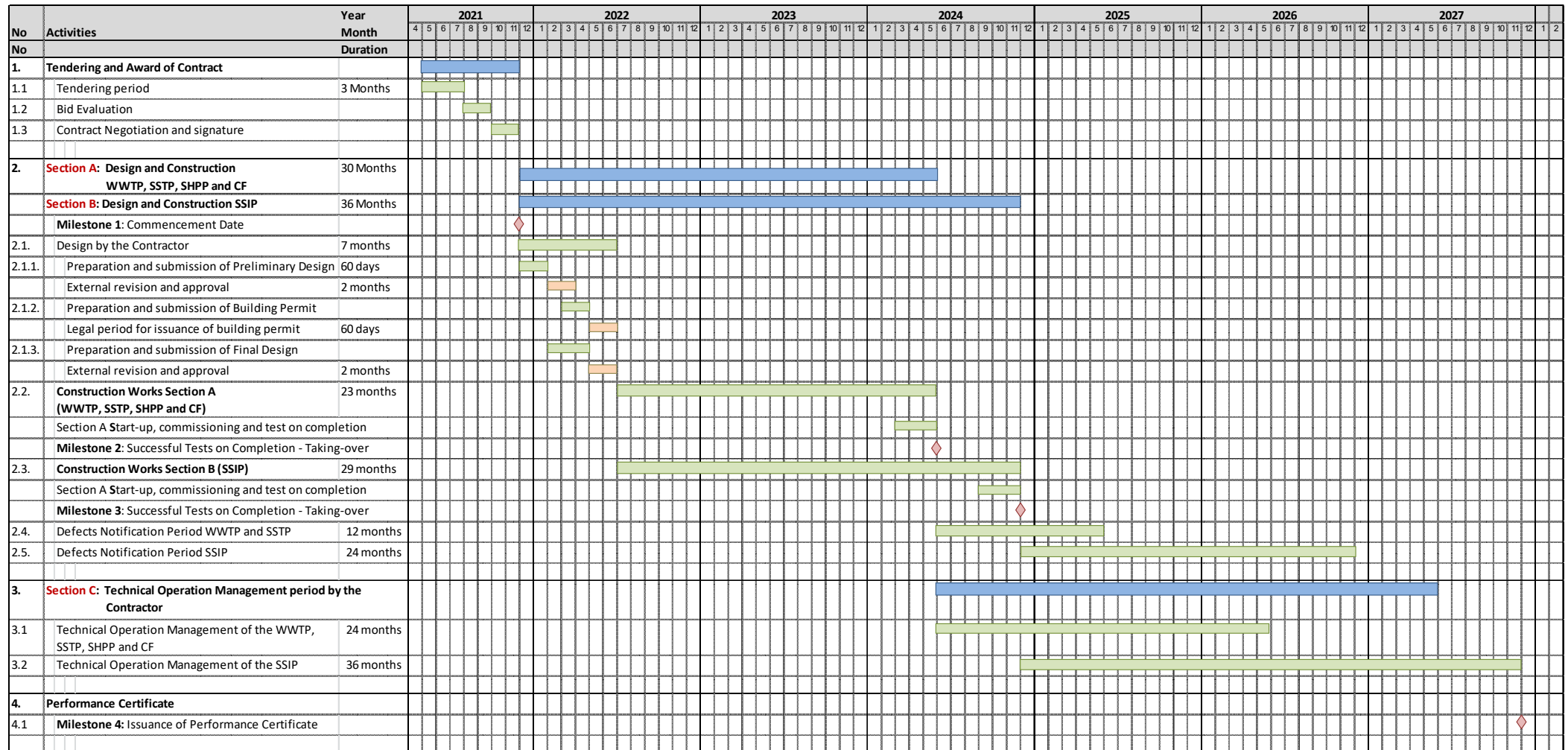


Figure 2: Construction of the WWTP Podgorica - Provisional time schedule

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b) Technical Specifications

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Part J: Training and Technical Operation Management

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

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b) Technical Specifications

Particular Technical Specifications

Part A: General Project Requirements

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Section VII – Employer's Requirements

1. Specifications

b) Technical Specifications

Particular Technical Specifications

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List of Acronyms

ATEX	ATmospheres EXplosible		Assessment
BOD ₅	Biochemical Oxygen Demand after 5 days	ESHS	Environmental, Social Health and Safety
BSCI	Business Social Compliance Initiative	ESMP	Environmental and Social Management Plan
C	Carbon	EU	European Union
CCTV	Close-Circuit Television	FC	Faecal Coliforms
CD	Commencement Date	FIDIC	Federation Internationale des Ingenieur-Conseils (International Federation of Consulting Engineers)
CEDIS	Crnogorski elektrodistributivni system (Montenegrin Company for Power Distribution)		
CFU	Colony Forming Unit	FGT	Flue Gas Treatment
CHP	Combined Heat and Power	FS	Faecal Streptococci
CL	Cover Level	GL	Ground Level
COD	Chemical Oxygen Demand	HAZOP	Hazard and Operability
CPM	Critical Path Method	HVAC	Heating, Ventilation, and Air Conditioning
DIN	Deutsche Industrienorm (German Standard)	I&C	Instrumentation and Control
DN	Nominal Diameter	ICT	Information and Communication Technology
DNP	Defects Notification Period	IEC	International Electrotechnical Commission
DO	Dissolved Oxygen	ISME	Institute for Standardization of Montenegro
DR	Dry Residue	ISO	International Organization for Standardization
DS	Dry Solids	IT	Information Technology
mDS	Mineral Dry Solids	JUS	Yugoslavian Standard
oDS	Organic Dry Solids	KAP	Kombinat aluminijuma Podgorica (Podgorica Aluminium Company)
d.o.o.	Drustvo sa ogranicenom odgovornoscu (private limited liability company)	KfW	KfW Entwicklungsbank
EC	European Commission	LED	Light-Emitting Diode
ECMA	European Computer Manufacturers Association	masl	Meter Above Sea Level
EIA	Environmental Impact Assessment	mbgl	Meter Below Ground Level
EMAS	Eco Management and Audit Scheme	MEICA	Mechanical, Electrical, Instrumentation, Control and Automation
EN	European Norm	MEST	Montenegrin Standard
ENG	English	MLSS	Mixed Liquor Suspended Solids
EPD	Explosion Protection Document	MNE	Montenegro or Montenegrin
EPEAT	Electronic Product Environmental Assessment Tool	N	Nitrogen
ESIA	Environmental and Social Impact		

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NTK	Total Kjeldahl Nitrogen	SSIP	Sewage Sludge Incineration Plant
OSHAS	Occupational Health and Safety Assessment Series	SSTP	Sewage Sludge Treatment Plant
P	Phosphorus	SVI	Sludge Volume Index
PA-ESMP	Project Area - Environmental and Social Management Plan	TC	Total Coliforms
PE	Population Equivalent	TKN	Total Kjeldahl Nitrogen
PEA	Project Executing Agency	TN	Total Nitrogen
PIU	Project Implementing Unit	TO	Taking-over
PLC	Programmable Logic Controller	TOC	Taking-Over Certificate
RAS	Return Activated Sludge	ToC	Tests on Completion
RCM	Reliability Centred Maintenance	TP	Total Phosphorus
RoHS	Restriction of Hazardous Substances	TSS	Total Suspended Solids
SA	Social Accountability	VDS	Volatile Dry Solids
SAS	Surplus Activated Sludge	VIK	Vodovod i Kanalizacija (Water and Sewerage Company)
SCADA	Supervisory Control and Data Acquisition	VSS	Volatile Suspended Solids
SHPP	Small Hydro-Power Plant	WWTP	Wastewater Treatment Plant
SS	Suspended Solids		

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the **decimal comma** is used and the dot is used as **thousand separator**.

A.1. GENERAL

The General Project Requirements presented herein define the scope of the Works to be implemented under the Contract, specify the purpose of the Works and particular requirements for the completed Works, including functional requirements, quality, performance and scope, requirements for the supply of certain items (such as consumables), special obligations and other details generally in accordance with the Conditions of Contract.

These General Project Requirements are to be read in conjunction with the following others parts of the Technical Specifications:

- Part B: Particular Process and Design Requirements;
- Part C: General Technical Specifications - General Requirements;
- Part D: General Technical Specifications for Civil Works for Facilities;
- Part E: General Technical Specifications for Civil Works for Pipe Works;
- Part F: General Technical Specifications for Civil Works for Buildings;
- Part G: General Technical Specifications for Mechanical and Electromechanical Civil Works;
- Part H: General Technical Specifications for Electrical and Instrumentation & Control Works;
- Part I: General Technical Specifications - Requirements for Sewage Sludge Incineration Plant (SSIP)

The Technical Specifications define the minimum specific requirements, materials and workmanship required for execution of the Works. The Particular Technical Specifications describe the specific scope of Works, supply and services to be provided by the Contractor.

Whenever there is a conflict between the Particular Technical Specifications (Part A and Part B) and the General Technical Specifications (Part C to Part I), the Particular Technical Specifications shall prevail.

These General Project Requirements shall also be read in conjunction with the following others parts of the Employer's Requirements:

- Specifications part c): Specifications for Project Area Environmental, Social, Health and Safety Management (ESHS);
- 2. Drawings
- 3. Supplementary Information

The Contractor shall familiarise himself with the law and statues applicable in Montenegro regarding construction of facilities, in particular wastewater treatment and sludge treatment

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and incineration plants, including requirements and procedures for preparation and approval of design and construction and should allow sufficient time and allocate the required resources.

Notwithstanding the subdivision of the Employer's Requirements under different headings, every part of it shall be deemed supplementary to and complementary of every other part.

The Bidding Documents shall be read and applied as a whole. The absence, in one part of the documents, of a reference to another part in no manner excludes the application of every other section of the Bidding Documents.

Omissions in the specifications, drawings and other documents shall not relieve the Contractor from the responsibility of supplying, installing and constructing any item required for the working, operation and maintenance of the plant, required by the law or usually supplied, installed or constructed in the scope of works of similar character.

The Employer's Conceptual Design is enclosed in this Tender Dossier (Part 3. Of the Employer's Requirements: Supplementary Information). Information given in the Conceptual Design has only an informative value. It is the Contractor's responsibility to prepare his own concept, design and process calculation in accordance to the Employer's requirements.

Remark:

In the present document the term Wastewater Treatment Plant (WWTP) is used to describe both the whole plant, including the wastewater treatment facilities, the sewage sludge treatment facilities, the sludge incineration plant and the general facilities as, in special cases, only the wastewater treatment facilities.

A.2. WORKS INCLUDED

The Contractor shall offer the whole works including civil, mechanical, electrical parts and I&C works and provision all staff, labour, plant, power, materials, consumables, etc. to implement the works so that the aim of the project is completely fulfilled, as specified and in accordance with the Employer's Requirements.

The scope includes also all temporary works required during execution as well as all services not expressly specified in the following, but which are essential for the satisfactory and reliable operation of the facilities, material and equipment. All works not expressly called for in this Bidding Document, but necessary for the complete and proper operation of the works shall be provided by the Contractor at no additional costs. It is the responsibility of the Contractor to include in his offer all civil works, deliveries and services required for the whole of the Works, and to state the exact quantity and dimensions as necessary to suit his design in accordance with the Works Requirements.

Where such items are not specified in the following, they shall be added and specified to supplement these Tender Documents.

The interfaces / terminal points are described in Section B.2.12. Any terminal points which are not specified / included but required for safe and reliable operation of the Works shall be deemed to be included in the Scope of Works and the Contractor shall carry out such terminal connection works at no extra cost to the Employer.

The Contractor's scope of works and supply shall include all elements and aspects to ensure the proper implementation of the project, which includes the design, construction and commissioning of the WWTP, training of the Employer's personnel and the operation, supervision and management of the WWTP during trial operation and operation management period by the Contractor.

Bidders shall submit a technical and financial proposal for the Base Solution depicted in the bidding documents which is in accordance to the Employer's approved Conceptual Design. Bidders may submit an alternative offer for alternative technical solutions in the form of a separate technical and financial offer clearly stipulating where the alternative offer deviates from the base solutions and the advantages of the alternative solution.

Bidders have to guarantee that the proposed technological solution(s) provides the required performances and fulfils the minimum requirements indicated in the Bidding Documents.

The contracting authority reserves the right to reject any technological solution which is not compliant with the technical specifications and mandatory Employer's requirements.

Works and services to be included in the Contractor's offer shall include but not be limited to the following.

A.2.1. General Scope of Works and Services

General works and services to be provided by the Contractor under the Contract shall include:

- Any and all necessary design encompassing process, civil, structural, mechanical, electrical, SCADA (incl. programming with relevant licenses) and including all necessary internal and external interface coordination as well as other "non-construction" activities;
- Site surveys, measurements and additional geotechnical surveys as required;
- Co-ordination of the design with competent Authorities and assistance to the Employer in obtaining the necessary approval of designs (Preliminary and Final Design);
- Assistance to the Employer in obtaining the necessary building and construction permits;
- Assistance to the Employer in the connection of the WWTP to the necessary services (electricity, potable water, telecommunication, etc.) in accordance to the relevant national regulations and conditions of the services providers;
- Construction and installation, erecting and commissioning of the works for the WWTP, including connections to the sewerage system and utilities;
- Construction and installation of all channels and interconnecting pipework within and between process units, structures and for inlet works, bypass systems, outlet, washouts, service water systems, process related piping and connections to the channels and pipe system; within the limits of the Contract as required, including pipes and drains of any description and of all materials with all fittings, penstocks, valves and pipe protection, with both coating and lining;
- Supply and installation of all necessary Mechanical, Electrical, Instrumentation, Control and Automation (MEICA) equipment, including motors and pumps;
- Supply and installation of laboratory equipment and furniture;
- Supply and installation of administration building and workshop equipment and furniture;
- Supply, installation and programming of Supervisory Control and Data Acquisition (SCADA) System, incl. all necessary IT infrastructure and equipment;
- Supply and installation of all necessary regulators, instruments, indicators, recorders, gauge plates, platforms, floor plates and frames, fixed and portable ladders, handrail, flanges, connectors, gaskets, bolts, nuts, flexible couplings, nameplates, identification tags and bandages, cable splices, glands, boxes, junctions and ancillary material; fasteners, clips, stands, trays, hangers, all other auxiliary materials of any description and all materials;
- Submission of testing, commissioning and taking over documentation;
- Trial operation and training of the Employers staff, incl. supervision, management and operation of the WWTP as required;

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- Operation of the WWTP for two (02) years from the successful completion of the Tests on Completion;
- Operation of the SSIP for three (03) years from the successful completion of the Tests on Completion.

The Works under the Contract shall furthermore include (inter alia) mobilisation and demobilisation of staff and equipment, provision of site installations, provision of temporary facilities during construction, housing for Contractor's staff, provision of all site offices and vehicles including running costs, purchase, receipt, storage of all material required for the Works, incl. setting out the construction in accordance with the Employers Requirements, Specifications and Schedules.

A.2.2. Common Works and Services

The Contractors proposal and scope of works shall cover, but not be limited to the following.

A.2.2.1. General

- Engineering design of complete works, including internal and external interface coordination;
- Quality control plan and safety plan;
- Elaboration, implementation and monitoring of the Project Area Environmental and Social Management Plan (PA-ESMP);
- Materials, consumables and personnel costs for tests and inspections;
- Complete documentation as set in the specifications;
- As-built drawings and documentation (in the data format as requested by the Engineer / Employer);
- Operating manual and detailed operating and maintenance instructions;
- Maintenance programme for all installed equipment / facilities;
- Training of Employer operating and maintenance staff;
- Housekeeping during construction;
- Staff facilities during construction;
- Health & Safety and fire protection during construction;
- Scaffolding for all works above ground level;
- Operation of temporary installation during construction;
- Security services;
- Insurance.

A.2.2.2. Civil Works

- All required surveying works, investigations and studies;

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- Mobilisation and site installation;
- Preparation of site, demolition works, removal of underground obstacles;
- Earthworks and reinstatement works, including site levelling, excavation, drainage, fill and other earth works;
- Any ancillary earthworks, such as dewatering, etc.;
- Transport of all debris, dumping and surplus material to appropriate dump locations;
- Temporary roads and fencing of construction site;
- Implementation and interpretation of geotechnical survey investigations;
- Concrete and reinforced concrete works;
- Foundation works;
- Interconnecting pipe works;
- Masonry;
- Water proofing works;
- Flooring, roofing and siding works;
- Concrete coating, painting, varnishing;
- Plumbing;
- Crane way works;
- Drinking water, process water and electricity supply during construction works and for the permanent works;
- Plumbing and HVAC;
- Landscaping and road works.

A.2.2.3. Mechanical Works

- All connections elements, screw, bolts, nuts, including gasket and seals as necessary;
- All necessary support structures, hangers, etc.;
- All necessary base frames, mounting plates, grouted in parts, rag bolts, covers, etc.;
- All required steel parts embedded in concrete;
- All necessary lifting equipment and hoists for maintenance and repair works where loads exceed 25 kg;
- Structural steel / metal works;
- All necessary steel structures, stairs, ladders or platforms;
- Walkways to the applied equipment, including escape routes as necessary;
- Required safety equipment;
- All necessary corrosion protection measures for the supplied equipment stored or mounted on site;

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- Complete primer and top coatings conforming to colour code as agreed with the Engineer;
- Necessary noise abatement measures;
- Complete labelling of all components according to the Employer's system and in plain language;
- All fire protection measures;
- Initial lubricant filling and sufficient lubricants for tests on completion and 12 months operation of the plant;
- Protection of all instrumentation and equipment to be installed during construction;
- All standard accessories and auxiliary equipment which normally form part of the scope of works;
- All necessary measurements, tests, inspection and acceptance of works as well as certificates and reports of these;
- Removal of any unused material.

A.2.2.4. Electrical Works, Instrumentation and Control

- Complete installation material, including wiring, cabling and piping material, all needed fastenings, conduits, brackets and other supports including cable trays and labelling and marking;
- All required switch gears and busbars;
- All necessary control panels, switches, sockets, junction boxes and cubicles;
- Electrical sub-station;
- All field control boxes;
- All instrument mounted on instrumentation racks;
- All necessary electrical drives;
- Lightning protection;
- Inside, outdoor and escape lights as specified;
- CCTV to cover whole WWTP;
- Operation and Maintenance software programme and hardware;
- Electrical earthing;
- Clarification of all logic interconnections: sequence, interlocking, protection, safeguarding for coordinated operation / start-up / shut down of individual items of equipment;
- Measuring device as specified and measuring devices list;
- All local measurement and fields control loops as well as instruments for reliability test and checks.

A.2.2.5. Packaging and Transportation

- Suitable packaging and transportation of the entire scope of supplies;
- On-site transportation, unloading at site and temporary storage including inspections and, if necessary, the prerequisites for transportation;
- Transport insurance;
- Disposal of packing and transportation material;
- Customs clearance;
- Crane or hoisting facility
- Transporting to Site;
- Unloading at Site.

A.2.2.6. Erection and Testing

- Complete erection of the works up to operational readiness. This includes mobilisation and provision of the required engineering staff, skilled and unskilled personnel, as well as of installation scaffolding, cranes, hoists, equipment and materials, personnel accommodation, prescribed tests and inspections;
- Supervision of erection, commissioning and optimisation of all works as well as conducting all necessary measurements;
- Tests on Completion of complete supplied works;
- All testing as specified.

A.2.2.7. Spare Parts

The Contract includes the supply of all required spare parts as well as wear-and-tear parts which are required to enable the works to be operated efficiently for a **period of two (02) years continuous operation** according the following requirements:

- The scope of supply shall include all spare parts required for testing of the works;
- A list of spare parts supplied by the Bidders shall be included in the Data Sheet of the corresponding equipment (Volume 2, Section IV – Bidding Forms – Schedules, Part B: Schedules of Particulars);
- For all major items of equipment, as a minimum, a set of bearings, seals, impellers gaskets and seals (as appropriate) shall be included. Where multiples of the equipment are included a set of spares shall be provided for every 5 pieces of the same equipment.
- Each item shall be clearly labelled in English or Montenegrin and separately packaged against damage and sealed to prevent deterioration due to climatic conditions and re-handling. The protection shall be appropriate for a minimum of five (5) years of storage in a dry weatherproof building;

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- The Contractor shall include in his supplies all required bins, racks, drawers, shelves, cabinets, etc... for storing the spare parts;
- The Contractor shall not use any of the spare parts without written permission from the Engineer. All parts so used shall be replaced by the Contractor prior to issuance of the Taking-Over Certificate;
- In addition to above mentioned necessary spare parts, bidders shall, where applicable submit with their offer a list and the price of recommended additional spare parts (Volume 2, Section IV – Bidding Forms – Schedules, Part C Schedules of Rates and Prices, Schedule 7);
- Costs of spare parts shall be included in the price of the corresponding item.

The price of these spare parts shall be included in the price of the respective equipment in the Price Schedule No. 1 [Plant including Mandatory Spare Parts Supplied from Abroad] and Price Schedule No. 2 [Plant including Mandatory Spare Parts Supplied from within the Employer's Country]. In case an equipment is not specifically mentioned in the Price Schedule No. 1 or the Price Schedule No. 2, the price of the spare parts are deemed to be included in other items of these price schedules.

The supply of spare parts as per Price Schedule No. 7 [Recommended Spare Parts] is not part of this contract and the Employer may order all or any of these spare parts at his discretion.

A.2.2.8. Tools and Appliances

Tools and appliances shall be supplied by the Contractor as set forth in these present Particular Specifications for the different Components; in any case, supply of tools and appliances shall comply at least with the following:

- The Contractor shall supply all tools and appliances which are required for the regular operation and maintenance of the works;
- The Contractor shall provide a schedule of all tools, appliances, lifting tackle, and other items being supplied, for the approval of the Engineer and the Employer;
- Each tool or appliance is to be clearly marked with its size and/or purpose;
- The supplied tools and appliances shall not be used for erection purposes by the Contractor and shall be handed over in new condition. The exception to this is the special lifting appliance (if applicable) which may be used, provided that when it is handed over to the Employer it has not been subjected to more than normal wear and is still fully suitable for its intended use;
- Where appropriate, each set of tools and appliances shall be suitably arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the layout of the plant and equipment in question. If the weight of any box and its content should be such that it cannot conveniently be carried, it shall be supported on steerable rubber-tire wheels;
- Workshop tools, where appropriate, shall be mounted to the floor or wall as required;

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- Each cabinet and box shall be painted, fitted with a lock and clearly marked in white letters, in the Montenegrin and the English language, with the name of the item of equipment for which the contained tools and appliances are intended;
- The scope of supply includes the supply of all necessary portable lifting tackle in accordance with following specifications:
 - Suitable storage racks shall be provided for all portable lifting tackle in this contract;
 - Suitable lifting lugs, ears or ring bolts, or tapped holes for lifting rings shall be provided on all equipment items where the weight exceeds 15 kg;
 - All lifting tackle shall be stamped with a unique identification number and safe working load;
 - A test certificate from an approved authority shall be supplied for each item of lifting tackle;
- The Contractor shall provide all runway beams, trolleys, lifting blocks, special slings, etc. necessary for the safe and efficient handling and maintenance of the work. Particular attention must be paid to high level equipment such as pump sets etc. Electrically operated hoists and runway trolleys shall be provided for all lifts in excess of two and one half (2,5) tons.
- The tool and appliances with the appropriate storage racks, cabinets and boxes shall be handed over to the Employer at the time of Taking-Over;
- Any special tools and appliances required solely for erection shall be provided by the Contractor for his own use and shall remain the property of the Contractor.

A.2.2.9. Consumables, Lubricants and Greases

All lubricants and grease proposed for the operation of the Works shall be suitable for all operating and environmental conditions that will be encounter on the Site. In addition, all oils and greases shall, where possible, be readily available in the country of installation.

The number of oils and greases shall be kept to a minimum. For each type and grade of lubricant recommended the Contractor shall list at least three equivalent lubricants manufactured by alternative companies.

The Contractor shall supply the first fill of lubricants, and shall provide at the Take-Over sufficient consumables (other than electrical energy, fuels oil and drinking water), lubricants and greases necessary for the efficient operation and maintenance of the Plant at full load, 24 hours per day, for a **period of two (2) years**.

A.2.2.10. Equipment for Maintenance

The Contractor has to supply and install all equipment, instruments, signs etc., for the maintenance of the WWTP, including but not limited to:

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- tools;
- handling equipment;
- portable pumps;
- flexible pipes;
- flanges, gaskets, etc.

A.2.2.11. Safety Equipment

The Contractor shall supply and install all safety equipment, instruments, signs etc. needed for the safe operation and maintenance of the WWTP, including but not limited to:

- portable gas analyzer (two sets);
- portable lamps safe for use in explosive environments (two pieces);
- respirators (two pieces);
- permanent first aid boxes;
- portable first aid boxes (two sets); and
- swimming belts and safety hook bars.

A.2.2.12. Other Equipment

Under this Contract, the Contractor shall procure and supply equipment to be used by the Beneficiary for the operation and maintenance of the works as described in the various sections of the present Particular Specifications.

A.2.3. Scope of Engineering Services

The Contractor will be responsible for the preparation and submission of the Preliminary Design (idejni projekat) and Detailed Design (glavni projekat) required in accordance with the Montenegrin Law on Spatial Planning and Construction of Structures (Off Gazette of MNE No. 82/20) and its by-laws for the approval of the project by the responsible authorities and issuance of the building permit. Details on the requirements regarding the Preliminary and Detailed Design are given in Section A.4.4.

The Contractor's completed Preliminary Design shall be submitted to the Engineer for review not later than 60 days after the Commencement Date. Following review by the Engineer and inclusion of all requested changes, as well as approval by the external Revision Committee, the Preliminary Design shall be submitted / provided in the required number of copies for Building Permit application. The Contractor shall proceed with the Detailed Design upon receipt of the Engineer's comments on the Preliminary Design. The Detailed Design shall be submitted in full not later than 150 days after the Commencement Date.

In addition to the above, the Contractor will be responsible for the preparation and submission to the Engineer for approval of working drawings and all necessary calculations and technical

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details of the works encompassing process, civil, structural, mechanical, electrical and SCADA, required for the implementation of the Works, prior to placing the order for the supply of the corresponding equipment or start of construction of the corresponding works.

The Contractor shall submit to the Engineer design calculations and technical details of the plant and structures further to those accepted with his Bid, in sufficient detail for the Engineer to satisfy itself that the items of the Plant and the structures are jointly and severally suitable for their intended purpose. If not otherwise specified, it is the contractor's duty to submit these documents early enough to not jeopardize the given time schedule requirements.

For parts of the works where the Contractor chooses to construct the Works in an alternative way he shall be fully responsible for elaboration of the detailed design, calculations and all technical details required for the implementation of the Works. This includes notably the structural design of all civil and metallic structures.

The design calculations and technical details shall include design calculations, piping and instrumentation diagrams, hydraulic flow diagrams, technical details and schedules of major plant and structures.

The Contractor shall also provide additional details and calculations and other data as may be reasonably required by the Engineer to satisfy itself to the stability, durability and safety of the works and for ascertaining and inspection of the plant and structures during construction that it is in conformity with the Contract.

The Contractor shall submit as part of his technical details, the magnitude and frequency of all out of balance forces of the plant to allow them to be taken into account in the structural design of civil and building structures.

Furthermore the Contractor shall actively participate in the preparation of all required licensing applications. All up-front preparations required to meet the time schedule of the contract shall be undertaken by the Contractor.

A.2.4. Contractor's Own Investigations and Surveys

A.2.4.1. Pre-Construction Survey and Setting Out

Prior to the commencement of the works, the Contractor shall carry out a complete new topographic survey of the construction sites and their vicinities in x, y and z coordinates in accordance to Section C.3.4.7.2. The proposed geodetic reference system shall be submitted for approval to the Engineer.

Locations, levels, dimensions and materials of existing works and / or other infrastructure referred to in Section B.2.11 are provisional and shall be investigated by the Contractor on his own responsibility, where required for the execution and completion of the works.

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In addition, the Contractor shall, upon commencement of the Works, implement all required additional topographical surveys required for setting out the Works in accordance to Section C.3.4.7.4, including levels of the original ground surface at the Site, and for works implementation. He shall also carry out all necessary additional topographic survey for the preparation of as-built drawings.

The Contractor shall submit a softcopy and two coloured hardcopies of the drawings to the Engineer for approval.

A.2.4.2. Geotechnical Survey and Investigations

Geotechnical survey investigations have been carried out at the site of the works and are provided to the Bidders (Volume 3, Section VII: Employer's Requirements, Part 3).

The Contractor shall carry out any additional geotechnical investigation and analysis of soil-mechanical parameters as he deems necessary for the implementation of the Works or as required by local authorities in accordance to local regulations, especially by local seismic and construction regulations, standards and norms. The Contractor shall bring to the attention of the Engineer any discrepancy discovered in the course of its additional geotechnical survey.

Two soft and 3 hard copies of the Contractor's geotechnical investigation report shall be submitted to the Engineer immediately upon preparation.

The Contractor shall prepare and submit for approval to the Engineer, detailed and structural design of the treatment works based on the results of the geotechnical survey investigations.

A.3. DATA PROVIDED TO THE BIDDERS / CONTRACTOR

Following data are provided in digital format to the Bidders and to the Contractor:

1. Drawing of the available Site construction of the WWTP, including topographic survey (Autocad processable format) (Volume 3, Section VII Employer's Requirements, Part 2. Drawings);
2. Urbanistic-Technical conditions (Urbanisticko-Tehnicki Uslovi) issued by the local authorities and service providers (pdf-format) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information). Contractor's design and implementation of works shall fully comply with and meet all requirements of the urbanistic-technical conditions;
3. Employer's approved Conceptual Design for the Wastewater Treatment Plant for Podgorica Capital City (pdf-Format) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information);
4. Environmental and Social Impact Assessment (ESIA) Report and Environmental and Social Management Plan (ESMP) (pdf-Format) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information);
5. Geotechnical Survey Report at the Construction Site of the WWTP (pdf-Format) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information);
6. Reports on Soil Contamination at the Construction Site of the WWTP (pdf-Format) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information);
7. KAP Wells Water Analysis Data (pdf-Format) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information).

The Contractor shall carry out himself all surveys, investigations, studies and analyses of any kind as may be necessary and specified elsewhere on his own expense and responsibility.

The Employer will not entertain any claim by the Contractor on account of incompleteness or inaccuracy of drawings and data furnished by him, irrespective of when the Contractor shall discover such incompleteness or inaccuracy.

A.4. PERMITS AND APPROVAL BY LOCAL AUTHORITIES

A.4.1. General provision

The Contractor will be responsible for preparing all required applications in order to receive all relevant local permissions for construction, testing, commissioning and operation of the WWTP, including when such permits, licenses or authorisations can be issued only to the Employer in accordance to Section A.4.3 below. Further the Contractor will be responsible for preparing any further studies, reports and design documents required for the permit application documents, plant implementation, commissioning and plant operation.

The Contractor shall obtain, through the Employer or other relevant statutory body, all permits necessary for construction, occupation and use of the WWTP, together with the sewerage reticulation extensions and the connections for potable water supply, electricity, gas supply, road connection etc., according to the National legislation. This is to include the required number of copies of the Contractor's design in the Montenegrin language for obtaining the building permit.

None of the works which require approval by local authorities or service provider shall be started before the approval has been obtained by the Contractor from the appropriate authorities. The obtaining of this approval is part of the Contractor's contractual commitments.

It is deemed that all related costs for obtaining the permissions and approvals are included in the Contractor's prices.

The Contractor shall allow a realistic timescale for dealing with the third parties responsible, for permits etc., in his planning and programming of the work.

A.4.2. Permits, Licences and Authorisations

Unless such permit, license or approval can be issued only to the Employer, the Contractor shall be fully responsible for obtaining all necessary permits, licences, approvals and authorisations required for the execution of the Works, prior to the commencement of the works.

The Contractor shall not supply material or equipment or start with construction works for works which require approval by local authorities, before the necessary approval has been obtained by the Contractor from the relevant authority.

A.4.3. Support to the Employer in Obtaining Approvals

The Contractor shall provide any necessary support and assistance to the Employer in obtaining a permit, approval or authorisation which can be issued only to the Employer. Such support include notably the preparation and submission to the Employer, in the Montenegrin

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language, of any study, report, design document or calculation that may be required by the relevant Authority or Institution in the form and format required by such Authorities and Institutions.

Such approvals and permits may include but are not limited to the following:

- Building permit;
- Environmental Permit or Consent in accordance to the Law on Environmental Impact Assessment (Off Gazete of MNE No. 75/18) and its by-laws;
- Water abstraction permit for the well to be constructed under the project for the supply of the plant with process, irrigation and firefighting water;
- Water discharge permit for the discharge of treated effluent into the Moraca River;
- Permit for emission of pollutants into the air (flue gas treatment foul air);
- Approval of the Protection Plan of the wastewater treatment plant in accordance to the Law on Protection of Persons and Property (Off Gazette of MNE No. 43/18);
- Approval of the Accident Prevention Plan, Seveso Plant Notice, Safety Report and Accident Protection Plan as required in accordance with the Rulebook on the Detailed Content of the Prevention Plan and Accident Protection Plan (Off. Gazette of MNE No. 067/16);
- Fire Protection Study or Fire Protection Project in accordance with the Law on Protection and Rescue (Off. Gazette of MNE No. 54/16);
- Approval for construction of access road;
- Approval for the connection on utilities from service provider (power supply, telecommunication company, water supply company....);
- Plant exploitation / operation permit.

A.4.4. Contractor's Design Approval

The Contractor will be responsible for the preparation of the Preliminary Design (idejni projekat) and of the Final Design (glavni projekat) of the wastewater treatment plant in accordance to the Law on Spatial Planning and Construction of Structures (Off Gazette of MNE No. 82/20) and its by-laws, including notably:

- the Rulebook on the Manner of Preparation and Content of the Technical Documentation for Building Objects (Off gazette of MNE No. 044/18);
- the Rulebook on the Manner of Preparation and Content of the Technical Documentation for Complex Engineering Facilities;
- the Rulebook on the Method of Review of Detailed Design (Off Gazette of MNE No. 018/18);
- the Rulebook on the Method of Review of Complex Engineering Facilities;

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With reference to the law of Spatial Planning and Construction of Structures (below referred to as "the Law"), attention of the Bidders is drawn on the following:

- the wastewater treatment plant is a complex engineering structure in the sense of the Law both with regard to the whole plant as for some of its sub-components;
- The Preliminary Design (idejni projekat) shall be developed for the need of the issuance of the building permit;
- External review and approval of the Preliminary and Final Design is mandatory;
- The Law requires that entities engaged in the development of engineering design possess the required licenses in the respective field of activity both at the level of the company than for the design engineers (natural persons) who are in charge of preparing the design;
- The Preliminary Design and Final Design shall be prepared in compliance with and meet all conditions and requirements of the Urbanistic-Technical conditions (Urbanisticko-Tehnicki Uslovi) (Volume 3, Section VII Employer's Requirements, Part 3. Supplementary Information).

A.4.5. Coordination with local Bodies and Relevant Entities

Addresses of local bodies and relevant utility provider are given in the table below. The list is by no means comprehensive and/or final. The Contractor shall undertake to maintain contact with relevant authorities and utility providers as may be required. The Contractor shall inform the Engineer promptly on any changes.

Table 1: Addresses of local bodies and relevant entities

Service	Name	Address	Telephone
Water Supply and Sewerage	Vovod i kanalizacija Podgorica	Ulica Zetskih vladara bb 81000 Podgorica	+382 20 440 388
Roads	Uprava za saobraćaj Podgorica	IV proletarske 19 81000 Podgorica	+382 20 655 095
Electricity	Crnogorski elektrodistributivni system (CEDIS)	Ulica Ivana Milutinovića br. 12; 81000 Podgorica;	+382 20 633 979
Telecommunication	Crnogorski Telekom	Moskovska 29 81 000 Podgorica	

A.5. APPLICABLE STANDARDS

All design and construction works must be performed according to the most recent relevant European and international codes, standards, regulations (ISO, EN, IEC, etc.) and the applicable national Regulations and Standards. National or local standards refer to valid and applicable Montenegrin Standards (MEST) issued by the Institute for Standardization of Montenegro (ISME) as well as still valid and applicable Yugoslavian standards (JUS).

The Standard with the highest quality will regulate where these differ.

Annex 1 to the present Part A of the Technical Specifications includes a list of relevant applicable Montenegrin Standards. This list is indicative and shall in no way be considered as being exhaustive.

All materials and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of goods, methods of inspection, specific design features of equipment and parts and acceptances of partial plants shall comply in every respect with rules and regulations of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and European Standards where applicable.

It is the Contractor's responsibility to provide sufficient evidence that any national or other standard the Contractor proposes will ensure an equivalent or higher standard.

Immediately after effective date of the Contract the Contractor shall supply an indexed list of all standards, codes and associated standards referred to, to which the work is to be performed.

The quality control systems and plans shall be according to ISO 9000 and subject to approval of the Engineer.

A.6. DOCUMENTATION

A.6.1. General Provision

All information, documentation, drawings, reports, calculations, etc. prepared and submitted by the Contractor shall be in accordance with the requirements of Section C.4.

Unless otherwise stated in these Particular Technical Specifications any documents shall be submitted in two (02) English hardcopies, two (02) Montenegrin hardcopies and two (02) softcopies on separate digital support, whereas softcopy shall mean the editable file as well as a pdf-file. Where scans are generated the resolution shall not exceed 300 dpi.

Construction site documents prepared by the Contractor shall comply with applicable Montenegrin regulations and notably the Law on Spatial Planning and Construction of Structures (Off. Gazette of Montenegro No. 82/20) and following by-laws:

- The Rulebook on the content of the Study on the construction site (Official Gazette of Montenegro No. 04/99);
- The Rulebook on the Content of the Study on Preparatory construction (Official Gazette of Montenegro No. 80/08);
- The Rulebook on the manner of keeping and contents of the construction diary and the construction book (Official Gazette of Montenegro No. 68/18).

A.6.2. Contract Documents

The Contractor shall be responsible for editing the Contract documents. Cost for reproduction the Contract documents shall be deemed to be included in the Contract price.

The Contractor shall provide ten (10) bound copies of the Contract documents based on the original prepared under supervision of the Engineer, of which 6 copies in Montenegrin language and 4 copies in English language.

The Contract document shall comprise the documents as stated in Volume 4, Conditions of Contract.

A.6.3. Insurances

Within 14 days after the Commencement date, the Contractor shall provide evidence for the following insurances:

- Insurance of the Works and Contractor's equipment;
- Insurance against injury to persons and damage to property;
- Insurance for Contractor's personnel.

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A.6.4. Documents to be delivered after Award of Contract

A.6.4.1. Approval Procedure for Drawings and Documents

The Table 2 below table shows the number of copies that are required for each activity:

Table 2: Deliverables for Documentation and Approval

Item	Description	Sender	Recipient	Copies
1	Document for approval	Contractor	Engineer	2 prints ENG + 1 print MNE + softcopies*
			Employer	1 print ENG + 1 print MNE + softcopies*
			Other as required	Additional copies as required for: - External auditor (print MNE) - KfW (print and softcopy ENG) - Other as required
2	Document reviewed	Engineer, Employer and other authorised person	Contractor	1 print with comments / status
			Employer	Copy of transmission
3	Document approved for construction	Contractor	Engineer	2 prints ENG + 1 print MNE + softcopies*
			Employer	1 print ENG + 1 print MNE + softcopies*
4	As-built for approval	Contractor	Engineer	2 prints ENG + 1 print MNE + softcopies*
			Employer	1 print ENG + 1 print MNE + softcopies*
5	As-built approved	Engineer	Contractor	1 print ENG
6	Final Records and as-built documents	Contractor	Employer	5 sets of all documents (ENG and MNE) + softcopies*
			Engineer	1 set of all documents (ENG + MNE) + softcopies*

ENG = English language. MNE = Montenegrin language

* softcopy shall mean pdf and editable Word, Excel, AutoCAD, etc. files

A.6.4.2. Documents to be submitted

The following table gives an overview of the most important documents to be submitted by the Contractor in the course of the project implementation. This list is and the time table for submission are only indicative. The detailed list of drawings and documents to be submitted for information or approval, including the time-table, shall be agreed after effectiveness of the contract.

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Table 3: Indicative list of documents to be submitted by the Contractor and tentative time table for submission

No	Document	No of copies ENG + MNE + digital	Submission deadline	Examination / Approval period	Comment
A	Statutory Design Documents				
A.1	Preliminary Design WWTP (idejni projekat)	2 + 5 + 2	CD + 60 days	External approval	In accordance to Montenegrin regulations
A.2	Final / Detailed Design WWTP (glavni projekat)	2 + 5 + 2	CD + 150 days	External approval	
B	General				
B.1	Project start-up Programme	2 + 4 + 2	CD + 10 days	14 days	
B.2	Detailed Programme of Works	2 + 4 + 2	CD + 28 days	14 days	Detailed programme
B.3	Updated Programme of Works	2 + 4 + 2	Monthly update	7 days	At least monthly updates submitted with the Monthly Report
B.4	Health & Safety Plan	2 + 4 + 2	CD + 28 days	21 days	Subject to Engineer's approval
B.5	PA-ESMP	2 + 4 + 2	CD + 28 days	21 days	Subject to Engineer's approval
B.6	Full QA/QC Plan	2 + 4 + 2	CD + 28 days	21 days	Subject to Engineer's approval
B.7	Report on Preparatory Works and Temporary Site Facilities	2 + 4 + 2	28 days before scheduled CoW	14 days	
B.8	List of sub-contractors, suppliers and manufacturers	2 + 4 + 2	CD + 8 weeks	14 days	To be periodically updated as required
B.9	Complete list of documents with proposed submission deadlines	2 + 4 + 2	CD + 4 weeks	14 days	To be periodically updated as required
C	Preparatory Works				
C.1	Topographic survey	1 + 4 + 2	CD + 4 weeks	14 days	
C.2	Additional geotechnical Survey (if applicable)	1 + 4 + 2	CD + 8 weeks	14 days	
D	Construction				
D.1	Request for approval of Contractor's Equipment	2 + 2 + 2	14 days prior to commencement of the respective works	7 days	

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No	Document	No of copies ENG + MNE + digital	Submission deadline	Examination / Approval period	Comment
D.2	Method statements	2 + 2 + 2	28 days prior to commencement of the respective works	14 days	As required for each component of works
D.3	Drawing list	2 + 2 + 2	28 days before scheduled CoW	14 days	To be updated at list monthly
D.4	Working Drawings	2 + 2 + 2	28 days prior to commencement of the respective works	14 days	As required for each component of works
D.5	Other and complementary detailed design data and documents, calculations, diagrams, graphs, etc.	2 + 2 + 2	14 days prior to commencement of the respective works	7 days	As required for each component of works
E	Supply				
E.1	Request for approval of good and materials	2 + 2 + 2	21 days prior to purchase order placement	14 days	
E.2	Test certificates	2 + 2 + 2	Latest on delivery of goods		Copy of certificates to be submitted with request under E.1
F	Testing and Commissioning				
F.1	Proposed overall Inspection and Testing Programme	2 + 2 + 2	CD + 3 months	21 days	To be periodically updated as required
F.2	Detailed Programme for Commissioning	2 + 2 + 2	3 months before scheduled Commissioning	21 days	
F.3.	Detailed Performance tests programme	2 + 2 + 2	3 months before scheduled Performance Tests	21 days	
F.4	Testing procedure documents	2 + 2 + 2	4 weeks before each scheduled Testing	14 days	
F.5	Report on test results	2 + 2 + 2	2 weeks after completion of test	14 days	

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No	Document	No of copies ENG + MNE + digital	Submission deadline	Examination / Approval period	Comment
G	As-built documentation				
G.1	Draft as-built documentation	2 + 4 + 2	14 days before ToC	14 days	
G.2	Approved as-built documentation	2 + 6 + 2	3 weeks before TOC	n/a	
H	O&M and Training				
H.1	Provisional O&M Manual	2 + 4 + 2	2 months prior to commissioning	42 days	
H.2	Final O&M Manual	2 + 6 + 2	3 weeks before TOC	14 days	
H.3	Updated O&M Manual	2 + 6 + 2	3 months prior to provisional PC	21 days	
H.4	Maintenance Plan	2 + 6 + 2	3 weeks before ToC	14 days	
H.5	Training Programme	2 + 6 + 2	3 months prior to ToC	42 days	
H.6	Spare part list	2 + 6 + 2	3 weeks before ToC	14 days	
H.7	Lubricant and consumable list	2 + 6 + 2	3 weeks before ToC	14 days	
I	Reporting				
I.1	Progress Report	2 + 4 + 2	7 days after beginning of the next month	n/a	To be submitted each month
I.2	Erection diary	To be kept updated daily on the Site			Statutory

ENG = English language. MNE = Montenegrin language
 CD: Commencement Date
 CoW: Commencement of Works
 ToC: Tests on Completion
 TOC: Taking-Over Certificate
 PC: Performance Certificate
 PA-ESMP: Project Area Environmental and Social Management Plan

A.6.4.3. Contract Planning Requirements

The Contractor shall prepare and submit to the Engineer's approval following work programmes:

- A project Start-up Programme in accordance to Section C.3.4.1 covering all activities scheduled in the first three (03) months;

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- A detailed Programme of Works in accordance to Section C.3.4.2.

The Programme of Works shall be co-ordinated to take into account transportation and delivery times for the materials and for climatic and other conditions to provide for the completions of the Works in accordance with the Contract. The Contractor shall make due allowance in his programme for national holidays. Beside contents listed in the General Technical Specifications, the programme shall clearly indicate the following:

- the sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity of percentage of work expected to be achieved on each activity by the end of each month;
- dates by which major drawings requiring the Engineer's approval will be submitted (a period of two weeks shall be allowed from date of receipt of these drawings for such approval);
- time allocated for work by others, including those of the Employer and by utility providers.

The Programme of Supplies and Works shall indicate for each item of the Works the various phases of the work, from the commencement of the Contract to its final completion, e.g. design, ordering of materials, manufacture, delivery, erection, construction, commissioning and testing.

The programme shall notably be submitted with details of the following:

- a statement giving the numbers and categories of engineering and technical staff, and skilled and unskilled workers to be employed on the Works;
- a list and type details of major Constructional Plant (including vehicles) which the Contractor proposes to employ on the Works;
- details of the Contractor's methods of working for all operations;
- details of the programme for the Works from the date of receipt of the Engineer's order to commence the Works, including a complete resource allocation showing the number of units and allotted times for each unit of Constructional Plant, materials and labour allocated to each part of the Works.

The Contractor shall maintain the Programme of Works to keep it updated and to reflect the current state of Contract progress during the whole construction period. He shall submit it as part of the Contractor's monthly progress report mentioned in Section A.6.4.4. All reports on the Contract programme shall show the original planned activities, their duration and dates without change as well as any agreed modifications.

If, at any time during the execution of the Contract, it is found necessary to modify the approved programme, the Contractor shall inform the Engineer and submit the modified programme for his approval. Any approval of changes to the approved programmes shall not constitute approval of an extension of time to the guaranteed completion date.

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The report on material procurement shall give the date and details of order placed and indicate the delivery quoted by the manufacturer, and in respect of the agreed Contract Programme. If any delivery has an adverse effect on the Contract Programme, the Contractor shall state the remedial action taken to ensure that delays do not occur.

The shipping of each order or part order shall be monitored on the progress report giving the date by which the equipment will be available for shipping, the estimated time of arrival on site and the actually achieved dates.

The sites erection portion of the progress report shall be segregated into the main and ancillary items of civil, mechanical, electrical and control and instrumentation work and each item of work shall be monitored giving the percentage completion and the projected completion date of the work in accordance with the agreed Programme of Works.

Any delay which will affect the completion, and or testing and commissioning dates of any item of works shall be detailed by the Contractor who shall state the action he is taking to remedy the cause.

The Contractor shall report in respect of the various sections of the works, the erection equipment in use or held in readiness, a return of labour and engineering staff, and details of any matters arising which may generally affect the progress of site work.

Access to the Contractor's and Sub-Contractor's Works shall be granted to the Engineer or the Engineer's Representative at any reasonable time for the purpose of ascertaining progress.

A.6.4.4. Progress Reports

The Contractor shall produce monthly and weekly progress reports in accordance with Section C.5.1.2 and Section C.5.1.3. in a format determined by the Engineer, showing the status of project, delayed and critical activities, etc.

These reports shall summarize site activities and record any details where difficulties in maintaining the agreed programme are being experienced or are likely to cause subsequent delay. Progress reports shall be submitted to the Engineer via electronic transmission in pdf- and docx-format.

The monthly progress reports shall contain at least the following information:

- Physical progress for the reported month and expected progress for the next month;
- Completion schedules (target and actual) based on the approved construction programme;
- Any report which may be specifically requested by the Employer and / or the Engineer.

The monthly progress reports shall be set out in a format to the approval of the Engineer, and shall be delivered not later than the 7th day of the month following the reporting period.

A.6.4.5. Site Diary

The Contractor shall maintain on site daily construction records in accordance with Section C.5.1.4, in a form agreed by the Engineer. The Site Diary shall summarise on a daily basis, weather conditions, main activities undertaken, manpower and resources active, and shall note special activities and occurrences such as tests, accidents, etc.

A.6.4.6. Photographs

As soon as work commences on Site, the Contractor shall provide, in the scope of the Monthly Report, colour photographs of the Works in accordance with Section C.5.2, illustrating each step of the construction works of each structure included in the Contract.

The Contractor shall include in the Monthly Report an annex with a limited number of photographs (the most relevant) illustrating the key works implemented during the month. This annex shall contain:

- 2 colour printed photographs per A4 page, occupying as much space as possible within the page, with print out good quality (not blurry, no pixel can be seen).
- With under each photograph, a short description of the work and a short description of the works implemented, in a maximum of 2 lines.

All photographs (the ones included in the monthly report annex and the other ones) shall be provided with the monthly report softcopy as digital files in a format in accordance with Section C.5.2.

A.6.4.7. Working Drawings

Working Drawings in accordance with Section C.4.11, in AutoCAD compatible format, shall be submitted by the Contractor to the Engineer for approval. Working Drawings shall include, but not be restricted to, reinforcement detail drawings and bending schedules, shop drawings for structural steel and miscellaneous metal work, working drawings for mechanical equipment, architectural items and electrical work.

Working drawings for works structures shall take into consideration the results of the geotechnical survey (see Section A.2.4.2) and all required review / re-design of these structures based on the underground stability analysis.

It shall be the Contractor's own responsibility to prepare such Working Drawings as he may require for the proper setting out and construction of all structures and facilities. Work shall not commence on an individual structure or facilities until the relevant Working Drawings have been approved by the Engineer.

Any changes or modifications to the Working Drawings that the Engineer considers necessary shall be made by the Contractor promptly and the drawings resubmitted for approval.

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Miscellaneous requirements:

- Unit of all drawing files shall be the “meter”.
- Objects drawn in the model of the drawing files shall be drawn with real dimensions, i.e. no scale. Scaling shall be solely done by setting the of print out layout view.
- All infrastructures shall be drawn in the model at their real and accurate coordinates, in order to produce layout drawings.
- Drawings shall follow the layer structure and styles approved by the Engineer. All objects shall be in specific layers and follow the layers styles (exceptions to be agreed by the Engineer).
- Drawing print outs:
 - Title block to be agreed by the Engineer.
 - Standard scale shall be used as agreed by the Engineer. Other scales only if agreed by the Engineer.
 - Scale bar and north arrow shall be included.

No examination by the Engineer of any document submitted by the Contractor or of the Contractor's Working Drawings, nor the approval expressed by the Engineer in regard thereto, either with or without modification, shall absolve the Contractor from any liability imposed upon him by any provision of the Contract. Notwithstanding the Engineer's approval of the Working Drawings, the Contractor shall be responsible for any dimensional or other errors.

Working drawings to be delivered in the scope of the design and construction works shall include the following, classified by degree of accuracy and as may be applicable:

- Preliminary layout drawings: showing the location of major structures and site layouts;
- Preliminary civil outline drawings: informing on the basic physical shape, including channel sizes and positions relative to one another, of the structures, and confirming the hydraulic levels throughout the plant. They shall indicate in broad terms the locations for plinths and pipelines through walls. Location, line and level of major equipment / structures shall be positioned to an accuracy of ± 300 mm.
- Detailed general arrangement drawings: These drawings shall include information required to allow all major structural design and civil general arrangement drawings to be completed. They shall comprise:
 - general arrangement drawings to scale of site plans showing each structure and building, principal routes for cables, pipes and chemical ducts and services;
 - drawings of each building / structure shown in plan and elevation to show position of major items of plant.
- Final civil outline drawings: These drawings shall include information to allow all major civil detail drawings to be completed as well as final positions and loadings and dimensions of major plant and equipment.
- Plant drawings: These drawings shall include following information:

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- general arrangement drawings to illustrate the position of the Plant in relation to the appropriate part of the Works in sufficient detail to show all the principal dimensions, methods of support and other relevant information;
- drawings of the Plant in sufficient detail for the Engineer to satisfy itself that jointly and severally the items of the Plant are suitable for their intended purpose;
- sectional drawings of each major item of the Plant, with a parts list and a list of materials to be used for each part. General arrangement of electrical panels with foundation and cable access details;
- diagrammatic outline and detail drawings of all services to, from and between the several items of the Plant, including drinking and process water supplies, pipework, connections and fittings, electrical single line and schematic diagrams, cable schedules and site cable layout, connections and fittings, and drainage pipework and fitting;
- requirements for incoming supplies, services etc. and details of interface connections in respect of the Plant, particularly where such connections are at the limit of Contract;
- details of wastes, effluent discharges, etc. and details of interface connections in respect of the Plant, particularly where such connections are at the limit of Contract;
- detailed drawings of the Plant and data in sufficient detail as may be reasonably required by the Engineer to satisfy itself as to the stability, durability and safety of the works and for ascertaining of inspection of the Plant during construction that it is in conformity with the Contract;
- fully detailed installation drawings giving complete dimensions of pedestals, cuts, chases, bolt holes, ducts and other provisions to be made in the civil structures and on site of fixing the Plant;
- Electrical Drawings: Wiring diagram and construction plans and drawings, installation plans, proposed electric panel layout, complete cable lists, clamping plans, etc. This also applies to the control and signal circuits as well as interlocking and interrelated control of other technical sectors. A clear illustration according to pertinent standards is imperative.

Working Drawings for Pipe Laying Works

For pipe works, the working drawings shall show the position, material, class, diameter, length and pipe invert and ground levels above mean sea level, other services to be encountered or crossed by the pipeline and any structures to be constructed along it, including valve chambers, sewer chambers, other chambers, trench cut-offs, anchor blocks, etc..

Labels for gravity sewer chambers:

- ground level (GL);
- cover level (CL) if different from ground level;

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- pipe depths below ground level and invert levels (in case multiple pipe invert levels, then number the indicated levels and depths text as on the chamber layout view;
- dimensions, material.

Labels for gravity sewer:

- length, material, slope (unit: per thousand ‰ and not per cent), class;
- cover level (CL) if different from ground level;
- pipe depths below ground level and invert levels (in case multiple pipe invert levels, then number the levels and depth;
- dimensions, material;
- characteristic pipe levels if pipe are close to other structures or pipes.

A complete documentation (lists of parts, descriptions, maintenance and operating instructions, test reports and certificates, etc.) shall be submitted, in 2 English and 2 Montenegrin copies, prior to the commencement of installation.

A.6.5. Operation and Maintenance Manuals

The Contractor shall prepare and submit to the Engineer's approval, Operation and Maintenance Manuals for the whole plant in accordance to Section C.7.6.

The timely submission of the operation and maintenance manuals is conditional to Tests on Completion. Two (02) English and four (04) Montenegrin sets of the draft manuals hardcopies and two sets of the draft manuals softcopies shall be submitted at the latest two (02) months before Commissioning of a particular item or section of the works and three months (3) in advance of Take-Over of the respective facility, whichever comes first.

The final and approved version of the operation and maintenance manuals shall be supplied in in two (2) English and six (6) Montenegrin versions and two softcopies containing all files on two separate digital supports, three (3) weeks prior to the issue of the Taking-Over Certificate.

Amended copies shall be submitted as required at the end of the Defects Notification Period.

A.6.6. As-Built documentation

At a time to be agreed between the Employer, the Engineer and the Contractor, but before handing over the spare parts and wear and tear parts and not later than the date on which the works are taken over by the Employer, the Contractor shall provide as-built documentation in accordance to Section C.7.1.

These documents shall be deemed to form part of the works for the purpose of the certificate of completion and taking over of the works.

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Deadlines for submission and number of copies to be delivered shall be as follows:

- The Contractor shall submit two (2) English and four (4) Montenegrin hard copies as well as two (2) soft copies of all draft as-built documentation clearly named as such to the Engineer for approval at the latest 14 days before the start of the Tests on Completion of the respective Section of the Works.
- The Contractor shall submit two (2) English and six (6) Montenegrin hard copies as well as two (2) soft copies of all approved as-built documentation at the latest 3 weeks before applying for the Taking-Over Certificate for the respective Section of the Works.

The scope of the "As-Built" documentation shall be agreed with the Engineer at the latest 1 month before as-built documentation submission. This shall be drawings and documents which, in the opinion of Engineer, are necessary for the proper understanding, operation and maintenance of the Works.

A.6.7. Operation and Maintenance Programme

A.6.7.1. General Requirements

The Contractor shall submit a maintenance programme in two (2) hard copies in English language, six (6) hard copies in Montenegrin language and two softcopy to the Engineer. The Maintenance programme shall be based on Reliability Centred Maintenance (RCM). The classical RCM process involves identifying the systems to be studied, their functions, functional failures, failure modes, failure causes, and the maintenance task selection. All relevant information must be used to most effectively initiate, schedule, track, record, and analyse the maintenance tasks.

The most critical pieces of equipment which affect the overall function of the system need to be identified. The facilities need in terms of reliability, safety, water quality, cost, etc. shall be considered accordingly. These attributes must be weighted to determine the optimum maintenance programme.

The maintenance programme has to cover all aspects of a RCM process and will be subject of approval by the Engineer.

A.6.8. Breakdown Reports

During the period of Test on Completion and also during the Defects Notification Period, the Contractor has to prepare a special report for each interruption of operation or extraordinary case of disturbance, describing in detail the failure that has occurred, the reason for its occurrence and the operational consequences. The Contractor shall further describe the special activities carried out and his measures to prevent repetition. In this respect, the Contractor shall also refer to and interpret the operation monitoring records.

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Additional investigation shall be carried out by the Contractor, if necessary to define the reason for damage or reconcile apparent contradictions. This report shall be subject to the Engineer's approval. The Contractor has to provide 5 (five) copies of the approved version in English and Montenegrin language.

A.7. SITE SERVICES DURING CONSTRUCTION

The Contractor shall provide all site facilities including offices, workshops, stores, accommodation, washrooms, sanitation etc. necessary for use by his own staff and the Engineer's staff, for the execution of the Works in accordance to Section C.3.3.

The Contractor shall account for the following site services in accordance with appropriate specifications included elsewhere in the Employer's Requirements and in compliance with following conditions:

- All building and equipment provided in accordance with these requirements shall be made available within four (04) weeks following the commencement of the works at the site and must not be removed without the prior approval of the Engineer; and
- Following completion or as directed by the Engineer, all temporary buildings and equipment, unless specified to the contrary, must be removed from the site on the Engineer's approval, as well as all resulting debris, both above and below ground. This is also applicable to all temporary fences and gates.

A.7.1. Facilities to the Engineer

Following facilities shall be provided by the Contractor to the Engineer from the beginning of the construction up to the date of the issuing of Taking-Over Certificate. The Contractor shall service and maintain all facilities provided for the use of the Engineer.

A.7.1.1. Site Office for Use by the Engineer

The Contractor shall establish on the Site and provide for the exclusive use of the Engineer at a location approved by the Engineer, following site office facilities adequately furnished and equipped and maintained by the Contractor in a clean, orderly condition:

- One Engineer's site offices, min 15 m² with one (01) work place;
- One Engineer's site offices, min 20 m² with two (02) work places;
- One fitted kitchen with all facilities, fitting and fixtures, min 15 m²;
- One (01) meeting room for at least eight (8) persons;
- Four (04) covered parking lots, dedicated to the Engineer's staff, with well drained access road and parking area.

These offices and rooms shall suit all needs for project implementation and construction supervision and shall be equipped with the necessary furniture, equipment, and services, subject to prior approval by the Engineer. Offices shall be weather tight, adequately insulated, ventilated, heated and lighted and equipped with air condition and all services such as electricity and water supply, lighting, telephone and internet connection. Air conditioning shall be designed to keep the temperature in each room below 23 °C. Each room shall have natural

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lighting through windows equipped with sunscreens. Each room shall have a minimum of three (03) electrical outlets.

Separate washrooms with toilet, washbasin with cold and hot water, mirror, paper holder and towel rack shall be provided for the sole use of the Engineer's staff during the entire construction period. Additional washbasins with cold and hot water shall be provided in each of the offices.

The buildings shall have lockable doors and burglar-proof windows fitted with mosquito netting.

Throughout the course of construction implementation the Contractor shall take best care of site offices and maintain them at best state of repair. The Contractor shall include for the cleaning of the Engineer's office on a daily basis.

A.7.1.2. Site Office Maintenance and Operation

The Contractor shall maintain, service and insure the Engineer's site offices for the duration of the contract period. He will be responsible for security and maintenance of offices and all equipment therein until Taking-Over.

The Contractor will bear the running cost of the Engineer's site office and facilities, including but not limited to rent, electricity, gas, water, sewer, cleaning, guarding, etc. Whenever these supplies are not available from the public utility services, the Contractor shall provide the facilities from his own resources.

The Contractor shall keep the Engineer's site office in a well maintained, clean and fully habitable condition and shall maintain all access roads, car parks, footpaths, fences, gates, drains, drinking water supplies and water-borne sewage disposal systems in a good state of repair, all to the satisfaction of the Engineer. The Contractor shall arrange for drinking water as well as for adequate sewage and refuse disposal.

The Contractor shall maintain all furniture and equipment, provided by him, in a good state of repair and usable condition and shall replace any item which becomes unserviceable due to fair wear and tear.

The Contractor shall provide soap and towels in the offices of the Engineer, cleaning services, cleaning equipment and day and night watchmen.

A.7.1.3. Equipment for use by the Engineer

The Contractor shall provide, install and maintain the following furniture and equipment in the Engineer's site office throughout the duration of the Contract.

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Table 4: Engineer's site office furniture and equipment

Item	Description	Unit	Quantity
1	Desk with lock up drawers both sides, size min. 2000 x 800 mm, height = 750 mm	nr	3
2	Office chairs, swivel, wheeled, upholstered with arm rest for the above desks	nr	3
3	Modular conference tables for 8 people	set	1
4	Conference chairs, metal framed, upholstered	nr	8
5	Cupboards, 2000 x 800 x 450 mm with five adjustable shelves	nr	3
6	Cupboards 750 x 800 x 450 mm with three adjustable shelves	nr	3
7	Shelves 2000 x 800 x 450 mm with five adjustable shelves	nr	3
8	Filing Cabinet on rolls, 3 drawers with file suspension & pockets, 1000 x 400 x 800 mm	nr	3
9	Plan table min 1,0 x 1,5 m	nr	1
10	Plan rack	nr	1
11	Coat rack and hooks	nr	2
9	Waste paper basket	nr	3
10	Sundry office items: paper punches (4 no. including 1 heavy duty); staplers (4 no. including 1 heavy duty, scissors (4 no.); staple removers (4 no.), etc...	set	3
11	Refrigerator (100 litres)	nr	1
12	Air conditioner, heater	nr	3
13	Safe box	nr	1
14	Kitchen fittings, coffee machine, kettle, cooker, cutlery and crockery for 6 persons	set	1

All furniture and equipment shall be of reputable make and approved by the Engineer.

The Contractor shall provide, install, inter-connect and maintain the following IT and communication equipment in the Engineer's site office throughout the duration of the Contract, including all cables and accessories.

Table 5: Engineer's Site office IT and communication equipment

Item	Description	Unit	Quantity
1	Desktop computer complete with 22" colour monitor, keyboard, optical mouse and UPS (APC Back-UPS /00 or equivalent), incl. software – Windows 10 Professional 64 bit, MS Office 2010, AutoCAD 2012, DWG Viewer, pdf-tools, anti-virus software, etc. with following minimal requirements: – Intel® Core™ i7-7700 processor or similar, 4,20 GHz with Intel® Turbo-Boost 2.0, 8 MB Intel® Smart-Cache – RAM: 16 GB, DDR 4 type – Hard-disk 1: 1 TB, 7200 U/Min. , SATA – Hard-disk 2: SSD , 128 GB , SATA	set	1

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Item	Description	Unit	Quantity
	– CD / DVD Drive with DVD-writer – Connectivity: 1x DVI, 1x HDMI, 3x DisplayPort, 2x USB 2.0, 3x USB 3.0, 1x USB 3.0 Type-C™, 1x RJ-45, Bluetooth, wireless, – Graphic card: VIDIA Quadro K2200 or equivalent		
2	Combined A3 inkjet colour printer / photocopier / fax and scanner with document feeder	nr	1
3	A4 colour laser printer	nr	1
4	Internet connection and facilities	set	2
5	Telephone connections and telephone sets suitable for international communications	nr	2
6	External hard drive, 1 TB	nr	1

IT and communication equipment shall be of reputable make approved by the Engineer. All hardware and software shall be supplied new and fully licensed in the name of the Employer. Full documentation and backup disks for the software and the computer are to be provided.

The proposed furniture and equipment shall be new, of the same type and harmonise together. The Contractor shall keep insured all furniture, fixtures and equipment to their full value (including duty where appropriate) and shall maintain them in good order until the end of the Defects Notification Period.

After issuance of the Taking-Over Certificate, above items shall be handed over to the Employer.

The Contractor shall supply all stationery and office consumables required for the normal functioning of the Engineer's offices, including inter alia survey books, drawing office supplies, computer CDs (Re-writable and Recordable), computer printout paper, printer cartridges and toners, but excluding headed correspondence paper.

A.7.1.4. Surveying Assistance and Equipment

The Contractor shall have permanently on the Site and at the Engineer's disposal following surveying equipment as requested by the Engineer.

Table 6: Survey equipment

Item	Description	Unit	Quantity
1	Total Station (theodolite, distomat, data recorder), including notebook with surveying software, complete with tripod, carrying case and all accessories	nr	1
2	Metric levelling equipment, Zeiss NI 2 automatic level, or similar, complete with tripod, carrying case and all accessories	nr	1
3	Survey umbrella	nr	1
4	Levelling staff, engine divided 4 m long, folding including staff level	nr	1
5	Staff levelling plate	nr	1

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Item	Description	Unit	Quantity
6	Rigid steel straight edge length 3 m	nr	1
7	Optical square	nr	1
8	Steel band 100 m	nr	1
9	Steel band 25 m	nr	1
10	Metric survey chain	nr	1
11	Steel tape 50 m	nr	1
12	Steel tape 30 m	nr	1
13	Steel hand tape 2 m	nr	1
14	Steel hand tape 5 m	nr	1
15	Conical plummet, 200 g weight	nr	1
16	Ranging rod, 3 m length	nr	10
17	Arrow, 400 mm length	nr	25
18	Spirit level with aluminium body, 1m long	nr	1
19	Torpedo level with aluminium body, 150 mm long	nr	1
20	Pipe measuring tape with linear and diametric scales	nr	2
21	String line, 50 m long	nr	2
22	Hammer, 3 kg weight	nr	1
23	Hand shovel	nr	2
24	Pedometer measuring to 10,000 m at 0.1 m intervals	nr	1
25	Pocket counter, counting to 9999 with push button for automatic return plus re-set knob	nr	1
26	Thermometer, maximum and minimum graduated in °C and °F	nr	2
27	Thermometer wet and dry bulbs, graduated in °C and °F	nr	2
28	Rain gauge with measuring bottle	nr	2
27	Concrete thermometer	nr	2
28	Schmidt Hammer for concrete strength test	nr	1

The instruments and equipment shall be in good condition and maintained in a good state of repair by the Contractor. In the event of loss or damage, they shall be replaced without delay. After issuance of the Taking-Over Certificate, above items shall remain the property of the Contractor.

The Contractor shall make available to the Engineer suitably educated and trained survey assistants and labourers for use on and about the site in sufficient numbers and at all reasonable times.

Additionally, the Contractor shall provide to the Engineer all survey consumables including but not limited to field books, survey stationary, road nails, materials for establishing temporary benchmarks, wax crayon, writing material, etc.

A.7.1.5. Assistance to the Engineer's Staff

The Contractor shall provide labour for attendance to the Engineer for operations connected with supervision of the Works. Such labour for attendance and assistance to the Engineer and his staff shall be included in the rates of lump sums.

A.7.1.6. Safety Equipment

The Contractor shall provide the Engineer with the following safety equipment:

- 10 no. of safety helmets;
- Unlimited high-vis waistcoats;
- 6 sets of waterproof clothing (one set summer version + one set winter version);
- 6 pairs of summer safety shoes (steel toed);
- 6 pair steel toe capped rubber boots.

A.7.2. Signboards

In addition to the legally required construction signboards, the Contractor shall provide, erect, maintain and remove on completion at the Construction Site, weather resistant signboards in English and Montenegrin language complying with following requirements:

- Minimum size: 4 x 2,5 m (10 m²);
- Number: 2 (1 x English + 1 x Montenegrin)
- The signboard shall contain:
 - Project description;
 - The date of commencement and scheduled date of completion;
 - following message: "A development project of the City of Podgorica, co-financed by the Federal Republic of Germany through KfW and by the European Union and European bilateral donors within the Western Balkans Investment Frameworks";
 - a Programme seal provided by the German Embassy
 - the name and logo of KfW and WBIF (Funding Agencies);
 - the name and logo of Podgorica Capital City (Employer);
 - the name and logo of ViK Podgorica (Project Executing Agency);
 - the name and logos of the Consultant in charge of site supervision ("Fichtner Water and Transportation GmbH" associated with "IWA Consalt d.o.o." and "Wandschneider + Gutjahr Ingenieurgesellschaft mbh").

The size of the letters shall not be less than 15 cm and clearly legible from the road side.

The location of each signboard shall be determined by the Engineer. The design of the signboards shall be approved by the Engineer prior to installation.

The billboard must be removed no later than 6 months after completion of the work and replaced by a permanent commemorative plaque.

A.8. MOBILISATION AND DEMOBILISATION

A.8.1. Mobilisation

Mobilisation on site shall include the erection of all site facilities and the furnishing of all equipment as necessary to carry out the works under this Contract. The site facilities shall include all site installations, temporary offices, safety provisions, accommodation and sanitary facilities, provisions for water, energy and access and the installation of signboards as required.

The Contractor shall make his own arrangements for his site compounds and shall set them up at the locations agreed with the Engineer. The Contractor shall maintain the site facilities free of charge.

A.8.2. Demobilisation

Immediately after the works are completed, which includes also the removal of parts of site material, the disposal of any rubbish, the cleaning of the surfaces, as well as any reinstatement of damage to roads, pavements, buildings, walls, manholes, etc., related to his works, the Contractor shall apply for inspection and acceptance of this part by the Engineer.

In result of the inspection, a certificate shall be issued that will comprise the actual state of condition. The certificate has to be signed by the Contractor, the Engineer, the representatives of the local bodies and property owners where required.

The demobilisation includes the removal of all site facilities and temporary installations, the demobilisation of all equipment from site, the removal of all surplus materials, the reinstatement of all damaged or worn facilities used by the Contractor (including access roads) and the cleaning up of the construction site.

A.9. ENVIRONMENTAL, SOCIAL, HEALTH AND SAFETY REQUIREMENTS

A.9.1. General

The Contractor shall comply with the local and National requirements and the issued permission for construction. The Contractor shall be legally responsible and financially liable to observe national environmental legislation.

The Contractor shall comply with ESHS requirements set forth in the Specifications for Environmental, Social, Health and Safety Management (ESHS) of the Works, attached hereto. As a basis the Environmental and Social Management Plan (included in Supplementary Information) shall be used.

The PA-ESMP shall comply with the Employers ESMP (Volume 3, Section VII: Employer's Requirements, Part 3. Supplementary Information, item c)) and with KfW guidelines and EU and Montenegrin applicable standards and regulations.

A.9.2. Environmental Requirements

The design of WWTP plant shall satisfy the requirements of the Environmental Impact Assessment (EIA) that has been prepared by a separate independent consultant distinguishing between the requirements during construction phase and operation of the WWTP (Volume 3, Section VII: Employer's Requirements, Part 3. Supplementary Information, item c)). The EIA- Study is not releasing the Contractor from his duty to observe additional environmental requirements which may not be explicitly mentioned in the study.

Annex 2 of the present Part A gives a list of relevant Montenegrin and European laws and regulations in the field of Environmental protection. This list shall not be deemed to be exhaustive. It is the Contractor's responsibility to inform himself about applicable local regulations and the absence of a regulations in the following list shall not relieve the Contractor from its obligation to comply with the requirements of this regulation.

During construction of the WWTP, precautions shall be taken concerning the emissions of sound and air pollution arising during preparation of the construction site and due to operation of noisy equipment. Disposal of solid waste such as stripped topsoil, excavated sub-soil, waste building materials, waste products from maintenance of machinery, human solid waste from the workers etc., to suitable locations must be ensured.

The Contractors design shall include adequate measures for the reduction of sound and odour emissions as well as for the reduction of solid wastes produced. Moreover an energy-optimised design and operation concept for the new WWTP is a precondition.

A.9.3. General Public Health and Safety Requirements

A.9.3.1. General

The Contractor shall take the necessary measure to protect the general public from hazards, including, but not limited to, surface irregularities or unramped grade changes in pedestrian sidewalk or walkway, and trenches or excavations in roadway. Temporary fences, lanterns, and proper signs shall be furnished in sufficient amount to safeguard the public and the work.

A.9.3.2. Noise and Vibration Nuisances

Noise and disturbances shall be kept a reasonable minimum. The Contractor shall take all necessary steps to ensure that his staff carries out its duties in a quiet manner particularly when working at night or close to sensitive areas and buildings.

The Contractor shall perform noise intensity measurements as required by the Engineer and shall submit the results to the Engineer. The Contractor shall comply with any additional measures required by the Engineer to keep noise and disturbance to the minimum.

The Contractor shall within 28 days of the Commencement date forward to the Engineer the following:

- A list of his equipment and his Sub-Contractor's equipment or procedures that may result in herein stated limits of noise and vibrations being exceeded;
- A description of countermeasures to be carried out in case the noise and vibrations are not within limits stated below;
- A programme for measuring noise and vibration levels. The programme shall describe in detail for which work procedure measurement shall be carried out, and where and when the measurements take place;
- the above items shall be corrected by the Contractor in case his scope of work is changed and in case of changes in the working method resulting in a different situation.

All above submitted material is subject to the Engineer's approval. Measurements shall be carried out by a company acceptable to the Engineer.

The Contractor shall select the equipment, organise his site and execute the work in such a way that the following noise and vibration levels are not exceeded during construction and during operation of the plant.

In accordance to the Decision on the determination of acoustic zones on the territory of the Capital City of Podgorica (Off Gazette on MNE – Municipal Regulations No. 27/15) the noise level of the plant shall not exceed 60 dB(A) during daytime and during the evening and 50 dB(A) during night at the boundary of the WWTP Site.

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The noise limits shall be measured as the equivalent, normalised noise level at nearby houses and at other areas sensitive to noise.

A.9.4. Occupational Health and Safety

The Contractor shall use his best endeavours to ensure, so far as is reasonably practicable and to the satisfaction of the Employer and Engineer, the health, safety and welfare at work of his employees including those of his Subcontractors and of all other persons on the site.

The performance of all work and all completed construction, particularly with respect to ladders, platforms, structure openings, scaffolding, shoring, lagging, machinery guards and the like, shall be in accordance with the applicable governing international and local health and safety protections regulations and the Code of Practice for similar works.

The Contractor shall design the Works in accordance with applicable local and international regulations on occupational health and safety and the current code of practice.

Annex 3 of the present Part A gives a list of relevant Montenegrin and European laws and regulations in the field of Occupational Health & Safety. This list shall not be deemed to be exhaustive. It is the Contractor's responsibility to inform himself about applicable local regulations and the absence of a regulations in the following list shall not relieve the Contractor from its obligation to comply with the requirements of this regulation.

The maximum admissible noise levels at the work place shall be in accordance with the Rulebook on Occupational Health and Safety Measures against Risk of Noise (Off. Gazette of MNE No. 037/16).

Unless more restrictive requirements are imposed by the applicable local regulations, the noise level at a distance of 1 m from each sound-producing item of mechanical or electrical plant or equipment shall not exceed 80 dB(A). The Contractor shall estimate and substantiate by calculation to be submitted at design submission stage, the equivalent noise levels.

A.9.5. Equipment Safety and Ex-Protection Requirements

The Contractor is obliged by his signature to supply the machines, devices, pieces of equipment and the like complete with the safety protection required for accident prevention according to regulations of the local accident insurance associations or trade associations. Devices installed in rooms that are potentially endangered by explosive materials and therefore assigned to an Ex-zone must be approved for use in such locations.

The Contractor will be responsible for implementation of Ex-Protection zones and other hazard protection measures at the WWTP site in general and all treatment units and buildings individually. The classification of ex-zone areas, inside and outside, shall be explicitly indicated by tables. All inscriptions shall be in the English and Montenegrin language.

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Ex-Protection regulations are determined by EU Directive 94/9/EC (ATEX 95) and 1999/92/EC (ATEX 137) as a minimum, however the Contractor will have to undertake all necessary activities to familiarize, harmonize and execute local and national regulations in this field.

Within the scope of the Contractor's design activities, the Contractor will furnish an Explosion Protection Document (EPD) in line with international and national standards and regulations. The EPD will be prepared by the Contractor or nominated licensed company in case the Contractor does not hold the required licenses stipulated by Law. The EPD should be elaborated during the Detailed design phase and will form an integral part thereof. It will identify hazardous areas at the WWTP site, treatment units and buildings, technical measures and solutions for protection, as well as provide specifications and requirements for equipment, installations and plants that will be procured and installed at the WWTP.

The Contractor should account for the EPD in carrying out all construction work and procurement and installation of equipment in order to facilitate acquisition of operational permit and safe WWTP operation.

A.10. SUSTAINABILITY

Sustainability is a core principle to be considered in projects funded by KfW. Reference is notably made to following documents summarizing KfW's approach and strategy in this matter:

- Sustainability guidelines of KfW Bankengruppe (https://www.kfw.de/Download-Center/Konzernthemen/Nachhaltigkeit/englisch/Umwelt-u-Sozialeitsaetze_E.pdf);
- Sustainability guidelines of KfW Development Bank (https://www.kfw.de/PDF/Download-Center/Konzernthemen/Nachhaltigkeit/FZ-Nachhaltigkeitsrichtlinie_E-2.pdf, or https://www.kfw-entwicklungsbank.de/PDF/Download-Center/PDF-Dokumente-Richtlinien/Nachhaltigkeitsrichtlinie_EN.pdf)

The elaboration of an energy-optimised design and operation concept for the WWTP, considering notably the use of energy efficient equipment as well as the optimum production and reuse of biogas and hydropower for the production of electrical energy to be used within the plant and to minimise the use of externally supplied electrical energy is a pre-condition and a minimum requirement. Technical solutions which are not complying with the above conditions will be rejected.

In addition to the above mentioned minimum requirements, Bidders are encouraged to consider in their proposal the implementation of appropriate technical solutions and measures allowing improving the environmental, economical and ecological sustainability of the Works and minimise adverse environmental, social and climate impacts and risks, above minimum requirements and at bearable costs. Such solutions and measures may include but shall not be limited to the following:

- Supply of energy efficient materials and equipment;
- Supply of eco-friendly equipment, material and furniture;
- Supply and use of building materials (sand, gravel, cement, ...) from environmentally certified origin and/or use of recycling materials;
- Energy efficient and sustainable building solutions, e.g.: increased insulation, natural light control, natural ventilation and cooling, use of eco-friendly building material, passive house building design, bioclimatic architecture, etc.;
- Use of energy efficient solutions for lighting (internal and external lighting), e.g. LED lighting, dimmable lighting;
- Provision of external lighting using photo-voltaic cells and battery banks;
- Eco-design requirements for electric motors according to Commission Regulation (EC) No 640/2009 implementing Directive 2005/32/EC;
- Supply of energy-efficient laboratory devices;
- Selection of chemicals, lubricants and consumables with minimized environmental impact;
- Reduced greenhouse gas emission;

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- Reduced waste production;
- Reduced water consumption;
- Certified ICT solutions;
- Minimised content of hazardous substances certified by a declaration of conformity in accordance with the European RoHS Directive No. 2002/95/EC and/or an eco-declaration (ECMA-370), EPEAT label or other;
- Use of additional renewable energy resources in addition to the reuse of biogas and hydro-power (e.g. photovoltaic panels or solar thermal heating systems);
- Specific training and capacity improvement of the Employer's staff in the fields of energy management, environmental protection, etc.

Bidders shall highlight in a separate section of the technical proposal, technical solutions and measures included in their offer which specifically contribute to the sustainability.

Sustainability is a criterion for the evaluation of the offers. Specific solution and measures proposed by the Bidders in the scope of their technical proposal to improve the sustainability of the works and specific sustainability parameters considered by the Bidders in the design will be assessed and evaluated.

Proposed solutions and measures shall be substantiated by appropriate documents such as design calculations, etc. and/or references to relevant standards, labels, regulations. Only solutions and measures with a traceable, documented and proven positive impact on sustainability will be considered in the evaluation.

In the following an indicative list of receivable proof of evidence and supporting documents is given:

- Energy-star label (www.energystar.gov);
- Reference to Eco-labels in accordance with ISO with a strong preference for Type I (verified by third parties) Eco-labels in accordance with ISO 14024. Type II (Manufacturer's declaration) in accordance with ISO 14021 and Type III (Quantitative details based on manufacturer's data) in accordance with ISO 14025 may also be used, but will be given a lower score in the evaluation;
- Social accountability standard SA 8000 certification;
- ISO 50001 Energy Management System certification;
- Environmental and social standards certifications of manufacturer's and suppliers (e.g. OHSAS 18001, EMAS, ISO 14001, BSCI, SA 8000, etc.).

CE marking and CE declaration of Conformity is not mandatory. However bidders complying with CE conformity will be awarded additional points during the evaluation of the offers under the present sustainability criteria.

Specific reference is also made to the Exclusion list and Sectorial Guidelines of KfW Group attached in Annex 2 to the KfW Development Bank Sustainability Guidelines (see above).

A.11. INSPECTION AND TESTING

A.11.1. General

This Section mainly relates to the Tests on and after Completion which are to be carried in accordance with Sections C.6.9 and C.6.10.

For site testing during implementation of works and tests on part completion of the different components of the works, reference is made to the respective clauses of Parts D to I of the Employer's Requirements.

Tests on completion and tests after completion presented hereinafter are to be read in conjunction with the Schedules of Operational Performances and Consumption Guarantees (Volume 2, Part B). The main purpose of these tests is to verify that the performances and consumption values of the plant comply with the guaranteed values.

Performance or functionality covers the functionality of individual functional units and the functionality of the plant as a whole. Failing of the Performance Tests (controlled by guarantee values) leads to refusal of the Taking-Over Certificate until all respective tests are passed.

Cost effectiveness and long-time stability of the process will be tested during the Tests after Completion during the whole Defects Notification Period (one (1) year for the WWTP and SSTP and two (2) years for the SSIP) by daily records, monthly reports and annual report. The records and reports are subject to the approval of the Engineer. Failing of the Tests after Completion (controlled by guarantee values) leads to refusal of the Performance Certificate until all respective tests are passed.

The Contractor is responsible for:

- submitting a detailed test programme as part of his programme to implement the Works to the approval of the Engineer;
- carrying out all tests as per the approved programme and additional tests if requested by the Engineer;
- submitting test reports and test certificates;
- retesting if needed;
- providing all apparatus, assistance, documents, electricity, equipment, fuel, consumables, instruments, labour, materials, and staff needed to carry out the tests.

The tests themselves shall be carried out in accordance with the Technical Requirements of the Contract. Inspection and testing shall be carried out in compliance with Section C.6.

The minimum requirements of the overall testing programme for the Contract shall consist of the following:

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- a) Factory inspections and testing: these are inspections and tests, at the place of manufacturing. This applies for building materials, mechanical (e.g. pumps) and electrical items of equipment (e.g. instruments). The manufacturer shall issue the relevant certificates;
- b) Construction inspections and testing at site: these are routine inspections and tests during construction;
- c) Tests on mechanical completion: these tests are performed at the completion of the mechanical and electrical installations;
- d) Tests on part completion: these tests are conducted on completed structures (e.g. leak tests);
- e) Pre-commissioning tests: these tests are performed before putting the Works or part of them into operation;
- f) Operational Performance tests (Test on Completion): under these tests the Works or part of them shall be operated for a period of time as stipulated in the Contract to prove that the specifications are met; and
- g) Reliability test run (Test on Completion): under this test the Works, or parts thereof, shall be operated for a period of time as stipulated in the Contract to prove its reliability.

As a general rule, passing successfully tests on mechanical completion and on partial completion shall be the pre-requisite for starting with pre-commissioning tests. Passing successful tests on pre-commissioning shall be the pre-requisite for the commissioning. At the end of commissioning the performance tests and the reliability test run will be carried out.

After successfully passing the above mentioned tests, and after submission of the as-built documentation and of the operation and maintenance manuals, the Works or parts of them, can be deemed to be completed and the Engineer will issue the relevant Taking Over Certificate (TOC).

Three (3) months after the Commencement Date of the Contract, the Contractor shall submit to the Employer and the Engineer a provisional **Programme of Testing**, which shall include:

- details of tests to be carried out;
- scheduled date of implementation of the tests;
- test standards;
- type of inspection and tests.

This programme shall be kept updated during the execution of the works until completion of all tests.

Three (3) months prior to the proposed start of commissioning the Contractor shall submit to the Engineer a **Commissioning Test programme**, indicating:

- the commissioning procedure with sequence and duration of the different phases;
- scheduled dates of the different phases of commissioning, and
- reports and results of tests on partial completion.

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Three (3) months prior to the Performance Tests the Contractor shall submit to the Engineer a **Performance Test Programme**, including:

- the detailed programme of tests with dates, sequence and duration of the different phases;
- test standards;
- manpower and deployment schedule of the Contractor for performing the tests, forms of test records and report;
- description of instrumentation to be used, including accuracy, and calibration test results;
- method of data recording; and
- method and equations/correction curves used for the adjustment of recorded data to the design conditions.

The results of all tests shall be certified by the manufacturer, Contractor or independent agency as appropriate.

The Test reports shall be submitted within two weeks after completion of each test in one (1) original and one (1) hardcopy and two (2) digital copies, both in English and Montenegrin language. The test reports have to contain the test results including their analyses and all relevant records about the analyses, measured flows, composition of incoming wastewater and outgoing effluent, chemical consumption, power consumption, etc.

Document files containing material certificates, welding procedures, test report etc. shall be compiled for each item of works and shall be suitably identified (including equipment classification reference) and bound.

A.11.2. Test on Completion

The power supply shall be tested together with the local electricity company before switching power on. The cost of power supply during the Tests on Completion shall be borne by the Contractor.

The performance tests shall last one (1) week (5 working days) while the reliability test run is scheduled for twenty eight (28) consecutive days. During the Reliability Test Run, the Works shall be operated continuously or as required by the Engineer.

The Reliability Test Run will not be deemed to be completed unless the relevant Performance Tests have been made.

In the event of interruptions during the Reliability Test Run, for which the Contractor is responsible, the duration of the Reliability Test Run shall be extended by a period equal to the accumulated time of interruptions. If an interruption of operation of the plant lasts more than four (4) hours, the Reliability Test Run shall be restarted, after making good the defect. The

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Reliability Test Run may be interrupted on a maximum of three occasions, provided that no interruption exceeds four (4) hours and that the Engineer is notified of the interruption in good time.

The **hydraulic capacity** of the Works shall be proved during designing, when submitting the hydraulic report. Each line shall have the hydraulic capacity of the design flow. Consequently the Works shall be certified to be partly completed after passing all tests, including leakage tests, that proves that the civil and pipe construction was done in accordance with the design. In addition the screens, pumps etc. shall pass the manufacturing, reliability and performance tests.

The compliance of the **WWTP with the effluent, sludge and by-products quality parameters** will be tested during performance tests. It is planned that during the performance tests, the biological wastewater treatment will be operated with two out of the three activated sludge tanks, with these two tanks being operated as close as possible to their design capacity. In case this would not be applicable, the Contractor shall provide correction curves to be approved by the Engineer. The performance test will be done for each line, either in parallel or in sequence, except the one activated sludge tank not being put in operation at the commissioning of the plant.

The power consumption, consumption of consumables and the amount of produced waste products and their composition, that are subject to liquidated damages, shall be tested during the performance tests based on the same provisions as described above.

After successful passing all above tests, passing of the Technical Acceptance in accordance with the Montenegrin legislation and receipt of the operation permit for the WWTP, the Works shall be deemed to be completed and the Engineer shall issue the Taking Over Certificate.

The Employer may, at his own discretion, instruct the Contractor to carry out the Reliability Test Run and the Performance test after Taking Over.

A.11.2.1. Commissioning and Testing Programme

Separate commissioning and testing will be carried out at least for:

- The Wastewater Treatment Plant (WWTP), the Sewage Sludge Treatment Plant (SSTP) and the Common Facilities (CF) on the one hand, and
- The Sewage Sludge Incineration Plant (SSIP) on the other hand.

The Contractor shall prepare and submit to the Engineer's approval a detailed time schedule for start up and commissioning works and a work programme which describes the test arrangements, the instrumentation to be used, both fixed and mobile, and including clear definitions of the roles of the Employer and the Contractor.

Testing of individual components of construction and mechanical and electrical installations shall be undertaken progressively as work proceeds (very probably the construction works will

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not be finished completely as the tests will already commence), up to and including dry running and clean water tests. Certain Tests on Completion may be performed during this phase, such as for instance hydraulic capacity.

When testing of individual components have been satisfactorily concluded, subject to the Engineer's approval, start up and commissioning of the plant on wastewater shall commence and the biological treatment process shall be established in line with the design parameters.

The plant shall be started progressively to attain normal operating conditions and when the Contractor deems that the whole plant can be operated continuously in a satisfactory manner an observation period of 28 consecutive days of continuous reliable and stable operation starts. During this period the plant shall be operated by the Contractor strictly within the requirements stated in this section.

On completion of the testing and commissioning, the Contractor shall provide a report which includes all the test results, a review of the process performance and the implications for normal operation to be incorporated in the Operating and Maintenance Manual.

The start-up and commissioning phase will be deemed to have been concluded when stable operating conditions have been achieved. In order to speed up the generation of biomass in the activated sludge tanks the application of seeding sludge from another WWTP is strongly recommended. For the main stream biological process stable operating conditions have been achieved when:

- a) the design level of the mixed liquor suspended solids concentration in the bioreactor is attained,
- b) excess sludge is being produced, and
- c) stable operating conditions have been achieved.

A period of stable process and plant operation shall then follow, during which time the effluent quality standard shall be met and all other remaining Tests on Completion shall be performed and passed.

This sequence of activities to be carried during the commissioning and testing period is illustrated in the following figure.

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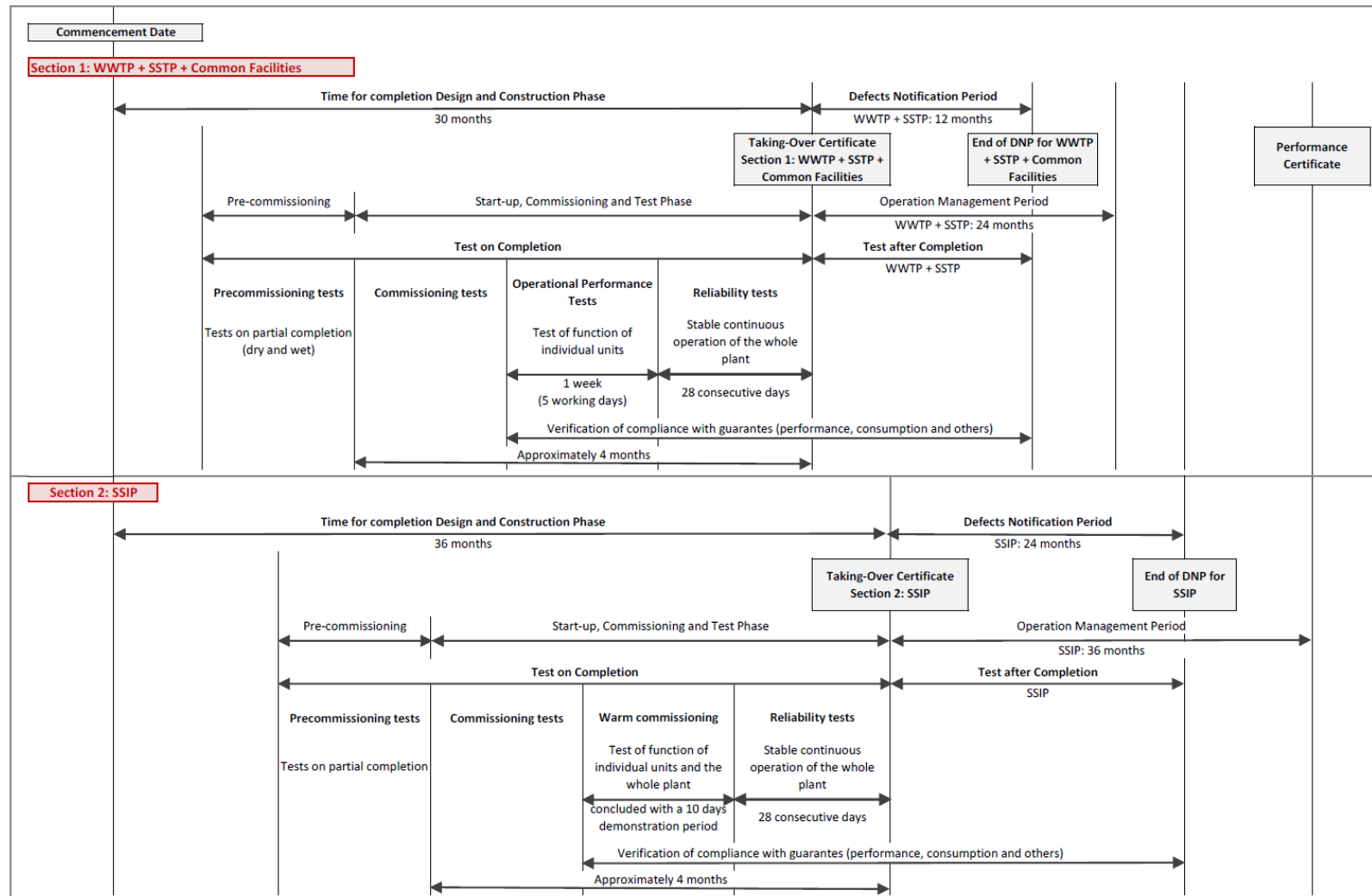


Figure 1: Commissioning and Testing programme time schedule

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Separate Taking Over Certificates will be issued after successful completion of the performance and reliability tests, subject to the other requirements for taking over, as required by the Conditions of Contract, having also been satisfied.

The total time for plant start-up and commissioning with wastewater and the establishment of a stable operating regime in which the required effluent standards are achieved, shall be not less than 3 months.

After issuing the Taking-Over Certificates of the Works, the Tests after Completion shall be performed during the one (WWTP + SSTP) year, or respectively two (SSIP) years of the Defects Notification Period to establish the performance of the plant in relation to the guaranteed effluent quality and the consumption guarantees.

Local law and FIDIC conditions of contract have to be “harmonized” where required, especially with regard to the issuance of the operation permit. For details on assisting the Employer in obtaining all required permissions under this Contract reference is made to Section A.4.3 of this Document.

A.11.2.2. Minimum Requirement for Tests

Reference is made to the Schedules of Operational Performances and Consumption Guarantees (Volume 2, Part B).

Without in any way limiting the obligations of the Contractor under the Contract, the Contractor shall consider the above indicated minimum requirements in his test programme.

All testing, sampling and analyses shall be performed on Site in a professional manner, in accordance with the Operation and Maintenance Manual. The Contractor shall, without limiting its obligations pursuant to the Operation and Maintenance Manual, promptly notify the Engineer of any unexpected performance shortfalls or excess of set limits in any part of the Plant's operations.

The Contractor shall perform tests including recording of pressure and flow data for a minimum period of 24 hours to ensure full compliance with the requirements. All tests shall be conducted in cooperation with the Engineer. The Tests on Completion shall comprise but not be limited to:

1. Hydraulic capacity;
2. Quality of treated effluent;
3. Separation efficiency of grit chamber;
4. Performance of processing of screenings and grit;
5. Aeration oxygen transfer;
6. Solids concentration of thickened sludge;
7. Solids concentration of dewatered sludge;

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8. Gas production of the digester and energy production of the CHP unit;
9. Noise and odour levels at Site boundaries.

The Contractor shall take, at his expense and cost, all necessary dispositions enabling the correct execution of the Test Programme. The required minimum Test Programme is described below.

A.11.2.3. Pre-Commissioning Tests (dry and wet):

- Each pump set shall be tested for capacity, head, electrical energy consumption and mechanical reliability;
- Each blower, radiator etc. set shall be tested for capacity, head, electrical energy consumption and mechanical reliability;
- Each mixing device and the digester sludge mixing system shall be tested for its purpose, electrical energy consumption and mechanical reliability;
- Each screen shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;
- Each screening press shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;
- Each grit classifier shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;
- Each sludge, screening, grit conveying equipment shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;
- Each settlement tank scraper shall be checked in a dry tank for alignment of scraper flight operation and for sludge / grit removal mechanism and for grease / scum / floating sludge removal mechanism, stability, vibration and free running throughout a complete revolution of the unit. Each scraper shall be tested in a full tank for its purpose, stability and vibration, free running over the complete operating range and full reliability in all respects;
- Each aeration unit shall be tested for vibration-free running, power consumption, complete mix of liquid and for oxygenation capacity and oxygen transfer efficiency under clear water conditions according DWA/ATV guideline M 209 or equivalent;
- If applicable, each sludge thickener rake system shall be checked in a dry tank for alignment of rake arms and scraper flight operation and for floating sludge removal mechanism, stability, vibration and free running throughout a complete revolution of the unit. Each rake system shall be tested in a full tank for its purpose, stability and vibration, free running over the complete operating range and full reliability in all respects;
- Each surplus sludge mechanical thickening and digested sludge dewatering machine shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;

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- Each digester sludge mixing system shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;
- Each polymer station shall be tested for its purpose, stability, capacity, electrical energy consumption and for full reliability in all aspects;
- Each motor for the emergency and co-generated heat and power plant shall be tested for fuel input, power and thermal output and effectiveness and for full reliability in all aspects;
- Pumps, pipes, valves and pressure vessels shall be hydraulically tested to the pressure as specified or to at least 2,0 times the maximum working pressure or 1,5 times the normal pressure, whichever is the greater. For testing watertightness of pipelines and tanks reference is made to Parts D and E of the Employer's Requirements.

After successful pre-commissioning tests to be approved by the Engineer, the commissioning tests and operating trials may start. The Contractor shall take, at his expense and cost, all necessary dispositions enabling the correct execution of the Test Programme. The required minimum Test Programme is described below.

A.11.2.4. Wastewater Treatment Line

- The influent and effluent flow shall be measured and recorded, continuously;
- The biological treatment should be operated with the designed MLSS concentration. The MLSS concentration shall be measured on line by the SS-probes;
- In addition to the on-line measurements of the MLSS, grab samples shall be analysed three times per week;
- Sludge volume and SVI shall be analysed three times per week;
- The excess activated sludge shall be analysed for SS and DS by grab sample once a week;
- If applicable, the metal salt consumption shall be recorded every day and calculated as specific metal salt consumption. It shall be expressed as kg metal salt/tonnes of removed phosphorus;
- As a minimum, the following analyses and measurements shall be executed during the test period on daily composite samples based on 24-hour flow-proportional composite samples at the inlet and the outlet of the plant:
 - Flow (m³/d);
 - BOD₅ (mg/l and kg/d);
 - COD (mg/l and kg/d);
 - TSS (mg/l and kg/d);
 - Total-N (mg/l and kg/d);
 - NH₄-N (mg/l and kg/d);
 - TKN (mg/l and kg/d);

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- Total-P (mg/l and kg/d);
- pH
- Temperature (continuous online measurement);
- Bacteriological parameters, at a minimum: Total Coliforms (TC), Faecal Coliforms (FC), Faecal Streptococci (FS).

The Dissolved Oxygen concentration of the effluent wastewater shall be demonstrated by sampling of the effluent twice a week.

The analyses shall be executed on the laboratory of the WWTP under the supervision of the Contractor and separately, on the same effluents, by an independent certified laboratory.

Mixing efficiency

The requirements for mixing efficiency shall be tested. The mixing efficiency is defined as follows:

Criteria 1. Mixing homogeneity in the reactors

The mixers shall provide for an homogenous environment in the anoxic zones in the biological reactor during the mixing stage. The homogeneity is defined by sampling of the mixed liquor during steady operation as follows:

- Ten typical sampling points are chosen in the reactor, and samples shall be taken within 30 minutes;
- The SS concentration is analysed;
- The arithmetic mean value of these samples is calculated;
- The maximum accepted deviation from the mean value is less than +/- 7,5 % from the arithmetic mean value.

Criteria 2. Re-suspension capacity

The mixers shall provide an efficient re-suspension of the mixed liquor after a stop lasting for at least two hours. The re-suspension is defined as establishing the homogeneity in the reactor again, as defined in Criteria 1. The maximum accepted time for the re-suspension is 10 minutes from the restart of the mixer.

A.11.2.5. Sludge Treatment Line

The following test procedure shall be applied for the sludge treatment line.

The sludge flow shall be measured and recorded continuously.

The following testing procedure shall apply to mechanical sludge thickening and dewatering.

1. Minimum twenty (20) samples of the incoming and the thickened / dewatered sludge

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shall be randomly chosen during the one month stable operation period. Analyses on the DS concentration of the incoming and the dewatered sludge are to be executed by an independent certified laboratory.

2. All samples shall meet the guaranteed minimum requirement on sludge concentration.

A.11.2.6. Noise

- The noise level shall be measured at the Site boundary monthly at eight locations, to be indicated by the Employer;
- The noise level of all noise producing equipment is to be measured monthly during one year at a distance of 1 m;
- Noise levels shall be measured by an independent certified institute at daily random times at normal operation / functioning conditions.

A.11.2.7. Hazard and Operability Risk Assessment of the WWTP Operation (HAZOP)

Before the commissioning of the Wastewater Treatment Plant will start the Contractor has to submit a HAZOP Study to determine if sufficient and adequate safety measures have been taken to prevent accidents.

The definition of a hazard and operability study is a systematic research on all imaginable deviations from the normal operation of the plant, to the causes and effects of these deviations. From these causes and effects, necessary actions shall be identified by the Contractor. During a HAZOP (fictitious) malfunctions are introduced and a specialised team of the Contractor shall determine the possible causes of these malfunctions. The effects of the causes and the severity of the effects are to be assessed by the team. Also the existing safety measures in the design are evaluated. If the specialists consider that corrections are necessary, an action or a recommendation is formulated. The action or recommendation could be technical or organizational, or both.

A.11.2.8. Commissioning and Testing of the Sewage Sludge Incineration Plant (SSIP)

A.11.2.8.1. General

The following descriptions detail and extend the procedure described in Parts A.11.1 to A.11.5 and C.6. These descriptions do not change the general approach for testing. In case of deviations, the following descriptions apply to the SSIP.

The basis of the commissioning and testing of the SSIP are the pre-commissioning and commissioning test programme (hereinafter referred to as test programme) and the operation manual. As required in Part C resp. C.7.6 the test programme and the operation manual shall be submitted before commissioning continuously updated with any lessons learnt. According

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to Part C.4.12, the preliminary as-built documentation must also be submitted before the start of commissioning.

The sludge and thus the fuel for the SSIP is only produced when the WWTP and SSTP are in operation. The commissioning of SSIP therefore depends on the commissioning of WWTP and SSTP and follows it in chronological order.

A.11.2.8.2. Commissioning Tests / Warm Commissioning

The dewatered sludge produced by the centrifuges during the commissioning of the WWTP and SSTP does not have a constant composition and quality. During the commissioning of the SSTP sludge stream from the centrifuges is collected in the bunker and mixed by the crane in order to gain sludge with a levelled quality. Thus, a homogeneous sludge is produced that allows to reach constant combustion conditions as well as possible during the warm commissioning of the SSIP. For warm commissioning of the SSIP, a sufficient sludge volume must be collected in the bunker that allows to operate the SSIP during commissioning in all load cases between MINLC and MAXLC independent from the operation of the SSTP and WWTP. The required stored sludge volume in the bunker shall at least be sufficient to operate the SSIP in DLC during the entire warm commissioning period including a sufficient buffer. This volume is defined and verified by calculation in the test programme of the Contractor and must be approved by the Engineer / Employer. Depending on whether the centrifuges of the SSTP are in operation, the SSIP is operated solely with sludge from the bunker or sludge from the bunker is mixed with sludge from the centrifuges in the collection chute.

The Contractor shall carry out the warm commissioning by involving the Employer's personnel in all operating procedures. The commissioning includes in particular also the troubleshooting up to the intended operation of the SSIP.

An essential part of warm commissioning is the testing of limits, interlocks and protection criteria, the adjustment and optimization of the control parameters for the various operating conditions and the operating of all function group controls (step chains). As an intermittent operating concept is intended, high priority must be given to start-up and shut-down procedures as well as standby operation.

The warm commissioning shall conclude with a 10-day demonstration operation on the basis of the updated manual and the completely operable automation. The demonstration period shall include a cold start-up and a shut-down. Furthermore a shut-down with a subsequent standby period of around 24 to 48 hours and a start-up from standby shall be included unless otherwise required by the Engineer / Employer.

Malfunctions or defects occurring during demonstration operation shall lead to a termination of the demonstration operation. In this case the 10-day demonstration period starts again.

The following minimum conditions apply for a successful completion of the warm commissioning:

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- Demonstration or test that no simulated values are present in the control systems.
- Demonstration of safety and protection systems and devices.
- The SSIP shall be operated as required by the Engineer / Employer at any load points including at least MINLC, DLC, MAXLC, cold and warm start-up, standby operation and shut-down.
- The complete function of the SSIP and the full operability of the systems including operation via the control system of the WWTP (SCADA) is achieved.
- The operational performance and consumption guarantees shall be considered as achievable for continuous operation in the essential points.
- The warm commissioning is completed without defects or residual work, which are contrary to operational safety or normal operation by the operating personnel.
- The uninterrupted and failure-free demonstration operation shall be completed successfully.

At the end of the commissioning, the Contractor will prepare a protocol including a list of open points that documents the successful commissioning of the SSIP. This warm commissioning protocol must be approved by the Engineer / Employer.

A.11.2.8.3. Reliability Test Run / Trial Operation

The trial operation shall be carried out in the foreseen operating concept of the SSIP, for which the DLC with intermittent operation (periodic standstills over weekend) is intended. As the sludge production of the SSTEP may not be sufficient, a sufficient sludge volume must be collected in the bunker before start of the trial operation.

The required stored sludge volume in the bunker for the trial operation shall at least be sufficient to operate the SSIP in foreseen operating concept of the SSIP during the entire warm commissioning period including a sufficient buffer of at least 10 days which allows to decouple SSTEP and SSIP trial operation. The required sludge amount is defined and verified by calculation in the test programme of the Contractor and must be approved by the Engineer / Employer. Failures in SSTEP centrifuge operation may not affect the trial operation of the SSIP.

The following further minimum conditions must be achieved for the start of the trial operation run:

- Successful completion of the warm commissioning including approval of the warm commissioning protocol by the Engineer / Employer.
- The sludge quality of the WWTP and SSTEP shall be continuous and stable. Variations and changes in sludge composition due to the commissioning of the SSTEP and WWTP and due to changing biological processes in the WWTP and SSTEP shall be ruled out on account of the Contractor.
- The operating manual shall be updated and finished with the results of the warm commissioning. All recommended set-points as well as minimum and maximum values

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for the settings shall be documented, including peak and average values. All other experience gained shall also be incorporated.

The trial operation lasts 28 days. The trial operation shall serve to prove the correct and undisturbed functioning of the SSIP. The trial operation shall be carried out under the management and responsibility of the Contractor. For this purpose, the Contractor shall provide a responsible manager of the trial operation for each shift, who shall be permanently on site. The Employer provides the operating and maintenance personnel intended for normal operation.

Defects and malfunctions of components and devices have no effect on the trial operation. If significant defects occur during operation, the trial operation shall be retaken after their elimination. Any violation of the operational performance and consumption guarantees shall lead to a rectification and retake of the trial operation. Any unsuccessful trial operation shall be repeated and the Contractor shall be charged with all costs. Undisturbed operating times from previous test runs shall not be taken into account for the repetition.

The Contractor may not claim that the trial operation was unsuccessful due to the staff of the Employer being insufficiently qualified.

The trial operation shall be recorded daily by the Contractor. The daily logs shall be submitted to the Employer on a daily basis; all malfunctions shall be reported immediately. All deviations from the intended operation, faults, malfunctions, failures and interruptions are recorded in the logs and—if possible—their cause and measures to eliminate them are described.

A.11.2.8.4. Performance Tests

In order to prove that the performance and consumption guarantees have been fulfilled, the Contractor shall carry out a performance test following or during the trial operation; the following shall apply with reference to the Schedules of Operational Performance and Consumption Guarantees in Volume 2:

- All performance guarantees (Section A.3.1) shall be proven with the exception of
 - No 3.1. Availability,
 - No 3.2 Operating period ("Reisezeit"),
 - No 3.3. Unscheduled shutdowns: Number of unscheduled shutdowns per operating period ("Reisezeit"),
 - No 3.4. Unscheduled shutdowns: Total length of unscheduled shut-downs per operating period ("Reisezeit"),
 - No 3.5. Maintenance period,
 - No 3.39 Lifetime refractory,
 - No 3.57 / 3.58 Lifetime convection / radiation heat exchangers,
 - No 3.60 Thermal oil lifetime.
- All consumption guarantees (Section A.3.3) shall be proven with the exception of

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- No 3.13 Maximum wear part consumption per year.

The following applies for the performance tests as well as the tests after completion (see Section A.11.3:

- 1) If possible and reasonable, the tests shall be performed by using the recorded operating values.
- 2) The Contractor is responsible for carrying out all required measurements and provides the necessary measurement technology with sufficient measurement accuracy. If additional measuring nozzles, temporary or permanently installed measuring equipment etc. are necessary for the test, these are included in the scope of supply and services of the Contractor and shall be included in the drawings already during the engineering phase.
- 3) If there is disagreement about the test results or if experts are required to carry out measurements or verifications with sufficient accuracy, appropriate external experts are included in the scope of services of the Contractor.
- 4) All tests and verifications that have to be carried out by notified bodies or approved inspection bodies, e.g. due to legal requirements (as described in Part A.4.2), such as the test of compliance with the required retention time at 850 °C in the furnace, are commissioned by the contractor and the costs are borne by the Contractor.

The results of the performance tests are submitted to the Employer as a detailed test report. The test report must be approved by the Engineer / Employer.

A.11.2.8.5. Taking-Over Certificate

The minimum requirements for issuance of the taking-over certificate shall be:

- 3.successful completion of the warm commissioning,
- 4.successful completion of the Trial Operation,
- 5.successful completion of the performance tests, approval of the performance test report by the Engineer / Employer,
- 6.as-built documentation including updated operation manual submitted.

A.11.2.9. SHPP

For commissioning and testing of the Small Hydro-Power Plant, refer to Section B.9.10.

A.11.3. Tests after Completion

The tests after completion shall be carried out during the Section C service period in order to test the compliance of the plant operation with the specified performance and consumption guarantees.

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A 12 months guarantee period (Defects Notification Period) for the Section A Works and 24 months for the Section B Works will commence after issuance of the Taking-Over Certificate. During this period, tests shall be carried out to ensure that the plant complies at all time with the guaranteed performances and consumption values.

These tests will be executed by and under the Supervision of the Contractor. The Contractor may undertake other tests of his choice during this period, at his own expense.

During this period the Contractor submits monthly and annual reports on the plant operation including all performance and consumption measurements and values as defined in the Schedule of Guarantees as well as all respective critical indicators / specific costs on a monthly basis and on an accumulated basis.

The results of the tests after completion are submitted to the Employer as a detailed test report. The test report must be approved by the Engineer / Employer.

A.11.3.1. Section A: WWTP, SSTP, SHPP and Common Facilities

The Tests after Completion shall comprise but not be limited to:

1. Hydraulic capacity;
2. Quality of treated effluent;
3. Solids concentration of thickened and dewatered sludge;
4. Electrical energy consumption of the WWTP, SSTP and Common Facilities;
5. Consumption of Precipitants for P-Elimination;
6. Consumption of polymer for sludge treatment;
7. Noise and odour levels at Site boundaries.

The sampling schedule will be carried out based on the Operation and Maintenance Manual provided by the Contractor, and reviewed and approved by the Engineer and in accordance to the applicable local regulations. No less than 1 sampling campaign a week is to be carried out, not depending on local regulations.

A.11.3.2. Section B: SSIP

The Tests after Completion shall comprise but not be limited to the verification during the Defects Notification Period of following performance and consumption guarantees, with reference to the Schedules of Operational Performance and Consumption Guarantees in Volume 2:

- Performance guarantees (Section A.3.1.3):
 - No 3.1. Availability,
 - No 3.2 Operating period ("Reisezeit"),

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- No 3.3. Unscheduled shutdowns: Number of unscheduled shutdowns per operating period ("Reisezeit"),
- No 3.4. Unscheduled shutdowns: Total length of unscheduled shut-downs per operating period ("Reisezeit"),
- No 3.5. Maintenance period.
- Consumption guarantees (SectionA.3.3):
 - No 3.13 Maximum wear part consumption per year.

A.11.4. Performance Certificate

The minimum requirements for issuance of the performance certificate shall be:

1. Successful issue of the taking-over certificate,
2. successful completion of the tests after completion, approval of the test report by the Engineer / Employer.

A.12. SERVICES DURING DEFECTS NOTIFICATION PERIOD

During the Defects Notification Period, the Contractor shall remain responsible to the Employer under the terms of the Contract and shall bear all expenses stated in respect of making good any defects in accordance with the Conditions of Contract.

Operation costs of the plant during the Defects Notification Period will be borne by the Employer in the limits indicated by the Contractor in his Schedules of Operational Performances and Consumption Guarantees (Volume 2, Part B).

A.13. ANNEXES

Annex 1: Selection of applicable Montenegrin Standards

Annex 2: Selection of applicable Montenegrin and European Regulations in the field of Environmental Protection

Annex 3: Selection of applicable Montenegrin and European Regulations in the field of Occupational Health and Safety

Annex 1

Selection of Applicable Montenegrin Standards

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1. Concrete and Reinforced Concrete Works and Masonry Structures

- MEST EN 12390-1:2013 Testing hardened concrete - Part 1: Shape, dimensions and other requirements for specimens and moulds
- MEST EN 12390-11:2016 Testing hardened concrete - Part 11: Determination of the chloride resistance of concrete, unidirectional diffusion
- MEST EN 12390-13:2015 Testing hardened concrete - Part 13: Determination of secant modulus of elasticity in compression
- MEST EN 12504-2:2013 Testing concrete in structures - Part 2: Non-destructive testing - Determination of rebound number
- MEST EN 12620:2015 Aggregates for concrete
- MEST EN 13055:2017 Lightweight aggregates
- MEST EN 13225:2014 Precast concrete products - Linear structural elements
- MEST EN 13369:2014 Common rules for precast concrete products
- MEST EN 1367-2:2017 Tests for thermal and weathering properties of aggregates - Part 2: Magnesium sulfate test
- MEST EN 1367-7:2015 Tests for thermal and weathering properties of aggregates - Part 7: Determination of resistance to freezing and thawing of Lightweight aggregates
- MEST EN 1367-8:2015 Tests for thermal and weathering properties of aggregates - Part 8: Determination of resistance to disintegration of Lightweight Aggregates
- MEST EN 13877-1:2014 Concrete pavements - Part 1: Materials
- MEST EN 13877-2:2014 Concrete pavements - Part 2: Functional requirements for concrete pavements
- METI CEN/TR 16912:2017 Guidelines for a procedure to support the European standardization of cements
- METI CR 13901:2015 The use of the concept of concrete families for the production and conformity control of concrete
- METI CR 13902:2015 Test methods for determining the water/cement ratio of fresh concrete
- Regional Specifications and Recommendations for the avoidance of damaging alkali silica reactions in concrete METI CR 1901:2015
- METI TS CEN/TS 12390-9:2017 Testing hardened concrete - Part 9: Freeze-thaw resistance with de-icing salts - Scaling
- METI CEN/TR 16142:2015 Concrete - A study of the characteristic leaching behaviour of hardened concrete for use in the natural environment
- METI CEN/TR 16349:2015 Framework for a specification on the avoidance of a damaging Alkali-Silica Reaction (ASR) in concrete
- METI CEN/TR 16369:2015 Use of control charts in the production of concrete
- METI CEN/TR 16632:2016 Isothermal Conduction Calorimetry (ICC) for the determination of heat of hydration of cement: State of Art Report and Recommendations
- METI CEN/TR 16639:2015 Use of k-value concept, equivalent concrete performance concept and equivalent performance of combinations concept

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- METI CEN/TR 15697:2015 Cement - Performance testing for sulfate resistance - State of the art report
- METI CEN/TR 15728:2017 Design and use of inserts for lifting and handling of precast concrete elements
- METI CEN/TR 15739:2015 Precast concrete products - Concrete finishes - Identification
- METI CEN/TR 15840:2015 Evaluation of conformity of fly ash for concrete - Guidelines for the application of EN 450-2
- METI CEN/TR 14245:2016 Cement - Guidelines for the application of EN 197-2 Conformity Evaluation
- METI CEN/TR 14862:2014 Precast concrete products - Full-scale testing requirements in standards on precast concrete products
- METI CEN/TR 15177:2015 Testing the freeze-thaw resistance of concrete - Internal structural damage
- MEST EN 932-5:2013 Tests for general properties of aggregates - Part 5: Common equipment and calibration
- MEST EN 933-6:2015 Tests for geometrical properties of aggregates - Part 6: Assessment of surface characteristics - Flow coefficient of aggregates
- MEST EN 933-8:2016 Tests for geometrical properties of aggregates - Part 8: Assessment of fines - Sand equivalent test
- MEST EN 933-9:2014 Tests for geometrical properties of aggregates - Part 9: Assessment of fines - Methylene blue test
- MEST EN 934-2:2014 Admixtures for concrete, mortar and grout - Part 2: Concrete admixtures - Definitions, requirements, conformity, marking and labelling
- MEST EN 480-1:2016 Admixtures for concrete, mortar and grout - Test methods - Part 1: Reference concrete and reference mortar for testing
- MEST EN 480-15:2015 Admixtures for concrete, mortar and grout - Test methods - Part 15: Reference concrete and method for testing viscosity modifying admixtures
- MEST EN 197-2:2015 Cement - Part 2: Conformity evaluation
- MEST EN 206:2018 Concrete - Specification, performance, production and conformity
- MEST EN 450-1:2015 Fly ash for concrete - Part 1: Definition, specifications and conformity criteria
- MEST EN 451-1:2017 Method of testing fly ash - Part 1: Determination of free calcium oxide content
- MEST EN 451-2:2017 Method of testing fly ash - Part 2: Determination of fineness by wet sieving
- MEST EN 196-1:2017 Methods of testing cement - Part 1: Determination of strength
- MEST EN 196-10:2017 Methods of testing cement - Part 10: Determination of the water-soluble chromium (VI) content of cement
- MEST EN 196-3:2018 Methods of testing cement - Part 2: Cement chemical analysis
- MEST EN 196-3:2018 Methods of testing cement - Part 3: Determination of setting times and soundness
- MEST EN 1744-1:2014 Tests for chemical properties of aggregates - Part 1: Chemical analysis

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- MEST EN 1744-7:2014 Tests for chemical properties of aggregates - Part 7: Determination of loss of ignition of Municipal Incinerator Bottom Ash Aggregate (MIBA Aggregate)
- MEST EN 1744-8:2014 Tests for chemical properties of aggregates - Part 8: Sorting test to determine metal content of Municipal Incinerator Bottom Ash (MIBA) Aggregates
- MEST EN 1766:2018 Products and systems for the protection and repair of concrete structures - Test methods - Reference concretes for testing
- MEST EN 16622:2017 Silica-calcium fume for concrete - Definitions, requirements and conformity criteria
- MEST EN 16757:2018 Sustainability of construction works - Environmental product declarations - Product Category Rules for concrete and concrete elements
- MEST EN 15743:2016 Supersulfated cement - Composition, specifications and conformity criteria
- MEST EN 15422:2014 Precast concrete products - Specification of glassfibres for reinforcement of mortars and concretes
- MEST EN 15564:2014 Precast concrete products - Resin bound concrete - Requirements and test methods
- MEST EN 15050:2013 Precast concrete products - Bridge elements
- MEST EN 15191:2014 Precast concrete products - Classification of glassfibre reinforced concrete performance
- MEST EN 14992:2013 Precast concrete products - Wall elements
- MEST EN 15037-4:2015 Precast concrete products - Beam-and-block floor systems - Part 4: Expanded polystyrene blocks
- MEST EN 15037-5:2017 Precast concrete products - Beam-and-block floor systems - Part 5: Lightweight blocks for simple formwork
- MEST EN 1504-10:2018 Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 10: Site application of products and systems and quality control of the works
- MEST EN 1504-5:2014 Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 5: Concrete injection
- MEST EN 1504-8:2017 Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and AVCP - Part 8: Quality control and Assessment and verification of the constancy of performance (AVCP)
- MEST EN 14647:2017 Calcium aluminate cement - Composition, specifications and conformity criteria
- MEST EN 14216:2016 Cement - Composition, specifications and conformity criteria for very low heat special cements

2. Steel Works

- MEST EN 10056-2:2014 Structural steel equal and unequal leg angles - Part 2: Tolerances on shape and dimensions

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- MEST EN 10149-1:2015 Hot rolled flat products made of high yield strength steels for cold forming - Part 1: General technical delivery conditions
- MEST EN 10149-2:2015 Hot rolled flat products made of high yield strength steels for cold forming - Part 2: Technical delivery conditions for thermomechanically rolled steels
- MEST EN 10149-3:2015 Hot-rolled flat products made of high yield strength steels for cold forming - Part 3: Delivery conditions for normalized or normalized rolled steels
- METI CEN/TR 10347:2015 Guidance for forming of structural steels in processing
- MEST EN ISO 15630-1:2014 Steel for the reinforcement and prestressing of concrete - Test methods -- Part 1: Reinforcing bars, wire rod and wire
- MEST EN ISO 15630-2:2014 Steel for the reinforcement and prestressing of concrete - Test methods - Part 2: Welded fabric
- MEST EN ISO 15630-3:2014 Steel for the reinforcement and prestressing of concrete - Test methods - Part 3: Prestressing steel
- MEST EN 10248-1:2016 Hot rolled sheet piling of non alloy steels - Part 1: Technical delivery conditions
- MEST EN 10248-2:2016 Hot rolled sheet piling of non alloy steels - Part 2: Tolerances on shape and dimensions
- MEST EN 10249-1:2016 Cold formed sheet piling of non alloy steels - Part 1: Technical delivery conditions

3. Masonry Works

These works are carried out in accordance with the Rulebook on Technical Requirements for Masonry Structures (Official Gazette of Montenegro, no. 018/18 from 23.03.2018.) and the Rulebook on Technical Requirements for Chimneys in Facilities (Official Gazette of Montenegro, no. 018/18 from 23.03.2018.).

The quality of the masonry materials shall be in accordance with the following standards:

- MEST CEN/TR 16886:2018 Guidance on the application of statistical methods for determining the properties of masonry products
- MEST CEN/TS 772-22:2017 Methods of test for masonry units - Part 22: Determination of freeze/thaw resistance of clay masonry units
- MEST EN 1015-12:2017 Methods of test for mortar for masonry - Part 12: Determination of adhesive strength of hardened rendering and plastering mortars on substrates
- MEST EN 1097-11:2015 Tests for mechanical and physical properties of aggregates - Part 11: Determination of compressibility and confined compressive strength of lightweight aggregates
- MEST EN 1097-6:2015 Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption
- MEST EN 13279-2:2015 Gypsum binders and gypsum plasters - Part 2: Test methods
- MEST EN 13639:2018 Determination of total organic carbon in limestone
- MEST EN 13914-1:2017 Design, preparation and application of external rendering and internal plastering - Part 1: External rendering

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- MEST EN 13914-2:2017 Design, preparation and application of external rendering and internal plastering - Part 2: Internal plastering
- METI CEN/TR 15124:2015 Design, preparation and application of internal gypsum plastering systems
- METI CEN/TR 15125:2015 Design, preparation and application of internal cement and/or lime plastering systems
- METI CEN/TR 15225:2015 Guidance on Factory Production Control for the CE Marking (Attestation of Conformity 2+) of designed masonry mortars
- MEST EN 934-3:2013 Admixtures for concrete, mortar and grout - Part 3: Admixtures for masonry mortar - Definitions, requirements, conformity and marking and labelling
- MEST EN 998-1:2017 Specification for mortar for masonry - Part 1: Rendering and plastering mortar
- MEST EN 998-2:2017 Specification for mortar for masonry - Part 2: Masonry mortar
- MEST EN 846-14:2014 Methods of test for ancillary components for masonry - Part 14: Determination of the initial shear strength between the prefabricated part of a composite lintel and the masonry above it
- MEST EN 846-9:2017 Methods of test for ancillary components for masonry - Part 9: Determination of flexural resistance and shear resistance of lintels
- MEST EN 845-1:2017 Specification for ancillary components for masonry - Part 1: Wall ties, tension straps, hangers and brackets
- MEST EN 845-2:2017 Specification for ancillary components for masonry - Part 2: Lintels
- MEST EN 845-3:2017 Specification for ancillary components for masonry - Part 3: Bed joint reinforcement of steel meshwork
- MEST EN 771-5:2016 Specification for masonry units - Part 5: Manufactured stone masonry units
- MEST EN 771-6:2016 Specification for masonry units - Part 6: Natural stone masonry units
- MEST EN 772-1:2016 Methods of test for masonry units - Part 1: Determination of compressive strength
- MEST EN 772-19:2017 Methods of test for masonry units - Part 19: Determination of moisture expansion of large horizontally perforated clay masonry units
- MEST EN 772-3:2017 Methods of test for masonry units - Part 3: Determination of net volume and percentage of voids of clay masonry units by hydrostatic weighing
- MEST EN 772-5:2017 Methods of test for masonry units - Part 5: Determination of the active soluble salts content of clay masonry units
- MEST EN 772-7:2017 Methods of test for masonry units - Part 7: Determination of water absorption of clay masonry damp proof course units by boiling in water
- MEST EN 772-9:2017 Methods of test for masonry units - Part 9: Determination of volume and percentage of voids and net volume of clay and calcium silicate masonry units by sand filling
- MEST EN 480-13:2016 Admixtures for concrete, mortar and grout - Test methods - Part 13: Reference masonry mortar for testing mortar admixtures
- MEST EN 771-1:2016 Specification for masonry units - Part 1: Clay masonry units

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- MEST EN 771-2:2016 Specification for masonry units - Part 2: Calcium silicate masonry units
- MEST EN 771-3:2016 Specification for masonry units - Part 3: Aggregate concrete masonry units (Dense and lightweight aggregates)
- MEST EN 771-4:2016 Specification for masonry units - Part 4: Autoclaved aerated concrete masonry units
- MEST EN 413-2:2017 Masonry cement - Part 2: Test methods
- MEST EN 459-1:2016 Building lime - Part 1: Definitions, specifications and conformity criteria
- MEST EN 459-3:2016 Building lime - Part 3: Conformity evaluation
- MEST EN 16908:2018 Cement and building lime - Environmental product declarations - Product category rules complementary to EN 15804
- MEST EN 15824:2018 Specifications for external renders and internal plasters based on organic binders

4. Insulation Works

- MEST CEN/TS 12697-52:2018 Bituminous mixtures - Test methods - Part 52: Conditioning to address oxidative ageing
- MEST EN 12085:2014 Thermal insulating products for building applications - Determination of linear dimensions of test specimens
- MEST EN 12086:2014 Thermal insulating products for building applications - Determination of water vapour transmission properties
- MEST EN 12087:2014 Thermal insulating products for building applications - Determination of long term water absorption by immersion
- MEST EN 12088:2014 Thermal insulating products for building applications - Determination of long term water absorption by diffusion
- MEST EN 12089:2014 Thermal insulating products for building applications - Determination of bending behaviour
- MEST EN 12090:2014 Thermal insulating products for building applications - Determination of shear behaviour
- MEST EN 12091:2014 Thermal insulating products for building applications - Determination of freeze-thaw resistance
- MEST EN 12430:2014 Thermal insulating products for building applications - Determination of behaviour under point load
- MEST EN 12431:2014 Thermal insulating products for building applications - Determination of thickness for floating floor insulating products
- MEST EN 12592:2016 Bitumen and bituminous binders - Determination of solubility
- MEST EN 12593:2016 Bitumen and bituminous binders - Determination of the Fraass breaking point
- MEST EN 12595:2016 Bitumen and bituminous binders - Determination of kinematic viscosity
- MEST EN 12597:2015 Bitumen and bituminous binders - Terminology
- MEST EN 12596:2016 Bitumen and bituminous binders - Determination of dynamic viscosity by vacuum capillary

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- MEST EN 12606-1:2016 Bitumen and bituminous binders - Determination of the paraffin wax content - Part 1: Method by distillation
- MEST EN 12607-1:2016 Bitumen and bituminous binders - Determination of the resistance to hardening under influence of heat and air - Part 1: RTFOT method
- MEST EN 12607-2:2016 Bitumen and bituminous binders - Determination of the resistance to hardening under influence of heat and air - Part 2: TFOT method
- MEST EN 12607-3:2016 Bitumen and bituminous binders - Determination of the resistance to hardening under influence of heat and air - Part 3: RFT method
- MEST EN 12697-17:2018 Bituminous mixtures - Test methods - Part 17: Particle loss of porous asphalt specimens
- MEST EN 12697-18:2018 Bituminous mixtures - Test methods - Part 18: Binder drainage
- MEST EN 12697-2:2016 Bituminous mixtures - Test methods - Part 2: Determination of particle size distribution
- MEST EN 12697-27:2018 Bituminous mixtures - Test methods - Part 27: Sampling
- MEST EN 12697-3:2015 Bituminous mixtures - Test methods for hot mix asphalt - Part 3: Bitumen recovery: Rotary evaporator
- MEST EN 12697-49:2015 Bituminous mixtures - Test methods for hot mix asphalt - Part 49: Determination of friction after polishing
- MEST EN 12697-43:2016 Bituminous mixtures - Test methods for hot mix asphalt - Part 43: Resistance to fuel
- MEST EN 12697-41:2016 Bituminous mixtures - Test methods for hot mix asphalt - Part 41: Resistance to de-icing fluids
- MEST EN 12697-4:2016 Bituminous mixtures - Test methods - Part 4: Bitumen recovery: Fractionating column
- MEST EN 12697-5:2010/Cor.1:2014 Bituminous mixtures - Test methods for hot mix asphalt - Part 5: Determination of the maximum density
- MEST EN 12697-7:2015 Bituminous mixtures - Test methods for hot mix asphalt - Part 7: Determination of bulk density of bituminous specimens by gamma rays
- MEST EN 13075-1:2017 Bitumen and bituminous binders - Determination of breaking behaviour - Part 1: Determination of breaking value of cationic bituminous emulsions, mineral filler method
- MEST EN 13075-2:2017 Bitumen and bituminous binders - Determination of breaking behaviour - Part 2: Determination of fines mixing time of cationic bituminous emulsions
- MEST EN 13162:2016 Thermal insulation products for buildings - Factory made mineral wool (MW) products - Specification
- MEST EN 13163:2017 Thermal insulation products for buildings - Factory made expanded polystyrene (EPS) products - Specification
- MEST EN 13164:2016 Thermal insulation products for buildings - Factory made extruded polystyrene foam (XPS) products - Specification
- MEST EN 13165:2017 Thermal insulation products for buildings - Factory made rigid polyurethane foam (PU) products - Specification
- MEST EN 13166:2017 Thermal insulation products for buildings - Factory made phenolic foam (PF) products - Specification

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- MEST EN 13167:2016 Thermal insulation products for buildings - Factory made cellular glass (CG) products - Specification
- MEST EN 13168:2016 Thermal insulation products for buildings - Factory made wood wool (WW) products - Specification
- MEST EN 13169:2016 Thermal insulation products for buildings - Factory made expanded perlite board (EPB) products - Specification
- MEST EN 13170:2016 Thermal insulation products for buildings - Factory made products of expanded cork (ICB) - Specification
- MEST EN 13171:2016 Thermal insulation products for buildings - Factory made wood fibre (WF) products - Specification
- MEST EN 13303:2018 Bitumen and bituminous binders - Determination of the loss in mass after heating of industrial bitumen
- MEST EN 13305:2013 Bitumen and bituminous binders - Framework for specification of hard industrial bitumens
- MEST EN 13398:2013 Bitumen and bituminous binders - Determination of the elastic recovery of modified bitumen
- MEST EN 13399:2013 Bitumen and bituminous binders - Determination of storage stability of modified bitumen
- MEST EN 13587:2013 Bitumen and bituminous binders - Determination of the tensile properties of bituminous binders by the tensile test method
- MEST EN 13589:2013 Bitumen and bituminous binders - Determination of the tensile properties of modified bitumen by the force ductility method
- MEST EN 13614:2013 Bitumen and bituminous binders - Determination of adhesivity of bituminous emulsions by water immersion test
- MEST EN 13632:2014 Bitumen and bituminous binders - Visualisation of polymer dispersion in polymer modified bitumen
- MEST EN 13702:2014 Bitumen and bituminous binders - Determination of dynamic viscosity of modified bitumen by cone and plate method
- MEST EN 13703:2014 Bitumen and bituminous binders - Determination of deformation energy
- MEST EN 13793:2014 Thermal insulating products for building applications - Determination of behaviour under cyclic loading
- MEST EN 13808:2014 Bitumen and bituminous binders - Framework for specifying cationic bituminous emulsions
- MEST EN 13820:2014 Thermal insulating materials for building applications - Determination of organic content
- MEST EN 13924-1:2016 Bitumen and bituminous binders - Specification framework for special paving grade bitumen - Part 1: Hard paving grade bitumens
- MEST EN 13924-2:2015 Bitumen and bituminous binders - Specification framework for special paving grade bitumen - Part 2: Multigrade paving grade bitumens
- MEST EN 14063-2:2015 Thermal insulation products for buildings - In-situ formed expanded clay lightweight aggregate products - Part 2: Specification for the installed products

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- MEST EN 14064-2:2014 Thermal insulation products for buildings - In-situ formed loose-fill mineral wool (MW) products - Part 2: Specification for the installed products
- METI CR 245:2015 Thermal insulation - Classification of building materials according to their thermal insulation properties
- METI CEN/TR 15352:2015 Bitumen and bituminous binders - Development of performance-related specifications: status report 2005
- MEST EN ISO 9229:2014 Thermal insulation - Vocabulary
- MEST EN 822:2014 Thermal insulating products for building applications - Determination of length and width
- MEST EN 823:2014 Thermal insulating products for building applications - Determination of thickness
- MEST EN 824:2014 Thermal insulating products for building applications - Determination of squareness
- MEST EN 825:2014 Thermal insulating products for building applications - Determination of flatness
- MEST EN 826:2014 Thermal insulating products for building applications - Determination of compression behaviour
- MEST EN 16849:2017 Bitumen and bituminous binders - Determination of water content in bituminous emulsions - Method using a drying balance
- MEST EN 16659:2017 Bitumen and Bituminous Binders - Multiple Stress Creep and Recovery Test (MSCRT)
- MEST EN 16724:2017 Thermal insulation products for building applications - Instructions for mounting and fixing for determination of the reaction to fire testing of external thermal Insulation composite systems (ETICS)
- MEST EN 16783:2017 Thermal insulation products - Product category rules (PCR) for factory made and in-situ formed products for preparing environmental product declarations
- MEST EN 16809-2:2018 Thermal insulation products of buildings - In-situ formed products from loose-fill expanded polystyrene (EPS) beads and bonded expanded polystyrene beads - Part 2: Specification for the bonded and loose-fill products after installation
- MEST EN 16345:2014 Bitumen and bituminous binders - Determination of efflux time of bituminous emulsions using the Redwood No. II Viscometer
- MEST EN 16382:2017 Thermal insulation products for building applications - Determination of the pull-through resistance of plate anchors through thermal insulation products
- MEST EN 16383:2017 Thermal insulation products for building applications - Determination of the hygrothermal behaviour of external thermal insulation composite systems with renders (ETICS)
- MEST EN 16069:2016 Thermal insulation products for buildings - Factory made products of polyethylene foam (PEF) - Specification
- MEST EN 1607:2014 Thermal insulating products for building applications - Determination of tensile strength perpendicular to faces

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- MEST EN 1608:2014 Thermal insulating products for building applications - Determination of tensile strength parallel to faces
- MEST EN 1609:2014 Thermal insulating products for building applications - Determination of short term water absorption by partial immersion
- MEST EN 16025-1:2014 Thermal and/or sound insulating products in building construction - Bound EPS ballastings - Part 1: Requirements for factory premixed EPS dry plaster
- MEST EN 16025-2:2014 Thermal and/ or sound insulating products in building construction - Bound EPS ballastings - Part 2: Processing of the factory premixed EPS dry plaster
- MEST EN 1603:2014 Thermal insulating products for building applications - Determination of dimensional stability under constant normal laboratory conditions (23 °C/ 50 % relative humidity)
- MEST EN 1604:2014 Thermal insulating products for building applications - Determination of dimensional stability under specified temperature and humidity conditions
- MEST EN 1605:2014 Thermal insulating products for building applications - Determination of deformation under specified compressive load and temperature conditions
- MEST EN 1606:2014 Thermal insulating products for building applications - Determination of compressive creep
- MEST EN 15715:2014 Thermal insulation products - Instructions for mounting and fixing for reaction to fire testing - Factory made products
- MEST EN 15732:2014 Light weight fill and thermal insulation products for civil engineering applications (CEA) - Expanded clay lightweight aggregate products (LWA)
- MEST EN 1602:2014 Thermal insulating products for building applications - Determination of the apparent density
- MEST EN 15322:2014 Bitumen and bituminous binders - Framework for specifying cut-back and fluxed bituminous binders
- MEST EN 15323:2014 Bitumen and bituminous binders - Accelerated long-term ageing/conditioning by the rotating cylinder method (RCAT)
- MEST EN 15501:2016 Thermal insulation products for building equipment and industrial installations - Factory made expanded perlite (EP) and exfoliated vermiculite (EV) products - Specification
- MEST EN 15599-2:2014 Thermal insulation products for building equipment and industrial installations - In-situ thermal insulation formed from expanded perlite (EP) products - Part 2: Specification for the installed products
- MEST EN 15600-2:2014 Thermal insulation products for building equipment and industrial installations - In-situ thermal insulation formed from exfoliated vermiculite (EV) products - Part 2: Specification for the installed products
- MEST EN 15626:2017 Bitumen and bituminous binders - Determination of adhesivity of cut-back and fluxed bituminous binders by water immersion test - Aggregate method

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- MEST EN 15101-1:2015 Thermal insulation products for buildings - In-situ formed loose fill cellulose (LFCI) products - Part 1: Specification for the products before installation
- MEST EN 15101-2:2015 Thermal insulation products for buildings - In-situ formed loose fill cellulose (LFCI) products - Part 2: Specification for the installed products
- MEST EN 14770:2014 Bitumen and bituminous binders - Determination of complex shear modulus and phase angle - Dynamic Shear Rheometer (DSR)
- MEST EN 14771:2014 Bitumen and bituminous binders - Determination of the flexural creep stiffness - Bending Beam Rheometer (BBR)
- MEST EN 14706:2014 Thermal insulating products for building equipment and industrial installations - Determination of maximum service temperature
- MEST EN 14707:2014 Thermal insulating products for building equipment and industrial installations - Determination of maximum service temperature for preformed pipe insulation
- MEST EN 14769:2014 Bitumen and bituminous binders - Accelerated long-term ageing conditioning by a Pressure Ageing Vessel (PAV)
- MEST EN 14496:2018 Gypsum based adhesives for thermal/acoustic insulation composite panels and gypsum boards - Definitions, requirements and test methods
- MEST EN 14318-1:2014 Thermal insulating products for buildings - In-situ formed dispensed rigid polyurethane (PUR) and polyisocyanurate (PIR) foam products - Part 1: Specification for the rigid foam dispensed system before installation
- MEST EN 14318-2:2014 Thermal insulating products for buildings - In-situ formed dispensed rigid polyurethane (PUR) and polyisocyanurate (PIR) foam products - Part 2: Specification for the installed insulation products
- MEST EN 14319-1:2014 Thermal insulating products for building equipment and industrial installations - In-situ formed dispensed rigid polyurethane (PUR) and polyisocyanurate foam (PIR) products - Part 1: Specification for the rigid foam dispensed system before installation
- MEST EN 14319-2:2014 Thermal insulating products for building equipment and industrial installations - In-situ formed dispensed rigid polyurethane (PUR) and polyisocyanurate foam (PIR) products - Part 2: Specification for the installed insulation products
- MEST EN 14320-1:2014 Thermal insulating products for building equipment and industrial installations - In-situ formed sprayed rigid polyurethane (PUR) and polyisocyanurate foam (PIR) products - Part 1: Specification for the rigid foam spray system before installation
- MEST EN 14320-2:2014 Thermal insulating products for building equipment and industrial installations - In-situ formed sprayed rigid polyurethane (PUR) and polyisocyanurate foam (PIR) products - Part 2: Specification for the installed insulation products
- MEST EN 14308:2016 Thermal insulation products for building equipment and industrial installations - Factory made rigid polyurethane foam (PUR) and polyisocyanurate foam (PIR) products - Specification

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- MEST EN 14309:2016 Thermal insulation products for building equipment and industrial installations - Factory made products of expanded polystyrene (EPS) - Specification
- MEST EN 14313:2016 Thermal insulation products for building equipment and industrial installations - Factory made polyethylene foam (PEF) products - Specification
- MEST EN 14314:2016 Thermal insulation products for building equipment and industrial installations - Factory made phenolic foam (PF) products - Specification
- MEST EN 14315-2:2014 Thermal insulating products for buildings - In-situ formed sprayed rigid polyurethane (PUR) and polyisocyanurate (PIR) foam products - Part 2: Specification for the installed insulation products
- MEST EN 14316-2:2014 Thermal insulating products for buildings - In-situ thermal insulation formed from expanded perlite (EP) products - Part 2: Specification for the installed products
- MEST EN 14317-2:2014 Thermal insulation products for buildings - In-situ thermal insulation formed from exfoliated vermiculite (EV) products - Part 2: Specification for the installed products
- MEST EN 1427:2016 Bitumen and bituminous binders - Determination of the softening point - Ring and Ball method
- MEST EN 1428:2013 Bitumen and bituminous binders - Determination of water content in bituminous emulsions - Azeotropic distillation method
- MEST EN 1429:2015 Bitumen and bituminous binders - Determination of residue on sieving of bituminous emulsions, and determination of storage stability by sieving
- MEST EN 14303:2016 Thermal insulation products for building equipment and industrial installations - Factory made mineral wool (MW) products - Specification
- MEST EN 14304:2016 Thermal insulation products for building equipment and industrial installations - Factory made flexible elastomeric foam (FEF) products - Specification
- MEST EN 14305:2016 Thermal insulation products for building equipment and industrial installations - Factory made cellular glass (CG) products - Specification
- MEST EN 14306:2016 Thermal insulation products for building equipment and industrial installations - Factory made calcium silicate (CS) products - Specification
- MEST EN 14307:2016 Thermal insulation products for building equipment and industrial installations - Factory made extruded polystyrene foam (XPS) products - Specification
- MEST EN 1426:2016 Bitumen and bituminous binders - Determination of needle penetration
- METI CEN/TR 16676:2016 Energy losses by industrial door
- METI CEN/TR 15894:2017 Building hardware - Door fittings for use by children, elderly and disabled people in domestic and public buildings - A guide for specifiers
- MEST EN 1932:2015 External blinds and shutters - Resistance to wind loads - Method of testing and performance criteria
- MEST EN 1933:2014 Exterior blinds - Resistance to load due to water accumulation - Test method

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- MEST EN 16864:2018 Building hardware - Mechatronic padlocks - Requirements and test methods
- MEST EN 16580:2017 Windows and doors - Wetness and splash water proof door leaves - Test and classification
- MEST EN 16361:2017 Power operated pedestrian doors - Product standard, performance characteristics - Pedestrian doorsets, other than swing type, initially designed for installation with power operation
- MEST EN 16433:2015 Internal blinds - Protection from strangulation hazards - Test methods
- MEST EN 16434:2015 Internal blinds - Protection from strangulation hazards - Requirements and test methods for safety devices
- MEST EN 1628:2016 Pedestrian doorsets, windows, curtain walling, grilles and shutters - Burglar resistance - Test method for the determination of resistance under static loading
- MEST EN 1629:2016 Pedestrian doorsets, windows, curtain walling, grilles and shutters - Burglar resistance - Test method for the determination of resistance under dynamic loading
- MEST EN 1630:2016 Pedestrian doorsets, windows, curtain walling, grilles and shutters - Burglar resistance - Test method for the determination of resistance to manual burglary attempts
- MEST EN 16034:2017 Pedestrian doorsets, industrial, commercial, garage doors and openable windows - Product standard, performance characteristics - Fire resisting and/or smoke control characteristics
- MEST EN 16035:2014 Hardware performance sheet (HPS) - Identification and summary of test evidence to facilitate the inter-changeability of building hardware for application to fire resisting and/or smoke control doorsets and/or openable windows
- MEST EN 15684:2014 Building hardware - Mechatronic cylinders - Requirements and test methods
- MEST EN 16005:2014 Power operated pedestrian doorsets - Safety in use - Requirements and test methods
- MEST EN 16005:2014/Cor.1:2017 Power operated pedestrian doorsets - Safety in use - Requirements and test methods
- MEST EN 1527:2014 Building hardware - Hardware for sliding doors and folding doors - Requirements and test methods
- MEST EN 14351-1:2017 Windows and doors - Product standard, performance characteristics - Part 1: Windows and external pedestrian doorsets

5. Joinery

- MEST EN 12209:2017 Building hardware - Mechanically operated locks and locking plates - Requirements and test methods
- MEST EN 12210:2017 Windows and doors - Resistance to wind load - Classification
- MEST EN 12211:2017 Windows and doors - Resistance to wind load - Test method
- MEST EN 12217:2016 Doors - Operating forces - Requirements and classification

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- MEST EN 12428:2014 Industrial, commercial and garage doors - Thermal transmittance - Requirements for the calculation
- MEST EN 12320:2013 Building hardware - Padlocks and padlock fittings - Requirements and test methods
- MEST EN 12604:2018 Industrial, commercial and garage doors and gates - Mechanical aspects - Requirements and test methods
- MEST EN 1303:2016 Building hardware - Cylinders for locks - Requirements and test methods
- MEST EN 1026:2017 Windows and doors - Air permeability - Test method
- MEST EN 1027:2017 Windows and doors - Water tightness - Test method
- MEST EN 12045:2014 Shutters and blinds power operated - Safety in use - Measurement of the transmitted force
- MEST EN 13120:2015 Internal blinds - Performance requirements including safety
- MEST EN 13120:2015/Cor.1:2015 Internal blinds - Performance requirements including safety
- MEST EN 13126-1:2013 Building hardware - Hardware for windows and door height windows - Requirements and test methods - Part 1: Requirements common to all types of hardware
- MEST EN 13126-13:2014 Building hardware - Hardware for windows and balcony doors - Requirements and test methods - Part 13: Sash balances
- MEST EN 13126-14:2014 Building hardware - Hardware for windows and balcony doors - Requirements and test methods - Part 14: Sash fasteners
- MEST EN 13126-19:2014 Building hardware - Requirements and test methods for windows and door height windows - Part 19: Sliding Closing Devices
- MEST EN 13126-2:2013 Building hardware - Requirements and test methods for windows and door height windows - Part 2: Window fastener handles
- MEST EN 13126-3:2013 Building hardware - Hardware for windows and door-height windows - Requirements and test methods - Part 3: Handles, primarily for Tilt&Turn, Tilt-First and Turn-Only hardware
- MEST EN 13126-5:2016 Building hardware - Hardware for windows and door height windows - Requirements and test methods - Part 5: Devices that restrict the opening of windows and door height windows
- MEST EN 13126-8:2018 Building hardware - Hardware for windows and door height windows - Part 8: Requirements and test methods for Tilt and Turn, Tilt-First and Turn-Only hardware
- MEST EN 13126-9:2014 Building hardware - Requirements and test methods for windows and door height windows - Part 9: Hardware for horizontal and vertical pivot windows
- MEST EN 13241:2017 Industrial, commercial, garage doors and gates - Product standard, performance characteristics
- MEST EN 13330:2015 Shutters - Hard body impact and prevention of access - Test methods

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- MEST EN 13358:2013 Bitumen and bituminous binders - Determination of the distillation characteristics of cut-back and fluxed bituminous binders made with mineral fluxes
- MEST EN 13469:2014 Thermal insulating products for building equipment and industrial installations - Determination of water vapour transmission properties of preformed pipe insulation
- MEST EN 13472:2014 Thermal insulating products for building equipment and industrial installations - Determination of short term water absorption by partial immersion of preformed pipe insulation
- MEST EN 13496:2015 Thermal insulation products for building applications - Determination of the mechanical properties of glass fibre meshes as reinforcement for External Thermal Insulation Composite Systems with renders (ETICS)
- MEST EN 13500:2013 Thermal insulation products for buildings - External thermal insulation composite systems (ETICS) based on mineral wool - Specification
- MEST EN 13561:2016 External blinds and awnings - Performance requirements including safety
- MEST EN 13561:2016/Cor.1:2017 External blinds and awnings - Performance requirements including safety
- MEST EN 13659:2016 Shutters and external venetian blinds - Performance requirements including safety

6. Metal Works

- MEST EN 14353:2018 Metal beads and feature profiles for use with gypsum plasterboards - Definitions, requirements and test methods
- MEST EN 14195:2016 Metal framing components for gypsum board systems - Definitions, requirements and test methods

7. Sheet Metal Works

- MEST EN 10051:2014 Continuously hot-rolled strip and plate/sheet cut from wide strip of non-alloy and alloy steels - Tolerances on dimensions and shape.
- MEST EN 10163-1:2016 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 1: General requirements
- MEST EN 10163-2:2016 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 2: Plate and wide flats
- MEST EN 10163-3:2016 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 3: Sections

8. Stone Works

- MEST CEN/TR 17024:2018 Natural stones - Guidance for use of natural stones
- MEST EN 12057:2016 Natural stone products - Modular tiles - Requirements
- MEST EN 12058:2016 Natural stone products - Slabs for floors and stairs - Requirements
- MEST EN 12371:2016 Natural stone test methods - Determination of frost resistance
- MEST EN 12440:2017 Natural stone - Denomination criteria

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- MEST EN 13161:2017 Natural stone test methods - Determination of flexural strength under constant moment
- MEST EN 14066:2014 Natural stone test methods - Determination of resistance to ageing by thermal shock
- MEST EN 14157:2018 Natural stone test methods - Determination of the abrasion resistance
- MEST CEN/TR 17024:2018 Natural stones - Guidance for use of natural stones
- MEST EN 1926:2017 Natural stone test methods - Determination of uniaxial compressive strength
- MEST EN 16301:2014 Natural stone test methods - Determination of sensitivity to accidental staining
- MEST EN 16306:2014 Natural stone test methods - Determination of resistance of marble to thermal and moisture cycles
- MEST EN 16140:2014 Natural stone test methods - Determination of sensitivity to changes in appearance produced by thermal cycles
- MEST EN 15286:2015 Agglomerated stone - Slabs and tiles for wall finishes (internal and external)
- MEST EN 14617-6:2013 Agglomerated stone - Test methods - Part 6: Determination of thermal shock resistance
- MEST EN 1467:2013 Natural stone - Rough blocks - Requirements
- MEST EN 1468:2013 Natural stone - Rough slabs - Requirements
- MEST EN 1469:2016 Natural stone products - Slabs for cladding - Requirements
- MEST EN 14617-1:2014 Agglomerated stone - Test methods - Part 1: Determination of apparent density and water absorption
- MEST EN 14617-10:2013 Agglomerated stone - Test methods - Part 10: Determination of chemical resistance
- MEST EN 14617-12:2013 Agglomerated stone - Test methods - Part 12: Determination of dimensional stability
- MEST EN 14617-13:2014 Agglomerated stone - Test methods - Part 13: Determination of electrical resistivity
- MEST EN 14617-2:2017 Agglomerated stone - Test methods - Part 2: Determination of flexural strength (bending)
- MEST EN 14617-4:2013 Agglomerated stone - Test methods - Part 4: Determination of the abrasion resistance
- MEST EN 14617-5:2013 Agglomerated stone - Test methods - Part 5: Determination of freeze and thaw resistance

9. Floor Installation

- MEST EN 1344:2015 Clay pavers - Requirements and test methods
- METI TS CEN 15209:2014 Tactile paving surface indicators produced from concrete, clay and stone

10. Gypsum Works

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- MEST EN 13915:2018 Prefabricated gypsum plasterboard panels with a cellular paperboard core - Definitions, requirements and test methods
- MEST EN 13950:2016 Gypsum board thermal/acoustic insulation composite panels - Definitions, requirements and test methods
- MEST EN 13963:2016 Jointing materials for gypsum boards - Definitions, requirements and test methods
- METI CEN/TR 16239:2015 Installation rules of fibrous (gypsum) plaster works
- MEST EN 520:2017 Gypsum plasterboards - Definitions, requirements and test methods
- MEST EN 14190:2016 Gypsum board products from reprocessing - Definitions, requirements and test methods
- MEST EN 14209:2018 Preformed plasterboard cornices - Definitions, requirements and test methods

11. Facade Works

- MEST EN 13050:2013 Curtain Walling - Watertightness - Laboratory test under dynamic condition of air pressure and water spray
- MEST EN 13119:2017 Curtain walling - Terminology
- MEST EN 13830:2016 Curtain walling - Product standard
- MEST EN 14019:2017 Curtain Walling - Impact resistance - Performance requirements
- MEST EN 16758:2017 Curtain walling - Determination of the strength of sheared connections - Test method and requirements

12. Other Works

- MEST EN 12697-1:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 1: Soluble binder content
- MEST EN 12697-11:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 11: Determination of the affinity between aggregate and bitumen
- MEST EN 12697-16:2017 Bituminous mixtures - Test methods - Part 16: Abrasion by studded tyres
- MEST EN 12697-19:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 19: Permeability of specimen
- MEST EN 12697-20:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 20: Indentation using cube or cylindrical specimens (CY)
- MEST EN 12697-21:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 21: Indentation using plate specimens
- MEST EN 12697-24:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 24: Resistance to fatigue
- MEST EN 12697-25:2017 Bituminous mixtures - Test methods - Part 25: Cyclic compression test
- MEST EN 12697-26:2013 Bituminous mixtures - Test methods - Part 26: Stiffness
- MEST EN 12697-30:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 30: Specimen preparation by impact compactor
- MEST EN 12697-34:2013 Bituminous mixtures - Test methods - Part 34: Marshall test

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- MEST EN 12697-35:2017 Bituminous mixtures - Test methods - Part 35: Laboratory mixing
- MEST EN 12697-39:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 39: Binder content by ignition
- MEST EN 12697-40:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 40: In situ drainability
- MEST EN 12697-42:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 42: Amount of foreign matter in reclaimed asphalt
- MEST EN 12697-45:2014 Bituminous mixtures - Test methods for hot mix asphalt - Part 45: Saturation Ageing Tensile Stiffness (SATS) conditioning test
- MEST EN 12697-46:2014 Bituminous mixtures - Test methods for hot mix asphalt - Part 46: Low temperature cracking and properties by uniaxial tension tests
- MEST EN 12697-6:2013 Bituminous mixtures - Test methods for hot mix asphalt - Part 6: Determination of bulk density of bituminous specimens
- MEST EN 13108-1:2017 Bituminous mixtures - Material specifications - Part 1: Asphalt Concrete
- MEST EN 13108-2:2017 Bituminous mixtures - Material specifications - Part 2: Asphalt Concrete for Very Thin Layers (BBTM)
- MEST EN 13108-20:2017 Bituminous mixtures - Material specifications - Part 20: Type Testing
- MEST EN 13108-21:2017 Bituminous mixtures - Material specifications - Part 21: Factory Production Control
- MEST EN 13108-3:2017 Bituminous mixtures - Material specifications - Part 3: Soft Asphalt
- MEST EN 13108-4:2017 Bituminous mixtures - Material specifications - Part 4: Hot Rolled Asphalt
- MEST EN 13108-5:2017 Bituminous mixtures - Material specifications - Part 5: Stone Mastic Asphalt
- MEST EN 13108-6:2017 Bituminous mixtures - Material specifications - Part 6: Mastic Asphalt
- MEST EN 13108-7:2017 Bituminous mixtures - Material specifications - Part 7: Porous Asphalt
- MEST EN 13108-8:2017 Bituminous mixtures - Material specifications - Part 8: Reclaimed asphalt
- MEST EN 13108-9:2017 Bituminous mixtures - Material specifications - Part 9: Asphalt for Ultra-Thin Layer (AUTL)
- MEST EN 13282-1:2014 Hydraulic road binders - Part 1: Rapid hardening hydraulic road binders - Composition, specifications and conformity criteria
- MEST EN 13282-2:2016 Hydraulic road binders - Part 2: Normal hardening hydraulic road binders - Composition, specifications and conformity criteria
- MEST EN 13282-3:2016 Hydraulic road binders - Part 3: Conformity evaluation
- MEST EN 13286-47:2014 Unbound and hydraulically bound mixtures - Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling

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- MEST EN 13637:2016 Building hardware - Electrically controlled exit systems for use on escape routes - Requirements and test methods
- MEST EN 14187-1:2018 Cold applied joint sealants - Test methods - Part 1: Determination of rate of cure
- METI TS CEN/TS 12697-50:2017 Bituminous mixtures - Test methods - Part 50: Resistance to scuffing
- MEST EN ISO 11819-2:2018 Acoustics - Measurement of the influence of road surfaces on traffic noise - Part 2: The close-proximity method (ISO 11819-2:2017)
- MEST EN 1906:2014 Building hardware - Lever handles and knob furniture - Requirements and test methods
- MEST EN 15221-6:2014 Facility Management - Part 6: Area and Space Measurement in Facility Management
- MEST EN 15221-7:2015 Facility Management - Part 7: Guidelines for Performance Benchmarking
- MEST EN 14227-15:2016 Hydraulically bound mixtures - Specifications - Part 15: Hydraulically stabilized soils
- MEST EN 14227-2:2014 Hydraulically bound mixtures - Specifications - Part 2: Slag bound granular mixtures
- MEST EN 14227-3:2015 Hydraulically bound mixtures - Specifications - Part 3: Fly ash bound mixtures
- MEST EN 14227-4:2014 Hydraulically bound mixtures - Specifications - Part 4: Fly ash for hydraulically bound mixtures
- MEST EN 14227-5:2014 Hydraulically bound mixtures - Specifications - Part 5: Hydraulic road binder bound mixtures
- MEST EN 14187-2:2018 Cold applied joint sealants - Part 2: Test method for the determination of tack free time
- MEST EN 14187-3:2018 Cold applied joint sealants - Part 3: Test method for the determination of self-levelling properties
- MEST EN 14187-4:2018 Cold applied joint sealants - Part 4: Test method for the determination of the change in mass and volume after immersion in test fuel
- MEST EN 14187-8:2018 Cold applied joint sealants - Part 8: Test method for the determination of the artificial weathering by UV-irradiation.

Annex 2

Selection of applicable Montenegrin and European Regulations in the field of Environmental Protection

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Relevant Montenegrin and European Laws and Regulations in the Field of Environmental Protection

No	MNE	ENG
1	Zakon o Zakon o životnoj sredini ("Službeni list Crne Gore", br. 052/16 od 09.08.2016)	Law on the Environment ("Official Gazette of Montenegro", No. 052/16 dated 08/09/2016)
2	Zakon o upravljanju otpadom („Službeni list Crne Gore“, br. 64/11, 12/29/2011, 039/16 od 29.06.2016)	Law on Waste Management ("Official Gazette of Montenegro. No. 064/11 dated 12/29/2011, 039/16 dated 06/29/2016)
3	Zakon o procjeni uticaja na životnu sredinu („Sl. list CG“ br. 75/18);	Law on Environmental Impact Assessment ("Official Gazette of the Republic of Montenegro. No. 080/05 dated 12/28/2005, "Official Gazette of Montenegro", No. 040/10 dated 01/22/2010. 073110 dated 12/10/2010. 040/11 dated 08/08/2011. 027113 od 06/11/2013.052116 od 08/09/2016)
4	Zakon o strateskoj procjeni uticaja na životnu sredinu (SEA) („Službeni list RCG", br. 80/05 i "Službeni list Crne Gore", br. 40/11, 59/11, 52/16)	The Law on the Strategic Environmental Impact Assessment (SEA) ("Official Gazette of the Republic of Montenegro", No. 80/05 and "Official Gazette of Montenegro", No. 40/11, 59/11, 52/16);
5	Zakon o strateskoj procjeni uticaja na životnu sredinu (Objavljen u "Sl. listu RCG", br. 80 od 28. decembra 2005, "Sl. listu CG", br.40 od 8.avgusta 2011, 59/11, 52/16)	Law on Strategic Environmental Assessment (Published in the Official Gazette of the Republic of Montenegro, No. 80 dated December 28. 2005, "Official Gazette of Montenegro". No.40 dated August 8,2011, 59/11, 52/16)
6	Zakon o odgovornosti za štetu po životnoj sredini ("Službeni list Crne Gore", br. 27/14);	The Law on Liability for Environmental Damage Official Gazette of Montenegro", No. 27/14);
7	Zakon o zaštiti prirode ("Službeni list Crne Gore", br. 54/16);	The Law on Nature Protection ("Official Gazette of Montenegro", No. 54/16);
8	Zakon o integrisanom spriječavanju i kontroli zagađenja - IPPC („Službeni list Crne Gore", br. 80/05, 54/09, 42/15, 54/16).	The Law on Integrated Pollution Prevention and Control - IPPC ("Official Gazette of Montenegro", No. 80/05, 54/09, 42/15, 54/16).
9	Zakon o integrisanom spriječavanju i kontroli zagađivanja životne sredine ("Službeni list Republike Crne Gore", br. 080/05 od 28.12.2005, Službeni list Crne Gore", br. 054/09 od 10.08.2009, 040/11 od 08.08.2011, 042/15 od 29.07.2015, 054/16 od 15.08.2016)	Law on Integrated Prevention and Control of Environmental Pollution ("Official Gazette of the Republic of Montenegro", No. 080/05 dated 12/28/2005, "Official Gazette of Montenegro", No. 054/09 dated 08/10/2009, 040/11 dated 08/08/2011, 042/15 dated 07/29/2015, 054/16 dated 08/15/2016)
10	Zakon o zaštiti prirode (Službeni list Crne Gore",br. 54/16. i 18/19)	Law on Nature Protection ("Official Gazette of Montenegro", No. 054/16 dated 08/15/2016)
11	Zakon o zaštiti vazduha (Službeni list Crne Gore", 25/10, 040/11, 043/15)	Law on Air Protection ("Official Gazette of Montenegro", No. 025/10 dated 05/05/2010, 040/11 dated 08/08/2011, 043/15 dated 07/31/2015)
12	Zakon o vodama („Službeni list Crne Gore", br. 27/07., 22/11., 32/11., 47/11., 48/15., 52/16., 55/16., 2/17., 80/17., 84/18.)	Law on Waters ("Official Gazette of the Republic of Montenegro", No.027/07, 22/11, 32/11, 47/11, 48/15, 52/16, 55/16, 2/17, 80/17, 84/18)
13	Zakon o hemikalijama ("Službeni list Crne Gore .br. 051/17)	Law on Chemicals ("Official Gazette of Montenegro ,No.051/17 dated 08/03/2017)

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No	MNE	ENG
14	Zakon o nacionalnim parkovima ("Službeni list Crne Gore .br.028/14 od 04.07.2014, 039/16 od 29.06.2016)	Law on National Parks (Official Gazette of Montenegro", No. 028/14 dated 07/04/2014, 039/16 dated 06/29/2016)
15	Zakon o ratifikaciji Kjoto protokola uz okviru Konvencije UN o promjenama klime ("Sl. list RCG", br.17/07 od 27.03.2007)	Law on Ratification of the Kyoto Protocol to the UN Framework Convention on Climate Change ("Official Gazette of the Republic of Montenegro", No. 17/07 dated 03/27/2007)
16	Uredba o djelatnostima koje utiču ili mogu uticati na kvalitet vazduh ("Sl. list Crne Gore", br.61/12 od 07.12.2012)	Decree on activities affecting or likely to affect air quality ("Official Gazette of Montenegro No.61/12 dated 12/07/2012)
17	Uredba o graničnim vrijednostima emisija zagađujućih materija u vazduhu iz stacionarnih izvora ("Sl. list Crne Gore". br.10/11 od 11.02.2011)	Regulation on Limit Values of Emissions of Pollutants into the Air from Stationary Sources ("Official Gazette of Montenegro", No.10/11 dated 02/11/2011)
18	Uredba o projektima za koje se vrši procjena uticaja na životnu sredinu ("Sl. list RCG", br. 020/07, "Sl. list CG", br. 047/13, 053/14, 037/18)	Regulation on projects for which environmental Impact assessment is being carried out ("Official Gazette of Montenegro". No. 037/18)
19	Uredba o utvrđivanju vrsta zagađujućih materija, graničnih vrijednosti i drugih standarda kvaliteta vazduha („Sl. list CG”, br. 25/12.).	Decree on determining the types of pollutants, limit values and other air quality standards ("Official Gazette of Montenegro", No. 25/12).
20	Uredba o uspostavljanju mreže mjernih mjesta za praćenje kvaliteta vazduha („Sl. list CG”, br. 44/10, 13/11. i 64/18.);	Decree on the establishing a network of measuring points for air quality monitoring ("Official Gazette of Montenegro", No. 44/10, 13/11 and 64/18);
21	Uredba o graničnim vrijednostima emisije zagađujućih materija u vazduhu iz stacionarnih izvora („Sl. list CG”, br. 10/11.);	Decree on limit values for emissions of air pollutants from stationary sources ("Official Gazette of Montenegro", No. 10/11);
22	Uredba o maksimalnim nacionalnim emisijama određenih zagađujućih materija („Sl. list CG” br. 03/12.);	Decree on maximum national emissions of certain pollutants ("Official Gazette of Montenegro" No. 03/12);
23	Uredba o klasifikaciji i kategorizaciji površinskih i podzemnih voda („Sl. list CG” br. 02/07.).	Decree on classification and categorization of surface and groundwater ("Official Gazette of Montenegro" No. 02/07).
24	Uredba o načinu i uslovima skladištenja otpada ("Sl. list CG", br. 33/13).	Decree on the manner and conditions of waste storage ("Official Gazette of Montenegro", No. 33/13).
25	Uredba o popisu vrsta opasnih materija, dozvoljenim količinama i kriterijumima za kategorizaciju opasnih materija („Sl. list CG”, br. 5/11.).	Decree on the list of types of hazardous substances, permitted quantities and criteria for categorization of hazardous substances ("Official Gazette of Montenegro", No. 5/11).
EU direktive koje su transponovane u nacionalni pravni okvir		EU Directives fully transposed into the national legal system
1	Direktiva 2001/42/EZ (SEA);	Directive 2001/42/EZ (SEA);
2	Direktiva 2011/92/EU (EIA), koja je kodifikovala Direktivu 85/337 I EEZ i njene izmjene Direktivom 97/11/EZ, Direktivom 2003/35/EZ i Direktivom 2009/31/EZ i izmjenjenom 2014/52/EU (EIA);	Directive 2011/92/EU (EIA), which codified Directive 85/337/EEC and its amendments by Directive 97/11/EC, Directive 2003/35/EC and Directive 2009/31/EC and as amended by 2014/52/EU (EIA);
3	Direktiva 2003/4/EC (pristup informacijama o životnoj sredini);	Directive 2003/4/EC (access to environmental information);

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No	MNE	ENG
4	Direktiva 2003/35/EZ (ucesće javnosti i pristup postupcima i procjenama uticaja na izdavanje IPPC);	Directive 2003/35/EC and Directive 2009/31/EC and as amended by 2014/52/EU (EIA)
5	Direktiva 2001/42/EZ (SEA);	Directive 2001/42/EZ (SEA);
6	Direktiva 2011/92/EU (EIA), koja je kodifikovala Direktivu 85/337 I EEZ i njene izmjene Direktivom 97/11/EZ, Direktivom 2003/35/EZ i Direktivom 2009/31/EZ i izmjenjenom 2014/52/EU (EIA);	Directive 2011/92/EU (EIA), which codified Directive 85/337/EEC and its amendments by Directive 97/11/EC,
7	Direktiva 2004/35 I EZ (odgovornost za zivotnu sredinu), izmjenjena Direktivom 2006/21 I EC (rudarski otpad), Direktivom 2009/31 I EC (geolosko skladistenje ugljen-dioksi da) i Direktivom 2013/30 I EU (bezbjednost operacije nafte igasa na moru);	Directive 2004/35/EC (environmental liability), as amended by the Directive 2006/21/EC (mining waste),
8	Direktiva 2008/99/EC (o zastiti zivotne sredine krivicnim zakonom);	Directive 2008/99/EC (on the protection of the environment through criminal law);
9	Okvima direktiva o otpadu 2006/12/EC;	Waste Framework Directive 2006/12/EC;
10	Direktiva o deponijama 1999/31 I EC;	Landfill Directive 1999/31/EC;
11	Direktiva o opasnom otpadu 91/689 / EEC, sa dodacima 94/31 / EC, 166/2006;	Hazardous Waste Directive 91/689/EEC, with accessories 94/31/EC, 166/2006;
12	Direktiva o mulju sa uređaja za preciscavanje otpadnih voda 861278 I EEC;	Sludge directive from wastewater treatment plants 861278/EEC;
13	Direktiva 2000n I EC o spaljivanju otpada;	Waste Incineration Directive 2000n/EC;
14	Direktiva o pakovanju i otpadu 94/62 I EC, sa dodacima 2005/20 I EC 2004/12 I EC, 1882/2003;	The Packaging and Waste Directive 94/62/EC, with accessories 2005/20/EC 2004/12/EC, 1882/2003;
15	Direktiva Saveta 1999/31/EC od 26. aprila 1999. o odlagalistu otpada.	Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste
16	Direktiva 2004/35 I EZ (odgovornost za zivotnu sredinu), izmjenjena Direktivom 2006/21 I EC (rudarski otpad), Direktivom 2009/31 I EC (geolosko skladistenje ugljen-dioksi da) i Direktivom 2013/30 I EU (bezbjednost operacije nafte igasa na moru);	Directive 2004/35/EC (environmental liability), as amended by the Directive 2006/21/EC (mining waste)
17	EU direktive u oblasti upravljanja vodama: • Okvima direktiva o vodi 2000/60 I EC; • Direktiva Saveta 91/271 I EEC o preciscavanju komunalnih otpadnih voda; • Direktiva 98/83 I EZ o kvalitetu vode za pice; • Direktiva Saveta 2006n I EC o kvalitetu vode za kupanje;	U directives regulating water management: • Water Framework Directive 2000/60/EC; • Council Directive 91/271/EEC on urban waste water treatment; • Council Directive 98/83/EC on drinking water quality; • Council Directive 2006n/EC on bathing water quality;
18	Direktiva EU 2008/105 I EC o standardima kvaliteta zivotne sredine u oblasti vodene politike;	EU Directive 2008/105/EC on environmental quality standards in the field of water policy;
19	Direktiva 2007/60 I EC Evropskog parlamenta i Saveta o proceni i upravljanju rizikom od poplava;	Directive 2007/60/EC of the European Parliament and the Council on flood risk assessment and management;
20	Direktivom 2006/111 I EC Evropskog parlamenta i Saveta o zagadenju uzrokovanom određenim opasnim materijama koje se ispuštaju u vodeni okolis	Directive 2006/111/EC of the European Parliament and the Council on pollution caused by certain hazardous substances discharged into the aquatic environment;

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Part A: General Project Requirements

No	MNE	ENG
21	Direktiva 2006/118 I EC Evropskog parlamenta i Savjeta o zaštiti podzemnih voda od zagađenja i narušavanja kvaliteta;	Directive 2006/118/EC of the European Parliament and the Council on groundwater protection against pollution and quality impairment;
22	Direktiva o vodi namenjenoj ljudskoj ishrani (EU) 2015/11787;	Directive on Water Intended for Human Consumption (EU) 2015/1787;
23	Direktiva o upravljanju kvalitetom vode za kupanje - Direktiva o kvalitetu vode za kupanje 2006n;	Directive on Water Quality Management Intended for Bathing - Bathing Water Quality Directive 2006n;
24	Direktiva o proceni i upravljanju rizikom od poplava 2007/60 I EC	Directive on Flood Risk Assessment and Management 2007/60/EC
25	Okvirna direktiva o otpadu 2006/12 I EC dopunjena Direktivom EU 2008/98 I EC o upravljanju otpadom;	Waste Framework Directive 2006/12/EC amended with EU Directive 2008/98/EC on waste management;
26	Direktiva EU 92/43 I EEZ od 21. maja 1992. o ocuvanju prirodnih stanista i divlje faune i flore, izmenjena Direktivama 97/62 I EZ i Uredbom EZ 1882/2003;	EU Directive 92/43/EEC of 21 May 1992 on the conservation of Natural Habitats and of Wild Fauna and Flora, as amended by Directives 97/62/EC and Regulation EC 1882/2003
27	Direktiva EU 2002/49 I EC o proceni i upravljanju bukom u zivotnoj sredini;	EU Directive 2002/49/EC on Assessment and Management of Environmental Noise;
28	Okvirna direktiva o kvalitetu ambijentalnog vazduha (96/62 I EZ), dopunjena Uredbom (EZ) 1882/2003	Ambient Air Quality Framework Directive (96/62/EC), as amended by Regulation (EC) 1882/2003 .
29	Direktiva EU 2008/105 I EC o standardima kvaliteta zivotne sredine u oblasti vodene politike;	Directive 2008/105/EC of the OF THE European Parliament and of the council on environmental quality standards in the field of water policy,
30	Direktiva 2007/60 I EC Evropskog parlamenta i Saveta o proceni i upravljanju rizikom od poplava;	Directive on Flood Risk Assessment and Management 2007/60/EC
31	Direktivom 2006/111 I EC Evropskog parlamenta i Saveta o zagađenju uzrokovanom određenim opasnim materijama koje se ispustaju u vodeni okoliš	Directive 2006/111/EC of the European Parliament and the Council on pollution caused by certain hazardous substances discharged into the aquatic environment
32	Direktiva 2006/118 I EC Evropskog parlamenta i Savjeta o zaštiti podzemnih voda od zagađenja i narušavanja kvaliteta;	Directive 2006/118/EC of the European Parliament and the Council on groundwater protection against pollution and quality impairment;
33	Direktiva o vodi namenjenoj ljudskoj ishrani (EU) 2015/11787;	Directive on the quality of water intended for human consumption (EU) 2015/11787
34	Direktiva o upravljanju kvalitetom vode za kupanje - Direktiva o kvalitetu vode za kupanje 2006;	Council Directive 2006n/EC on bathing water quality;
35	Direktiva o procjeni i upravljanju rizikom od poplava 2007/60 I EC -;	Directive 2007/60/EC on the assessment and management of flood risks
36	Okvirna direktiva o otpadu 2006/12 I EC dopunjena Direktivom EU 2008/98 I EC o upravljanju otpadom	Waste Framework Directive 2006/12/EC amended with EU Directive 2008/98/EC on waste management;

Annex 3

Selection of applicable Montenegrin and European Regulations in the field of Occupational Health and Safety

Section VII – Employer's Requirements – Particular Technical Specifications
Part A: General Project Requirements

Relevant Montenegrin and European Laws and Regulations in the field of Occupational Health and Safety

No	MNE	ENG
1	Zakon o zaštiti na radu ("Službeni list CG", br 34/14 i 44/18)	Law on Occupational Safety and Health (Official Gazette of Montenegro 34/14 and 44/18)
2	Pravilnik o poslovima sa posebnim uslovima rada i uslovima koje treba da ispuni zaposleni za rad na tim poslovima("Službeni list CG", br 70/16)	Rulebook on jobs with special working conditions and conditions to be fulfilled by employees to work in those jobs (Official Gazette of Montenegro 70/16)
3	Pravilnik o mjerama zaštite i zdravlja na radu od rizika izloženosti hemijskim materijama ("Službeni list CG", br 81/16)	Rulebook on Occupational Health and Safety Measures against Chemical Exposure risks (Official Gazette of Montenegro 0644/17 i 81/16)
4	Pravilnik o mjerama zaštite i zdravlja na radu od rizika izloženosti kancerogenim i mutagenim materijama ("Službeni list CG", br 60/16)	Rulebook on Measures for Occupational Safety and Health at Risk of Exposure to carcinogenic and Mutagenic Substances (Official Gazette of Montenegro 60/16)
5	Pravilnik o mjerama zaštite i zdravlja na radu od rizika izloženosti vibracijama ("Službeni list CG", br 37/16)	Regulation on Occupational Health and Safety Measures against Noise Exposure Risks (Official Gazette of Montenegro 37/16)
6	Pravilnik o mjerama zaštite i zdravlja na radu ("Službeni list CG", br 24/16)	Regulation on Occupational Health and Safety Measures against Vibration Exposure Risk (Official Gazette of Montenegro 24/16)
7	Pravilnik o upotrebi sredstava i opreme lične zaštite na radu ("Službeni list CG", br 0/15)	Rulebook on Use of personal Protective Equipment and Equipment at work (Official Gazette of Montenegro No 0/15)
8	Pravilnik o mjerama zaštite prilikom ručnog prenošenja tereta ("Službeni list CG", br 29/15)	Rulebook on security measures for the manual transfer of cargo (Official Gazette of Montenegro 29/15)
9	Pravilnik o mjerama zaštite prilikom upotrebe sredstava za rad ("Službeni list CG", br 27/15)	Rulebook on safeguards for the use of means of work (Official Gazette of Montenegro 27/15)
10	Pravilnik o znakovima za zaštitu i zdravlje na radu("Službeni list CG", br 24/15)	Rulebook on Signs for Occupational Safety and Health (Official Gazette of Montenegro 24/15)
11	Pravilnik o postupku i rokovima za vršenje periodičnim pregleda i ispitivanja sredstava za rad, sredstava i opreme lične zaštite na radu i uslova radne sredine ("Službeni list CG", br 71/05)	Rulebook on the Procedure and Deadlines for performing Periodic Inspections and Tests of Work Tools. Personnel Protective Items and Equipment and Working Conditions (Official Gazette of Montenegro 71/05)
12	Pravilnik o vođenju evidencije iz oblasti zaštite na radu ("Službeni list CG", br 67/05)	Rulebook on keeping records in the field of occupational safety (Official Gazette of Montenegro 67/05)
13	Pravilnik o opremi licne zastite (Sl. list Crne Gore, br. 17/15)	Rulebook on personal protection equipment (Official Gazette of Montenegro 17/15)
14	Pravilnik o zastitnim mjerama protiv opasnosti od elektricne struje u radnim prostorijama i na radilistima (Sl. list RCG 6/86 i 16/86);	Rulebook on protective measures against the dangers of electricity in work premises and on work sites (Official Gazette of Montenegro 6/86 and 16/86);
15	Pravilnik o opstim mjerama zastite na radu za gradevinske objekte namijenjene za radne i pomocne prostorije (Sl.list RCG 27/87);	Rulebook on special safety at work measures for constructions intended for work and auxiliary premises (Official Gazette of the Socialist Republic of Montenegro 27/87);

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No	MNE	ENG
16	Pravilnik o mjerama zaštite na radu na privremenim i pokretnim gradilisti (Sl.list CG br. 20/19)	Rulebook on occupational safety measures on temporary or mobile construction sites (Official Gazette of Montenegro 20/19);
17	Pravilnik o sadržini i načinu izdavanja izvještaja o povredi na radu ("Službeni list CG", br 18/93)	Rulebook on the content and manner of issuing Reports on occupational injuries (Official Gazette of Montenegro 18/93)
18	Pravilnik o mjerama i normativima zaštite na radu na oruđima za rad ("Službeni list SFRJ", br 18/91)	Rulebook on Measures and Norms of Occupational Safety at Work Tools (Official Gazette of SFRY 18/91)
19	Pravilnik o zaštiti na radu pri utovaru i istovaru tereta ("Službeni list SRCG", br 13/88)	Rulebook on Occupational Safety at Loading and Unloading of Cargoes (Official Gazette of SRM 13/88)
20	Pravilnik o opštim mjerama zaštite na radu od opasnih dejstva električne struje u objektima namijenjenim za rad u radnim prostorijama na gradilištima ("Službeni list SRCG", br 6/86)	Rulebook on General Measures for Occupational Safety and Health at the Facilities for Work Rooms and Work sites (Official Gazette of SRM 6/86)
21	Pravilnik o obezbjeđenju sredstava ishrane i prevoza radnika od mjesta smještaja do mjesta rada i nazad ("Službeni list SRCG", br 5/86)	Rulebook on provision of funds, food and transportation of workers from place of residence to place of work and back (Official Gazette of SRM 5/86)
22	Pravilnik o vrsti načinu i obimu i rokovima za obavljanje zdravstvenih pregleda zaposlenih na radnim mjestima sa posebnim uslovima rada ("Službeni list CG", br 043/17 od 04.07.2017.)	Rulebook on the type of scope and deadlines for carrying out health examinations of employees in work placed with special working conditions (Official Gazette of Montenegro no 43/17 dated 07/04 /2017)
23	Pravilnik o opremi i postupku za pružanje prve pomoći i organizovanju službe spasavanja u slučaju nezgode na radu ("Službeni list SFRJ", br 21/71)	Rulebook on Equipment and Procedure for First Aid and Organisation of the Emergency Service (Official Gazette of SFRY no 21/71)
24	Pravilnik o mjerama zaštite pri rukovanju eksplozivnim sredstvima (miniranj u rudarstvu) ("Službeni list SFRJ", br 9/67 i 35/67 i 35/72)	Rulebook on Measures of Protection in the Operation of Explosives and Blasting in Mining (Official Gazette of the SFRY no 9/67 35/67 and 35/72)
25	Opšti pravilnik o higijenskim i tehničkim zaštitnim mjerama pri radu ("Službeni list SFRJ", br 56/47)	General Rulebook on Hygiene and Technical Protective Measures at Work (Official Gazette of the SFRY no 56/47)
26	Pravilnik o planu mjera zaštite izdavlja na radu ("Sl. list Crne Gore", br. 38/19)	Rulebook on the Plan of Measures for Occupational Safety and Health ("Official Gazette of Montenegro ", No. 38119)
27	Pravilnik o nacinu i postupku procjene rizika na radnom mjestu (Sl. list Crne Gore 43/07);	Rulebook on the manner and procedure of workplace risk assessment ("Official Gazette of Montenegro" No. 43/07);
28	Pravilnik o nacinu i postupku osposobljavanja zaposlenih za bezbjedan rad (Sl. list Crne Gore 57/06)	Rulebook on the manner and procedure of training employees for safe work ("Official Gazette of Montenegro" No. 57/06)
29	Pravilnik o prenosivoj opremi pod pritiskom ("Sl. list CG", br. 001/16);	Rulebook on transportable pressure equipment (Official Gazette of Montenegro 001/16);
30	Pravilnik o sadržaju i nacinu vođenja evidencija o eksplozivnim materijama ("Sluzbeni list CG", br. 026/15 od 26.05.2015);	Rulebook on the content and manner of keeping records of explosive substances ("Official Gazette of Montenegro", No. 026/15 of May 26, 2015);
31	Pravilnik o tehničkim zahtjevima i postupcima za ocjenjivanje usaglasenosti, znakovima nacinu označavanja eksplozivnih materija ("Sl. list CG", br. 045/15, 068/15);	Rulebook on Technical Requirements and Procedures for Conformity Assessment, Signs and Manner of Marking of Explosives (Official Gazette of Montenegro 045115, 068/15);

Section VII – Employer's Requirements – Particular Technical Specifications
Part A: General Project Requirements

No	MNE	ENG
32	Pravilnik o sadržaju mjera specifične zdravstvene zaštite zaposlenih ("Sl. list RCG", br. 044/06);	Rulebook on the Content of Measures for Specific Employee Health Care ("Official Gazette of the Republic of Montenegro", No. 044/06
33	Pravilnik o mjerama zaštite i zdravlja na radu od rizika izloženosti buci ("Službeni list CG", br. 37/16)	Rulebook on safety at work measures and norms concerning noise at working premises (Official Gazette of the Socialist Federal Republic of Yugoslavia 21/92);
34	Pravilnik o posebnim mjerama zaštite na radu o tehničkim mjerama za razvijanje acetilena i acetilenske stanice ("Službeni list SFRJ", br. 6/67, 29/67, 27/69 i 52/90);	Rulebook on special safety at work measures and on technical measures for acetylene generators and acetylene stations (Official Gazette of the Socialist Federal Republic of Yugoslavia 6/67, 29/67, 27/69 and 52/90
35	Pravilnik o opremi i postupku za pružanje prve pomoći i o organizovanju službe spasavanja u slučaju nezgode na radu ("Službeni list SFRJ", br. 21/71);	Rulebook on equipment and procedure for the provision of first aid and on organisation of industrial accident aid service (Official Gazette of the Socialist Federal Republic of Yugoslavia 21/71).
36	Rjesenje o donesenim crnogorskim standardima iz oblasti bezbjednosti, zaštite i životnesredine (lična zaštitna oprema) ("Sl. list CG", br. 043/08);	Decision on the adopted Montenegrin standards in the field of safety, protection and environment (personal protective equipment) ("Official Gazette of Montenegro", No. 043/08);
37	Rjesenje o donesenim crnogorskim standardima iz oblasti lične zaštite opreme ("Sl. list CG", br. 038/08);	Decision on the adopted Montenegrin standards in the field of personal protection of equipment ("Official Gazette of Montenegro", No. 038/08);
Standardi		Standards
1	Standard ISO 9001 2015	Standard ISO 9001 2015
2	Standard ISO 1400	Standard ISO 1400
3	Standard zaštite i zdravlja na radu ISO 45001 2018	Standard on Occupational Health and Safety Standard ISO 45001 2018
EU direktive koje su transponovane u nacionalni pravni okvir		EU directives in the field of occupational health and safety
1	Direktiva 1999/92/EZ - rizici od eksplozivnih atmosfera	Directive 99/92/JEC - risks from explosive atmospheres
2	Direktiva 92/58/EEZ - sigurnosni znakovi i/ili znakovi za zaštitu zdravlja	Directive 92/58/EEC - safety and/or health signs
3	Direktiva 89/656/EEZ - upotreba lične zaštitne opreme	Directive 89/656/EEC - use of personal protective equipment
4	Direktiva 89/655/EEZ - upotreba radne opreme	Directive 89/655 I EEC - use of work equipment
5	Direktiva 89/654/EEZ - zahtjevi na gradilistima	Directive 89/654 I EEC - requirements at construction sites Directive 2006/95 / EC - electrical equipment
6	Direktiva 2006/95/EZ - električna oprema	Directive 2006/95 / EC - electrical equipment
7	Direktiva 2006/42/EZ - direktiva o novim masinama	Directive 2006/42/ec - new machinery directive
8	Direktiva 2001/95/EZ - sigurnost proizvoda	Directive 2001/95 / EC - Product safety
9	Direktiva 94/9/EZ - zaštitni sistemi - potencijalno eksplozivne atmosfere	Directive 94/9 I EC - Protective systems - potentially explosive atmospheres
10	Direktiva 90/396/EEZ - uređaji za izgaranje plinovitih goriva	Directive 90/396 I EEC - Appliances burning gaseous fuels
11	Direktiva 89/686/EEZ - lična zaštitna oprema	Directive 89/686 I EEC - personal protective equipment

Section VII – Employer's Requirements – Particular Technical Specifications
Part A: General Project Requirements

No	MNE	ENG
12	Direktiva 89/106/EEZ - građevinski proizvodi	Directive 89/106 I EEC - construction products
13	Direktiva 87/404/EEZ -jednostavne posude pod pritiskom	Directive 87/404 I EEC - simple pressure vessels
14	Direktiva 85/374/EEZ - odgovornost za neispravne proizvode	Directive 85/374 / EEC - liability for defective products
15	Direktiva 84/527/EEZ - zavarene plinske boce od nelegiranog celika	Directive 84/527 I EEC - welded unalloyed steel gas cylinders
16	Direktiva 84/526/EEZ - plinske boce od aluminijuma	Directive 84/526 I EEC - aluminium alloy gas cylinders
17	Direktiva 84/525/EEZ - besavne	Directive 84/525 I EEC - seamless, steel gas cylinders
18	Direktiva 2006/15/EZ - indikativne granicne vrijednosti profesionalne izlozenosti	Directive 2006/15 I EC - indicative occupational exposure limit values
19	Direktiva 2004/37/EZ - karcinogene iii mutagene materije na radu	Directive 2004/37 I EC - carcinogenic or mutagenic substances at work
20	Direktiva 2000/39/EZ - indikativne granicne vrijednosti profesionalne izlozenosti	Directive 2000/39 I EC - indicative occupational exposure limit values
21	Direktiva 2006/25/EZ - vjestacko opticko zracenje	Directive 2006/25 I EC - artificial optical radiation
22	Direktiva 2004/40/EZ - elektromagnetska polja i talasi	Directive 2004/40 I EC - electromagnetic fields and waves
23	Direktiva 2003/110/EZ - buka	Directive 2003/110 I EC - noise
24	Direktiva 2002/44/EZ - vibracija	Directive 2002/44 I EC - vibration
25	Direktiva 96/29/EEZ -jonizirajuće zračenje	Directive 96/29 / EEC - ionizing radiation
26	Direktiva 2000/54/EZ - bioloski agensi na radu	Directive 2000/54 I EC - biological agents at work Directive 90/269 I EEC - manual handling of loads Directive 2003/88 I EC - Working time
27	Direktiva 90/269/EEZ - rucno prenosenje tereta	Directive 90/269 / EEC - manual handling of loads
28	Direktiva 2003/88/EZ - radno vrijeme	Directive 2003/88 / EC - Working time
29	Direktiva 92/185/EEZ - trudne radnice	Directive 92/85 / EEC - pregnant workers
30	Direktiva 92/57/EEZ - privremena iii pokretna gradilista	Directive 92/57 I EEC - temporary or mobile construction sites
31	Direktiva 89/656/EEZ - upotreba licne zastitne opreme	Directive 89/656/EEC - use of personal protective equipment
32	Direktiva 89/655/EEZ - upotreba radne opreme	Directive 89/655 I EEC - use of work equipment
33	Direktiva 89/654 I EEZ - zahtjevi na radnom mestu, koji se ticu minimalnih bezbjednosnih i zdravstvenih zahtjeva za radno mjesto;	Directive 89/654/EEC - workplace requirements, concerning the minimum safety and health requirements for the workplace (first individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC);
34	Direktiva 2003/10 I EC o minimalnim zdravstvenim i bezbjednosnim zahtjevima u vezi sa izlozenoscu radnika rizicima koji nastaju od fizickih agenasa (buke);	Directive 2003/10/EC on minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise);
35	Direktiva 1989/391 I EEZ o uvođenju mjera za podsticanje poboljšanja sigurnosti izdravlja radnika na radu.	Directive 1989/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work

WWTP and Sewer Extension Project Podgorica Vodovod i kanalizacija Podgorica d.o.o.	Bidding Documents – Components 1-2-3 Volume 3: Employer's Requirements

Bidding Documents for the Construction of the Wastewater Treatment Plant, Sewage Sludge Treatment Plant and Sewage Sludge Incineration Plant for the City of Podgorica

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

1. Specifications

b) Technical Specifications

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Part B: Process Requirements

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- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
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- e) Reports on Soil Contamination;
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Section VII – Employer’s Requirements

1. Specifications

b) Technical Specifications

Particular Technical Specifications

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List of Acronyms

A2/0	Anaerobic, Anoxic, Oxidic		Abfall e. V (German technical association for water, sewerage and solid waste)
AC	Activated Carbon		
AFDD	Arc-Fault Detection Device	d.o.o.	Drustvo sa ogranicenom odgovornoscu (private limited liability company)
AST	Activated Sludge Tank		
AT	Activated (Sludge) Tank		
ATV	Abwassertechnische Vereinigung e.V (German technical association for sanitation)	EBPR	Enhanced Biological Phosphorus Removal
		EN	European Norm
BAT / BREF	Best Available Techniques Reference Documents	ERP	Enterprise Resource Planning
BOD ₅	Biochemical Oxygen Demand after 5 days	ESP	Electrostatic Precipitator
		ESTP	Electrostatic Precipitation
C	Carbon	EU	European Union
CAPEX	CAPital EXpenditures	FIDIC	Federation Internationale des Ingenieur-Conseils (International Federation of Consulting Engineers)
CCTV	Closed-Circuit Television		
CEDIS	Crnogorski elektrodistributivni sistem (Montenegrin Power Distribution Company)	FF	Fabric Filter
		FGT	Flue Gas Treatment
CEMS	Continuous Emission Monitoring System	FRP	Fiberglass Reinforced Plastic
CFC	Continuous Function Chart	GRP	Glas Fibre reinforced Plastic
CFD	Computational Fluids Dynamics	H&S	Health and Safety
CFU	Colony Forming Unit	HART	Highway Addressable Remote Transducer
CHP	Combined Heat and Power	HDPE	High Density Polyethylene
COD	Chemical Oxygen Demand	HVAC	Heating, Ventilation, and Air Conditioning
DECT	Digital Enhanced Cordless Telecommunications	I&C	Instrumentation and Control
DI	Ductile Iron	ID	Induced Draft (fan)
DIN	Deutsche Industrienorm (German Standard)	IEC	International Electrotechnical Commission
DN	Nominal Diameter	IED	Industrial Emission Directive
DO	Dissolved Oxygen	I/O	Input / Output
DR	Dry Residue	IP	Internet Protocol
DS	Dry Solids	ISME	Institute for Standardization of Montenegro
mDS	Mineral Dry Solids	ISO	International Standardisation Organisation
oDS	Organic Dry Solids	JUS	Yugoslavian Standard
DUP	Detaljni urbanisticki plan (Detailed Urban Plan)	KAP	Kombinat aluminijuma Podgorica (Podgorica Aluminium Company)
DWA	Deutsche Vereinigung für Wasserwirtschaft, Abwasser und		

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KfW	KfW Entwicklungsbank	RS	Return Sludge
KVM	Kernel-based Virtual Machine	RTP	Real-time Transport Protocol
LAN	Local Area Network	SAE	Standard Aeration Efficiency
LCD	Liquid-Crystal Display	SCADA	Supervisory Control and Data Acquisition
LV	Low Voltage	SFC	Sequential Function Chart
LVD	Low Voltage Directive	SFRY	Socialist Federal Republic of Yugoslavia
masl	Meter Above Sea Level	SHPP	Small Hydro-Power Plant
MAXLC	Maximum Load Case	SNCR	Selective Non-Catalytic Reduction System
mbgl	Meter Below Ground Level	SS	Suspended Solids
MCC	Motor Control Centre	SSIP	Sewage Sludge Incineration Plant
MEST	Montenegrin Standard	SSTP	Sewage Sludge Treatment Plant
MINLC	Minimum Load Case	SVI	Sludge Volume Index
MLDB	Main Low Distribution Board	TCP/IP	Tape Carrier Package Internet Protocol
MLSS	Mixed Liquor Suspended Solids	TKN	Total Kjeldahl Nitrogen
MNE	Montenegro	TN	Total Nitrogen
MV	Medium Voltage	TOC	Taking-Over Certificate
MVDB	Medium Voltage Distribution Board	TOC	Total Organic Carbon
N	Nitrogen	TP	Total Phosphorus
NTK	Total Kjeldahl Nitrogen	TPH	Total Petroleum Hydrocarbons
OPEX	Operational EXPenditures	TSS	Total Suspended Solids
ORP	Oxydo-Redox Potential	UPVC	Unplasticized Polyvinyl chloride
OS	Operator Station	UV	Ultra-violet
P	Phosphorus	UWWD	Urban Waste Water Directive
PAH	Polycyclic Aromatic Hydrocarbon	VDI	Verein Deutscher Ingenieure
PE	Polyethylene	VIK	Vodovod i Kanalizacija (Water and Sewerage Company)
PE	Population Equivalent	VNC	Virtual Network Computing
PED	Pressure Equipment Directive	WLAN	Wireless Local Area Network
PFD	Process Flow Diagramm	WWTP	Wastewater Treatment Plant
PLC	Programmable Logic Controller		
PN	Nominal Pressure		
PCB	Polychlorinated Biphenyl		
PP	Polypropylene		
PVC	Polyvinyl chloride		
RFID	Radio Frequency Identification		

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Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the **decimal comma** is used and the dot is used as **thousand separator**.

Section VII – Employers Requirements – Particular Technical Specifications
Part B: Particular Process and Design Requirements

B.1. INTRODUCTION

The present Part B of the Employer's Requirements refer to the Particular Process and Design Requirements for the Wastewater Treatment Plant (WWTP), Sewage Sludge Treatment plant (SSTP), Sewage Sludge Incineration Plant (SSIP), Small Hydro-Power Plant (SHPP, optional services) as well as common facilities for the WWTP for the city of Podgorica.

Bidders are requested to submit a technical and financial offer for the Employer's base solution described in the present specifications. Bidders may submit a separate technical and financial offer for alternative technical solutions.

The present specifications shall be read in conjunction with other parts of the technical specifications, the Instruction to Bidders, the Schedules (Volume 2) and other documents and data submitted with the Biding Documents.

Remark:

In the present report the term Wastewater Treatment Plant (WWTP) is used to describe both the whole plant, including the wastewater treatment facilities, the sewage sludge treatment facilities, the sludge incineration plant and the general facilities as, in special cases, only the wastewater treatment facilities.

B.2. LOCATION OF THE WORKS AND PREVAILING SITE CONDITIONS

B.2.1. General

Information provided in the Bidding Documents on the conditions of the Site is only indicative. It is the Contractor's responsibility to carry out any necessary additional survey or investigation on the conditions of the Site. The Employer shall not be liable for consequences of any variance or discrepancy between conditions as indicated in the Bidding Documents and the actual conditions revealed during progress of works or otherwise.

B.2.2. Location of the Works

The location of the Works is indicated in following Figure 1. The Site for the construction of the municipal wastewater treatment plant for the city of Podgorica is located south-west of the city of Podgorica in the areas of Dajbabe and Botun. Between the KAP aluminium factory and the River Moraca.

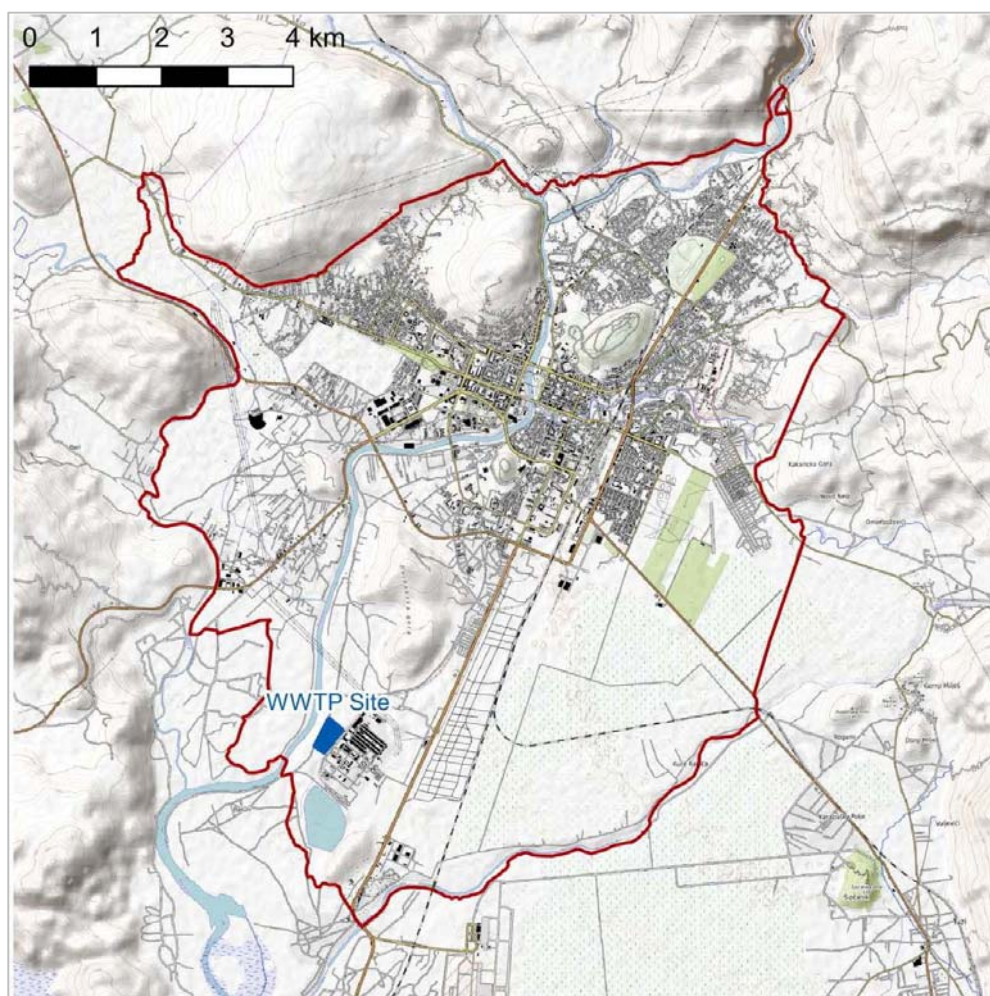


Figure 1: Wastewater collection catchment area and location of the site of the new WWTP

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The location of the Site allows to drain by gravity the wastewater collected in the existing and future sewer networks of a large part of the sewer area to the future WWTP with minimised requirements for pumping.

B.2.3. Available Construction Site

B.2.3.1. Delineation of the available Site for the Construction Works

The delineation of the available construction site is indicated in the Drawing in Volume 3, Section VII: Employer's Requirements, Part 2.).

The available Site corresponds to the dedicated area for the construction of the municipal wastewater treatment in accordance to the valid urban planning documents and notably to the Detailed Urbanistic Plan (DUP) "ID DUP Industrial Zone of KAP". November 2019.

The available construction Site has a total area of 12,81 ha divided in two plots:

- The construction Site for the WWTP as such, located between the KAP factory and the municipal road from Dajbabe to Botun (Urban Parcels UP 2F and UP 3F, with an area of 11,11 ha;
- The required land for the construction of the discharge pipe for treated effluents of the WWTP to the River Moraca, located between the municipal road from Dajbabe to Botun and the River Moraca (Urban Parcel UP 9F), with an area of 1,70 ha. On this plot shall also be installed the Small Hydro-Power Plant (SHPP) for the generation of electrical hydropower from the discharge of treated effluents to Moraca River.

The following non-constructible areas shall be considered with regard to the available site for the construction of the WWTP:

- Investigations carried out on the site revealed a potentially contaminated area on the north-eastern edge of the site which is recommended to be excluded from the construction site because of possible issues for the disposal of contaminated excavation material (see Section B.2.10);
- A 10 m wide strip shall be reserved within the Site along the municipal road from Dajbabe to Botun for the relocation of the overhead power line which currently crosses the construction Site (see Section B.2.11).

B.2.3.2. Site Ownership Confirmation

The above described selected Site for the construction of the WWTP is property of the Podgorica Capital City (or of the country of Montenegro at the disposal of Podgorica Capital City) and the site is reserved in the current valid urban planning documents for the construction of a municipal WWTP.

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B.2.4. Access

Access to the site shall be provided from the municipal road from Dajbabe to Botun which runs along the construction site on its north-western border.

Crossing of the road will be required for the construction of the treated effluents discharge pipe to the Moraca River as well as for the by-pass pipe.

B.2.5. Meteorological Conditions

Podgorica has a Mediterranean climate, with hot and dry summers and mild winters.

The average annual temperature is 18,8 °C, with a minimum average monthly temperature of 5,5 °C in January and a maximum average monthly temperature of 26,8 °C in July.

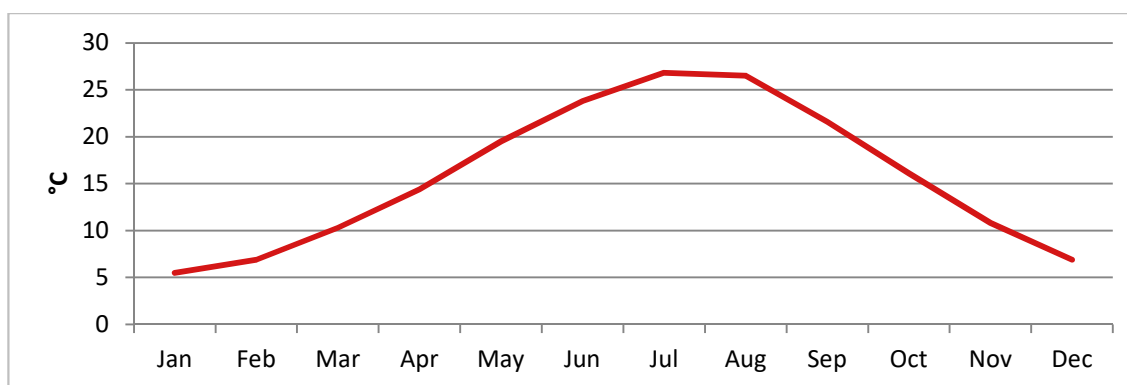


Figure 2: Average monthly temperature in Podgorica for the period 1949 to 2018

The average annual precipitation in Podgorica is 1.633 mm. November is the wettest month, with an average monthly precipitation of 242,8 mm, the driest is July with an average monthly precipitation of 36,8 mm, only.

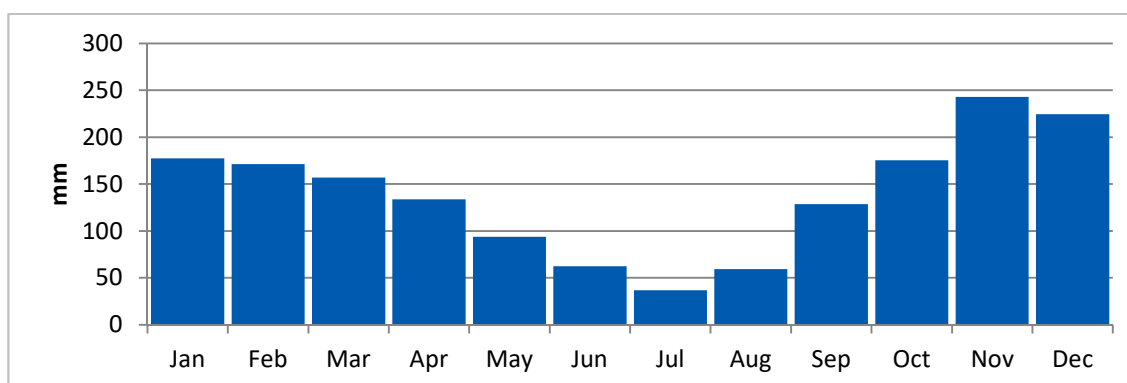


Figure 3: Average monthly precipitation in Podgorica for the period 1949 to 2018

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Snow is a rare occurrence in Podgorica and it rarely snows more than a few days per year. In February 2012, Podgorica had a snow cover for a record of 25 days.

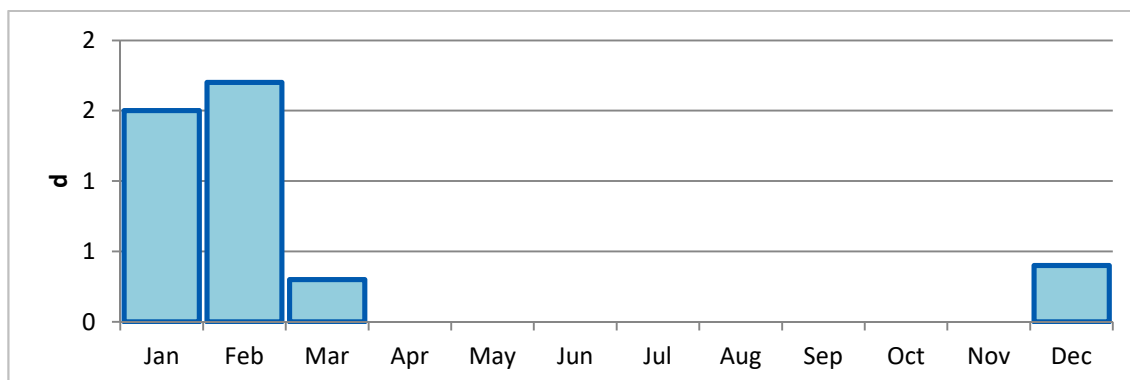


Figure 4: Average monthly number of days with snow cover in Podgorica for the period 1951 to 2018

The average global solar irradiation in Podgorica is 161,8 W/m². In July, the average global solar irradiation is 267,4 W/m², in December it is 53,2 W/m².

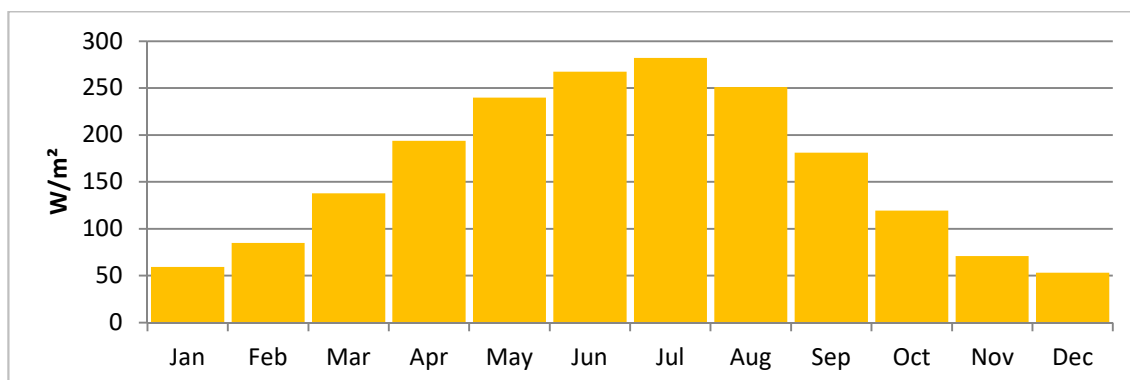
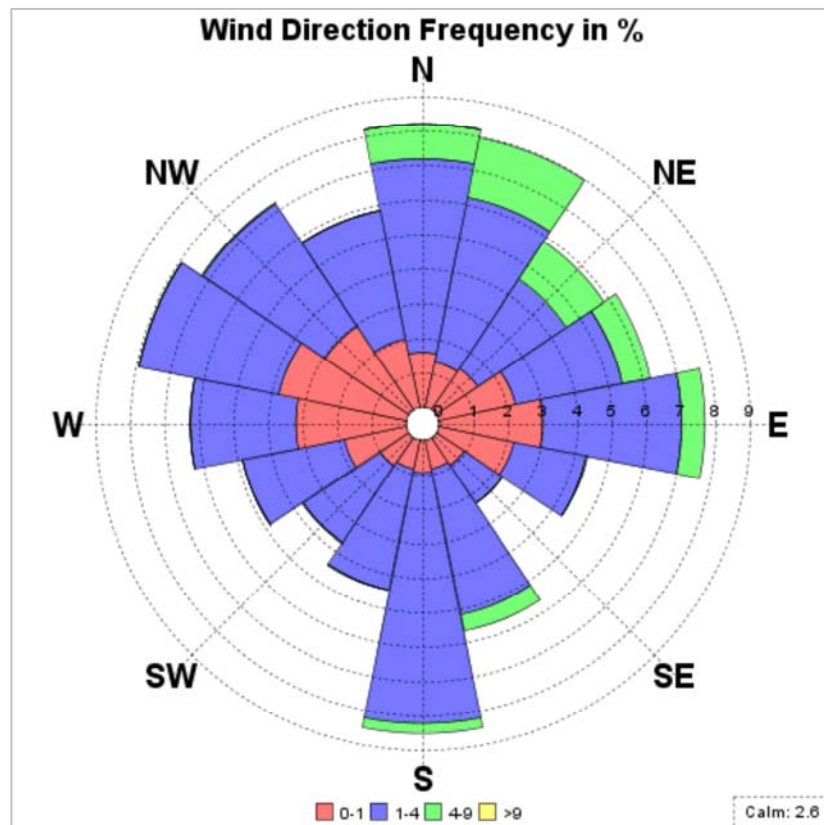


Figure 5: Solar irradiation in Podgorica

Wind in Podgorica is usually calm, with wind speeds of 1 to 4 m/s occurring 60 % of the time. The predominant wind direction is from the north.

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Source: Crna gora zavod za hidrometeorologiju i seizmologiju (Montenegrin Institute for hydrometeorology and seismology)

Figure 6: Wind direction and strength distribution in Podgorica for the period 2003 to 2018

B.2.6. Site Topography

The Site for the construction of the WWTP is flat with an elevation between approx. 30,8 masl at the eastern corner of the Site, close to the KAP factory and approx. 28,9 masl at the western corner and a general but very low slope from east to west.

The topography of the plot which is reserved for the construction of the treated effluent discharge pipe exhibits a slope which is increasing progressively towards the River Moraca between approx. 28,8 masl and approx. 24 masl at the edge of river Moraca. The River bank is very steep with a difference of elevation of more than 10 m between the top of the river bank at approx. 24 masl and the absolute minimum water level of Moraca River of 13,70 masl. The highest water level of River Moraca is 21,4 masl and so still around 2,5 m below the top of the River bank.

B.2.7. Geological and Geotechnical Conditions

The topography of the area is flat. The underground and layer sequence shall be characterized as follows:

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- The Upper Cretaceous limestone and dolomites belong to the High Karst Zone and consist of medium to thick-bank limestone and dolomites with varying clay proportions. Thin clay layers can be interposed locally. The limestone rocks are relatively strongly karstified. In the area of the Podgorica plain, they usually occur at depths between 5 m and 30 m. In the area of the hills and mountains, the calcareous solid rocks are near the surface or are directly outcropping;
- Quaternary deposits are widely spread around Podgorica and its surrounding. Youngest geological deposits are represented by fluvio-glacial sediments which are dominantly settled in the Zetska ravnica plain, nearby capital city of Podgorica. Fluvio-glacial sediments consist of sand, gravel and sandy gravels, which are occasionally consolidated into conglomerates.
- The bonding material is usually of sand origin, while rounded gravel fragments originated from limestone and dolomites. Grain size varies from fine sand to rounded blocks, whereas rounded gravel fragments, in the range from 3 to 10 cm, are dominating. The thickness of the fluvio-glacial deposits is from 30 m at the north part of the Zetska ravnica plain, up to 80 m in the south;
- The accumulation of the Quaternary sediments of the Zetska ravnica plain, as well as at the Moraca and Cijevna riverbeds, are related to different glaciations, which caused the geological determination of three terraces, created during different glacial phases. The Site belongs to the third terrace created during Riss glaciation.
- During the Pleistocene, the biggest temperature drop down happening during the Riss glaciations, caused deposition of the thick layer of fluvio-glacial sediments, up to 50 m, in the area of Moraca and Cijevna rivers valleys. At man-made open cross-sections it is possible to see heterogeneous shifts of pure sand of various thicknesses, with gravels of various grain sizes. Based on that fact, it can be concluded that there is no strict order in which sediments were deposit.
- The area of the third terrace is covered by the thin layer of Terra Rossa, which is sometimes mixed with gravel.

An overview is given in the following Geological Map.

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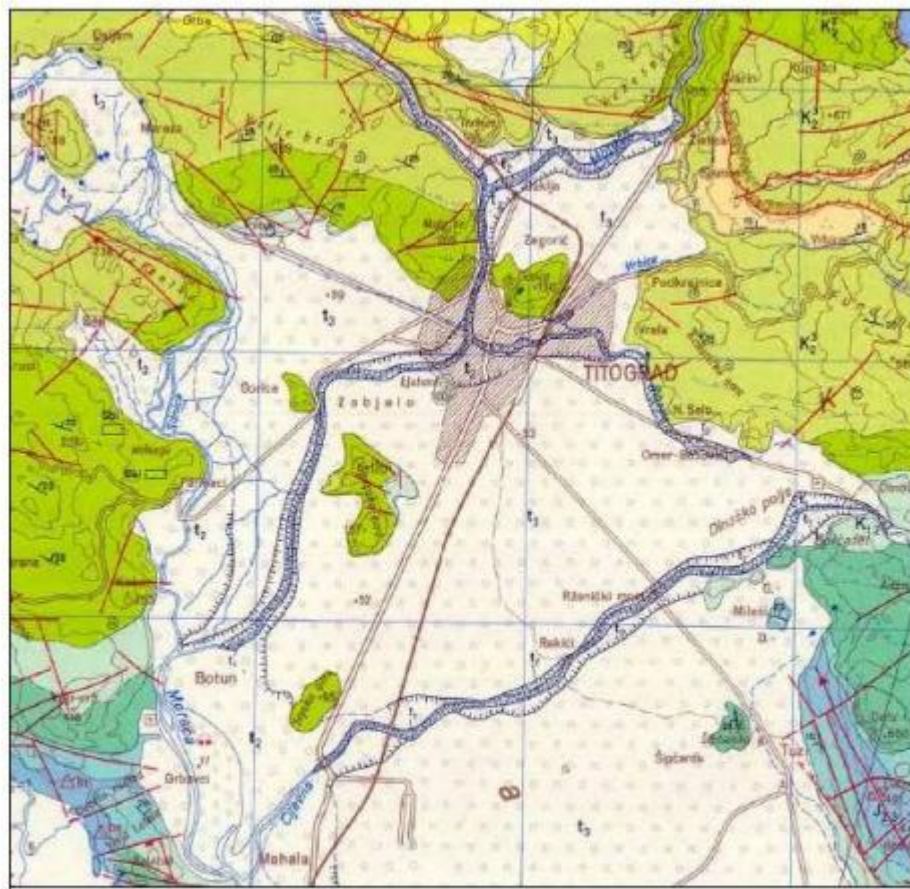


Figure 1. Geological map¹ (Legend: t_3 and t_4 – Quaternary fluvio glacial sediments (terraces); K_2^3 – Upper Cretaceous limestone and dolomites; K_2^2 – Upper Cretaceous limestone and dolomites; $K_{1,2}$ – Unclassified Lower and Upper Cretaceous limestone and dolomites; $J_{2,3}$ – Unclassified Mid and Upper Jurassic dolomites and limestone)

¹ Source: Basic Geological Map – OGK list Titograd, 1:100 000, Federal Geological Survey, Belgrade, 1973;
Authors: Živaljević Milorad, Đokić Vukota, Pajović Marko

Figure 7: Geological map of the project area

A report on geotechnical investigations carried out at the site of the WWTP is provided for information with the present Bidding Documents in Volume 3, Section VII, Part 3. Supplementary Information.

B.2.8. Hydrology

The hydrology of the site is characterised by the River Moraca which flows through Podgorica and discharges into the Skadar Lake. The Moraca River basin has a total area of 3.200 km². The Moraca River has an average flow at the site of the WWTP of approx. 150 m³/s with an absolute peak flow over the period 1948 – 2019 of 1.900 m³/s and an absolute minimum flow of 9,3 m³/s.

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Detailed data on the water level of Moraca River at Site are provided for the purpose of the design of the Small Hydro-Power Plant with this Bidding Documents.

The maximum water level of Moraca River at the site of the WWTP is 21,4 m. The site of the WWTP is therefore not prone to risks of flooding.

B.2.9. Hydrogeology

Data of the wells from the KAP aluminium Factory located close to the Site indicate a groundwater level at a depth of (see Section B.13.2.1.1) approx. 13 mbgl.

It is not expected that construction works of the WWTP will have to be carried out in the groundwater.

B.2.10. Soil Contamination

Two surveys of the potential contamination of the Site for the construction of the WWTP through the activity of the neighbouring KAP aluminium factory have been carried out in 2017 and 2019. Detailed results of these surveys are provided with the present Bidding documents Volume 3, Section VII, Part 3. Supplementary Information. Relevant results are summarised below.

B.2.10.1. Soil Contamination Assessment

Soil investigations carried out in 2017 and 2019 indicate the following:

- In the north and eastern parts of the considered plot for the construction of the WWTP, critical values were observed with regard to: Polycyclic Aromatic Hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPHs) and Fluoride. Polychlorinated Biphenyls (PCBs) were not found ;
- The increased concentrations of the above indicated components were mainly observed in the superficial layers of the underground. Only hydrocarbons exhibited increased values also in deeper soil layers;
- Relevant fluoride concentrations were observed throughout the site with a maximum in the eastern part, where, close to the surface, threshold values for the evaluation of the effect on the soil-human path for industrial areas were partially exceeded;
- In the groundwater the slightly increased fluoride indicates an influence of the surface. Apart from that, the groundwater is not influenced by the pollutants measured on the surface.

It is assumed that the detected contaminations are mainly due to the influence of the adjacent industrial plant (KAP Aluminium factory), either through atmospheric deposition or by direct deposit.

In general, the selected site for the new WWTP is however considered as suitable for the construction of the WWTP. As a result of the identified soil contaminations a shift of the

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construction area towards the south, out of the contaminated area, was proposed to minimize possible interference on the construction works.

The potentially contaminated – and therefore non-constructible - area is indicated on the Drawing provided in Volume 3, Section VII, Part 2.

B.2.10.2. Preparatory Works

The construction Site of the wastewater treatment plant has been used previously by the KAP aluminium factory for disposal of residues – mainly slag from the aluminium melting process – and waste from the factory. After depositing of waste, the land has been levelled so that waste and residues are spread on larger areas. The disposed material contains hazardous residues and waste, notably asbestos and cinder with high concentrations of fluorine, but also chromium, nickel and Polycyclic Aromatic Hydrocarbons (PAHs).

Before the start of any construction activity, the entire construction site shall be cleaned from all superficial solid waste. The waste collected should be disposed of in coordination with the local authorities and in accordance to the local legislation, e.g. to the municipal landfill. The amount of waste generated is roughly estimated at approx. 100 m³, thereof approx. 5 m³ asbestos cement, slags from melts etc. Above figures are however only an estimate. It is the Contractor's responsibility to make his own investigations on the site before he submits his offer.

B.2.10.3. Excavation and Evacuation of Surplus Material

To avoid issues of disposal and/or treatment of contaminated excavation material, no construction activities shall be carried out in the potentially contaminated area as indicated in the Drawing in Volume 3, Section VII, Part 2 and this area shall be excluded from the available area for the construction of the WWTP.

Sampling and soil analysis carried out on the remaining part of the land dedicated for the construction of the WWTP did not indicate critical concentrations for the analysed pollutants. However, unusually high concentrations of Total Chromium, Nickel, Fluoride and total Polycyclic Aromatic Hydrocarbons (PAHs) are measured in all surface layers for most of the samples and high concentrations of Fluoride and PAHs in deeper layers. The existence of locally contaminated areas with concentrations of pollutants exceeding thresholds value for safe reuse or disposal of the excavated soil cannot be ruled out.

In addition to being potentially contaminated with hazardous substances (see Section B.2.10.1), the geotechnical survey indicates that the upper layer of the existing soil is not suitable for foundation of civil works structures. The topsoil, has to be removed for building the plant. The removed topsoil should remain on the site.

For the above indicated reasons, it is recommended to conform to the following recommendations regarding excavation and earth-moving works:

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- At the location of construction works, the upper layer of the existing soil shall be removed and stored on the site to be reused as landscaping material after completion of the civil works. The amount of topsoil generated during excavation is estimated at approx. 3.500 m³. This amount of topsoil cannot simply be distributed over a large area, but should be installed in defined earthworks;
- Surplus excavated material for the construction of civil structures shall be stored on the site and – as much as possible - reused after construction as filling material and material for levelling and embankment of constructed structures. Export of excavated material outside of the construction site shall be as much as possible avoided;
- In case export of surplus material cannot be avoided, the quality of the material shall be controlled before its transportation to the final disposal / reuse site especially with regard to concentrations of Total Chromium, Nickel, Fluoride and total Polycyclic Aromatic Hydrocarbons (PAHs) and Total Petroleum Hydrocarbons (TPHs).

The deeper gravel-sand subsoil is unlikely to have any particular contamination. However, it is expected that, due to the increased content of fluoride, it does probably not comply with the requirements of the Rulebook on the permitted amount of hazardous and harmful substances in the soil and the methods for its examination ("Official Gazette of the Republic of Montenegro", No. 18/97) for disposal on agricultural land. For this reason, recycling on agricultural land shall not be considered.

B.2.11. Existing Infrastructure and Utilities

Following infrastructure exist on the Site as indicated in the Drawing in Volume 3, Section VII, Part 2:

- An overhead 35 kV power supply line crossing the site in the South-North direction;
- A well house built by the KAP aluminium factory for the water supply of the factory including the underground connection pipe in the northern corner of the Site;
- A pressure pipeline from the KAP aluminium factory raw water pumping station at the bank of Moraca River to the factory, crossing the site in the northern part.

The overhead power line shall be relocated in order to not interfere with the construction works of the WWTP, inside of the Site along the municipal road from Dajbabe to Botun. A 10 m strip shall be reserved for that purpose as indicated in the Drawing.

The relocation of the overhead power supply line is out of the scope of the Contractor and will be carried out by the Employer.

The existing well and raw water pipeline are located within the contaminated and non-constructible area and shall therefore not interfere with the construction of the WWTP.

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B.2.12. Interfaces and Limits of Supply

B.2.12.1. Wastewater

Wastewater collected in the municipal sewerage system will be transported to the Site of the new WWTP with an approx. 5 km long main collector to be constructed in the scope of the project from the site of the existing WWTP to the new WWTP. This main collector will be a DN 1.200 and DN 1.300 mm gravity sewer made of GRP pipes.

The DN 1.300 pipe of the main sewer shall be connected to the inlet works of the WWTP.

The construction of the transfer collector is out of the scope of the present contract. Bidders shall consider the terminal point of the main collector at the Site of the WWTP as indicated on the Drawing, as the starting point of Works to be carried out in the scope of this project.

B.2.12.2. Treated Effluent Disposal

Treated effluent from the WWTP will be discharged to the Moraca River.

At the outlet of the discharge pipe a small hydro-power plant shall be installed to benefit from the more than 10 m fall height, to produce electrical power for the operation of the plant.

The construction of the discharge pipe and of the small hydro-power plant shall be included in the scope of works of the present contract. The attention of the Bidders is drawn on the fact that untreated or only partly treated wastewater discharged at the general by-pass at the inlet of the WWTP, downstream of the mechanical pre-treatment (grit and grease removal) or downstream of the preliminary sedimentation, shall not be transferred to the hydro-power plant. For this reason, a separate discharge pipe is required for the above indicated by-passed effluents.

B.2.12.3. Access Road

Access to the wastewater treatment plant will be provided from the municipal road from Dajbabe to Botun which runs along the site of the WWTP.

B.2.12.4. Power Supply

The WWTP will be connected to the local public electrical network with two independent 10 kV feeders in order to ensure the safe operation of the plant:

- one 10 kV power supply line from the CEDIS transformer station Podgorica 5, located close to ViK Headquarters at a distance of approx. 8 km from the WWTP site;
- one 10 kV power supply line from the CEDIS transformer station Gornja Zeta south of the WWTP site at a distance of approx. 2 km.

The installation of the main power supply cable from the grid-substations up to the boundary of the WWTP is out of the scope of the present project.

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B.2.12.5. Drinking Water Supply

Drinking water will be supplied to the wastewater treatment plant, from the public water supply system managed by ViK Podgorica. A new connection will be installed on the DN 160 mm main distribution pipe installed in the public road from Dajbabe to Botun, passing along the plant. According to information received from ViK Podgorica, the maximum flow which can be supplied from this pipe is 5 l/s.

Bidders are requested to consider the above indicated maximum flow in the design of the plant and, if required, to consider any necessary measures to overcome exceedance of the available maximum flow (e.g. intermediate storage, water tower, etc...).

The use of drinking water supply shall be restricted to the supply of the administration building (kitchen, laboratory and sanitary facilities) and to the supply of other sanitary facilities installed elsewhere within the plant.

Process water shall be provided from a production well to be constructed within the area of the plant as indicated in Section B.13.2. Bidders may propose in addition the reuse of treated effluents where appropriate.

B.2.12.6. Telecommunication

The plant shall be connected to the telecommunication network for telephone and internet, through a fibre optic connection.

B.2.13. General Provision

It is considered that Bidders will visit the Site in order to investigate the existing conditions of the Site and to establish the precise location of terminal points and verify limits of supply and feasibility. No additional costs will be accepted after order placement, should the Contractor consider relocation of any terminal and supply point is desirable and / or necessary for whatever reason.

Any terminal point which is not specified / included in the Specifications but required for safe and reliable operation of the systems shall be deemed to be included in the scope of work and the Contractor shall carry out such terminal connection works at no extra cost to the Employer.

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B.3. DESIGN PARAMETERS

B.3.1. General

In case of discrepancies, performance requirements as defined in this Section B.3 of the Employer's Requirements, shall have precedence over design criteria mentioned elsewhere.

B.3.2. Design Horizon and Phased Implementation

The wastewater treatment plant and all its components shall be designed for the required treatment capacity at the design horizon 2045 as indicated in Table 1 below. A staged implementation is not foreseen.

Reservation shall however be made in the design of the plant for an extension of the activated sludge tank capacity by 33 % (fourth treatment line equivalent to the three initial treatment lines).

It is planned that the plant will be commissioned with only two out of the three activated sludge tanks being operated. The third aeration tank shall be put into service at a later stage according to the needs with regard to the increase of the pollution load received at the WWTP.

B.3.3. Wastewater Flow, Pollution Load and Concentration

Wastewater flows, pollution loads and influent concentrations to be considered in the design of the WWTP are indicated in the following table for the design horizons 2023 (anticipated commissioning of the plant) and 2045 (design horizon of the plant).

Table 1: Wastewater Treatment Plant Design Parameters

Parameter	Unit	2023			2045	
		Average	Max	Peak	Average	Max
Nominal capacity	PE₆₀	137.900	138.900	177.500	228.600	229.600
Hydraulic loads						
Dry weather flow	m ³ /d	36.600	37.000	37.000	48.900	49.300
Dry weather peak flow	m ³ /h	2.250	2.280	2.280	3.090	3.120
Wet weather wastewater flow	m ³ /d	52.400	52.800	52.800	60.600	61.000
Wet weather peak flow	m ³ /h	5.100	5.100	5.100	5.400	5.400
Pollution load						
Biochemical Oxygen Demand (BOD ₅)	kg/d	8.274	8.331	10.649	13.717	13.775
Chemical Oxygen Demand (COD)	kg/d	16.699	16.891	20.456	27.515	27.707
Suspended Solids (SS)	kg/d	9.780	9.837	10.755	16.080	16.138
Total Nitrogen (TN)	kg/d	1.368	1.371	1.403	2.199	2.202
Total Phosphorous (TP)	kg/d	228	229	235	376	376

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Parameter	Unit	2023			2045	
		Average	Max	Peak	Average	Max
Concentrations (dry weather daily average)						
Biochemical Oxygen Demand (BOD ₅)	mg/l	226	225	288	280	279
Chemical Oxygen Demand (COD)	mg/l	457	457	554	562	562
Suspended Solids (SS)	mg/l	267	266	291	329	327
Total Nitrogen (TN)	mg/l	37	37	38	45	45
Total Phosphorous (TP)	mg/l	6,2	6,2	6,4	7,7	7,6
Wastewater temperature						
Minimum temperature	° C	12			12	
Maximum temperature	° C	20			20	

The wastewater treatment plant, sewage sludge treatment plant, sewage sludge incineration plant and all ancillary facilities shall have the capacity to receive, convey and adequately treat the influent having the characteristics indicated in the following Table A for the **maximum values in the design horizon 2045**.

Testing of the plant shall be carried out with two of three aeration tanks in operation (two third of total capacity) and an influent having the characteristics indicated in the following Table A for the **maximum values in the design horizon 2023** (planned year of commissioning).

The plant shall furthermore be designed and built to accept temporary peak loads due to the discharge of untreated effluents from 13.-jul Plantaže winery. The Contractor guarantees that the plant can accept, convey and adequately treat the effluent having the characteristics indicated in the following Table A for the **peak values in the design horizon 2023 with such peak load discharges occurring in the period between 1st of August and 31st of October**.

B.3.4. Effluent Standards and Treatment Efficiencies

The quality of the treated effluent shall comply with the following Table 2 and shall be in entire compliance with the requirements of:

- The Rulebook Quality and sanitary technical Conditions for Wastewater Disposal, the Method and Procedure of Wastewater Quality Testing and the Content of the Wastewater Quality Report (Off Gazette of MNE No. 56/19);
- the EU Directive 91/271/EEC concerning urban wastewater treatment.

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Table 2: Guaranteed effluent parameters

Parameters	Abbreviation	Unit	Effluent requirement	Removal efficiency [%]
Biochemical Oxygen Demand	C _{BOD,e}	mg/l	≤ 25	> 70
Chemical Oxygen Demand	C _{COD,e}	mg/l	≤ 125	> 75
Total Suspended Solids	C _{SS,e}	mg/l	≤ 10 ⁽¹⁾	> 90
Total Nitrogen	C _{TN,e}	mg/l	≤ 10	> 70
Total Phosphorus	C _{TP,e}	mg/l	≤ 1	> 80
Faecal Coliform ⁽²⁾	C _{FC}	CFU/100 ml	≤ 100	n/a
Total Coliform ⁽²⁾	C _{TC}	CFU/100 ml	≤ 500	n/a
Faecal Streptococci ⁽²⁾	C _{FS}	CFU/100 m	≤ 50	n/a

⁽¹⁾ The requirement according to the Montenegrin and EU legislation is 35 mg/l. However a maximum concentration of 10 mg/l is required for the adequate and efficient operation of the UV disinfection.

⁽²⁾ To be complied with on minimum 75 % of the samples.

B.3.5. Standards on Qualities of Treatment Residues and By-Products

Treatment residues and by-products produced at the WWTP shall comply with the requirements indicated in the following table.

Table 3: Requirements on the quality of residues and by-products

No	Parameter	Performance indicator	Unit	Requirement
1.	Screenings	Washed and compacted	--	--
2.		Dry solids content	% DS	≥ 30
3.		Reduction of compacted screenings by volume	%	≥ 60
4.	Grit removal efficiency	Separation efficiency for diameter 0,25 mm	%	≥ 95
5.	Grit	Washed and classified	--	--
6.		Dry solid content	% DS	≥ 90
7.		Organic matter content	% ODS	≤ 3
8.	Sludge dewatering	Dry solid content of dewatered digested sludge	% DS	≥ 25

DS = dry solids in % of weight

ODS = organic dry solids (volatile solids) in % of weight

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B.4. DESIGN AND PROCESS REQUIREMENTS

B.4.1. General

Process design requirements indicated in the following sections are based on the Conceptual Design approved by the Employer and the design parameters indicated in Section B.3. The Conceptual Design is attached to the present bidding documents and is provided for information and guidance only.

Fulfilment of the specified design criteria indicated in the following sections of the present Process Requirements is a precondition for acceptance of the Bidder's Technical Proposal for the base solution.

B.4.2. Design Concept

The whole of the Plant shall be designed and constructed to the best standard. A manufacturer's standard design may be used for a plant item where such a design is available and where it is at least equal to and compatible with that required by the Specifications.

The Plant and all installed equipment and components shall be new, of sound workmanship and robust design, and of a grade and quality suitable for the duty concerned and for the conditions at the place of installation.

All treatment facilities have to be designed to facilitate operation, inspection, cleaning, maintenance and repair and in accordance to a modular concept allowing for a maximum flexibility and reliability.

The minimum number of units has to be based on the consideration of taking any of the parallel process lines, tanks, reactors, etc, out of operation, one at a time, for maintenance and still maintain the operation of the treatment facility. A reliable Plant is to be achieved using spare capacity, spare equipment, by-pass possibilities etc. so that the Plant can still work satisfactorily when one component or facility is out of operation for reason of maintenance or malfunction.

The design of the facilities shall be state of the art, adapted to local conditions and such as to facilitate operation, inspection and maintenance of all processes and equipment. All mechanical and electrical equipment to be supplied shall, wherever possible, have a proven reliability record in similar works.

Bidders shall describe how problems caused by breakdowns and servicing will be minimized by the inclusion of stand-by equipment, spare capacity, by-pass possibilities etc.

Operability, maintenance and safety shall be taken into account by the incorporation of following requirements in the design of all parts of the plant:

- Easy access;

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- Provision of adequate equipment lifting devices;
- Separate storage facilities for chemicals;
- Sufficient lighting to all operating areas;
- Ventilation of all covered operating areas for odour control;
- Protection against the entry of vermin and dust;
- Protection against pollution, noise and nuisances of any kind;
- Provision of machinery guards;
- Proper electrical insulation facilities;
- Minimise fire risk and consequential fire damage;
- Noise and vibration suppression and insulation;
- Stairs, handrails, covers etc.;
- Best international health and safety practices and procedures, local Health and Safety Regulations must be fulfilled at a minimum.

B.4.3. Design Lifetime

All materials and equipment shall be designed for long life and continuous operation during prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service records of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel. The materials of construction of the Plant shall be selected, taking into consideration their location and duty, such that the economic life of the Plant is not less than 25 years. Except for consumable items such as gland packing, carbon brushes etc. which normally require more frequent replacement, no part subject to wear shall have a life from new to replacement or repair of less than three years of continual operation. Where major dismantling is required to replace a part, such life shall be not less than five years.

Civil engineering and building works are to be designed based on a minimum 50-year service life period. Mechanical and electrical installations shall be suitable for continuous operation 24 hours per day, as well as for intermittent operation, under all local climatic conditions and under the prevalent conditions at the place of installation and be designed such that complete replacement shall not be required until at least 15 years after the issue of the Taking-Over-Certificate.

The minimum service lifetime for the various components shall be as indicated in the following table.

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Table 4: Minimum service lifetime of WWTP components

Technical part	Service period
Civil works (facilities and buildings)	50 years
Sewerage networks	50 years
Drinking water networks	50 years
Process equipment	20 years
Mechanical equipment	15 years
Transformers	30 years
Switch gears	15 years
Control systems	15 years

The Design of the facilities shall be in accordance with best modern European practice and applicable local design standards, and shall be such as to facilitate construction, operation, inspection and maintenance of all processes and equipment. All mechanical and electrical equipment to be supplied shall, wherever possible, have a proven reliability record in similar works.

B.4.4. Warranty for Materials and Equipment incorporated in the Works

Over and above the Design Life specified for the Plant, a written warranty shall be provided by the manufacturers of the materials and equipment listed below. The warranty shall include appropriate dimensioning of components, correct choice of materials (including auxiliary materials like ancillary materials of welding, rust preventing coats) and workmanlike installation for the periods shown.

Table 5: Minimum warranty period for materials and equipment

Component	Warranty period
Machine units, machines and fittings	2 years
Pipelines and steelworks	5 years
Civil works like reservoirs, chambers, etc.	5 years
Electric equipment	2 years
Instruments and control equipment	2 years

The warranty period shall commence after the issue of the Taking-Over Certificate.

B.4.5. Redundancy Concept

The Facilities shall be designed with a high grade of flexibility and reliability of the different parts. Therefore all items controlling the process (main equipment, power supply and distribution systems, control panels and centres, data processing systems, etc) shall be designed with a sufficiently high degree of redundancy (by means of installed spare capacity and/or spare units of equipment), enabling to overcome without problems and without resulting in a failure to satisfy the Technical Specifications and guaranteed performances, all normal

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maintenance situations and local calamities due to temporary malfunctioning (or non-functioning) of main mechanical and electrical equipment and civil constructions.

All relevant process components shall in general be designed with a sufficiently high degree of redundancy to ensure uninterrupted and continuous plant operation in case of failure or when one item has to be taken out of operation.

B.4.5.1. Equipment Redundancy Concept

In order to achieve the above condition, the following general rule for standby equipment shall be considered in the design:

- ≤ 3 units in operation: 1 standby unit (n+1)
- > 3 units in operation: 2 standby units (n+2)

For units with different capacities the standby unit(s) are sized to match the unit(s) with the greatest capacity.

In cases where the installation of standby units is not possible (e.g. mixers in activated sludge or in anaerobic reactors), a sufficient number of not installed spare units shall be kept in storage for vital equipment components in order that, in principle, the process or the hydraulic flow shall not suffer disruptions.

B.4.5.2. Hydraulic Redundancy Concept WWTP

The treatment units are designed in such a way that the maximum flow $Q_{WW,p}$ shall pass through the plant with n-1 units in operation, yet with reduced treatment efficiency. For separation of the individual treatment units each unit shall be equipped with motor-driven penstocks at the inlet and the outlet.

The minimum number of treatment lines required for the main wastewater treatment steps and units are indicated in the Table 6 below.

Table 6: Numbers of units in duty under normal operation conditions and numbers required under emergency conditions for wastewater treatment

Numbers	Installed	Required for Operation			
		Normal		Emergency	
Unit	Total	Duty	Standby	QDW,p	QWW,p
Coarse screens	4	3	1	2	3
Dry weather inlet pumps	6	4	2	4	3
Wet weather inlet pumps	2	1	1	0	1
Fine screens	4	3	1	2	3
Grit and grease removal	2	2	0	1	2
Primary settlement tanks	2	2	0	1	1
Biological treatment	3	3	0	2	2

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Numbers	Installed	Required for Operation			
		Normal		Emergency	
Unit	Total	Duty	Standby	QDW,p	QWW,p
Final settlement tanks	4	4	0	3	4
Return sludge pumps	4	3	1	2	2
Disc filters	4	3	1	3	bypass
UV disinfection	2	2	0	1	bypass

All treatment lines / units are designed identically in terms of size and capacity.

For an accurate flow distribution on individual wastewater treatment lines/units, distribution chambers with adjustable weir penstocks upstream of the inlet of primary settlement tanks, aeration tanks, final sedimentation tanks and polishing filters are foreseen. In order to achieve a high operation flexibility the effluent of the individual treatment lines/units shall be combined downstream of the screening facility, the grit and grease traps, the primary settlement tanks, the aeration tanks, the final sedimentation tanks and the polishing filters.

B.4.5.3. Hydraulic Redundancy Concept SSTP

The treatment units are designed in such a way that the sludge generated under design load conditions can be treated in the plant with n-1 units in operation, except the digesters. It shall furthermore be possible for each treatment unit to be taken out of operation and emptied individually.

The number of treatment lines / units for the main sludge treatment steps and units are indicated in Table 7 below.

Table 7: Units in duty under normal operation conditions and quantity required under emergency conditions for sludge processing

Number	Installed	Required for Operation			
		Normal		Emergency	
Type of Unit	Total	Duty	Standby	QDW,p	QWW,p
Centrifuges for primary sludge thickening	2	1	1	1	1
Centrifuges for excess sludge thickening	2	1	1	1	1
Centrifuges for sludge dewatering	2	1	1	1	1
Supernatant pumps	2	1	1	1	1
Digesters	2	2	0	1	1
CHP units	2	2	0	1	1

Each of the standby units are dimensioned identical in terms of size and capacity.

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B.4.6. Selection and Standardisation of Material and Equipment

Continuity of operation, availability, lowest maintenance requirements and continuity of supply shall be of a prime concern in the selection of material and equipment.

All similar items of the Plant and their components together with spare parts, as well as all equipment performing similar functions, shall be made of the same type and manufacture and shall be fully interchangeable to limit the stock of spare parts required and to maintain uniformity of plant and equipment. The standards of workmanship and finish shall be uniform throughout and the final colours shall be designated by the Engineer.

The Employer reserves the right to advise the Contractor of preferred type and manufacture to secure the above-mentioned requirements.

B.4.7. Operation of the Facility

It is envisaged that the WWTP and the SSTEP will be manned five days per week, with two eight hours shifts per day, i.e. sixteen hours per day. The SSIP shall be manned full time with operation staff during the period in which the plant is operated, in accordance with the operational concept, to cope with the increased load of the plant (tentatively 5 days per week at commissioning of the plant up to 7 days per week a full load).

Outside of the above indicated periods, where no operational staff will be on the site, on-call service will be organised.

The WWTP and SSTEP shall be designed, especially with regard to instrumentation, control and supervision for full continuous automatic operation (without any need for manual operation) over a period of up to two days (night and week-ends).

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B.5. GENERAL DESIGN REQUIREMENTS

B.5.1. General

The Design of the plant shall fully comply with the General and Particular Technical Specifications (Employer's Requirements) which shall be understood as minimum requirements.

The proposed technology shall comply with the Specifications. Bidders shall submit a technical and financial proposal for the Employer's selected base solution indicated in the present Part B. Bidders may submit an alternative technical solution to the base solution indicating:

- Derogations made to the base solution in the alternative solution;
- Advantages provided by the proposed alternative solution.

The proposed technology shall in any case be well proven and have operating references with similar size, load and conditions.

Bidders shall in any case submit with the Bid any necessary design and process calculation and other data substantiating that the proposed solution meets the minimum Technical Requirements.

The WWTP and SSTP process design prepared by the Contractor shall be in accordance with the German Design Regulations DWA-ATV-A131 or equivalent European / International standard.

B.5.2. Principle Design Objectives

The following fundamental objectives, minimum requirements and constraints shall be generally considered in the process design of the new Podgorica WWTP:

- High operation safety and high system stability of the wastewater and sludge treatment and incineration process with regard on the required effluent standards;
- Ease of operation in order to allow the WWTP to be operated by a reasonably experienced personnel and to minimize personnel requirements;
- High flexibility of the treatment process in order to easily allow plant operation to be very well adjusted to variations in the quality and quantity of the influent (high concentrations and diurnal peaks for short periods of time) of the WWTP and to allow to reasonably keep up with the effects of unexpected industrial wastewater discharges;
- Reduction of residues in order to minimize disposal expenditures;
- Minimization of system capital costs;
- Minimization of system operation and maintenance costs, including minimization of the required primary energy.

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B.5.3. Wastewater Treatment Plant Layout

The Contractor shall design the WWTP to fit within the boundary of the available site for the construction of the WWTP. The Contractor is free to propose the design of the plant he considers the most adequate in compliance with the requirements set out in the Employer's requirements. Following requirements shall be considered for the layout of the WWTP:

- Elevated buildings and facilities (e.g. sludge incineration plant, sludge digesters, etc.) shall be located close to the KAP factory (south-eastern boundary of the site);
- The administration building and the work-shop shall be located as much as possible distant from treatment steps with a risk of emission of odours (inlet works, mechanical pre-treatment, sludge treatment, especially digesters);
- The administration building and the work-shop shall be located as much as possible distant from treatment steps with a risk of noise, especially from the aeration tank blowers building;
- The direction of prevailing winds shall be considered in preparing the site layout;
- Accessibility to all buildings and facilities shall be provided by all-weather roads and footpaths.

The WWTP shall be designed and constructed so that individual elements of the WWTP such as tanks, chambers, grit channels etc. can be isolated from the flows without affecting the overall operation of the works. Furthermore, the WWTP shall be designed for maximum flexibility of operation that will allow it to operate as two or more streams so that one stream can be taken out of operation without affecting the operation of the second (and other) stream. The Contractor shall provide appropriate interconnection between the different treatment lines (there should not be two separate, distinct and not interconnected treatment lines).

B.5.4. Requirements for Operation Stability and Reliability

The whole Plant shall be designed for maximum operation stability, reliability and flexibility at lowest operation / maintenance and capital costs considering at least the following requirements:

- Provision of alarm systems indicating at an early stage not predictable situations and conditions like inflow of substances into the WWTP susceptible of disturbing or inhibiting the treatment process;
- Provisions to manage particular operation conditions like start-up, regular shut-down, emergency shut-down, operation with reduced number of process units, etc. without any deterioration of the effluent quality;
- Provisions to manage normally expectable particular operation conditions like capacity under- and overloading and shock load (in-flowing wastewater, sludge waters etc.), without any deterioration of the effluent quality;
- Provisions to manage normally expectable failures in operation like bulking sludge, foaming, etc. for any process unit, without any deterioration of the effluent quality;

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- Provision of by-passes of all principal process units so that each process unit can be put out of operation without stopping the whole treatment process;
- Provision of fix piped installation of spare pumps, machines, aggregates, easily to put into operation;
- Provision of connection points sufficient in number and capacity for easy installation of additional and spare pumps, machines, aggregates;
- Provision of not fix installed spare pumps, machines, aggregates in sufficient number and easily to install where fix installation is economically not feasible;
- Simplification and unification of makes and types to allow for utmost interchangeability of pumps, machines, and aggregates and to ease preventive maintenance;
- Free adjustable and wide range of controlled variables to cover all possible operation conditions;
- Emergency power supply of the plant.

B.5.5. Hydraulic Design

The hydraulics of the whole Plant shall be designed considering at least the following requirements:

- Hydraulic structures, interconnections, distribution shafts, etc., and treatment units shall be designed and constructed for the peak hydraulic load for the design horizon 2045;
- Hydraulic losses shall be kept as low as possible;
- The “n-1” rule for two or more tanks of a treatment stage: the hydraulic capacity of any weir, collection trough, pipe, channel, chamber, tank shall be sufficient for the maximum flow increased by the factor $n/(n-1)$, whereas n = number of tanks;
- Distribution chambers shall be sized and constructed to permit future units to be easily connected;
- Arrangement of any weir, collection trough, pipe, channel, chamber, tank in that way that later extension is possible without any major alterations;
- Sufficient hydraulic uncoupling that shall be accomplished by free overflows. Free overflow is defined herein as the case that the energy level of the tail water is lower or equal than the weir crest level;
- Sufficient freeboard of channels and basins is set to minimum 0,7 m;
- The minimum and maximum flow speeds according to international standards are not fallen short off respectively exceeded in channels and pipes;
- Pressure pipe bends points shall have a minimum radius of $1,5 \times$ pipe diameter. Changes in direction of gravity pipe bends have to be executed with manholes. Then the minimum radius to the centre line of the chute shall be $2,0 \times$ pipe diameter. Benches shall be built up the top of the pipe;

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- Pipes subject to clogging (sludge, polymer, lime pipes, etc.) shall be provided with flush valves in sufficient number and diameter;
- All channels shall be designed to avoid creation of pockets and corners;
- Suitable gates of non-corrodible materials shall be used to seal off unused sections;
- Incoming sewers shall be designed for unrestricted flow;
- Plant components shall be arranged for greatest operating and maintenance convenience, flexibility, economy, continuity of maximum effluent quality, and ease of installation of future units.

B.5.6. Requirements for Access for Operation and Maintenance

The Contractor shall supply and erect sufficiently large safe platforms, galleries, stairways and access ways necessary for providing safe and easy access to all the plant items for operation and maintenance. The Contractor shall ensure that the whole of the access ways is of uniform design and pattern throughout the works.

The design of all stairways, access ways, etc. shall conform to the requirements of the relevant international and local norms and standards.

To guarantee access to all mechanical and electrical parts of the whole plant for cleaning, maintenance and repair, the following requirements shall be fulfilled as a minimum:

- Space between the process different units (tanks, chambers, channels, pipe, machines, aggregates etc.) shall be big enough to guarantee acceptable accessibility for the working personnel to facilitate inspection, cleaning and repairs, especially when working with lifting units;
- All submersible aggregates (pumps, mixers, aeration grits) as well as screens and blowers shall be provided with sufficient lifting devices for operation and maintenance; Between the main units (e.g. blowers, pumps) a minimum gangway width of 0,80 m shall be provided;
- For heavy engines and for all mechanical and electrical parts (> 25 kg) where practical, appropriate lifting units such as cranes or crabs, assembling aids, etc., shall be provided. For lighter units, mobile lifting units shall be provided.
- Assembly orifices holes and access facilities such as doors and gates shall be provided. Access to assembly orifices holes over consolidated ways or lifting facilities must be guaranteed;
- All covers such as gratings for channels or assembly orifices holes shall be provided / designed with antiskid surface and constructed in such way that they can be opened by one person only, without danger;
- All railings and security installations shall be so arranged in that way that they can be removed easily and quickly in the case of assembly, disassembly, maintenance or repair of mechanical or electrical units;

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- Handrailings shall have a worksafe height of 1,1 m, access bridges and stairs shall have a minimum clear width of 0,8 m;
- All tanks and reservoirs, etc., shall be provided with platforms and gangways, duckboards if they are not readily accessible; Access to platforms and gangways shall be simple (without vertical ladders, for instance);
- All tanks and chambers shall be designed in a way so that easy emptying is possible, either by providing a washout for each tank or a pump sump;
- The arrangement of the individual pieces of apparatus, pipelines and operational monitoring device must be such that the operation of the installation can be carried out unhindered and that any necessary repairs, which may arise, can be carried out without difficulty and without hindering the running of the other parts. Special care must be taken that the control systems and monitoring instruments are arranged so as to be easily visible;
- Accessible means shall be provided for the easy lubrication of all bearings, mechanisms and moving parts. Grease lubricating points shall be fitted with hexagon nipples.

B.5.7. General Structural Design

The Contractor shall carry out and document the structural design for all structures included in the Works according to the scope of works mentioned in the Tender Documents, in general in accordance with the following design criteria:

- Reinforced concrete structures and water retaining structures shall be designed in accordance with Eurocode and applicable local regulations;
- Structures should be capable of withstanding external lateral soil pressure when empty. For design purposes it should be assumed that the ground water level is at the final ground level when calculating the safety against uplift;
- Structures should be capable of withstanding internal water pressure when filled with water to maximum design water level and assuming no lateral external support from soil and/or groundwater;
- All structures in which the water levels can drop suddenly (even if the operators make a mistake) shall be secured against uplift by their own weights together with the surrounding soil. Where needed tension piles have to be applied;
- Securing against uplift by permanent or occasionally ground water drawdown is not allowed; In this context installation of anti-flood valves in tank slabs and walls is also not allowed;
- The safety factor against uplift should meet the following requirements when calculated:
 - The safety factor shall be at least 1,05 when the weight of the concrete together with the weight of soil on bottom slabs (calculated vertical upwards from the edges of the slabs-without any friction in the soil) only is taken into consideration;

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- The safety factor shall be at least 1,2 when allowing friction in the soil to be taken into account;
- The safety factor shall be 1,5 for pipes when soil coverage or anchorage in subsoil is taken into consideration;
- The maximum allowed crack width is 0,2 mm in the service ability limit state (structures filled with water to normal working minimum design water level and with soil back-filled if any. The ground water level and the pressure from the surrounding soil should in this state be stipulated with low values);
- Even though the crack widths normally are calculated in the serviceability limit state only, the maximum allowed crack width is 0,3 mm in a state where structures either are filled with water without any surrounding soil or structures are empty only taking the full pressure from the soil and ground water;
- The partial safety factor $[\gamma_f]$ for water pressure shall be 1,0 and for earth pressure 1,4 in this state. Where the external restraint factor R is greater than zero, a minimum amount of reinforcement for reduction of crack widths shall be placed;
- The minimum concrete coverage of the reinforcement of new water retaining structures shall be 5 cm for the permanently wet surface and 3 cm for the permanently dry surface of concrete walls;
- In order to incorporate the effects from thermal action, shrinkage and creep, the Contractor should make the construction joints in accordance with the approved drawings. No other joints will be allowed. The Contractor shall make his structural documentation in accordance with his layout.

The Contractor may adopt alternative design codes of practice subject to the approval of the Engineer.

B.5.8. General Electrical, Electromechanical and Mechanical Design

All materials used shall be of the best quality of the class most suitable for working under the conditions specified and shall withstand the variation of temperature and climatic conditions arising under working conditions without distortion or deterioration or the setting up of undue stresses in any part, and without affecting the strength and suitability of the various parts for the work which they have to perform.

All mechanical and electrical equipment shall be thus designed considering:

- Provision of machinery, electrical systems, and instrumentation according to the principles “simplicity” and “reliability” with long trouble-free service with low maintenance needs;
- All apparatus shall be designed to ensure satisfactory operation under the climatic conditions prevailing at the Site, and under such sudden variations of loads, pressures, and/or voltage, temperatures as may be encountered under normal working conditions;

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- All electrical equipment shall be of adequate strength to withstand the stresses and forces imposed by the working and ambient conditions without distortion or deterioration affecting the efficiency and reliability of the plant;
- Electrical equipment shall be completely satisfactory for use with the mechanical equipment chosen;
- Each component or assembly shall have been proven in service in a similar application and under conditions no less arduous than those specified herein;
- Outdoor equipment shall be weatherproof and designed to prevent the collection of water at any point;
- Corresponding parts requiring replacement shall be interchangeable in order to limit the stock of spare and wear parts required;

All works to be carried out under this Contract shall take special attention on the local conditions, i.e. climatic, economic and cultural conditions, etc.

B.5.9. Buildings Generally

Buildings shall fit for purpose and comply with local building standards and requirements. Buildings are to be provided where included in the conceptual design. Finishes and other room details are given on the following table.

Table 8: Finishing requirements for buildings

Building Type	Plant Room	Offices
Roofs	Aluminium sheeting	Tiles
Floors	Floated concrete	Tiled
Walls	Fair-faced block work painted	Plastered and painted.
Ceilings	Plastered and painted	Plastered
Doors	Hardwood oiled, aluminium or steel	Hardwood painted or aluminium
Windows	Aluminium or steel	UPVC or aluminium double glazed
Small power points	1 per 15 m ²	1 outlet per 5 m ²
Telephone point	1 No.	1 per 10 m ²

Windows opening and sizing shall provide adequate natural light levels during daylight hours in all rooms of the plant and adequate cross ventilation.

Ventilation shall comply with following requirements:

- Toilets and washroom areas shall have a minimum of 7 air changes per hour forced ventilation;
- Operation rooms, such as screen house or pumping stations shall have a minimum of 7-10 air changes per hour forced ventilation.

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The clear room height shall be 4,00 m to allow for suspended ceiling. Electrical rooms shall be equipped with steel doors. The walls of the laboratory shall be covered by room high acid-proof tiles. All rooms have to be equipped with air condition.

B.5.10. Pipe Works

All pipe works shall be constructed of materials acceptable for the purposes and conditions they are intended to serve. The pipe material shall comply with following requirements:

- Gravity sewer storm water drainage DN < 1000: HDPE, PVC; PP, DI;
- Gravity sewer DN > 1000: GRP-FRP, DI;
- Sewer Pressure Pipe: HDPE, DI, PP;
- Water supply, service water: HDPE, DI;
- Internal piping system (above ground)
for wastewater and sludge: stainless steel (316 L or 1.4571)
- Cable ducts: HDPE;
- Manhole cover: DI.

The DN 1.300 mm by-pass pipe shall be made of GRP.

All internal piping systems for wastewater or sludge **shall be made of stainless steel** (316 L or 1.4571).

Sewer manholes shall have a minimum diameter of 1.000 mm and shall be constructed of pre-cast reinforced concrete. Manholes shall be provided for sewer networks and storm water drainage networks:

- At a minimum every 50 m for sewer DN ≤ 400 and 80 m for sewer DN > 400;
- At all changes of direction, diameter or slope;
- At all intersections

Control chambers (connection manholes) shall be foreseen at each connection point of buildings.

All underground cables shall be laid in ducts. There shall always be at least a spare duct in each duct trench.

B.5.11. Odour Control and Ventilation

In addition to the specifications of these requirements the WWTP shall be designed to ensure that:

1. The principal sources of odour shall have minimum odour emission. The principal sources are:
 - Inlet works and screen;

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- Septic sludge acceptance and treatment facility;
 - Raw wastewater pumping station;
 - Grit and grease removal units;
 - Scum collecting and treatment facilities;
 - Sludge collecting and pumping facilities;
 - Sludge digestion facilities;
 - Sludge thickening and dewatering facilities;
 - Dewatered sludge storage.
2. Ventilation systems shall provide a safe working environment to comply with National and International Regulations and to the following key-principles:
- Those areas, which will regularly be entered by personnel in the course of operating the plant, shall have a minimum air change rate of 7-10 air changes per hour;
 - Those areas with hazardous and occupational H&S potential concerning dangerous gas concentrations for hydrogen sulphide, methane gas and aerosols, shall have a minimum air change rate of 10 air changes per hour. Furthermore they are to be clearly indicated as hazardous areas;
 - Those areas that would not normally be occupied or entered regularly may be ventilated to a lower air change rate and be constructed from sulphate resistant cement as determined by the Contractor in his proposal.

Bidders shall indicate in their proposal the type and rate of air exchange facilities provided for each inside area of the plant.

B.6. WASTEWATER TREATMENT PLANT PARTICULAR PROCESS DESIGN REQUIREMENTS

B.6.1. Inlet Chamber

The wastewater will be delivered to the plant by a new trunk main sewer (DN 1300), which shall be connected at an inlet chamber with emergency overflow and aerated stone pit. The emergency overflow shall pass a manually raked coarse screen and will then be discharged to the bypass discharge main of the WWTP. A flow indication and metering shall be installed on the bypass discharge main and displayed in the control room of the plant.

The inlet chamber shall be completely covered and served by an air extraction system, connected to an odorous air treatment system. From the inlet chamber the wastewater will flow to the inlet works of the WWTP.

The Contractor is free to determine the diameter of the connection pipes and the pipe material as long as the design criteria and the operation requirements as set out in the Tender Requirements are satisfied.

B.6.2. Inlet Works, Pumping Station and Mechanical Wastewater Pre-treatment Facilities

B.6.2.1. Faecal Sludge Reception Station

A faecal reception facility shall be located adjacent to the building of the inlet works. The faecal sludge will be delivered by vacuum tankers or similar. The facility shall mainly consist of a tanker unloading facility incl. flow and quality monitoring (pH and conductivity), a screening unit (treatment capacity: 100 m³/h) with screenings container, a storage tank (100 m³) and a pumping facility (30 m³/h) for the transport of the faecal sludge. The faecal reception facility shall be equipped with a by-pass to enable to optionally discharge the received faecal sludge directly to the inlet chamber before the coarse screens without any treatment.

Two faecal sludge reception socket connections shall be provided for taking over the faecal sludge from vacuum tankers. For the design of the socket connections the Contractor has to consider the geometric features of the vacuum tankers used by the Employer.

The sludge storage tank shall be collected in a buffer tank with a capacity of minimum 100 m³, equipped with one duty and one stand-by submersible pumps in order to pump the faecal sludge to the inlet works of the WWTP upstream of the coarse screens. Each pump shall have a minimum capacity of 30 m³/h.

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B.6.2.2. Manual Coarse Screens

In order to protect the coarse screens from damages by large objects a manually raked coarse screen made from stainless steel 316L with 200 mm bar spacing shall be installed in front of each coarse screen.

B.6.2.3. Coarse Screens

Four (3+1) automatically operated coarse screen units made from stainless steel 316L (1.4404) with 20 mm spacing between the bars, shall be installed upstream of the inlet pumping station. Each coarse screen shall be installed in a separate channel with appropriate up- and downstream channel sections. Up and downstream of each coarse screen unit, automatically operated penstocks shall be installed.

Raw sewerage shall gravitate from the inception chamber into the receiving and distribution channel and shall be evenly distributed into the individual channels of the coarse screens.

The channels are to be designed as open concrete channels in monolithic design with installation platforms inside the inlet building. Inspection manholes, access ladder and service platform with lifting devices for heavy equipment, and coverings shall be provided, accordingly. All channels shall be profiled in such a way that sedimentation of coarse matters will be prevented, moreover sufficient flushing facilities (service water) shall be considered.

The capacity of each coarse screen unit shall be dimensioned to cope with one third of the maximum wet weather flow ($Q_{WW,p}$). Under dry weather conditions 1 or 2 coarse screens and under wet weather conditions 3 coarse screens shall be in operation. In case of malfunction of one unit the respective screen channel shall be separated by automatically operated penstocks. Eventual excess flow shall be discharged towards the emergency bypass, via an overflow weir at the interception chamber.

All screens shall be controlled by individual differential ultrasonic level measurement and timers. When the preset and adjustable differential level is reached the screen rake mechanism shall operate and rake all screening to the conveyor. The screen rake shall continue to operate until the differential level is reduced to a further preset and adjustable value. In the case the screen rake has not been operated for a certain preselected period of time, it should be automatically put into operation for a preselected duration.

Screenings shall be discharged into screw conveyors with spraying / washout device for conveyance into the subsequent screening wash-presses. The washing of screenings shall be performed with service water taken from the service water network. The washed and compacted screening material shall be discharged into containers. At minimum each two screens shall be provided with one common screw conveyor with wash-press and compactor.

The coarse screens, including the screenings processing equipment and the containers for the storage of washed, dewatered and compacted screenings shall be installed inside the building

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for inlet works and screens. Foul air from this building shall be extracted automatically and transported to the odour treatment unit described in Section B.6.9.

Design Criteria

Coarse screens shall comply with following design criteria.

Design Horizon		2023 - 2045
Max daily screenings volume before compaction	m ³ /d	6
Type of screens	-	automatically raked
Bar spacing	mm	20
Number of screens	-	3 + 1
Type of conveyors	-	screw conveyor
Number of conveyors	-	≥ 2
Type of screening press		wash-press
Number of screening presses	-	≥ 2
Number of containers	-	≥ 4
Size of containers	m ³	≥ 5
Design Criteria		
Velocity between the bars	m/s	≤ 1,2
Velocity upstream screens at $Q_{DW,h24,min}$	m/s	≥ 0,5
Compaction of screenings	%	≥ 60

B.6.2.4. Inlet Pumping Station

The inlet pumping station shall comprise of 2 pump sumps, each having an area of approximately 40 m², which can be separated by an automatically operated penstock. The inflowing wastewater after the coarse screens shall be directed either to both chambers or to only one of them by automatically operated penstocks. The pump sumps shall be built as rectangular concrete building in monolithic design with concrete and integrated in the Building for Inlet Works and Screens. Inspection manholes, access ladder and service platform with lifting devices shall be provided, accordingly. Individual pressure pipes or a main header, complete with all necessary armatures and fittings, shall be installed for raw wastewater conveyance into the distribution channel of the fine screens. The pump sump shall be profiled in such a way that sedimentation of coarse matters will be prevented.

The pumps shall lift the incoming wastewater to the designed level of the fine screen channels. Each pump sump shall be equipped with 3 (2+1) frequency controlled dry weather submersible pumps (290 l/s each) and one (1+0) wet weather submersible pump (711 l/s). The pump capacities are to be dimensioned so that under dry weather conditions at most 4 (4+2) dry weather pumps shall be operated. Under wet weather conditions 3 dry weather and 1 wet weather pump installed either in the same pump well or from both pump wells shall be operated. In both cases the total capacity under wet weather shall cope with the maximum wet

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weather flow of 1.581 l/s. This will assure that the maximum incoming flow can be pumped also in case that one pump well is out of service.

Design Criteria

The following design criteria shall be considered.

Design Horizon	Unit	2023 - 2045
Dry weather pumps		
Number of pumps in duty (n_d)	-	4
Number of pumps in stand-by	-	2
Type of pumps	-	submersible
Impeller type	-	N-type
Free passage	mm	80
Unitary capacity of dry weather pumps	l/s	290
Wet weather pumps		
Number of pumps in duty	-	1
Number of pumps in stand-by	-	1
Type of pumps	-	submersible
Impeller type	-	N-type
Free passage	mm	80
Unitary capacity of wet weather pumps	l/s	711
Total capacity without standby units	l/s	1.871

Under minimum flow conditions at least one pump shall be operated without interruptions.

The effective volume of the pump sumps shall be dimensioned to allow maximum 6 cycles of pump shut off per hour. The pump sumps shall be equipped with ultrasonic continuous level measurement with remote transmission to the local PLC and WWTP control room. In order to unify the operation hours of the individual pumps an automatic changeover "Duty/Standby" shall be considered. The submersible pumps shall be equipped with frequency converters. The frequency of the pumps in operation shall be adjusted in accordance to the water level.

Low-tension power supply and operation control shall be arranged in a separate room in the building for inlet works and screens. The local PLC shall be interlocked with the main operation control of the plant.

B.6.2.5. Fine Screens

The fine screens shall be installed in the building for inlet works and screens adjacent to the inlet pumping station. It shall contain also the grit classifiers where the grit shall be washed and conveyed into grit containers.

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The fine screen section shall comprise of a receiving and distribution channel with installation channels for the screen units and effluent channel to the Grit Chambers. Raw sewage, which shall be feed from the Inlet Pumping Station into the receiving and distribution channel, shall be evenly distributed into the individual fine screen channels. Additionally, a by-pass channel to the grit and grease removal tanks with a manually raked screen shall be provided.

Four (3+1) automatically operated fines screen units shall be installed in separate channels with appropriate up- and downstream channel sections. The fine screens shall be of the type of perforated belt screens made of stainless steel 316L with 3 mm aperture. Up and downstream of each fine screen unit automatically operated penstocks shall be installed.

All screens shall be controlled by individual differential ultrasonic level measurement and timers. When the preset and adjustable differential level is reached, the screen rake mechanism shall operate and rake all screening to the conveyor. The screen rake shall continue to operate until the differential level is reduced to a further preset and adjustable value. In the case the screen rake has not been operated for a certain preselected period of time, it should be automatically put into operation for a preselected duration.

The capacity of each fine screen unit shall be dimensioned to cope for one third of the maximum wet weather flow ($Q_{WW,p}$). Under dry weather conditions 1 or 2 fine screens and under wet weather conditions 3 fine screens shall be in operation. In case of malfunction of one unit the respective screen channel shall be isolated by automatically operated penstocks.

The channels are to be designed as open concrete channels in monolithic design with installation platforms inside the screen building. Inspection manholes, access ladder and service platform with lifting devices for heavy equipment, and coverings shall be provided, accordingly. All channels shall be profiled in such a way that sedimentation of coarse matters will be prevented, moreover sufficient flushing facilities (service water) shall be considered.

Screenings shall be discharged into screw conveyors with spraying / washout device for conveyance into the subsequent screening wash-presses. The washing of screenings shall be performed with service water taken from the service water network. The washed and compacted screening material shall be discharged into containers. At minimum each two screens shall be provided with one common screw conveyor with wash-press and compactor. With regard to the length of the sewer, extreme variations in the screenings generation, especially by rain after a long dry period, should be considered for the design of the screenings compaction and conveyance units.

Under normal operation conditions, the automatic operation of the screens will be controlled by continuous measurement of the up- and downstream water level in the installation channel. Depending on pre-set values for the water-level-difference discontinuous operation of the cleaning mechanism shall be initiated. In addition, in case of failure or under low flow conditions a secondary timer control shall initiate regular cleaning of the screens. The operation of the screenings conveying system shall be synchronized, accordingly.

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The fine screens, including the screenings processing equipment and the containers for the storage of washed, dewatered and compacted screenings shall be installed inside the building for inlet works and screens. Foul air from this building shall be extracted automatically and transported to the odour treatment unit described in Section B.6.9.

Design Criteria

Fine screens shall comply with following design criteria.

Design Horizon		2023 - 2045
Max daily screenings volume before compaction	m ³ /d	10
Type of screens	-	perforated belt screen
Aperture of perforated belt	mm	3
Number of screens	-	3 + 1
Type of conveyors	-	screw conveyor
Number of conveyors	-	≥ 2
Type of screening press	-	wash-press
Number of screening presses	-	≥ 2
Number of containers	-	≥ 4
Size of containers	m ³	≥ 5
Design Criteria		
Velocity in apertures at maximum flow	m/s	≤ 1,0
Velocity upstream screens at $Q_{DW,h24,min}$	m/s	≥ 0,5
Compaction	%	≥ 60

B.6.3. Grit and Grease Removal Facility

Grit and grease shall be removed from the wastewater by two parallel operated aerated longitudinal grit chambers with peripheral grease traps.

The two grit and grease removal facilities shall be designed as twin-chamber, rectangular concrete structure in monolithic design with in- and effluent chamber, sand and scum pumps. Each chamber shall be dimensioned to treat the maximum dry weather flow at minimum retention time of 5 minutes. The length / width ration of the grit traps shall be ≥ 10. Automatically operated penstocks in the influent and effluent sections of each grit chamber shall be installed. A bypass channel equipped with automatically operated penstock shall be foreseen.

Aeration shall be performed over the whole length of the structure by means of horizontally installed coarse bubble tube aerators. Frequency controlled blowers (2+1) for the air supply of the sand and grease traps shall be installed in a separate blower building or blower room. It shall have sufficient size for installation of the blowers, local switchboards and compressed air pipework with natural lighting and ventilation.

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The flow generated within the grit trap chamber by the aeration system transports the grease through the slotted scum board into the grease chamber. The collected grease shall be pumped to the primary sludge storage tank.

Design Criteria

The grit and grease removal unit shall comply with following design criteria.

Design Horizon		2023 - 2045
Max daily grit / sand amount	m ³ /d	3
Max daily grease amount	m ³ /d	0,2
Type of grit & grease removal	-	aerated longitudinal
Number of grit & grease removal units	-	≥ 2
Type of sand and scum removal	-	scraper bridge, twin or single
Type of grit pumps	-	submersible, vortex
Number of grit pumps	-	≥ 2
Capacity of grit pumps	m ³ /h	≥ 10
Type of aeration	-	coarse bubble
Type of blowers	-	rotary piston
Number of blowers	-	≥ 2 + 1
Number of grit classifier	-	1
Capacity of grit classifier	m ³ /h	≥ 20
Number of containers	-	≥ 4
Size of containers	m ³	≥ 5
Design Criteria		
Grit separation efficiency for Ø ≥ 250 mm, ρ ≥ 2,65 kg/dm ³	%	≥ 95
Retention time in grit chamber at Q _{DW,p}	min	≥ 10
Horizontal velocity at Q _{DW,p}	m/s	≤ 0,2
Surface load grease trap (q _{A,FF})	m ³ /m ² /h	≤ 25
Width / depth ratio grit chamber	-	0,8 - 1,0
Length / width ratio grit chamber	-	≥ 10
Ratio width grease trap / width grit chamber	-	0,2 - 0,5
Specific air flow rate	m ³ /(m ³ x h)	0,5 - 1,3
Organic dry matter of washed sand	%	≤ 3
Dry solids content of washed sand	%	≥ 90

The effluent weirs shall be equipped with scum baffles. The structure shall have an inclined bottom allowing the settled sand to slide towards a sand collection channel.

Travelling service bridges for discontinuous sand and scum removal shall be installed. The twin grit chambers can be served either by one single travelling bridge or by separate individual travelling bridges. Scraper blades shall remove the sand from the bottom sand trap

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and discharge it into sand hoppers at the grit chambers head. Height adjustable scum blades shall be provided for the grease traps in order to remove the scum layers into grease pits at the front side of the tanks. Scrapers and scum blades shall be fixed parts of the travelling service bridges.

Alternatively, sand removal can be carried out by use of a twin-type suction scraper system comprising travelling service bridges with submersible suction pumps which discharge the sand from the bottom sand trap into a lateral concrete effluent channel, which conveys the flow into a sand pumping station at the front side of the tanks.

Inspection manholes, access ladders and service platforms with lifting devices for heavy equipment, and coverings shall be provided.

A grit washing plant shall be provided for sand washing and dewatering. It shall be installed in the solid waste treatment and storage area of the fine screen building. Washed and dewatered grit shall be fed into grit containers, which shall be provided in a sufficient number.

Conveyance of the sand-water mixture from the sand hoppers or the sand pumping station at the grit chambers into the grit washing plant shall be carried out by air-lift pumps or submersible pumps. Pump-body and impeller of submersible pumps to be used for sand conveyance shall be made of special, abrasive resistant design (High Chrome white iron EN-GJN-HB555(CR14)).

Operation control of the sand removal, conveyance, washing and dewatering system shall consider alternating operation of the grit washing plant in such a way that the washing plant serves one twin- chamber tank after the other.

Separated scum and grease shall be discontinuously discharged from the grease pits at the grit chambers to the raw sludge collecting tank by submersible pumps.

Operation control of the travelling scraper bridge shall be realized by means of a PLC unit with timer control of the operation sequences, installed in a local switchboard, which is assembled onto the bridge with power supply via a motorized cable reel. The operation of the grit and grease discharging systems, incl. grit washing plant, shall be synchronized.

The effluent flow of both grit and grease traps shall be combined and be gravitated by pipe, equipped with ultrasonic or inductive flow meter, to the distribution chamber upstream of the primary sedimentation tanks. Probes for measurement of wastewater temperature, pH and conductivity shall be foreseen in the distribution chamber.

A refrigerated automatic sampler shall be provided with arrangements to take flow proportional 2-hour-composite or 24-hour-composite samples.

All signals shall be processed by the control centre (PLC-control-system) of the primary treatment facilities at the screen building and furthermore transmitted to the main operation control centre of the plant.

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B.6.4. Primary Sedimentation Tank

B.6.4.1. Primary Sedimentation Tank

Two parallel operated circular primary sedimentation tanks shall be designed and completed for the ultimate design horizon 2045 under consideration of the finally required treatment efficiency.

Supernatant from sludge processing shall be fed to the distribution chamber upstream of the primary sedimentation tanks. The following reloads shall be considered in the design of the primary sedimentation tanks.

Reloads to Primary Sedimentation	Unit	2023	2035	2045
Minimum hydraulic reload ($Q_{r,PC}$)	m ³ /d	2.100	2.600	3.200
Minimum total nitrogen reloading rate ($L_{N,r,PC}$)	kg/d	255	332	256
Minimum total phosphorus reloading rate ($L_{P,r,PC}$)	kg/d	23	32	39

The primary sedimentation tanks shall have a minimum effective diameter of 31 m (at the outer overflow weirs) with central supporting structure and sludge hoppers and shall be designed for the total loads including reloads from sludge processing.

Design Criteria

Primary sedimentation tanks shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific primary sludge production	g DS/PE/d	≈ 50
Dry solid content of primary sludge	%	2 - 4
Type of primary sedimentation tank	-	circular
Diameter of primary sedimentation tank	m	≥ 31
Side water depth (effective vertical height)	m	≥ 2,5
Type of scraper bridge	-	full diameter
Number of tanks	-	2
Design Criteria		
Surface load at $Q_{WW,p,IPST}$	m ³ /m ² /h	≤ 4
Retention time at $Q_{DW,h24,max,IPST}$	h	≥ 1,5
Weir load at $Q_{WW,p,max,IPST}$	m ³ /m/h	≤ 30

The removal efficiencies of the primary sedimentation tanks with the above retention time of 1,5 h according to DWA-A 131 shall be considered as specified in below table.

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Removal Efficiency of Primary Sedimentation	Unit	Value
BOD ₅ removal efficiency (η_{BOD})	%	33
COD removal efficiency (η_{COD})	%	35
Suspended solids removal efficiency (η_{SS})	%	60
Total nitrogen removal efficiency (η_{TN})	%	10
Total phosphorus removal efficiency (η_{TP})	%	10

The evenly distributed flows from the grit and grease traps shall gravitate to the centre of the primary sedimentation tanks, where it shall be evenly distributed radially into the sedimentation zones of the tanks below the inlet structure. A concrete channel equipped with adjustable V-notch overflow weirs on both sides (double weir), shall collect the treated effluent. Scum baffles shall be installed at the effluent section of the tank.

The primary sedimentation tanks shall be equipped with travelling scraper bridges, with bottom sludge scraper blades and scum removal system. The scraper bridges shall be of the type of full diameter with peripheral drive / actuating unit. All submersed parts shall be made from stainless steel 316L. Height adjustable scum blades made from stainless steel 316L shall be provided for scum removal into a scum-collecting pit. Scrapers and scum blades are to be fixed on the assembled at the travelling service bridges.

A bypass system shall enable to fully or partly bypass the primary sedimentation tanks in order to provide the necessary flexibility during the operation.

Operation control of the travelling scraper bridge shall be realized by means of a PLC unit installed in a local switchboard, which is assembled onto the bridge. Operation control of the primary sludge pumping station shall be synchronized in accordance to the operational conditions and requirements of the WWTP and the filling level of the primary sludge storage tank.

The effluent of both primary sedimentation tanks shall be combined and conveyed to the distribution chamber upstream of the biological treatment units for flow distribution of the primary treated wastewater flow into the individual biological treatment units.

The distribution chamber shall be conceived as concrete building in monolithic design with influent chamber and peripheral effluent pits. Inspection manholes, access ladders and service platforms and coverings shall be provided.

Primary treated wastewater shall be feed into the influent compartment of the distribution chamber. Manually adjustable overflow weirs with complete overflow shall be provided at the effluent compartments for flow distribution into the individual treatment lines of the activated sludge tanks. Motorised penstocks shall be installed in the outflows of the effluent compartments in order to set individual activated sludge tanks out of operation.

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B.6.4.2. Primary Sludge Pumping Station

A separate primary sludge pumping station shall be completed close to the primary sedimentation tanks..

The primary sludge pumping station shall be designed for dry installation of minimum three (2+1) pumps, dimensioned to cope for the total amount of daily produced primary sludge during normal working hours (8 h/day, 7 days/week). The primary sludge shall be evacuated from the primary sedimentation tanks by gravity. Each primary sedimentation tank shall have a separate evacuation pipe to the sludge pumping station, isolated by automatically operated valves. Each sludge evacuation pipe shall be equipped with inductive flow measurement. The sludge level in the pumping station shall be controlled by ultrasonic level measurement.

With regard to possible emissions of methane in the pump room, the classification of the pump room shall be as Ex-zone Ex1. Efficient ventilation shall be provided.

The primary sludge pumping station shall have a sufficient size for installation and maintenance of the pumps, local switchboards, suction and pressure sludge pipework with natural lighting and ventilation. Lifting devices for heavy equipment and coverings shall be provided accordingly.

The primary sludge pumps shall convey the sludge to the primary sludge storage tank via pressure pipe equipped with inductive flow measurement.

Scum shall be discontinuously discharged from a separate pumping pit by submersible pumps to the primary sludge pumping station.

Design Criteria

The pumping station shall comply with following design criteria.

Primary Sludge Pumping Station	Unit	2035 - 2045
Specific primary sludge production	g DS/PE/d	≈ 50
DS concentration primary sludge	%	2 - 4
Primary sludge withdrawal time	h/d	8
Peak factor	-	1,5
Number of pumps	-	≥ 2 + 1
Type of primary sludge pumps	-	dry installed/vortex/single channel with F- or D-type impeller

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B.6.5. Biological and Chemical Wastewater Treatment Facility

B.6.5.1. Activated Sludge Tanks

B.6.5.1.1. General Design Requirements

For carbon, nitrogen and phosphorus removal the A2/O process (Anaerobic, Anoxic & Oxic, equivalent to upstream denitrification with biological phosphorus removal process) shall be applied. The biological treatment units of the A2/O process shall comprise 3 parallel and independently operated treatment lanes, each lane including a separate anaerobic zone for biological phosphorus removal (Bio-P, EBPR), an anoxic zone for denitrification, an anoxic / aerobic and an aerobic zone for nitrification and carbon removal in one monolithic structure.

The process and the tank dimensions shall be designed in accordance with German DWA-A131 (2000) and additionally in accordance with DWA-A131(2016) "Dimensioning of Single-Stage Activated Sludge Plants" for the design loads of horizon 2023, 2035 and 2045 by use of the factors and coefficients specified in below table.

Factors and coefficients for dimensioning according to A131(2000/2016)	Unit	Value
Temperature correction factor heterotrophic (F_T)	-	$1,072^{(T - 15^{\circ}\text{C})}$
Temperature correction factor nitrification ($F_{T,N}$)	-	$1,103^{(15^{\circ}\text{C} - T)}$
Nitrification growth rate $\mu_{A,max}(15^{\circ}\text{C})$	d^{-1}	0,47
Safety factor for nitrification (SF)	-	1,45
Heterotrophic decay coefficient, 15°C (b_H)	d^{-1}	0,17
Heterotrophic yield coefficient (Y_H)	$\text{g COD}_{BM}/\text{g COD}_{deg}$	0,67
Substrate respiration (d)	$\text{kg O}_2/\text{kg BOD}$	0,56
Endogenous respiration rate (e)	$\text{kg O}_2/(\text{kg SS} \times \text{d})$	0,20
Factor $f_{COD,ed}$ for easily degradable soluble COD ($C_{COD,ed}$)	-	0,15
Factor f_s for inert part of soluble COD ($S_{COD,inert}$)	-	0,05
Factor f_A for inert part of particulate COD ($X_{COD,inert}$)	-	0,30
Factor f_B for inorganic part of filtrable solids ($X_{inorg,SS}$)	-	0,20
Factor $f_{orgN,inert}$ for inert part of organic nitrogen $X_{orgN,inert}/(X_{COD,BM,inert} + X_{COD,inert,IAT})$	-	0,03
Factor $f_{orgN,BM,COD(BM)}$ for nitrogen incorporated in biomass ($X_{orgN,BM}/X_{COD,BM}$)	$\text{g COD}/\text{g oMES}$	1,60
Factor $f_{orgN,BM,BOD}$ for nitrogen incorporated in biomass ($X_{orgN,BM}/B_{BOD,IAT}$)	-	0,07
Factor $f_{orgN,BM,COD}$ for nitrogen incorporated in biomass ($X_{orgN,BM}/B_{COD,IAT}$)	-	0,045
Factor $f_{orgN,BM,COD}$ for nitrogen incorporated in biomass ($X_{orgN,BM}/B_{COD,IAT}$)	-	0,0225

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Factors and coefficients for dimensioning according to A131(2000/2016)	Unit	Value
Factor $f_{P,BM,BOD}$ for phosphorus eliminated by built up of biomass	g P/g BOD ₅	0,01
Factor $f_{P,BM,COD}$ for phosphorus eliminated by built up of biomass	g P/g BOD ₅	0,005
Factor $f_{bioP,BOD}$ for phosphorus eliminated by Bio-P	g P/g BOD ₅	0,015
Factor $f_{bioP,COD}$ for phosphorus eliminated by Bio-P	g P/g BOD ₅	0,007

Reloads from sludge processing as stipulated under B.6.4.1 shall be taken into account. The required bioreactor volumes shall be calculated for the average design load cases 2023, 2035 and 2045, at 12 °C and 20°C and a sludge volume index of SVI = 120 l/kg and additionally for the seasonal high loads in 2023 during the production period of Plantaze winery (August – September) at temperature 20°C and SVI = 180 l/kg. For start-up and commissioning in 2023 only two lanes shall be operated.

The Activated Sludge Tanks (AST) shall be designed and completed as parallel operated longitudinal concrete basins with horizontal flow and a maximum water depth of 6,5 m. All corners in the concrete basins shall be rounded with filling concrete to a height of at least 0,5 m. The effluent of the activated sludge tanks shall be equipped with weirs and scum baffles and be hydraulically uncoupled from the downstream units. All tanks shall be equipped with walkways and bridges allowing easy access to all installed equipment and measuring devices and with lifting devices for all installed mixers.

B.6.5.1.2. Anaerobic Zones (Bio-P, EBPR)

The anaerobic zone for biological phosphorus removal of each process line shall either be integrated in the monolithic concrete structure of the respective process line or constructed as a separate structure upstream of the activated sludge tanks. The inflow of mechanically pre-treated waste water and return sludge flow from the distribution chamber shall be achieved by inverted siphon pipes. Effluent shall be discharged either into the distribution chamber to the Activated Sludge Tanks (in case the Bio-P tanks are single structures) or into the following anoxic zones of the process tanks (in case the Bio-P tanks are integrated in the AST's).

The anaerobic reactors are to be designed as carousel reactors, equipped with at least two energy efficient, slow rotating, submerged mixers with banana shape blades. The mixers shall guarantee sufficient mixing of return sludge and wastewater and prevent settling of sludge in the tanks. The mixers shall therefore be designed for an average horizontal velocity in the tanks of minimum 0,3 m/s.

The retention time in the anaerobic reactor shall be $\geq 0,5$ h at the maximum dry weather wastewater inflow including return sludge flow.

Design Criteria

The design of the anaerobic zones shall comply with following design criteria.

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Design Horizon	Unit	2023	2035	2045
Number of treatment lanes in operation	-	2	3	3
Type of process	-	A ² /O		
Type of tank	-	caroussel type either integrated in AST or separate		
Number of mixers per tank		≥ 2		
Type of mixers	-	submersible, slow motion, banana shape		
Design Criteria				
Water depth	m	≤ 6,5		
Return sludge ratio RS at Q _{DW,p}	%	75		
Return sludge dilution factor boottom sludge	-	≤ 0,75		
Retention time in anaerobic zone at Q _{DW,p,lBioP}	h	0,5 - 0,75		
Phosphorous elimination by Bio-P	g P/g BOD	≤ 0,015		
Specific energy input for mixing	W/m ³	≥ 2		
Horizontal flow velocity	m/s	≥ 0,3		

The design and configuration of the anaerobic zones shall allow to convert them temporarily into anoxic zones in cases when biological phosphorous removal is inefficient or when reduced nitrogen removal efficiency requires additional volumes for denitrification, or if an increase of aerobic sludge age is required and the anoxic / oxic zone shall therefore be operated aerobically. During such operation periods phosphorus shall be removed mainly by increased precipitant dosing.

B.6.5.1.3. Anoxic / Oxic Zones (Carbon and N-Removal)

Downstream of the anaerobic zone an anoxic zone for denitrification shall follow. The anoxic zones shall be designed as carousel reactors and be equipped each with at least four energy efficient, slow rotating, submerged mixers with banana shape blades. The mixers shall guarantee sufficient mixing and prevent settling of sludge in the tanks. The mixers shall be designed for an average horizontal velocity in the tanks of 0,3 m/s.

The anoxic zones shall be dimensioned for the seasonally minimum anoxic volume required for denitrification. The required internal recirculation from the nitrate containing aerobic reactor shall be performed either by wall mounted and frequency controlled propeller pumps or by frequency controlled recirculation pumps for the transfer of the effluent of the activated sludge tanks into the anoxic reactor. The possibility shall be provided to optionally temporarily recirculate the effluent of the activated sludge tank to the anaerobic reactor to obtain an enlarged anoxic volume for denitrification during times when the biological phosphorus removal efficiency is low. The capacity of the internal recirculation pumps shall be dimensioned according to DWA-A131. Probes, installed for continuous measurement of ORP (redox potential) shall enable the operators to control the denitrification process. At least two probes for ORP measurement shall be installed in each anoxic zone.

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The subsequent anoxic / oxic zone, designed as carousel reactor, equipped with at least two energy efficient, slow rotating, submerged mixers with banana shape blades and diffusers for aeration, shall allow flexible aeration or non-aeration thus enabling either denitrification or nitrification as desired. The volume of these zones shall close the gap between the minimum required volume for denitrification, already covered by the anoxic reactor and the maximum required volume.

Fine bubble aeration diffusers shall be installed at the bottom of the reactors on separated grid units in order to enable flexibility in the aeration of the individual zones of the reactor. Probes, installed for continuous measurement of oxygen and ORP (redox potential) shall enable the operators to control the denitrification process.

In oxic operation mode the air supply shall be dependent on the dissolved oxygen concentration in each aerated zone, which shall be measured by installed DO meters. At least two DO-meters (dissolved oxygen content measurement) for continuous measurement of the content of dissolved oxygen inside the anoxic / oxic reactor shall be provided for each basin.

Bypass facilities for the facultative anoxic / oxic reactor shall allow for taking this reactor out of service during periods when it is not required.

The final process step shall be the aerobic zone, to be dimensioned to nitrify the TKN and to remove carbon¹. This reactor shall also be designed as carousel reactor, equipped with energy efficient, slow rotating, submerged mixers with banana shape blades to maintain always a minimum flow velocity of 0,30 m/s and diffusers for aeration. This reactor shall be aerated continuously while the oxygen concentration shall be kept on a minimum level of 2 mg/l. The reactor shall therefore be equipped with probes for continuous oxygen measurement. At least three DO-meters (dissolved oxygen content measurement) for continuous measurement of the content of dissolved oxygen inside the oxic reactor shall be provided for each basin.

Submersible propeller pumps installed at the end of the tank shall provide the required recirculation flow of nitrate rich wastewater to the anoxic reactor or facultative to the anaerobic reactor when this is used for denitrification.

The following continuous on-line measurements shall be provide at the outlet of each of the three aeration tanks:

- TSS-probe;
- Ammonium (NH_4). The Measurement shall be carried out by analyzer with continuous sampling;
- Nitrates (NO_3);
- Phosphate (PO_4). The Measurement shall be carried out by analyzer with continuous sampling.

¹ Aeration tanks shall be dimensioned and designed taking into consideration the different sludge age requirements for summer and winter temperatures and load cases

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Design Criteria

Anoxic / oxic zones of the activated sludge tanks shall comply with following design criteria.

Design Horizon	Unit	2023	2035	2045
Sludge volume index	l/kg	120	120	120
Design temperature	°C	12 / 20	12 / 20	12 / 20
Alkalinity	mmol/l		≥ 5	
Peak factor f_c	-		1,2	
Peak factor f_N	-		1,6	
Number of treatment lanes	-		3	
Number of treatment lanes in operation	-	2	3	3
Type of process	-		A ² /O	
Type of tanks	-		monolythic, carrousel type	
Number of mixers per anoxic zone			≥ 4	
Number of mixers per anoxic/oxic zone			≥ 2	
Number of mixers per oxic zone			≥ 4	
Type of mixers	-		submersible, slow motion, banana shape	
Total volume of anoxic and oxic zones of tanks V_{AT} (without Bio-P tanks)	m ³		≥ 31.000	
Type of aeration system			fine bubble	
Oxygen transfer coefficient at SS_{AT} and $T=20^{\circ}C$ $\alpha(20^{\circ}C)$			≤ 0,65	
Salinity-surface tension correction factor (β)	-		0,95	
Altitude above sea level	m		25	
Type of blowers for aeration	-		turbo blower	
Total capacity of blowers in duty			≥ 115% of maximum air demand	
Number of turbo blowers	-		≥ 3 + 1	
Design Criteria				
Water depth	m		≤ 6,5	
Return sludge ratio RS at $Q_{DW,p}$	%		75	
Return sludge dilution factor bottom sludge	-		≤ 0,72	
Dry solids concentration in AST	kg MLSS/m ³		≤ 3,3	
Aerobic sludge age	d		≥ 6,6 / ≥ 3	
Sludge load	kg BOD ₅ /kg MLSS/d		≤ 0,1 / ≤ 0,2	
V_D/V_{AT}	-		0,3 - 0,5	
Specific energy input for mixing	W/m ³		≥ 2	
Horizontal flow velocity	m/s		≥ 0,3	

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Design Horizon	Unit	2023	2035	2045
Oxygen transfer coefficient at SS_{AT} and $T = 20^{\circ}C$ $\alpha(20^{\circ}C)$	-		$\leq 0,65$	
Fouling factor membrane aerators	-		$\leq 0,9$	
Dissolved oxygen concentration in AST (C_x)	mg/l		0,5 - 2	
Oxygen yield membrane aerators (pure water)	g O_2 /Nm ³ /m		≥ 18	
Standard aeration efficiency SAE	kg O_2 /kWh		≥ 2	

Oxygen shall be supplied by compressed air only. For compressed air aeration an aeration system comprising of non-clogging membrane aerators, compressed air supply and distribution pipework with blowers for compressed air generation are to be provided. A sufficient number of disc, tube or plate diffusers which are to be installed on a certain number of aerator panels shall be distributed over the tank bottom in such a way that an area-covering arrangement of the aerators in the individual zones can be guaranteed. Aerator panels shall be provided with a drain system and shall be connected to the supply pipework individually via separate shut-off devices.

To control the air flow to each activated sludge tank, regulating valves shall be provided for each main supply air pipe. The air supply shall be dependent on the dissolved oxygen concentration in each aerated zone. Operation control of the aeration systems of the individual zones / basins shall be realized by regulation of the compressed air flow in accordance to the measuring value against a pre-set standard value.

Low-tension power supply and operation control shall be arranged in the adjacent blower building. The local PLC shall be interlocked with the main operation control of the plant.

B.6.5.2. Blower Station

The blower building shall be located close to the Activated Sludge Tank (AST) and shall house the blowers for the activated sludge tanks with appertaining equipment, local control panels and the local power sub-distribution and control room.

A minimum of four (3 + 1) turbo blowers with servo-operated variable diffusers and servo-operated variable pre-rotation systems for maximum efficiency for aeration, designed for the maximum air demand at horizon 2045 with 15 % reserve capacity, shall be provided. The blower capacities shall be dimensioned to provide the required amount of compressed air to keep the minimum oxygen concentration in the aeration tanks at a level of 2 mg/l at maximum air demand conditions and to be operated at minimum 45 % of their nominal capacity. The blowers shall operate in an alternating mode.

The number and capacity of the blowers shall be selected so that even during the trial operation and minimum load case, the blowers shall operate efficiently. In particular blowers

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shall be designed in order of being capable to be operated efficiently at a minimum air demand of 10 % of the maximum air demand. In case this condition cannot be fulfilled with 3 + 1 blowers of the same capacity, the bidder shall propose an economic alternative solution which may consist in a configuration with 4 + 2 blowers or with blowers of different capacity. For the calculation of the blower capacities, the minimum required oxygen concentration in the tanks, maximum water and ambient temperature, water depth, diffuser performance, static head and dynamic friction losses shall be taken into consideration.

The blowers shall operate fully automatically based on a preset oxygen value and directly based on the air pressure in the main air pipe. The blowers shall be autonomous and locally controlled. The set point for the oxygen concentration in the aerobic zones shall be controlled by the SCADA system which shall also monitor the operation of the blowers.

The discharge pressure of the blower station shall be measured by an electronic pressure transmitter. The measuring signal is used as process value for the air pressure regulation on the main air pipe of the activated sludge treatment. The internal setpoint of the pressure regulation will be adjusted by the operator at the SCADA system in the control room.

The control value acts via fieldbus connection directly to the blower control. These blower control units will control the optimum number of blowers operated as well as the optimal duty point of each blower.

The pressure regulation can also be operated with an external setpoint. In this case the pressure setpoint on the main air pipe depends on the current air consumption of the activated sludge tanks.

If the air consumption is high, the air pressure setpoint will be increased until the air regulation valves are nearly open.

If the air consumption is decreasing, the air regulation valves are working in close-direction. In this case the pressure setpoint will be decreased and then the air regulation valves are working in open-direction to minimise the pressure losses in the air regulation valves.

The external mode of the pressure regulation will be adjusted by the operator via the SCADA system in the control room.

The aeration pipework shall be made from stainless steel 316L and shall be designed with a general slope of 1 % towards condensate traps with drains, installed at the deepest level of the pipe system.

The blower building shall comprise two sections for the installation of the blowers for the activated sludge tanks with appertaining equipment and local control panels and the local power sub-distribution and control room.

The blower room shall be designed in such a way that it fulfils the requirements for noise control and working security. Therefore each blower shall be provided with a sound protection

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hood. Access to blowers and components (such as valves and local control panels) shall be secured and unhindered. The blower room shall be provided with an overhead crane for installation and service requirements. With regard to the waste heat production of the blowers sufficient ventilation – as well as natural lighting - shall be provided.

Low-tension power supply and operation control of the secondary treatment facilities shall be arranged in a separate control room located in the blower building. It shall have sufficient size for installation of the required number of control cabinets for the individual electric drives, feeder and measuring cabinets of the local sub-distribution as well as control boards for PLC and measuring instruments. The local PLC shall be interlocked with the main operation control of the plant. It shall have sufficient natural lighting and ventilation with access from the blower room and from outside.

B.6.5.3. Final Sedimentation Tanks

The effluent of the biological treatment lanes shall be combined and transferred to the distribution chamber upstream of the final sedimentation tanks. The distribution chamber shall be conceived as concrete building in monolithic design with influent chamber and peripheral effluent outlet. Inspection manholes, access ladders and service platforms and coverings shall be provided.

The mixture of biologically treated wastewater and mixed liquor suspended solids (MLSS) shall be feed into the influent compartment of the distribution chamber. Manually adjustable overflow weirs with complete overflow shall be provided at the effluent compartments for flow distribution into the individual final sedimentation tanks. Motorised valves shall be installed in the outflows of the effluent compartments in order to set individual final sedimentation tanks out of operation.

Four circular final sedimentation tanks shall be provided, designed to cope with the loads at the horizon 2035 and the ultimate design horizon 2045. From the distribution chamber, the mixture of biologically treated wastewater and mixed liquor suspended solids shall gravitate to the four final sedimentation tanks where it shall be evenly distributed into the horizontal-flow sedimentation zones of each tank.

Design Criteria

The design of the sedimentation tanks shall comply with following design criteria.

Design Horizon	Unit	2023	2035	2045
Type of final sedimentation tank	-		circular	
Type of sludge removal	-		scraper bridge	
Number of tanks	-		4	
Diameter	m		≥ 42	
Design Criteria				
Thickening time at secondary clarification	h		≤ 2,5	
Sludge volume loading rate (q_{sv})	l/m ² /h		≤ 500	

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Design Horizon	Unit	2023	2035	2045
Surface overflow rate (q_A)	m/h		$\leq 1,3$	
Depth of tank at 2/3 radius	m		$\geq 4,0$	
Return sludge ratio at $Q_{WW,p}$	-		1	
Return sludge dilution factor bottom sludge (f_{BS})	-		$\leq 0,75$	
SS activated sludge tank concentration (SS_{AT})	kg SS/m ³		$\leq 3,3$	
Weir load at $Q_{WW,p}$	m ³ /m/h		≤ 6	

The sedimentation tanks shall be provided with circular scraper bridges with scraper system for bottom sludge removal and scum removal system. All submersed parts shall be made from stainless steel 316L. Bottom sludge shall be continuously removed by a scraper blade with a logarithmic spiral shape. The scraper mechanism shall be designed as dragged scraper blades with lifting gear. The scum removal system comprises skimming troughs with manually operated scum discharge flaps, one of them with integrated pump sump. Floating materials and scum will be conducted to the pump sump and from there pumped by a submersible pump through the central bearing into the scum discharge pipe. Furthermore the scraper bridges shall be provided with antifoam facilities comprising a spraying mechanism with pressurized service water supply, distribution pipework with spray nozzles, which shall be assembled under the scraper bridge.

Clear water discharge shall be achieved via peripheral effluent channels with V-notched overflow weirs at both wall crests (double weir) and a scum baffle at the inner circle, both made from stainless steel 316L.

The scraper blades and scum removal system are to be assembled at the travelling service bridges. A return and excess sludge pumping station shall be built close to the final sedimentation tanks. Continuous sludge withdrawal from the sludge hoppers into the pump sump takes place by hydrostatic pressure.

Operation control of the travelling scraper bridge shall be realized as PLC control, installed in a local switchboard, which is assembled onto the bridge, with power supply via a central slip ring.

The effluent system of the final sedimentation tanks shall be hydraulically uncoupled from the downstream units.

B.6.5.4. Return and Excess Sludge Pumping Station

The sludge from the final sedimentation tanks shall be continuously withdrawn by gravity to a common return sludge and excess sludge pumping station with dividing wall, equipped with submersible pumps for return and excess sludge. Each secondary settlement tank shall have a separate evacuation pipe to the sludge pumping station, isolated by automatically operated valves. Each sludge evacuation pipe shall be equipped with inductive flow measurement with

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remote control and transmission to the central operation control of the plant for process supervision.

Return sludge shall be pumped by axial flow pumps or frequency controlled low rotation speed submersible pumps (3+1) from the return sludge chamber of the pumping station to the individual biological treatment lanes through pressure pipes equipped with inductive flow measurement with remote control and transmission to the central operation control of the plant for process supervision. Operation control of the return sludge pumps shall be initiated flow-proportional to the influent wastewater flow. Excess sludge conveyance from the final sedimentation tanks shall be time controlled, in accordance to the MLSS content in the AST's, which shall be determined by day-to-day laboratory analysis. The sludge level in the pumping station shall be controlled by ultrasonic level measurement. Excess sludge shall be pumped by submersible pumps (1+1) discontinuously to the excess sludge storage tank. The excess sludge flow shall be measured by inductive flow meter with transmission to the central operation control of the plant for process supervision.

Design Criteria

The return and excess sludge pumping station shall comply with following design criteria.

Return and Excess Sludge Pumping Station	Unit	2023 - 2045
Return Sludge Pumping Station		
Return sludge ratio at $Q_{WW,p}$	-	1
Dry solid concentration return sludge	%	< 0,8
Number of pumps	-	≥ 3 + 1
Type of pumps	-	submersible
Excess sludge pumping station		
Specific excess sludge production	g DS/PE/d	35 - 40
Dry solid concentration excess sludge	%	< 0,8
Excess sludge withdrawal time	h/d	12
Peak factor	-	1,2
Number of pumps	-	≥ 1 + 1
Type of pumps	-	submersible

Low-tension power supply and operation control shall be arranged in the adjacent blower building. Remote signals of all relevant data as well as of operation signals (manual / auto / failure) of all main electric drives shall be stored and transmitted into the PLC-control-system. The local PLC shall be interlocked with the main operation control of the plant.

B.6.5.5. Chemical Phosphorus Precipitation Unit

Due to seasonal variations in load and temperature the biological phosphorus removal efficiency may not be enough to achieve the effluent standard for total phosphorus. For such

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cases additional phosphorus removal will be achieved by simultaneous chemical precipitation. Dosing points for precipitant (FeCl_3) shall be at the distribution chamber upstream of the primary settling tanks and at the aeration tanks. Enhanced biological phosphorus removal (Bio-P) shall not be taken into account for dimensioning of the precipitation facilities.

Design Criteria

The design of the chemical phosphorus precipitation unit shall comply with following design criteria.

Design Horizon		2045
Phosphorus concentration in the effluent ($C_{\text{TP,e}}$)	mg/l	< 1
Maximum amount of phosphorus to be precipitated ($L_{\text{P,prec,max}}$)	kg/d	270
Precipitant	-	FeCl_3 (40%)
Specific consumption of FeCl_3 (100%)	kg FeCl_3 /kg P_{prec}	7,8
Type of dosing pumps	-	membrane
Number of dosing pumps		$\geq 3 + 1$
Storage capacity FeCl_3 (40%)	d	≥ 30

The dosing of precipitant shall be measured by inductive flow meters. The resulting extra sludge quantities from phosphorus precipitation shall be considered in the design calculations for the biological process and for the sludge treatment facilities. Two (1 + 1) additional membrane dosing pumps shall be foreseen for dosing to the raw sludge mixing tank in order to limit H_2S formation in the digesters..

B.6.6. Tertiary Wastewater Treatment and Effluent Monitoring

B.6.6.1. Disc Filtration Units

For reduction of turbidity and suspended solids prior to UV disinfection, disc filters with a mesh aperture of 10 - 20 μm shall be applied. The disc filter station shall be designed for dry weather peak flow conditions (3.200 m^3/h). Excess amounts of effluent flow shall be bypassed and directly discharged into the receiving water without disinfection.

The disc filter station shall comprise of a minimum of 4 disc filter units (3 + 1). The facility shall be designed to treat the dry weather hourly peak flow of 3.200 m^3/h with the duty filter units and comply with the requirements stipulated in below table.

Design Criteria

The disc filtration units shall comply with following design criteria.

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Disc Filtration	Unit	Value
Maximum flow ($Q_{DW,p}$)	m ³ /h	3.200
Type of disc filters	-	rotary
Mesh size	μm	10 - 20
Design filtration rate	m/h	≤ 7
Suspended solids in filtrate	mg/l	≤ 10
Number of filter units (duty)	-	≥ 2
Number of filter units (stand-by)	-	≥ 1

Even distribution of the wastewater to the individual disc filter units in operation shall be controlled by adjustable weirs at the outlet of each unit. The effluent of the disc filter units shall be combined in a common effluent channel. The disc filter station shall be equipped with a by-pass allowing secondary effluent to be transferred towards UV-disinfection or direct discharge to the receiving water if required.

Backwash of the disc filters shall be continuous and shall be controlled by an automatic level control system. Each disc filter chamber shall be equipped with its own backwash pump using treated effluent water. Backwashing shall be continuous during operation of the disc filters and will not interrupt the process. The backwash water shall be collected in a central backwash water channel from where it shall gravitate to the adjacent backwash water pumping station. From there the backwash water shall be pumped either to the distribution chamber upstream of the primary sedimentation tanks or the one upstream of the biological treatment units. The pumping station shall be equipped with a set of two (1 + 1) submersible pumps.

B.6.6.2. UV-Disinfection

Prior to discharge to the receiving water the effluent shall be disinfected by UV. The UV-disinfection system shall be designed for installation in a gravity flow effluent channel to treat the total maximum effluent flow under dry weather conditions.

The system shall comprise a minimum of two banks of UV lamps per channel. The lamp module frame shall be made of type 316L stainless steel. The ultraviolet disinfection unit shall utilize low or medium pressure mercury germicidal lamps of instant start, Each lamp shall produce ultraviolet light with at least 90 % of the emission within the wavelengths of 253,7 nm.

Design Criteria

The UV disinfection shall comply with following design criteria.

Design Horizon	2023 - 2045	
Max flow dry weather $Q_{DW,p}$	m ³ /h	3.200
Total suspended solids	mg/l	≤ 10
UV Transmittance	%	≥ 60

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Design Horizon		2023 - 2045
Type of UV system	-	open channel
Number of channels	-	1
Number of UV banks per channel	-	2
Design Criteria		
Radiation dose	J/m ²	≥ 300
Emission at wavelength 253.7 nm	%	≥ 90
Faecal coliform effluent	CFU/100 ml	≤ 100
Total coliform	CFU/100 ml	≤ 500
Faecal streptococci	CFU/100 ml	≤ 50

Each bank shall be equipped with minimum one UV sensor. High and low water level in the channel shall be controlled by level sensors.

A stainless steel outlet baffle or weir shall be installed to control the water level so the UV lamps are submerged in the effluent irrespective of the flow rate. The UV banks shall be equipped with automatic mechanical / chemical cleaning systems and automatic raising systems.

The Contractor shall supply and install all accessories required to achieve the above mentioned conditions.

B.6.7. Effluent Monitoring

The flow shall be measured continuously by an inductive or ultrasonic full pipe flow measurement device. For laboratory analysis and monitoring of the quality of the effluent an automatic refrigerated sampler comprising a closed cubicle for installation of 12 sample bottles with automatic probe pump, probe distribution in order to complete composite samples, incl. sufficient frost protection and ventilation, shall be installed near to the flow measuring device.

Online monitoring instruments for continuous measurement of following parameters on the treated effluent shall be provided:

- Temperature;
- Turbidity;
- Conductivity;
- pH;
- ammonium (NH₄);
- nitrates (NO₃).

All signals shall be transmitted to the main operation control centre of the plant.

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B.6.8. Bypass

A by-pass pipe shall be installed inside of the area reserved for the construction of the WWTP. It shall connect the inlet chamber (general by-pass) and also allow for the discharge of the totality or part of the partially treated effluent:

- downstream of the grit and grease removal units (discharge of pre-treated effluent);
- downstream of the primary decantation (discharge of pre-decanted effluent), and
- downstream of the secondary clarifier (by-pass of the tertiary treatment).

The by pass pipe shall be a DN 1300 mm GRP pipe with a minimum slope of 1,5 ‰.

Raw wastewater discharged from the general by-pass or partially treated wastewater discharged downstream of the pre-treatment or downstream of the primary decantation shall not be transferred to the hydro-power plant (SHPP) but discharged to the River Moraca. Biologically treated effluent downstream of the secondary clarifier shall be transferred to the hydro-power plant in normal operation conditions of the plant.

In addition to the above, the plant shall be provided with following internal by-pass possibilities:

- Bypass of fine screens to grit and grease removal;
- Bypass of primary sedimentation tanks to biological treatment;
- Bypass of disc filters to UV-disinfection;

B.6.9. Odour Control

The principal odour sources shall be housed and the foul air mechanically transferred to the odour control plant via a forced air ventilation system. The odorous air extracted shall be treated by humidified biofilter with humus as filter medium. In order to avoid long piping routes for transport of extracted air and related cost (CAPEX & OPEX), the biofilter shall be located adjacent to the inlet and fine screen building. The capacity of the biofilter shall be sufficient to enable the treatment of extracted odorous air from the relevant units of the WWTP.

The minimum air exchange rates shall be as indicated in Section B.5.11. The Contractor may propose higher air exchange rates.

In order to avoid corrosion of concrete and metal parts, areas without normal access shall also be ventilated furthermore the concrete used for such areas shall be resistant to H₂S.

Odour control equipment suitably sized for the process requirements shall include the following features:

- The odour control plant shall be covered in order to protect the filter material from rain and sunlight. Furthermore sprinkler utilities shall be foreseen to avoid a dry-out of the filter material during summer season.

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- Hoods and covers to contain odours shall be installed at the odour source along with adequately supported ducting to convey the odorous air to the treatment units. .
- Access and measurement points shall be included in hoods and ducting. Quick release catches are to be fitted to the covers and hoods which shall be lift able by one person without the use of crane wherever possible.
- Ducting systems shall include provision for flow balancing on multi-extraction source systems and shall incorporate condensate traps fitted with accessible manual drain valves. Ducting shall be routed above ground level.
- Odour extraction fans shall be of the axial or centrifugal type suitable for use in zone 1 hazardous area. The fan rating shall be adequate to extract from all parts of the odour controlled space via the system ducting.
- The Contractor shall design the odour control plant to treat the foul air to a quality that will allow the permitted odour concentrations at the site boundary to be met.

A maximum surface load of $150 \text{ m}^3/\text{m}^2 \cdot \text{h}$ for biological odour control plant shall be fulfilled. The Contractor is expected to carry out an odour survey of the site and modelling of the odour emissions prior to the detailed design of the odour control plant. For odour control, all potential emission zones shall be sufficiently ventilated. Tanks shall be covered and machines and equipment shall be enclosed and foul air mechanically extracted.

B.7. SEWAGE SLUDGE TREATMENT PLANT PARTICULAR DESIGN REQUIREMENTS

B.7.1. Sludge Storage and Mechanical Thickening

B.7.1.1. Primary Sludge Storage Tank

Primary sludge shall be collected in storage tanks acting as buffer capacity prior to the mechanical thickening. The capacity of the primary sludge storage tank shall be dimensioned to cope with 8 h/d primary sludge extraction from the primary sedimentation tanks and considering the capacity of sludge processing in the thickening units. Before entering the storage tank, the sludge shall pass a sludge screen where coarse and fibre materials are removed from the sludge to protect aggregates like pumps, mixers and centrifuges against clogging and damage. The tank shall be equipped with high speed submersible mixers for homogenization.

Design Criteria

The primary sludge storage tank shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific primary sludge production	g DS/PE/d	≈ 50
DS concentration primary sludge	%	2 - 4
Primary sludge withdrawal time t_w	h/d	8,0
Number of tanks n	-	≥ 1
Number of high speed mixers per tank	-	≥ 2 + 0

Alternatively the primary sludge tank may be designed as static pre-thickener. In this case the tank(s) shall be equipped with a fence thickener or scraper.

With regard to possible emissions of methane the classification of the tank as Ex-zone Ex1 shall be considered. The tank shall be completely covered, equipped with air extraction system, connected to the odorous air treatment system, to prevent emission of odours and equipped with ultrasonic level measurements.

B.7.1.2. Mechanical Thickening of Primary Sludge

Primary sludge shall be thickened from 2-4 % to 6-7 % dry solid content by centrifuges. Minimum two (1 + 1) centrifuges shall be installed, each with the capacity to cope with the maximum primary sludge production at the design horizon 2045. Primary sludge from the storage tank shall be pumped to the centrifuges by frequency controlled eccentric screw pumps. Two macerators (1 duty + one stand-by) shall be foreseen between the primary sludge pumping station and the thickening centrifuges to shred coarse and fibrous material potentially

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contained in the primary sludge. Each centrifuge feeding pipe shall be provided with inductive flow measurement devices for continuous sludge flow measurement with registration, remote transmission and operation control of the sludge thickening process.

For conditioning of the sludge, polymer shall be used as required. The polymer shall be prepared in a polymer preparation unit for use of either liquid or granular polymer. The polymer shall be dissolved by intensive mixing and then matured in two separate maturation tanks, which shall serve alternately as dosing tank. The polymer shall be dosed by frequency controlled eccentric screw pumps into the feeding pipe of the centrifuges.

Design Criteria

Mechanical thickening of primary sludge shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific primary sludge production	g DS/PE/d	≈ 50
Dry solid content	%	2 - 4
Thickening system	-	centrifuge
Number of thickeners	-	≥ 1 + 1
Type of feed pumps	-	eccentric screw
Number of feed pumps	-	≥ 1 + 1
Operation time weekly	d/w	7
Operation time daily	h/d	24
Polymer dosing concentration	%	0,1
Design Criteria		
Dry solid content thickened sludge	%	≥ 6
Capture of solids	%	≥ 95
Specific polymer consumption	g/kg DS	≤ 2
Specific energy consumption	kWh/m ³ primary sludge	≤ 0,65

Gravity thickening of primary sludge can be proposed as technical alternative solution to mechanical thickening.

Thickened primary sludge shall be pumped by eccentric screw pumps to the thickened raw sludge mixing tank.

Reject water shall be collected in the reject water pumping station and shall be returned either to the distribution chamber upstream of the primary clarifiers or upstream of the activated sludge tanks.

The primary sludge thickening facilities shall be located in the sludge treatment building that shall consider two sections for the installation of the machinery with appertaining equipment and local control panels, and the local power sub-distribution and control room. The operation

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room shall be designed in such a way that all requirements for noise / odour control and working security are fulfilled. Access to the machines, pumps and components (such as valves and local control panels) shall be secured and unhindered. The operation room shall be provided with a crane hoist for installation and service requirements. With regard to the humid environment in the operation room sufficient heating, ventilation and natural lighting shall be provided.

Low-tension power supply and operation control of the sludge thickening facilities shall be arranged in a separate control room in the sludge processing building. It shall have sufficient size for installation of the required number of control cabinets for the individual electric drives, feeder and measuring cabinets of the local sub-distribution as well as control boards for PLC and measuring instruments. The local PLC shall be interlocked with the main operation control of the plant. It shall have sufficient natural lighting and ventilation with access from outside only.

B.7.1.3. Excess Sludge Storage Tank

The excess sludge storage tank(s) shall be dimensioned for maximum 12 h/d excess sludge extraction from the final sedimentation tanks under excess sludge peak flow conditions, unfavourable settlement characteristics of the sludge (SVI = 180 l/kg) at maximum load conditions 2023 and shall be equipped with high speed submersible mixers for homogenization. For dimensioning of the required volume(s) the capacity of sludge processing in the thickening units shall be considered.

Design Criteria

The excess sludge storage tank shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific excess sludge production	g DS/PE/d	35 - 40
Dry solid concentration excess sludge	%	< 0,8
Excess sludge withdrawal time t_w	h/d	12
Number of tanks n	-	≥ 1
Number of high speed mixers per tank	-	$\geq 2+0$

The tank(s) shall be completely covered, equipped with air extraction system, connected to the odorous air treatment system, to prevent emission of odours, and equipped with ultrasonic level measurements.

B.7.1.4. Mechanical Thickening of Excess Sludge

Excess sludge shall be thickened from $\approx 0,7\%$ to 6% dry solid content by centrifuges. Minimum two (1 + 1) centrifuges shall be installed, each with the capacity to cope with the maximum excess sludge production at the design horizon 2045 under favourable settlement

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characteristics of the excess sludge ($SVI \leq 120$ l/kg). Under temporarily unfavourable settlement characteristics of the excess sludge ($SVI \geq 150$ l/kg) the stand-by unit of the centrifuges may be operated.

Excess sludge from the storage tank shall be pumped to the centrifuges by frequency controlled eccentric screw pumps. Two macerators (1 duty + one stand-by) shall be foreseen between the excess sludge pumping station and the thickening centrifuges to shred coarse and fibrous material potentially contained in the excess sludge. Each centrifuge feeding pipe shall be equipped with inductive flow measurement devices for continuous sludge flow measurement with registration, remote transmission and operation control of the sludge thickening process.

For conditioning of the sludge, polymer shall be used. The polymer shall be prepared in a separate polymer preparation unit for use of either liquid or granular polymer. The polymer shall be dissolved by intensive mixing and then matured in two separate maturation tanks, which shall serve alternately as dosing tank. The polymer shall be dosed by frequency controlled eccentric screw pumps into the feeding pipe of the centrifuges. The criteria for dimensioning of the primary sludge thickening are specified in the following table.

Design Criteria

Mechanical thickening of excess sludge shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific excess sludge production	g DS/PE/d	35 - 40
Sludge volume index SVI	l/kg	120
Dry solid content	%	< 0,8
Thickening system	-	centrifuge
Number of thickeners	-	$\geq 1 + 1$
Type of feed pumps	-	eccentric screw
Number of feed pumps	-	$\geq 1 + 1$
Operation time weekly	d/w	7
Operation time daily	h/d	24
Polymer dosing concentration	%	0,1
Design Criteria		
Dry solid content thickened sludge	%	≥ 6
Capture of solids	%	≥ 95
Specific polymer consumption	g/kg DS	≤ 4
Specific energy consumption	kWh/m ³ excess sludge	$\leq 0,65$

The thickened excess sludge shall be pumped by eccentric screw pumps to the thickened raw sludge mixing tank. Reject water shall be collected in the reject water pumping station and shall be returned either to the distribution chamber upstream of the primary clarifiers or upstream of the activated sludge tanks.

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The excess sludge thickening facilities shall be located in the sludge treatment building that shall consider two sections for the installation of the machinery with amended equipment and local control panels, and the local power sub-distribution and control room. The operation room shall be designed in such a way that all requirements for noise / odour control and working security are fulfilled. Access to the machines, pumps and components (such as valves and local control panels) shall be secured and unhindered. The operation room shall be provided with a crane hoist for installation and service requirements. With regard to the humid environment in the operation room sufficient heating and ventilation, as well as natural lighting, shall be provided.

Low-tension power supply and operation control of the sludge thickening facilities shall be arranged in a separate control room in the sludge processing building. It shall have sufficient size for installation of the required number of control cabinets for the individual electric drives, feeder and measuring cabinets of the local sub-distribution as well as control boards for PLC and measuring instruments. The local PLC shall be interlocked with the main operation control of the plant. It shall have sufficient natural lighting and ventilation with access from outside, only.

B.7.1.5. Raw Sludge Mixing Tank

In order to equalize and to homogenize the feed of the anaerobic digester a raw sludge buffer and mixing tank, equipped with submersible mixers, shall be provided at the sludge treatment building. It shall have a minimum volume of 110 m³, appropriate for 8 hours of storage time.

Design Criteria

The raw sludge mixing tank shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific daily raw sludge amount	g DS/PE/d	≈ 85
Dry solid content	%	≥ 6
Minimum required storage time	h	8,0
Number of tanks	-	1
Number of high speed mixers	-	≥ 2 + 0

With regard to possible emissions of methane the classification of the tank as Ex-zone Ex1 shall be considered. The tank shall be completely covered, equipped with air extraction system, connected to the odorous air treatment system, to prevent emission of odours, and equipped with ultrasonic level measurements.

The raw sludge shall be pumped by three (2 + 1) eccentric screw pumps either continuously or semi-continuously into the digesters while heat exchangers shall heat the raw sludge up to 37 °C before it enters into the digesters.

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B.7.1.6. Reject Water Pumping Station

Reject water from sludge thickening and various sources of the sludge treatment shall be drained into one common pump sump and shall be piped back either into the distribution chamber of the primary sedimentation tanks or into the distribution chamber of the activated sludge tanks. With regard on the high loads (particularly ammonia) of the supernatant of the sludge dewatering the supernatant shall be collected in a separate buffer tank.

The reject water pumping station shall be equipped with at least 1 + 1 submersible pumps. It shall be conceived as circular or rectangular concrete building in monolithic design with concrete ceiling. Inspection manholes, access ladder and service platform with lifting devices shall be provided, accordingly. Individual pressure pipes or a main header, including all necessary armatures and fittings, shall be installed for reject water conveyance into the distribution chamber.

Design Criteria

The reject water pumping station shall comply with following design criteria.

Design Horizon	Unit	2035 - 2045
Specific reject water quantity	l/PE/d	≈ 6
Minimum required storage time	h	1,0
Number of high speed mixers	-	≥ 1
Reject water withdrawal time	h	≤ 1
Peak factor	-	1,3
Type of pumps	-	submersible
Number of pumps in duty	-	≥ 1 + 1

With regard to possible odour emissions and the Ex-environment, sufficient ventilation of the pump sump shall be provided.

Operation control and power supply of the facilities shall be included in the scope of works for Mechanical Sludge Dewatering.

B.7.2. Anaerobic Digester

Raw sludge shall be anaerobically digested in two parallel operated digesters, where organic dry solids of the sludge shall partially be converted into methane. The anaerobic process used for the treatment of sludge shall be mesophilic, fully mixed digestion where the sludge is heated to 35-37 °C. To create optimum process conditions for the methane bacteria in the digesters, effective mixing has to be assured. Mixing shall be performed by gas injection through gas compressors and gas injection lances in order to avoid moving mechanical installations in the digesters and to ensure complete mixing of the sludge to be digested.

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Mixing by gas injection also prevents sedimentation of sludge at the bottom of the digesters and floating sludge layers.

Design Criteria

Digesters shall comply with following design criteria.

Design Horizon		2023 - 2045
Process design temperature	°C	35 -37
Specific daily raw sludge amount	g DS/PE/d	80 - 85
Total dry solid content raw sludge	%	≥ 6
Percentage organic/total dry solids	%	68 -72
Specific biogas production per oDS _{red}	Nm ³ /kg oDS _{red}	≈ 0,92
Ambient temperature	°C	-10 ... + 40
Raw sludge temperature	°C	12 - 20
Number of digesters	-	2
Effective volume per digester	m ³	4.000
Type of digester mixing	-	gas injection
Number of compressors	-	≥ 1 + 1
Type of digester feed pumps	-	eccentric screw
Number of digester feed pumps	-	≥ 2 + 1
Type of feed heat exchangers	-	tube in tube
Number of feed heat exchangers	-	≥ 2
Type of digester recirculation pumps	-	dry installed centrifugal pumps with N-type impeller
Number of digester recirculation pumps	-	≥ 2 + 1
Type of recirculation heat exchangers	-	tube in tube
Number of recirculation heat exchangers	-	≥ 2
Design Criteria		
Heat transfer coefficient of digester isolation	W/m ² /k	≤ 1
Specific energy input for digester mixing	Wh/m ³ /d	≥ 24
Daily mixing time per digester	h/d	6 - 12
Sludge recirculation per digester	m ³ /h	≥ 100
Heat transfer capacity heat exchangers raw sludge heating	kW	≥ 400
Heat transfer capacity recirculation heating	kW	≥ 100

The digesters shall have a volume for sludge digestion of minimum 4.000 m³ each and shall either be built as concrete structure or as steel structure with segmented glass-enamelled steel plates and stainless steel roof on concrete foundation. The enamel quality on the steel plates in the gas exchange zone shall comply with the Trifusionemail© quality standard, the

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enamel quality in the liquid area with the Isofusionemail® quality standard. In case of steel structure of the digesters the stainless steel roof, consisting of stainless steel sheets, shall be designed for fermenter operation, as self-supporting construction, including gas dome and foam fighting installations.

The digesters shall be fully insulated and provided with a walkway of self-supporting construction, with non-skid grates made of hot galvanized steel and railings. The central digester service building located adjacent to the digesters shall house a lift and staircase up to the level of the digester roofs. They shall also be provided with a spiral stair, consisting of complete ladder sets with tubular steps and one-sided hand rail.

Heating of the digester shall be accomplished by recirculating sludge from the digester through heat exchangers by dry installed recirculation pumps.

The digesters shall be provided with independent installations, i.e. each digester shall have one separate heat exchanger, minimum of one duty pump and one common standby pump for the recirculation, separate feeding, recirculation and discharge pipework. The pipework shall be connected in such a way that crosswise operation is possible.

The digester feeding system shall include heat exchangers and feeding pipes up to the digesters head. The recirculation system shall comprise of the digested sludge suction pipework which enables withdrawal of digested sludge from at least three different zones, recirculation pumps with pressure pipe to the heat exchangers. The recirculation suction and pressure pipes shall be provided with temperature measurement. Furthermore one pH-value measurement device shall be provided for each digester recirculation system. All instruments shall be with registration and remote transmission for operation control of the digestion process.

Internal piping of the digester shall comprise suction and pressure pipework for connection of the recirculation and feeding system as well as the interior standpipe and sludge discharge pipe, and the exterior sludge and scum downpipe. The digesters shall be provided with sufficient scum discharge device. Supernatant shall be fully mixed with the sludge and shall not be withdrawn.

The digester mixing system shall be designed in accordance to the design of the digester. It shall be designed in such a way that sedimentation of sludge can be avoided permanently. Mixing by gas injection shall be applied assuring a minimum energy input for mixing of 24 Wh/m³/d. Mixing by external pumps will not be accepted.

The heat exchangers for sludge heating shall be hot water “counter flow tube in tube type” heat exchangers that shall be supplied with heat water from a central hot water boiler plant (mainly during start-up) and from the CHP units which shall be used for primary heat production. A boiler plant shall be provided as supplementary heat producer and shall be dimensioned in accordance to the total heat requirement of the WWTP (administration and operation buildings) and sludge treatment facilities under consideration of the local climatic

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conditions and regulations. The CHP units and the boiler plant shall supply one common distributor to which all consumers shall be connected. Operation control of the heating system shall be temperature and pressure controlled.

Materials and equipment shall comply with the overall design requirements of this Tender Dossier. All automated valves shall be provided with pneumatic drives or Ex-proof actuators, only.

Access ladders and service platforms with lifting devices for heavy equipment and coverings shall be provided accordingly. The digesters shall be provided with inspection manholes for assembling in the digester tank wall at the lower third of the cylindrical part of the digesters.

The sludge digestion plant shall include the digesters periphery. The machinery shall be installed in the adjacent digester service building or in the sludge thickening building which also includes the central power supply and operation control of the sludge digestion plant. The operation control shall furthermore be interlocked with the WWTP process control (main control centre).

All operation rooms shall be designed in such a way that all the requirements for noise / odour control and working security will be fulfilled. Access to the machines, pumps and components (such as valves and local control panels) shall be secured and unhindered. The operation rooms shall be provided with lifting devices for installation and service requirements, where required. With regard to the humid environment in the operation room sufficient heating and ventilation, as well as natural lighting, shall be provided.

Low-tension power supply and operation control of the digestion plant shall be arranged in a separate control room. It shall have sufficient size for installation of the required number of control cabinets for the individual electric drives, feeder and measuring cabinets of the local sub-distribution as well as control boards for PLC and measuring instruments. The local PLC shall be interlocked with the main operation control of the plant. It shall have sufficient natural lighting and ventilation with access from outside only.

Digested sludge shall be fed by gravity to the digested sludge storage tanks. The produced biogas shall be utilized for heat and power generation.

B.7.3. Digested Sludge Storage and Mechanical Dewatering

B.7.3.1. Digested Sludge Storage

Digested sludge shall be conveyed by gravity from the digesters to minimum two digested sludge storage tanks. Each tank shall have a storage capacity of 500 m³ to provide a total storage capacity for digested sludge of 3 days, in order to comply with working hours requirements (2 shifts, 16 h/d, 5 d/week). The tanks shall be equipped with submersible mixers, completely covered, equipped with air extraction system, connected to the odorous air treatment system, to prevent emission of odours and equipped with ultrasonic level measurements.

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Design Criteria

The digested sludge storage shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific daily digested sludge amount	g DS/PE/d	≈ 55
Dry solid content of digested sludge	%	3,5 - 4
Minimum required storage time	d	≥ 3
Number of tanks	-	≥ 2
Volume per tank	m ³	≥ 500
Number of high speed mixers per tank	-	≥ 2

B.7.3.2. Mechanical Dewatering of Digested Sludge

Digested sludge shall be dewatered by centrifuges. Two (1 + 1) centrifuges shall be installed, each with a capacity to cope with the maximum digested sludge production at the design horizon 2045.

Design Criteria

The following design criteria shall be considered.

Design Horizon	Unit	2023 - 2045
Specific daily digested sludge amount	g DS/PE/d	≈ 55
Dry solid content	%	3,5 - 4
Thickening system	-	centrifuge
Number of thickeners	-	1 + 1
Type of feed pumps	-	eccentric screw
Number of feed pumps	-	≥ 1 + 1
Operation time weekly	d/w	5
Operation time daily	h/d	16
Polymer dosing concentration	%	0,1
Design Criteria		
Dry solid content dewatered sludge	%	≥ 25
Capture of solids	%	≥ 98
Specific polymer consumption	g/kg DS	≤ 8
Specific energy consumption	kWh/m ³ digested sludge	≤ 1,2

The centrifuges shall be installed in the incineration building on the level above the bunker in such a way that all requirements for noise / odour control and working security are fulfilled. Access to the machines, pumps and components (such as valves and local control panels) shall be secured and unhindered. A crane hoist for installation and service requirements shall

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be provided. With regard to the humid environment in the operation room, sufficient heating and ventilation, as well as natural lighting, shall be provided.

Digested sludge shall be pumped from the storage tanks to the centrifuges by frequency controlled eccentric screw pumps. Two macerators (1 duty + one stand-by) shall be foreseen between the digested sludge pumping station and the dewatering centrifuges to shred coarse and fibrous material potentially contained in the digested sludge. Each centrifuge feeding pipe shall be equipped with inductive flow measurement devices for continuous sludge flow measurement with registration, remote transmission and operation control of the sludge thickening process.

The dewatering centrifuges shall be operated and controlled from the central control room of the waste water treatment plant, completely independent of the incineration plant.

For conditioning of the sludge, polymer shall be used. The polymer shall be prepared in a polymer preparation unit, solely used for sludge dewatering purpose, for use of granular polymer, which shall be located in the sludge processing building. The polymer shall be dissolved by intensive mixing and then matured in two separate maturation tanks, which shall serve alternately as dosing tank. The polymer shall be dosed by frequency controlled eccentric screw pumps into the feeding pipe of the centrifuges.

Dewatered sludge shall be conveyed by shaftless screw conveyors to one common screw conveyor for both centrifuges. The common screw conveyor shall convey the dewatered sludge to the sludge bunker.

Supernatant shall be collected in the supernatant tank.

Low-tension power supply and operation control of the sludge dewatering facilities shall be arranged in the control room in the sludge processing building. It shall have sufficient size for installation of the required number of control cabinets for the individual electric drives, feeder and measuring cabinets of the local sub-distribution as well as control boards for PLC and measuring instruments. The local PLC shall be interlocked with the main operation control of the plant. It shall have sufficient natural lighting and ventilation with access from outside only.

B.7.3.3. Supernatant Storage Tank

The supernatant from the mechanical dewatering units as well as condensate from the sludge incineration plant shall be conveyed to the supernatant storage tank. Pumps shall transfer the supernatant and condensate to the inlet of the primary sedimentation tanks. The regime of transfer shall be manually scheduled in order to avoid overload of nitrogen in the biological treatment process. The supernatant / condensate shall be preferably fed to the primary sedimentation tanks during high organic loads in the wastewater influent. The supernatant storage tank shall have a minimum storage capacity of 450 m³ (approx. 1 day storage capacity).

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The tank shall be equipped with at least two high speed submersible mixers for homogenization and with at least two (1 + 1) submersible pumps. It shall be conceived as rectangular or circular concrete structure in monolithic design with concrete ceiling. Inspection manholes, access ladder and service platform with lifting devices shall be provided, accordingly. Individual pressure pipes or a main header, including all necessary armatures and fittings, shall be installed for supernatant conveyance into the distribution chamber.

Design Criteria

The design of the supernatant storage tank shall comply with following design criteria.

Design Horizon	Unit	2023 - 2045
Specific daily supernatant amount (working days)	l/PE/d	≈ 2
Supernatant storage time	d	≥ 1
Number of tanks	-	≥ 1
Total storage capacity	m ³	≥ 450
Number of high speed mixers each tank	-	≥ 1
Supernatant withdrawal time	h/d	≤ 12
Peak factor supernatant withdrawal	-	1,5
Capacity of pumping station	m ³ /h	≥ 55
Type of pumps	-	submersible
Number of pumps each tank	-	≥ 1+1

With regard to possible emissions of methane the classification of the tanks as Ex-zone Ex1 shall be considered. The tank shall be completely covered, equipped with air extraction system, connected to the odorous air treatment system, to prevent emission of odours and equipped with ultrasonic level measurements.

B.7.4. Biogas Utilisation

Digester gas (biogas) shall be utilized for combined heat and power production. The facilities for biogas utilization shall comprise of but not be limited to the following process units:

- Digester Gas System;
- Gas Storage Tank and Gas Flare;
- Combined Heat and Power Units (CHP) including boiler plant;
- Power supply and connection to main control centre;
- Related infrastructure connections;
- interconnecting pipework & cabling.

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B.7.4.1. Digester Gas System

The digester gas system shall comprise the suction and connection pipework from the digesters to all apparatus and consumers. For purification the biogas produced in the anaerobic digesters shall be processed in a gravel filter and a ceramic filter. The gravel filter shall remove coarse particles like sludge flocks and foam and the subsequent ceramic filter shall remove ultrafine particles and humidity from the biogas.

Design Horizon	Unit	2023 - 2045
Specific amount of organic dry solids in raw sludge	g oDS/PE/d	≈ 60
Total org DS reduction in digester in percent	%	50 - 52
Specific biogas production per kg oDS reduced	m ³ /kg oDS _{red.}	0,90 – 0,92
Methane content of biogas	Vol %	60 - 65
H ₂ S content of biogas	Vol %	0 - 0.7
Daily biogas production time	h/d	20 - 24

The gas piping system shall consist of gas bleed pipes leading from the gas dome at the digester head into a separate gas filter room where gravel and ceramic fine filters shall be provided for coarse and fine purification and dehumidification of the digester gas.

The gas system shall furthermore comprise of the connection pipework to the gasholder and gas flare as well as to the CHP units and to the boiler plant. The gas system shall be designed as low-pressure system for an operation pressure of ≤ 40 mbar.

The gas discharge and connection pipework shall be designed with a general slope of 1 % towards condensate traps with ex-proof drains, installed at the deepest level of the pipe system. At the gas dome an appropriate, automatic operated foam trap shall be installed in order to prevent the gas system from entering of foam and scum. The gas system must be provided with flame arrestors at the bleed connections and at each individual consumer.

To keep a pressure of approx. 30 – 40 mbar in the gas system depending on the requirements for the CHPs at least 2 + 1 gas blowers shall be provided.

Gas flow meters with metering orifice for continuous measurement of the total gas production shall be installed in the individual gas discharge pipe. The supply lines to the individual consumers (incl. gas flare) shall be equipped with gas flow meters from the positive displacement gas meter (rotary vane) type, for continuous measurement of individual gas consumption. The flow meters are to be provided with temperature compensation for monitoring, summarising and registration of the gas flow, with local display and remote transmission to the digestion plant system control. Pressure and vacuum gauges and indicators shall be supplied as necessary at different locations.

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B.7.4.2. Biogas Holder and Gas Flare

For compensation of biogas flow and flexible utilization of biogas during electrical peak load conditions of the WWTP, the digester gas system shall be provided with at least 1 low pressure biogas holder. The criteria for dimensioning are summarized in the table below.

Design Horizon	Unit	2023 - 2045
Storage time at average biogas production 2035	h	≥ 8
Biogas holding capacity	m ³	≥ 2.000
Type of biogas holders	-	membrane
Number of biogas holders	-	≥ 1
Capacity of gas flare	Nm ³ /h	≥ 300
Number of gas flares	-	1

The gas flare shall be provided for perfect combustion of excess digester gas, in accordance to the filling level of the biogas holder and the requirements of the digester gas utilization plant (CHP). A standard unit, completely made of stainless steel, shall be arranged in shunt connection to the biogas holder.

B.7.4.3. Gas Desulphurization

For desulfurization of the biogas iron chloride (FeCl₃) shall be dosed into the thickened raw sludge collection tank to provide sufficient iron ions to bind Hydrogen Sulfide directly in the digester. The precipitant dosing shall be designed for an average daily digested gas volume production and for a sufficient reduction of hydrogen sulphide to meet the demands of the CHP units.

B.7.4.4. Combined Heat and Power Units (CHP)

The complete combined heat and power plant (CHP) includes an emergency cooler system and a co-heating boiler. The emergency cooler is required in case there is no demand for heat from the digesters or other heat consumers. A co-heating plant is required for the situation where the biogas produced is insufficient to heat the digesters satisfactorily or for start-up of the digesters, and optionally also for heating of selected buildings in the wastewater treatment plant. The co-heat boiler shall be suitable for dual fuel (biogas / fuel oil) and hot water production of 90 °C at nominal capacity. The Combined Heat and Power Units shall be supplied from the low-pressure biogas holder(s). The design criteria for the CHP units and the boiler plant are summarized in the table below.

Design Horizon	Unit	2023 - 2045
Maximum total organic dry solids (raw sludge)	kg oDS/d	14.100
Minimum total organic dry solids (raw sludge)	kg oDS/d	8.700
Total org DS reduction in digester in percent	%	50 - 52

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Design Horizon	Unit	2023 - 2045
Specific biogas production per kg oDS reduced	m ³ /kg oDS _{red.}	0,90 – 0,92
Maximum biogas production	m ³ /d	6.700
Minimum biogas production	m ³ /d	3.900
Methan content of biogas	Vol%	60 - 65
H ₂ S content of biogas	Vol%	0 - 0,7
Total capacity of all CHP units to be provided	kW	≥ 800
Type of CHP units	-	Compact/ containerised
Number of CHP units	-	≥ 2
Capacity of boiler unit for hot water heat production	kW	≥ 700
Number of boiler units	-	1
Capacity of emergency cooler(s)	kW	≥ 900
Design Criteria		
Daily operation time of CHP units	h/d	16 - 24
Annual availability each CHP unit	h/y	8.000
Gas system operation pressure	mbar	< 50
Mechanical efficiency of motor	%	≥ 38
Electrical efficiency of generator	%	≥ 95
Thermal efficiency of CHP units	%	≥ 42

The CHP units shall be of the containerized type to be installed on a suitable concrete foundation slab.

The Contractor is solely responsible for the operational concept of the electric power feeding into the local network of the WWTP.

The capacity of the CHP units shall allow for flexible usage, strategically to be used to cover peak daily consumption or to equally contribute to the power supply over the day. Therefore the capacity of the engines shall allow for the conversion of the calorific energy of daily biogas within 16 – 24 hours.

The gas engines shall comprise compact CHP units with water-cooled, spark-ignition engine with turbocharger and direct coupled three-phase synchronous alternator construction for generating at 0,4 kV mounted on a common base frame.

The CHP units shall be provided with a biogas supply line. They shall be provided with complete heat exchange cabinets, including low temperature heat exchangers for lubricating oil and cooling water, charge cooling, complete exhaust heat exchangers, exhaust pipe with exhaust flaps and bypass of the waste heat exchanger, as well as the pre- and post-exhaust mufflers, measurement, drive and control boxes.

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B.7.5. Odour Control

The principal odour sources of the sewage sludge treatment process shall be covered and ducted to an odour control plant via a forced air ventilation system. The foul air treatment plant shall be of the type of a humidified biofilter with humus as filter medium and shall fully comply with the requirements given in Section B.6.9.

The capacity of the biofilter shall be sufficient to enable the treatment of extracted odorous air from the relevant units of the SSTP.

B.8. SEWAGE SLUDGE INCINERATION PLANT PARTICULAR DESIGN REQUIREMENTS

B.8.1. General Design Criteria

B.8.1.1. Standards and Technical Guidelines

The following essential requirements apply for the Sewage Sludge Incineration Plant (SSIP):

- The design of the SSIP complies with the following national Montenegrin laws:
 - Law on Air Protection (Off. Gazette of MNE, No. 25/10);
 - Decree on Limit Values for Emissions of Air Pollutants from Stationary Sources (Off. Gazette of MNE No. 10/2011);
- The design of the SSIP complies with the following EU directives:
 - 2014/68/EU Pressure Equipment Directive (PED);
 - 2006/42/EC Machinery Directive;
 - 2006/95/EC Low Voltage Directive (LVD).
- The design of the flue gas treatment and the exhaust air system comply with the directive 2010/75/EU of the European Parliament on industrial emissions (IED).
- The thermal oil boiler system and its control system are designed and manufactured according to DIN 4754 Heat Transfer Installations Working with Organic Heat Transfer Fluids.
- The Best Available Techniques Reference Document (BAT / BREF) for waste incineration is not applicable, since the capacity considered does not exceed 3 t/h.

B.8.1.2. General Technical Specifications

Part I of the Employer's Requirements summarizes the technical specifications that are relevant for the construction of the SSIP. The design of the SSIP is primarily based on these *Requirements for Sewage Sludge Incineration Plant* in Part I. In case of contradictions Part I take precedence over Parts F to H of the Employer's Requirements.

B.8.1.3. Main Offer and Options

The Bidder's proposal shall comply with the process and operational concept and design described in Section B.8.2, Section B.8.3, Section B.8.4 and Section B.8.5. Alternative technical concepts may be offered by the bidder where allowed in the Bidding Documents.

Alternative technical concepts must be clearly indicated as such and separated from the base offer. The benefits and effects on the overall concept must be described in detail including PFD, diagrams and construction drawings if applicable.

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If a SSIP concept with flue gas recirculation is submitted as alternative solution, the successful realisation of this technology by the bidder shall be demonstrated based on reference projects.

A concept with a reduction of the cross-section of the furnace by installing extra refractory is allowed only as an alternative offer.

B.8.2. Plant Operation

B.8.2.1. Sludge Production of the SSTP

The sludge amount will increase steadily in the years after the commencement of the operation of the wastewater treatment plant (WWTP). There are three different stages defined:

- 2023: start of operation;
- 2035: intermediate load case;
- 2045: final stage.

The sludge production increases gradually, not stepwise and fluctuates over the day and depending on the season. The expected average sludge production per day of the SSTP is listed in the following table.

Table 9: Sludge Production of the SSTP

Designation	Unit	2023	2035	2045
Annual Sludge Production (Dry Solids)	t _{DS} /y	2.651	3.492	4.373
Daily Sludge Production (Dry Solids)	kg _{DS} /d	7.262	9.568	11.980
Dry Residue (DR)	kg _{DS} /kg	0,25 – 0,28		
Organic Dry Solids (oDS)	kg _{oDS} /kg _{DS}	0,56		
Annual Hours of Operation	h/y	8.760		

The sludge production of the SSTP and the operation of the SSIP are decoupled due to the use of the bunker for dewatered sewage sludge, see Section B.8.4.2.3.

Thus, the bunker allows to define a deviating operating concept for the SSIP. The sludge production of the SSTP has only to be considered additionally for the design of the sludge reception and sludge storage including the crane system.

B.8.2.2. Availability, Operating Period and Maintenance Period

The SSIP is available if either the plant is operated between MINLC (Minimum Load Case) and MAXLC (Maximum Load Case) as required by the Employer or the SSIP is available for operation between MINLC and MAXLC without any restrictions. In both cases, the plant has to comply with the requirements of this specification including the performance and consumption guarantees in Volume 2, Part A. If a standstill period is required by the Employer (i.e. for intermittent operation, see Part B.8.2.4), the SSIP is considered to be available during the start-up, shutdown and standstill period.

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The operating period ("Reisezeit") is the period between two annual scheduled maintenance stops. The operating period is usually limited due to the boiler fouling and wear of the refractory of the furnace. During the operating period, the SSIP is continuously available. Any violation of the operational performance guarantees and contractual operating data shall constitute the end of the operating time.

During operating period, a fixed maximum number of unscheduled standstills with a fixed maximum a total length are allowed (see Schedules of Operational Performance and Consumption Guarantees in Volume 2). Unscheduled shutdowns are defined as shutdowns typically caused by unexpected failure.

The minimum operating period of the SSIP is fixed (see Schedules of Operational Performance and Consumption Guarantees in Volume 2).

The availability is defined as the percentage of hours per total hours (of one year) in which the SSIP is available. The total hours (of one year) shall include one full operating period as well as one full scheduled annual maintenance stop.

The minimum availability of the SSIP is fixed (see Schedules of Operational Performance and Consumption Guarantees in Volume 2).

The maintenance period is the period required for the scheduled annual maintenance of the SSIP. The maximum maintenance period of the SSIP is fixed including start-up and shut-down (see Schedules of Operational Performance and Consumption Guarantees in Volume 2).

The operating period and availability are proved within the Defects Notification Period of two (2) years.

B.8.2.3. Load Cases

The load cases for the design of the SSIP are based on the final stage 2045:

- MINLC: Minimum load case, defined by the Bidder ($\leq 80\%$);
- DLC: Design Load Case, based on final stage 2045 (100 %);
- MAXLC: Max load case with 105 % load ($1,05 \times \text{DLC}$).

All components of SSIP are designed to operate in all load cases between the MINLC and the MAXLC and are optimised for the operation at the DLC. The load cases are defined in Table 10.

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Table 10: Load Cases SSIP

Designation	Unit	MINLC	DLC	MAXLC
Sludge Input SSIP	t/h	$\leq 1,81$	2,26	2,38
Sludge Input SSIP (Dry Solids)	t_{DS}/h	$\leq 0,45$	0,57	0,59
Dry Residue (DR)	kg_{DS}/kg		0,25	
Organic Dry Solids (oDS)	kg_{oDS}/kg_{DS}		0,56	

The minimum load case is defined by the Bidder in the see Schedules of Operational Performance and Consumption Guarantees in Volume 2. A MINLC with more than 80 % of the DLC is not allowed.

B.8.2.4. Operational Concept: Intermittent Operation

In the initial years of operation, the sludge production in relation to the maximum load case MAXLC will be below 60 % (see Table 11). As a MINLC of < 60 % is considered technically not feasible, the SSIP shall be designed for intermittent operation, i.e. periodic standstills (over weekend).

Table 11: Sludge Input SSIP, mean value during operation time

Designation	Unit	2023	2035	MINLC $\leq 80\%$ DLC	2045 DLC	MAXLC
Sludge Input SSIP	t/h	1,37	1,81	$\leq 1,81$	2,26	2,38
Sludge input relative to DLC	%	60,6	79,9	≤ 80	100	105
Sludge input relative to MAXLC	%	57,7	76,1	$\leq 76,2$	95,2	100

Alternative technical concepts with flue gas recirculation, a reduction of the cross-section of the furnace by installing extra refractory or similar concepts are not allowed as base offer to enable the comparability of all offers, see Section B.8.2.2.

B.8.2.5. Fast Start-up and Shut-down Capability

The SSIP shall be designed for fast and energy-efficient start-up and shut-down processes. The start-up and shut-down procedures are simplified.

Especially the design of the dryer, the furnace and the burners allow a fast start-up process. For the shut-down process, the operation of the burners is minimised due to the use of a thin-film dryer, which shall not necessarily need to be emptied.

The heat exchangers shall be designed to withstand weekly start-up and shut-down procedures, with thermal expansion without the occurrence of mechanical stresses in the boiler and thermal oil system.

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B.8.3. Process Description

In addition, please refer to the process flow diagrams in the Conceptual Design Drawing M-3-00-DG-01 and the detailed functional descriptions in Section B.8.4 for more details.

B.8.3.1. Normal Operation

The dewatered sludge from the dewatering centrifuges of the SSTP is fed to the collection chute of the sludge bunker. The moving floor of the collection chute pushes the sludge to the discharge conveyors. Here, a certain amount of sludge is transported to the drying system. The excess sludge amount is discharged into the bunker.

The sludge is fed to the thin-film dryer with a screw conveyor. The heat source for the drying process is the thermal oil from the boiler. The dry matter of the dried sludge is controlled to maintain a product with a consistent quality (0,35 - 0,45 kg_{DS}/kg). The heat input can be varied by varying the thermal oil supply.

The vapour condensate is collected on the top and transported to the exhaust vapour condenser and quenched by injecting cold vapour condensate on the top. The condensate is removed by the condensate pumps and discharged to the supernatant storage tank of the SSTP. The remaining non-condensable vapour is injected into the fluidised bed furnace.

The dried sludge output of the dryer is fed to the combustion chamber at the top. The sludge is incinerated in the fluidised bed. The pre-heated air is supplied through nozzle floor at the bottom of the furnace. Flue gas and ash are transported through the freeboard and exit the furnace on the top.

The flue gas temperature shall be raised to > 850 °C for at least two seconds, and simultaneously shall be kept below the ash melting temperature. The combustion temperature can be controlled by:

- adjusting the air preheating;
- adjusting the combustion air flow;
- the addition of auxiliary fuel (oil / gas);
- adjusting the dry matter of the sludge;
- adjusting of the sludge throughput and
- the injection of water in the furnace (if considered necessary by the Bidder).

The flue gas is lead to the boiler and flows vertically through the boiler and the heat exchangers. The thermal oil flows through the heat exchangers in cross-counterflow and the flue gas is cooled down while the thermal oil is heated up. The outlet temperature of both the flue gas and the thermal oil is controlled by the thermal oil flow through the boiler. The fly ash is collected in dust collectors at the bottom of the boiler and transported to the ash silo.

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The flue gas is lead to the electrostatic precipitator for the removal of the fly ash from the flue gas stream. The ash particles are collected in the ash chute and conveyed to the ash silo. This ash shall be suitable for later phosphorus recovery.

Activated carbon (AC) is used as adsorbent for volatile heavy metals and organic pollutants. Bicarbonate is used as the reactant for the desulfurization process. In the reactor, the bicarbonate and AC are mixed with the flue gas stream.

The resulting reaction salts are separated in the fabric filter. The flue gas flows through filter hoses. All particles are collected on the surface of the filter hoses. The filter hoses are periodically cleaned by compressed air and the residues are collected in the chute and transported to the residue silo.

The induced draft fan ensures the correct sub-atmospheric pressure in the combustion chamber and the transport of the flue gas through the whole system. The clean flue gas is released in the atmosphere through the stack. The stack is equipped with emission measurements to monitor the emission values.

B.8.3.2. Start-Up

For the start-up of the fluidised bed incineration, the combustion chamber is heated up with a burner. The start-up burner can be operated with gas and fuel oil. During the start-up process, the digester gas is used for heating up the furnace to 650 °C followed by the use of fuel oil to accelerate the start-up process.

As soon as the temperature in the furnace exceeds 850 °C, the dryer is put into operation and the dried sludge is fed to the combustion chamber. The thin-film dryer contains a relatively small sludge volume. Thus, the start-up of the dryer is very fast.

B.8.3.3. Shut-Down

The shut-down of the SSIP is very fast due to the small sludge amount of the thin-film dryer. The sludge inflow is stopped. During the shut-down process, the thermal oil supply to the dryer is lowered and the incineration temperature is controlled by the injection of gas and/or oil. When the dryer is emptied, the oil injection is stopped. After the incineration in the fluidised bed stops, the fluidising air supply is turned off. Finally, the ID fan is switched off.

B.8.3.4. Standby (Warm-Keeping Mode)

For intermittent operation the SSIP is shut down and operated in warm-keeping mode. In warm-keeping mode, the SSIP is kept warm to keep it ready for start-up, reduce the start-up period and minimize thermal stress. Depending on the outside temperature and the duration of the standby period, digester gas is used to keep the furnace warm. If required, a flue gas valve can be installed to reduce the heat loss of the furnace.

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B.8.3.5. Malfunctions

In case of a breakdown, the fluidised bed incineration process is interrupted due to the stop of the fluidising air supply. The thermal oil primary system pumps and the cooling water pumps maintain the circulation of the thermal oil in the primary system and a cooling of the thermal oil by the water cooler. A standstill of the thermal oil circuit would disintegrate the thermal oil and shall be avoided.

In case of power failure, the thermal oil primary system pumps and the cooling water pumps shall be supplied by the emergency power generator (see Section B.10.2.3).

B.8.4. Process Design

The SSIP includes all supplies and services required for a ready-to-operate plant. The SSIP is complete and fully suitable for the functional task in every regard. All of the following specifications shall represent the minimum functional and quality requirements and the Contractor shall provide the necessary supplies and services for an operational construction.

The process is shown schematically in the process flow diagrams in the Conceptual Design Drawing M-3-00-DG-01.

B.8.4.1. General

B.8.4.1.1. SSIP Building

The SSIP building shall consist of five different building sections:

1. Bunker section as concrete structure including:

- reception building and bunker;
- sludge crane opening to the outside ("Schwalbennest" / Swallow nest structure);

2. Boiler house (section 1): sludge treatment and drying as closed concrete structure including:

- stair tower or stairwell for all level and connected with the bunker crane level;
- facade with entrance gate;
- assembly gate for dryer, accessible from the roof of the reception building;
- crane opening for all level, accessible by the boiler house crane and the entrance gate;

3. Boiler house (section 2): furnace and boiler as closed steel structure including:

- steel platforms around the furnace and boiler on all levels;
- facade;

4. Flue gas treatment section as steel structure including:

- stair tower for all level and connected with the bunker crane level;

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- facade and lightweight roof;

5. Ancillary building section as one-level expansion of the boiler house and flue gas treatment section including:

- facade and lightweight roof;

B.8.4.1.2. Installation

The installation of the process components is shown in the layout plans, floor plans and section in the Conceptual Design Drawings M-3-00-FS-01.

The components shall be arranged inside the SSIP building according to the following concept:

- expansion vessel: boiler house (section 1), above the thermal oil boiler;
- centrifuges: boiler house (section 1), above the collection chute;
- thin-film dryer: boiler house (section 1), below the collection chute, above the furnace;
- sand silo: boiler house (section 2), above the furnace;
- boiler house crane: boiler house (section 1, 2), with access to the centrifuges, dryer (including rotor), furnace and boiler;
- transformer room: boiler house (section 1), on ground floor;
- LV room: boiler house (section 1), above the transformer room;
- MV room: boiler house (section 1), same level as the LV room;
- PLC room: boiler house (section 1), same level as LV room.

B.8.4.1.3. Scope and Interfaces

The scope of the SSIP includes at least the following constructions, components and systems:

- civil works
 - exterior surfaces, including:
 - roads, parking areas;
 - access roads and green areas;
 - building, including:
 - foundation;
 - concrete structure;
 - facades, roof;
 - doors, windows, gates;
 - technical building equipment, including:
 - ventilation, air conditioning;
 - lighting, power;
 - steelwork, including:

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- steel construction;
 - platforms and stairways;
- process components, as described in Part B.8.4, including:
 - sludge reception and storage;
 - sludge drying and feeding system;
 - fluidised bed incineration;
 - thermal oil boiler system;
 - flue gas treatment;
 - crane systems, as described in Part B.8.4, including:
 - sludge bunker crane;
 - boiler house crane;
 - ancillary facilities.

At least the following media flows occur:

- incoming:
 - dewatered sewage sludge from centrifuges;
 - dewatered external sewage sludge (delivery);
 - cooling water;
 - sodium bicarbonate;
 - activated carbon;
 - fuel oil;
 - digester gas;
- outgoing:
 - cooling water;
 - exhaust air;
 - exhaust vapour condensate;
 - fly ash;
 - flue gas treatment (FGT) residues;
 - storm water drainage;
 - wastewater (washing water, sanitary effluents);
- components of the SSTP but located in the SSIP building include:
 - sewage sludge to centrifuges (in), see Section B.7.3.2;
 - centrate from centrifuges (out), see Section B.7.3.3.

For scope and interfaces for electric and control see Section B.8.5.1. The media are defined in the following chapter.

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B.8.4.1.4. Media

For clarification, refer to the process flow diagram in the Conceptual Design Drawing No M-3-00-DG-01.

The initial filling of all media excluding sewage sludge and including engine oil and all operating materials and supplies shall be delivered by the Contractor.

Sewage Sludge

Dewatered sludge from the centrifuges (SSTP) is fed to the drying system or bunker of the SSIP. The sludge parameters of the dewatered sludge from the centrifuges are defined in Section B.8.2.

The reception system allows the supply of external delivered dewatered sludge. A constant or regular reception is not planned yet.

Thermal Oil

A mineral-based thermal oil is used in the thermal oil boiler system, see Section B.8.4.5. The initial filling of the thermal oil system is part of the scope of delivery of the Contractor.

Cooling Water

Cooling water is delivered by the WWTP cooling water system. Cleaned and treated water from the WWTP or borehole water is used as cooling water, see Section B.13.2.

Exhaust Vapour Condensate

Exhaust vapour condensate with a maximum temperature of 70 °C is produced by the drying system and discharged to the supernatant storage tank of the SSTP which will collect also the centrate from the sludge dewatering units (Section B.7.3.3).

Fuel Oil

Fuel oil is provided from a fuel oil tank dedicated for the SSIP and for the start-up of the sludge digester (initial heating before biogas is produced), see Part B.8.4.7.2.

Digester Gas

Digester gas produced by the SSTP is used as an auxiliary fuel, see Section B.7.4.

Fly Ash

The ash produced by the fluidised bed incineration is carried over by the flue gas and is mainly collected in the electrostatic precipitator (ESP). The ash is non-toxic and inert and may be used for phosphorus recovery in the future.

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FGT Residues

The FGT residues contain the reaction products of the dry flue gas cleaning using sodium bicarbonate for desulphurisation. The main product contained in the FGT residues is sodium sulphate. Further, it contains unreacted bicarbonate and fly ash as well as activated carbon which is used for the separation of heavy metals.

Sodium Bicarbonate

Sodium bicarbonate (sodium hydrogen carbonate, NaHCO_3) – hereafter referred to as *bicarbonate* – is used as the reactant for the desulfurization process. There are two types of bicarbonate, both can be used in the SSIP:

- fine grained bicarbonate with $d_{90} < 20 \mu\text{m}$;
- coarse-grained bicarbonate, in this case a mill has to be used to grind the grains.

Activated Carbon

Activated carbon (AC) is used in the flue gas treatment as adsorbent for volatile heavy metals (especially mercury) and organic pollutants.

Exhaust Air

During the operation of the fluidised bed incineration, the exhaust air from the bunker is fed to the furnace as combustion air. In case of a standstill, the air is cleaned prior to being released in the environment.

Drainage Water

Storm water drainage water from the exterior surfaces (roofs, pavement) will be drained to the storm water drainage system of the WWTP.

Polluted effluents generated at the SSIP, excepted exhaust vapour condensate, e.g. washing water or sanitary water will be collected in the WWTP internal wastewater collection system and returned to the inlet of the WWTP.

B.8.4.2. Sludge Reception and Storage

The sludge reception and storage system contains the bunker with the sludge input from the SSTP sludge dewatering centrifuges, the crane and the conveyor system that functions as a separator and transports the sludge into the bunker or to the drying system (see Section B.8.4.3).

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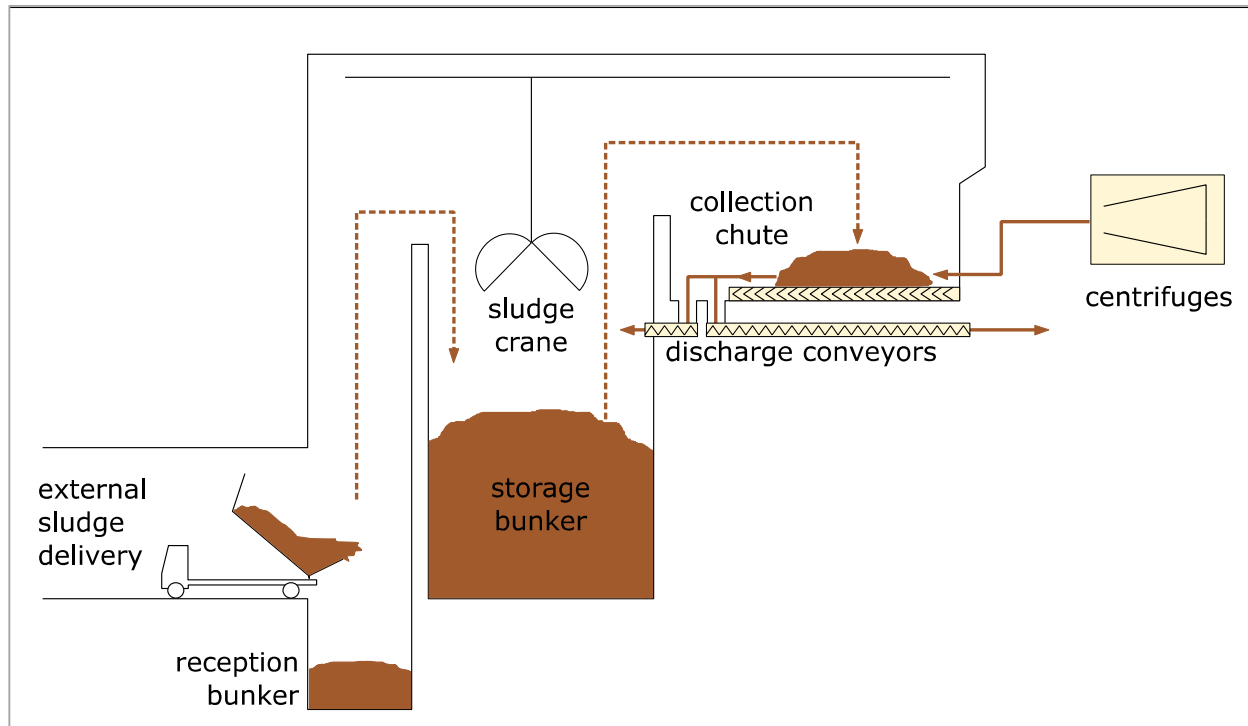


Figure 8: Sludge Reception and Storage

B.8.4.2.1. Sludge Dewatering: Interface to SSTP

Components

This system consists of at least the following components:

- centrifuges;
- conveyor.

Function

The centrifuges (SSTP) are located in the SSIP building above the collection chute. The dewatered sludge is transported with screw conveyor to the collection chute of the sludge bunker (see Section B.8.4.2.3).

Automation

A failure of both centrifuges is signalled to the SSIP control system. In this case, the SSIP has to be operated completely with sludge from the bunker (see crane system in Section B.8.4.2.4).

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B.8.4.2.2. External Sludge Reception

Since external dewatered sewage sludge is only accepted occasionally, a single delivery point is sufficient. The double door system ensures that no odours escape while unloading the sewage sludge from the truck.

Components

The system consists at least of the following components:

- two high-speed spiral doors;
- control point and identification terminal;
- methane and hydrogen measurements.

Function

After the truck has been weighed by the entry scale of the WWTP (see Section B.13.3) the drivers continue to the incineration plant. The truck driver then waits in front of the outer door of the double door system. A light signal on top of the outer door gives him the signal to approach the double door system. Normally a green signal indicates a free system, while a red light stands for occupied or locked.

The outer door is opened automatically when the truck approaches and when the traffic light shows green. As soon as the truck is inside the double door system, the outer door closes. A Terminal inside the double door system allows the truck driver to identify himself before opening the inner door to the bunker. The terminal is identical to the one at the entry scale and connected to a higher-level system.

When the truck has been emptied and the inner door has been closed, the truck can leave the double door system while the outer door closes behind it.

Automation

The double door system is equipped with a traffic light system and connected to the crane software. The software ensures that the traffic light system is red and the outer door locked, when the crane is working in the bunker. As soon as the double door system is empty (no truck is positioned in the external sludge delivery area), the crane empties the deliver / acceptance bunker.

Induction loops are installed in the floor to open the door for approaching vehicles and to detect if a vehicle is in the double door system.

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Design

A local control point is provided for the truck driver in the double door system and provides at least an emergency button, manual control of the doors, indication lights and a telephone system with connection to the PLC room.

To prevent trucks from approaching the edge of the bunker too close, thresholds with a sweeping opening are provided at the tipping point.

The danger area in front of the delivery point is colour-coded to prevent falling into the bunker when sweeping. As an additional safety measure, a coarse-meshed grid is installed inside the cassette at the edge of the tipping point.

B.8.4.2.3. Bunker

Components

This system consists of at least the following components:

- sludge bunker;
- exhaust air system;
- collection chute.

The components of the crane are described in Section B.8.4.2.4.

Function

The bunker serves as a sludge buffer and decouples the sludge production of the SSTP from the sludge incineration in the SSIP. The connection of this system is realised by the collection chute. Both, the crane and the dewatering centrifuges of the SSTP, discharge the sludge into the collection chute.

The collection chute is equipped with a moving floor system that pushes the sludge to the discharge conveyors. The first conveyor (dryer discharge conveyor) transports the sludge to the drying system (see Section B.8.4.3), the second screw conveyor (bunker discharge conveyor) discharges the sludge into the bunker.

In case of a standstill of the SSIP, only the bunker discharge conveyor is in operation. If the SSIP is in operation, the dryer discharge conveyor is in operation. If the sludge input into the collection chute exceeds the incineration capacity, the sludge level in the collection chute increases and the bunker discharge conveyor is activated temporarily.

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Automation

The level of the collection chute is detected and the bunker discharge conveyor is automatically switched on and off, whenever required. In case of a failure of the moving floor, the discharge conveyors and subsequent processes are stopped.

The dryer discharge conveyor does not work automatically. It is operated depending on the operation of the drying and incineration system.

Design

The sludge bunker shall have a minimum storage capacity of dewatered sludge of 1.500 m³.

The discharge conveyors are shaftless spiral conveyors. The bunker discharge conveyor is designed to empty the collection chute in all load cases of the SSTP centrifuge without operation of the dryer discharge conveyor.

The moving floor is powered by a hydraulic drive.

The design of the collection chute ensures that the sludge falls into the bunker if the collection chute it is overfilled and the bunker discharge conveyor is not in operation.

B.8.4.2.4. Crane System

The fully automated crane system is implemented in double girder design with hydraulic clamshell grabs. The crane system is considered in the bunker design and conforms to the legal minimum distances. The bunker itself consists of three compartments: stacking bunker, crane parking and reception bunker for external sewage sludge.

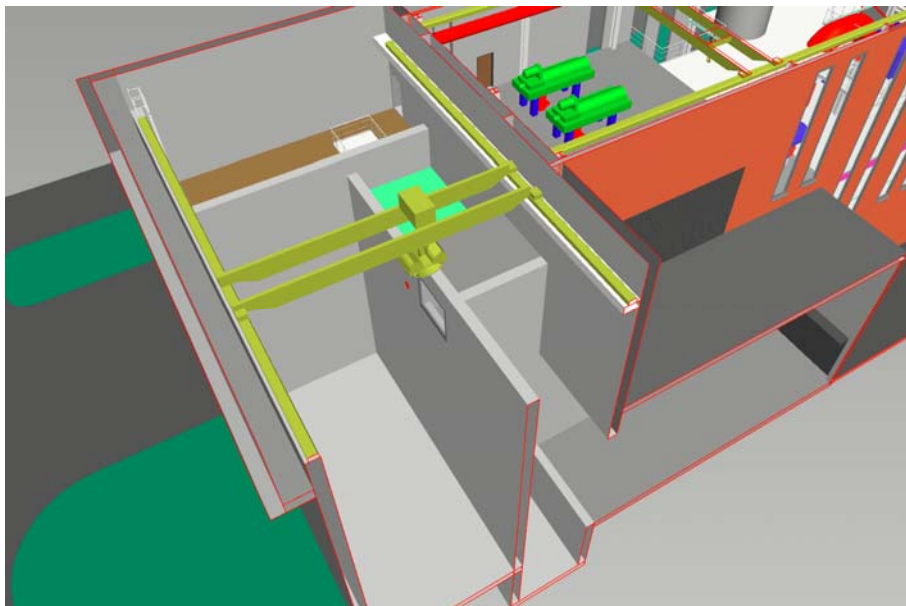


Figure 9: 3D view of bunker and crane

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Components

The crane system consists at least of the following parts and components:

- crane bridge in double girder design with rails for trolley, buffer and walkway on the side;
- complete crane trolley including trolley drive and wire rope hoist;
- energy chain for trolley and bridge including laying trough;
- two hydraulic clamshell grabs (one as a reserve);
- video surveillance for complete bunker including the hatch from the outside;
- fully equipped crane control in the PLC room;
- remote control for controlling the crane in the bunker in emergency situations;
- crane rails including all fastening materials and buffers.

Function

The crane system provides fully automatic operation. The automatically operating crane is monitored from the PLC room in the SSIP building. The remote control in the bunker is only being operated manually in special situations; if a direct view in the bunker is necessary or if a malfunction of the crane occurs. Fully automatic operation is technically possible at any given time.

The crane is designed for the following main functions:

- clear the reception bunker and "scatter" in the respective stacking area;
- loading the collection chute (including weighing);
- mixing and stacking in the respective area.

In the event of failure, the crane can be pushed / pulled into the parking position without any special precautions or modifications. The crane is designed to handle the different load cases indicated in Section B.8.1.3 in automatic operation.

The reserve grab is stored in the parking position and can be changed there. In case of maintenance or defect components, a hoist is located in the parking position. The hoist is designed to lift the heaviest component off the trolley and load them off outside the bunker through the hatch in the parking position. For this reason, the hoist is exactly located over the hatch in the parking position and leaves enough space to the trolley below.

The crane system is able to mix the sewage sludge in the bunker to minimize fluctuations in the sludge composition. This is done by spreading the sewage sludge in the stacking area of the bunker as homogeneously as possible.

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Automation

An essential requirement for fully automatic crane operation is the knowledge of the cranes exact position in the bunker. For this reason, redundant linear encoders are mounted next to the rails of trolley and bridge. The signals are evaluated autonomously by the crane system and displayed on the operation screens in the PLC room.

When approaching an edge area such as the bunker wall or feed hopper, the automated system automatically reduces the travel speeds of the crane or trolley.

The level of the collection chute is being monitored (low and high). The crane system detects automatically, when the collection chute needs to be loaded and how urgent that task is. The crane is equipped with a 2D-Scanner which is mounted on the bridge. Through this 2D-Scanner, the crane is continuously recording the distribution of sewage sludge in the bunker. Based on the individual height values, the brake assistance reduces the lowering speed of the hydraulic grabs when it is placed on the surface of the sewage sludge.

Basically, it is assumed that the fill level in the bunker is evened due to the consistency of dewatered sewage sludge, at least after a certain time period.

The stacking and reception bunker are displayed in the crane software and divided into many smaller areas which correspond to the diameter of the opened grab. In normal operation, the crane operator is periodically checking the conditions in the bunker using video surveillance and adjusting the tasks for the crane. This is done by selecting certain areas in the bunker from which the crane should pick up and discharge the sewage sludge.

Design

The hydraulic clamshell grabs are equipped with scrapers on the inside and meet all requirements of explosion protection report. The grabs open themselves in the long direction of the bunker. This has the advantage of handling the sewage sludge in the reception bunker because the grabs can be brought closer to the bunker wall.

To illuminate the bunker and generate a high-contrast video image, LED lighting is provided on the bridge and the trolley. The lamps are heat-resistant.

All components of the crane are anti-corrosive and designed for the harsh conditions in the bunker environment.

The capacity of the crane is designed to handle the MAXLC and have another 1,5 t/h capacity for mixing the sewage sludge in the bunker. This results in a total capacity of at least 4,0 t/h.

The crane control in the PLC room is equipped with a video wall or big LCD screen to display the surveillance images from the bunker and the user interface of the crane software. Furthermore, there are joysticks embedded in the table.

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B.8.4.3. Sludge Drying and Feeding System

The sludge drying and feeding system contains the sludge dryer and the treatment system for the exhaust vapour.

B.8.4.3.1. Thin-film Dryer

Components

The thin-film dryer consists at least of the following parts and components:

- feeding conveyor;
- thin-film dryer;
- Instrumentation for measuring dry residues (DR).

Function

The thin-film dryer works as a closed-system contact dryer. Thermal oil from the thermal oil boiler system (see Section B.8.4.5) is used as the heat source. The thermal oil flows through the shell of the dryer, while the sludge is continuously mixed and moved with non-heated rotor blades through the interior of the dryer. The sludge forms a layer of around 1 cm thickness on the inner side of the heating jacket and the water content of the sludge is partially evaporated.

The dryer is fed with the speed-controlled screw conveyor of the discharge conveyor of the bunker collection chute (see Section B.8.4.2.3). The dried sludge is fed with a constant-speed screw conveyor to the fluidised bed furnace (see Section B.8.4.4.1).

To ensure a steady combustion in the fluidised bed, the drying process is controlled to produce dried sludge with constant dry matter (DR: 0,35 - 0,45 kg/kg expected). For this purpose, the DR of the incoming and outgoing sludge stream is measured and the thermal power for the evaporation of the respective water content is determined. The heating power is controlled by the thermal oil throughput and the temperature difference over the dryer.

The air-free exhaust vapour is collected on the top and transported to the exhaust vapour condensation (see Section B.8.4.3.2).

Automation

The control system includes an automatic drying process control system with automated start-up and shut-down as well as safety procedures. The shut-down procedure can include a complete emptying if required by the operator. All process variables of the drying process are provided to the SCADA. A manual operating mode is included.

The drying process, including sludge and thermal oil throughput, is controlled automatically by the drying process control system to produce a defined sludge stream with a given dry matter (DR). The calculation of the DR difference between input and output takes the load-case-dependent retention time of the sludge inside the dryer into account.

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Overfeeding is automatically avoided by the drying process control system by monitoring the power consumption of the rotor drive. If it exceeds a certain level, the speed of the input screw conveyor is reduced automatically.

Design

The sludge output is equipped with a gate valve to separate the dryer in case of a standstill. The drive of the thin-film dryer is equipped with a water-cooling system. The vapour pressure in the dryer is controlled by a control valve.

Heating surface and all parts of the dryer in contact with sludge are made of or clad with acid-resistant Cr-Ni-steel. The rotor plates are made out of duplex steel.

The thin film dryer shall not necessarily need to be emptied for a shut-down period of up to 60 h.

The dryer is placed accessible for the boiler house crane and with enough space for the dismantling of the rotor (around 10 m). All special tools, trolleys (including rails) that are required for the dismantling work shall be supplied. The dryer is positioned next to an assembly gate in the facade of the boiler house that allows a subsequent removal of the dryer and / or rotor.

B.8.4.3.2. Exhaust Vapour Condensation

Components

The exhaust vapour condensation consists at least of the following parts and components:

- condenser;
- condensate pump;
- blower;
- heat exchanger.

Function

The exhaust vapour condensation system condenses the exhaust vapour produced by the thin-film dryer (see Section B.8.4.3.1). The exhaust vapour is lead to the condenser and quenched by injecting cold vapour condensate on the top. The condensate is removed by the condensate pumps on the bottom and lead through the water-cooled heat exchanger and returned to the condenser nozzles. If the level in the condenser exceeds a maximum value a part stream is discharged to the SSTP.

The exhaust vapour blower maintains a small negative pressure (2 - 5 mbar) in the condenser to remove non-condensable vapour. These are fed into the fluidised bed furnace (see Section B.8.4.4).

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Automation

The exhaust vapour condensation system operates automatically.

Design

The condenser is a vertical cylindrical stainless-steel tank and is designed to cool down the vapour condensate to 70 °C in MAXLC (650 kW expected). Two redundant condensate pumps are installed (n-1 criterion). The condensate circulation is equipped with a filter upstream of the condensate pumps. The filter is designed with a backwash function.

The vapour blowers are installed with redundancy (n-1 criterion) and each blower is equipped upstream with a demister. The demisters can be cleaned manually with process water and are both equipped with a difference pressure measurement.

All components including pipes are made of stainless steel.

B.8.4.4. Fluidised Bed Incineration

Fluidised bed incineration contains the furnace as the main component, the combustion air system, fuel lances and burners as well as several auxiliary systems. The furnace is fed with dried sludge from the sludge dryer (see Section B.8.4.3) and the produced flue gas is transported to the thermal oil boiler (see Section B.8.4.5).

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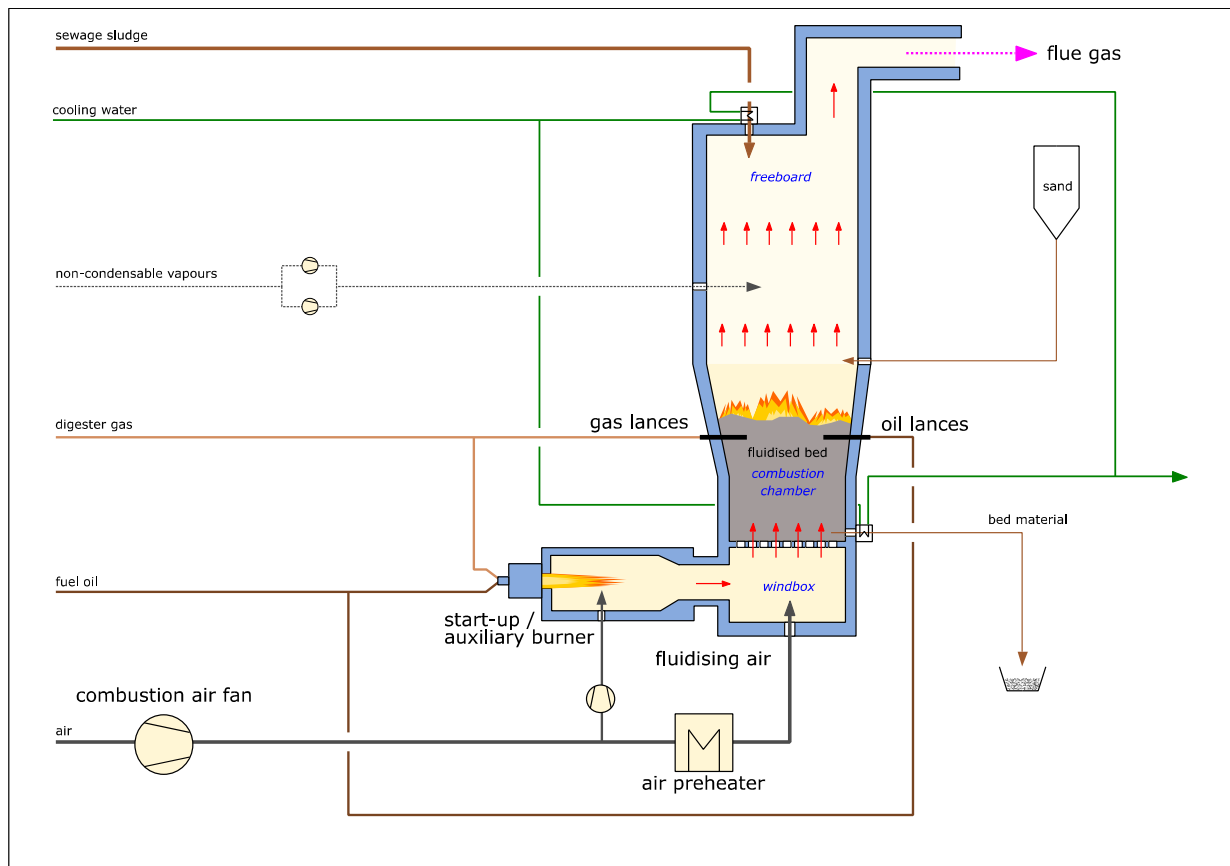


Figure 10: Fluidised bed incineration

B.8.4.4.1. Fluidised Bed Furnace

Components

The furnace consists at least of the following parts and components:

- sludge feeder;
- windbox with start-up / auxiliary burner (see Section B.8.4.4.3);
- nozzle floor;
- combustion chamber with fuel lances (see Section B.8.4.4.3);
- freeboard.

Function

The fluidised bed furnace is a stationary fluidised bed combustion system for the incineration of dried sludge. The start-up burner and the primary air supply are connected with the windbox at the bottom of the furnace. Pre-heated air is transferred through the nozzle at the bottom into the combustion chamber as fluidising air.

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The sewage sludge is fed to the combustion chamber at the top or in the freeboard area with a sludge feeder. The fluidised bed is formed in the combustion chamber. Oil and gas lances are placed in the fluidised bed area to allow the feeding of fuel to the combustion chamber. Flue gas and ash are transported through the freeboard and exit the furnace on the top.

Combustion reaction processes take place in the freeboard and the flue gas duct between the furnace and the boiler. The non-condensable vapours from the drying process are fed to the freeboard and mixed with the flue gas.

Automation

The key task of the operation of the SSIP is to maintain the combustion temperature within the prescribed levels. The flue gas temperature shall be raised to $> 850^{\circ}\text{C}$ for at least two seconds, and simultaneously kept below the ash melting temperature.

The combustion temperature shall be controllable by the following variables:

- air preheating: increase / decrease temperature of the fluidising air (fast);
- combustion air fan: increase / decrease combustion air flow (fast);
- oil / gas lances: addition of extra fuel (fast);
- auxiliary burner: decrease the temperature of the fluidising air (fast);
- thin-film dryer:
 - increase / decrease dry matter of the dried sewage sludge (slow);
 - increase / decrease throughput (slow);
- if considered necessary by the Bidder: injection of water in the furnace (fast).

Adjusting the combustion air flow is just a short-term solution due to an unwanted change of the oxygen concentration in the flue gas. But if necessary, the oxygen set-point can be adjusted by the operator within fixed limits.

Design

The combustion chamber and freeboard shall be designed to guarantee a retention time of at least two seconds at a temperature of $\geq 850^{\circ}\text{C}$ in the furnace (IED: Industrial Emissions Directive 2010/75/EU, Article 50.2). To verify the retention time, a measuring plane with at least two axes is placed at the inlet respectively at the outlet of the retention zone. In order to minimize N_2O and NH_3 emissions, a higher reaction time than required by IED is mandatory. Therefore, a minimum reaction time of at least four seconds at $\geq 850^{\circ}\text{C}$ shall be achieved before the flue gas enters the boiler. The combustion chamber, freeboard and flue gas ducts shall be designed for a homogeneous velocity distribution without dead zones.

The combustion chamber, freeboard and flue gas ducts are insulated with refractory from the inside and with conventional insulators like mineral wool from the outside to limit the heat losses. All openings are coated with ramming mix and the suspended ceiling is built with special shaped refractory bricks and sprayed concrete. The insulation is designed to reliably

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keep the shell temperature above the acid dew point and prevent the furnace from corrosion in case of a crack in the refractory.

The fluidised bed is equipped with a nozzle floor with nozzles having an umbrella-shaped cover. Impurities in the sludge are not expected. The sludge feeder is designed as a water-cooled injection system with an emergency cooling function (see Section B.8.4.7.1). All components are designed to allow their own thermal expansion and of their connected components. The combustion chamber and the windbox are equipped with manholes (see Section B.8.2.2) as well as inspection glasses.

Non-condensable vapours from the exhaust vapour condensation (see Section B.8.4.3.2) are led to the combustion chamber. To ensure an optimal distribution and avoid formation of layers in the flue gas the vapours are injected with high velocity (25 m/s) through several concentrically arranged nozzles. Additionally, the vapours support the denox process due to their ammonia content.

Alternatively, the furnace can be designed as a two-stage combustion with secondary air.

B.8.4.4.2. Combustion Air System

Components

The system consists at least of the following components:

- combustion air fan;
- air preheater;
- start-up burner air fan;
- air ducts.

Function

The combustion air is used for the fluidisation in the combustion chamber. The air is preheated with thermal oil from the boiler system up to around 200 - 250 °C. The preheating of the air is required for self-sustaining combustion, i.e. the operation of the combustion process without additional fuel.

Additionally, the volume flow increases due to the temperature increase and improves part-load operation with a sufficient fluidisation in the combustion chamber.

The combustion will be operated with an oxygen set-point for optimal emission values and energetic operation of the SSIP. The start-up burner air is taken from the combustion air stream before the air preheater and supplied with the start-up burner fan (see Figure 10).

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Automation

The combustion air flow is controlled automatically to maintain a specific oxygen content in the flue gas. Additionally, the pressure drop across the fluidised bed is used as a control variable too, as it is an indicator for the stability of the fluidisation.

Design

The air preheater is designed as a finned tube bundle heat exchanger with extractable tube bundles for cleaning and inspection. The heat exchanger is situated on an oil collection tray with a leakage control.

The combustion air duct has its highest point on the top of the bunker and does not have any other local high points. All ducts are designed as noise-reducing systems with reinforcements to prevent vibration. Sections with a high risk of pollution and deposits are equipped with inspection and cleaning openings and designed resistant to high pressure water cleaning.

The combustion and start-up burner air fans are designed as radial fans with variable frequency drives. The fan and the drive are situated on a base-frame with vibration dampers. The fans are equipped with inspection and drains for water cleaning.

B.8.4.4.3. Start-up / Auxiliary Burner and Fuel Lances

Components

The system consists at least of the following components:

- start-up / auxiliary burner;
- fuel lances for oil and gas.

Function

Burner and lances are used to increase the temperature in the fluidised bed furnace. The start-up burner is connected to the windbox below the nozzle floor and is mainly used for the start-up of the fluidised bed incineration. The fuel lances are situated in the combustion chamber and used to increase the combustion temperature.

The start-up / auxiliary burner can be operated with gas and fuel oil simultaneously and separately. Fuel oil has a higher caloric value than the digester gas that is available as a product of the SSTP. During the start-up process, the digester gas is used for heating up the furnace to 650 °C followed by the use of fuel oil to accelerate the start-up process

If the head temperature of the combustion chamber falls below a minimum temperature, the burners step in to increase the temperature and maintain it above 850 °C. Fuel oil can be used for a faster heating-up process.

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In case of a rapid increase of the combustion temperature, water can be sprayed into the combustion chamber via lances, if the furnace is equipped with a water injection system.

Automation

The control of the combustion temperature with burners and water is executed automatically. All set-points can be adjusted manually based on the operation experience. The heating of the furnace is executed gradually as per specified characteristics.

Design

The start-up / auxiliary burner is a combined burner for gas and oil. The burner air is supplied by the combustion air system and realised with a separate booster fan (see Section B.8.4.4.2). The burner is designed for 50 % of the combustion capacity of the furnace and in combination with the lances a furnace temperature of at least 900 °C can be ensured in the fluidised bed without the injection of sludge.

The lances are designed as separate lances for gas and oil or alternatively as combined lances for gas and oil with a mixing vessel. The lances are arranged concentrically in the combustion chamber and do not require cooling air.

All burners and lances have low-NO_x designs. The furnace and boilers are designed to minimize the use of fuel oil and the SSIP can be operated and controlled solely with digester gas. Fuel oil is only needed for start-up.

Each burner is equipped with a separate black box control system which is located in the SSIP building.

B.8.4.4.4. SNCR Retrofitting Capability

It is expected that the ammonia content in the sewage sludge shall be inherently sufficient to adhere to the NO_x emission limit of 200 mg/Nm³. Hence, it is not necessary to employ a separate Selective Non-Catalytic Reduction System (SNCR).

However, the furnace and the plant are designed to include a possible retrofit of a urea-based SCNR in order to cope with possible emission reductions in the future.

The furnace is designed for the installation of SNCR lances at a later stage.

B.8.4.4.5. Sand Feeder and Bed Material Drainage System

Components

The system consists at least of the following components:

- sand silo;
- sand feeder system;

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- bed material removal system including cooling;
- truck loading and unloading device;
- conveying systems.

Function

The bed material of the fluidised bed incineration is quartz sand. During operation, the grain size gradually decreases due to abrasion. Small sand particles are carried away with the flue gas. If the sand content of the sewage sludge fed to the combustion chamber is lower than the loss due to abrasion sand has to be fed. Otherwise bed material has to be drained.

The removal system allows draining the bed material to ensure the function of the fluidised bed. This is necessary for the incineration of sewage sludge with a high sand content. The cooled discharge screw enables a quick and safe drainage of the bed material. The bed material is deposited in a container.

Automation

The level of the bed material is measured in terms of the pressure drop over the fluidised bed. If defined maximum and minimum fill levels are detected the operator is notified. The drainage system and the sand feeder system are operated manually if required.

Design

The bed material removal system includes at least an outlet shaft with a flanged gate valve, water-cooled conveyors (e. g. screw conveyors) and a container. The diameter of the flange must be sufficient for the removal of impurities like parts of the refractory lining. The design and positioning of the drainage system take into account, that the bed material container can be removed and delivered during the operation of the SSIP.

The sand feeder system includes a silo, a dosing unit and conveyor system to the furnace. The sand silo is filled pneumatically by delivery vehicles, draining must be possible, too. The volume of the sand silo is at least 20 m³ and is situated in the steel structure above the combustion chamber.

B.8.4.5. Thermal Oil Boiler System

The thermal oil boiler system provides the heat transfer from the flue gas produced by the fluidised bed incineration (see Section B.8.4.4) to the heat consumers. Thermal oil is used as heat transfer media, see Section B.8.4.1.4. The system is divided into the primary and secondary system. The primary system includes the thermal oil boiler as heat source and the sludge dryer and the water cooler as heat sinks. The secondary system bypasses the sludge dryer and provides the heat for the air preheater.

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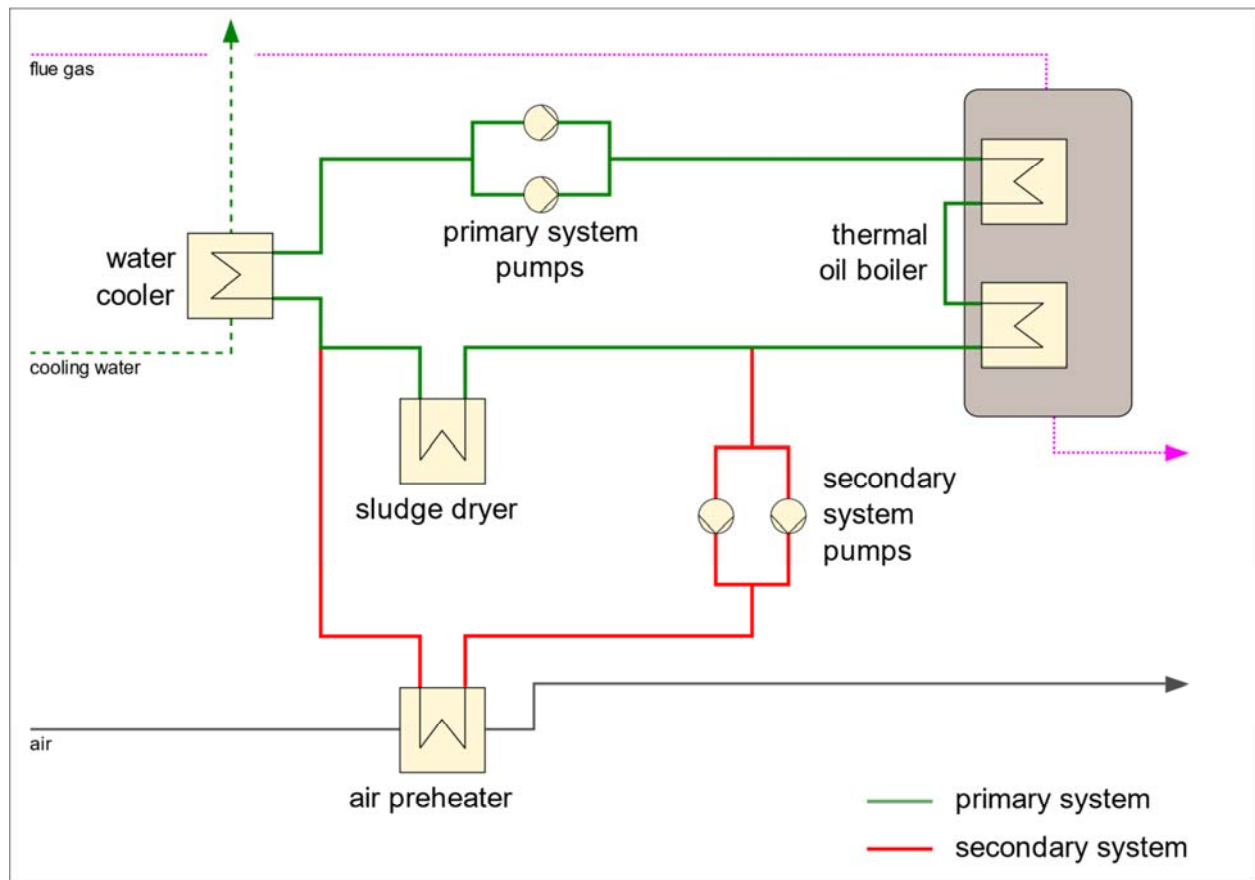


Figure 11: Thermal oil boiler system

The thermal oil boiler system and its control system are designed and manufactured according to DIN 4754 *Heat Transfer Installations Working with Organic Heat Transfer Fluids*.

B.8.4.5.1. Thermal Oil Boiler

Components

The system consists at least of the following components:

- boiler casing;
- heat exchangers;
 - radiation heat exchanger;
 - convection heat exchangers;
- ash collection and separation;
- draining and venting system.

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Function

The thermal oil boiler is a vertical one-pass or two-pass forced circulation boiler with radiation and convection heat exchangers. The boiler is arranged downstream of the fluidised bed incineration; both are connected with the flue gas ducts (Section B.8.4.6.5).

The flue gas enters the boiler on the top and flows vertically through the boiler casing. The casing includes the heat exchangers. The thermal oil flows through the heat exchangers in cross-counterflow to the flue gas flow. Thus, the flue gas is cooled down in the boiler and the thermal oil is heated up. The outlet temperature of both the flue gas and the thermal oil is controlled by the thermal oil flow through the boiler.

Dust is collected in an ash collector on the bottom of each boiler pass and transported with a pneumatic transportation system to the ash silo (see Section B.8.4.6.7).

A cleaning device is not considered necessary.

Automation

The thermal oil outlet temperature maintains a fixed safety margin (see Schedule of Operational Performance and Consumption Guarantee in Volume 2) to the maximum operation temperature in all load cases and while load changes. The design has to ensure a lifetime of the thermal oil of at least 10 years.

The automation system of the SSIP includes a leakage monitoring system. Leakages are detected at least by the following functions:

- flue gas temperature control: A rapid increase of the flue gas temperature might be caused by a leakage in a heat exchanger tube;
- flue gas analyses: High CO values might be caused by thermal oil leaking into the boiler;
- level control of the expansion vessel.

Fouling is monitored with multiple temperature measurements between the bundles. If a cleaning device is installed, these measurements are used for the determination of the necessary operation and break periods.

Design

The convection heat exchangers are designed as tube bundle or tube coil heat exchangers. These bundle heat exchangers are made of plain tubes with aligned tube rows. The radiation heat exchanger is designed as membrane walls or tube coil walls without bundles. All tube coil walls or heat exchangers are made of plain tubes. The radiation heat exchanger can also be situated above the fluidised bed furnace if a reaction time of four seconds at $\geq 850\text{ }^{\circ}\text{C}$ can be guaranteed in all load cases (see Section B.8.4.4.1).

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The insulated rectangular boiler casing is dust-tight and equipped with openings which allow pulling out each bundle horizontally. The construction of the bundle mounting, the thermal oil pipes and headers are designed for this purpose. These openings are accessible from the main platforms and designed with sufficient space for the removal and the revision works of the heat exchangers (see Employer's Requirements Part I).

The flow velocity is sufficient to ensure heat transfer and self-cleaning capability. The casing, the radiation part, the bundles and the tubes are designed to resist corrosion and erosion. Therefore, all heat exchange areas have a corrosion allowance of at least 2 mm. The design of the whole system includes the calculation of the film temperature in the heat exchangers of the boiler to minimize the risk of fouling.

The ash collector chutes are designed with a minimum angle of 60 ° to the horizontal and are equipped with manual gate valves below as well as inspection openings and if required trace heating. All chutes can withstand manual hammering to clear blockages.

The boiler can be designed without an ash collector alternatively, if a one-pass boiler is used. In this case the following applies: The boiler outlet has to be arranged in the same height as the ESP inlet. The flue gas duct, as well as the boiler outlet, have to be designed to ensure a high flue gas velocity to prevent dust deposits. It must be proved, e.g. by calculation or CFD simulation, that no dust deposits will occur.

If the contractor has to provide a cleaning device in order to achieve the minimum operating period ("Reisezeit", see Section B.8.2.2), a compressed air cleaning system is installed. A shot ball cleaning system can also be used for the second boiler pass.

B.8.4.5.2. Thermal Oil Pump Stations

Components

This system consists of at least the following components:

- thermal oil pumps:
 - primary system pumps;
 - secondary system pumps;
- emergency generator.

Function

The primary system pumps ensure the circulation of the thermal oil in the primary system and the cooling of the flue gas. A standstill of the pumps could lead to a damage of the heat exchanger tubes and also deteriorate the thermal oil. The secondary system pumps provide the heat transfer to the air preheater.

Both pump stations shall be installed with redundancy ($n + 1$ criterion). The primary system pumps shall be connected to the emergency power supply generator.

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Automation

The following functions are implemented:

- pump change in case of failures, warnings or after a defined operating period;
- flow monitoring;
- leakage detection.

Design

The pumps are equipped with speed-controlled drive motors with frequency converters and uncooled mechanical seals. Each pump station includes at least two pumps (n-1 redundancy criterion).

The design of the emergency power supply shall ensure that the standstill time does not exceed the maximum standstill time of the thermal oil in the heat exchangers even under the most unfavourable conditions and load cases.

All pump stations are equipped with manual valves which allow removing a pump, without halting the operation of the individual pump station. Each pump has a pressure gauge and measurement on inlet and outlet side.

Each pump is situated on its own base-frame with oil collection trays and leakage control. The leakage control is realised by a vibrating fork (e. g. "liquiphant") level switch and a temperature measurement of the end-face mechanical seal of each pump.

B.8.4.5.3. Primary and Secondary System

Components

This system consists of at least the following components:

- pipes;
- (safety) valves;
- expansion vessel;
- storage tank.

Function

The primary system is the main thermal oil cycle and connects the main components of the thermal oil boiler system. It includes the thermal oil boiler, the sludge dryer and the water cooler. The secondary system is connected with the primary system and provides the heat for the air preheating. This arrangement of the two systems decouples the sludge dryer and the air preheating and ensures a constant inlet temperature for both processes.

Both systems are equipped with a thermal oil pump station (see Section B.8.4.5.2).

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Automation

Flow and pressure measurements as well as temperature measurements in each inlet and outlet of all heat transfer components are provided for the system. Each system has at least one flow measurement at the outlet of the pump stations.

Design

The systems are equipped with valves that allow draining and venting all pipes and components. The draining system is connected to the atmospheric storage tank which is designed and placed to take the whole amount of thermal oil of the thermal oil boiler system if it has to be emptied. The inlet pipe of the storage tank is equipped with an inspection glass. The thermal oil boiler system is refilled with an extra feed pump.

The expansion vessel is situated as the highest point of the thermal oil system and equipped with a level control. Its capacity is large enough for the thermal oil volume which results from the thermal expansion. The expansion vessel provides a temperature isolation vessel which ensures a temperature of less than 60 °C in the expansion vessel so as to increase the lifetime of the oil. The expansion vessel is pressurised with nitrogen atmosphere.

If possible, all valves are designed for the same nominal pressure (PN) and diameter (DN) to simplify spare part management. All heatable systems that can be isolated with valves have to be equipped with safety valves. If possible, all safety valves are mechanical spring-loaded safety valves. At least two sample points are included in the system.

The pipes are made out of welded tubes. Pumps, valves and components can be connected with flanges. After assembly at least 10 % of the welding seams have to be checked with x-ray inspection. Each detected fault leads to a test of another 10 % and if ten faults are detected 100 % has to be checked. If applicable, EN 12952-6 needs to be adhered to.

B.8.4.5.4. Water Cooler

Components

This system consists of at least the following components:

- water cooler heat exchanger.

Function

The task of the water cooler is the discharge of the residual heat, if the heat production of the fluidised bed furnace exceeds the heat demand of the dryer and the air preheater and in case of a failure (blackout) or a standstill of one or more systems or components.

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Automation

The thermal oil outlet temperature is controlled by the cooling water flow through the heat exchanger and a bypass with a control valve or similar.

Design

The water cooler is designed as an emergency cooler with heat output equal to the heat generation of the thermal oil boiler with maximum load. If necessary, an emergency water tank can be installed.

The cooler is designed as a tube bundle heat exchanger with extractable tube bundles for cleaning and inspection. The cooler is situated on an oil collection tray with a leakage control.

B.8.4.6. Flue Gas Treatment

A dry flue gas treatment technology with sodium bicarbonate (sodium hydrogen carbonate, NaHCO_3) – hereafter referred to as bicarbonate – is used. The system is designed to separate ash from the boiler in the electrostatic precipitator and the FGT residues from the fabric filter.

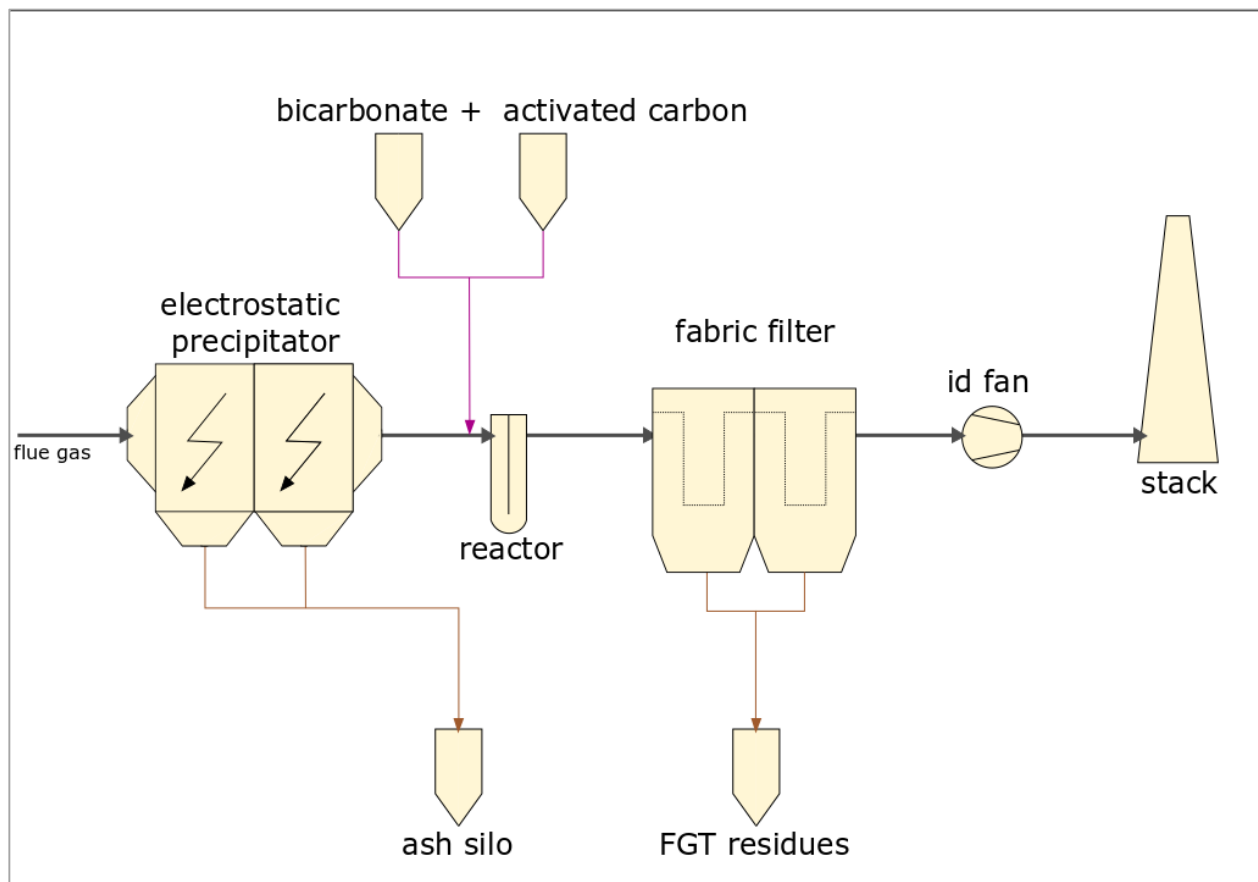


Figure 12: Flue gas treatment

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B.8.4.6.1. Electrostatic Precipitator

Components

The electrostatic precipitator (ESP) consists at least of the following components:

- flow distributor;
- high-voltage distribution;
- spray and collecting electrodes;
- vibration and rapper devices;
- ash chute with screw conveyor.

Function

The ESP uses electrostatic precipitation for the removal of the fly ash from the flue gas stream at the boiler outlet.

The flue gas is distributed by a flow distributor (perforated plate or similar). Electrons are emitted from the spray electrodes and the ash particles are negatively charged and directed to the collecting electrode. The collecting electrodes and flow distributor are cleaned with a vibration or rapping device. The ash particles are collected in the ash chute and conveyed with a screw conveyor to the residue system (see Section B.8.4.6.7).

The ash is suitable for phosphorus recovery by an external process at a later stage.

Automation

Each field is equipped with a separate voltage control to operate the filter as close as possible to the flashover limit. Electric arcs are detected and extinguished by lowering the voltage.

The ESP is controlled by a black box control system which is situated in the SSIP building. The parameters of the beating and vibration system can be modified from the SSIP control system.

Design

The ESP is a dry electrostatic precipitator with two fields for a high separation performance. The two-field design additionally allows operating the ESP in emergency operation with one field in case of a failure.

The ESP is designed and insulated to keep the casing temperature significantly above the acid dew point and prevent the precipitator from corrosion. The system is designed for easy replacement of the electrodes and equipped with mechanical vibration and rapping devices, where necessary.

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At the inlet and outlet side, the ESP is connected to the adjacent components with compensators. The ESP is accessible with manholes (see Section B.8.2.2), these manholes and the compensators are accessible without scaffolding. The ash chute is equipped with heating to avoid corrosion by sulphuric acid and an emergency discharge opening which can be used in case of a failure of the screw conveyor.

The manholes and the high-voltage distribution are equipped with a mechanical lock system.

B.8.4.6.2. Reactor

Components

The system consists at least of the following components:

- dosing units for:
 - bicarbonate;
 - activated carbon;
- reactor.

Function

Activated carbon (AC) is used as an adsorbent for volatile heavy metals (especially mercury) and organic pollutants like dioxins and furans. Bicarbonate is used as the reactant for the desulfurization process. Both are added to the flue gas stream prior to the reactor.

In the reactor, the bicarbonate and AC are mixed with the flue gas stream. For an optimal reaction process, the flue gas flow is deflected and the flow velocity is increased. The resulting reaction salts are carried along with the flue gas to the fabric filter.

Automation

The dosage of activated carbon (AC) depends on the flue gas volume flow. The dosing of bicarbonate is implemented as a function of the sulphur dioxide (SO₂) and hydrogen chloride (HCl) content in the raw gas.

Design

The reactor is designed to be abrasion-resistant. If required, the reactor is equipped with a flow distributor. The reactor is equipped with a manhole at the bottom as well as a discharge opening. The reactor is equipped with an electric heater to avoid the condensation and thereby the corrosion due to sulphuric acid.

The bicarbonate dosing unit is equipped with a mill for coarse-grained bicarbonate.

For optimal mixing of the reactants, the reactor is equipped with 90° flow deflections.

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B.8.4.6.3. Fabric Filter

Components

The system consists at least of the following components:

- flow distributor;
- ash chute with screw conveyor;
- carbon monoxide differential measurements;
- nitrogen fire extinguishing device.

Function

Particles in the flue gas flow are separated in the fabric filter (FF). The flue gas is passed through the filter hoses from the outside to the inside. Reaction salts, ashes, bicarbonate and activated carbon are collected on the surface of the filter hoses. The collection of bicarbonate and AC result in a reactive filter layer.

The pressure loss in each the fabric filter chamber is detected. If the maximum value is exceeded, the filter hoses are cleaned with pulses of compressed air. The particles are collected in the chute carried out by screw conveyors and transported to the residue system (see Section B.8.4.6.7).

CO differential measurements are placed in the flue gas ducts up- and downstream of the fabric filter to detect smouldering fires. In this case, the fabric filter is provided with inert nitrogen.

Automation

Smouldering fires are detected automatically with CO differential measurements. This detection takes the offset time of the flue gas flow through the fabric filter into account.

Design

The fabric filter is a two-chambered filter. Each filter chamber is designed for MINLC with increased filter load. Each chamber can be separated during operation on the raw gas side and clean gas side from the flue gas stream.

The flue gas enters the fabric filter from the bottom and is divided evenly over both chambers via a distribution channel. The flue gas, that passes the raw gas valves, the filter hoses and clean gas valves, is collected in the horizontal clean gas chamber on the upper side.

For cleaning of the compressed air, nozzles are used. Each filter hose line is equipped with a separate compressed air connection tube with the nozzles. Each tube is equipped with a separate membrane valve.

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The chutes and dead flow zones are equipped with a heating system to avoid corrosion due to the condensation of sulphuric acid. The chutes have emergency discharge openings which can be used in case of a failure of one of the screw conveyors.

B.8.4.6.4. Induced Draft Fan

Components

The system consists at least the following components:

- fan with impeller and casing;
- main drive;
- silencer.

Function

The induced draft fan (ID fan) ensures the correct negative pressure in the combustion chamber and transports the flue gas through the whole system to the stack. The silencer minimizes the noise output through the stack.

Automation

The negative pressure in the combustion chamber is controlled automatically.

Design

The ID fan is a single-flow radial fan with a two-part casing. The fan and the fan drive are designed with a spare capacity of at least 10 % for pressure and volume flow.

The welded impeller is housed in a casing made of steel plates with external stiffening to prevent vibration. The impeller shaft is double-mounted in anti-friction bearings. The impeller and the drive are connected with a flexible coupling.

An alternative design with a single-mounted impeller is possible, if the distance between the drive bearing and the impeller bearing is extended. In this case, the exact design has to be approved by the Engineer.

The impeller is designed as a vibration resistant construction and is statically and dynamically balanced. The casing has inspection and cleaning openings and is designed for high pressure water cleaning. The whole system has a noise reducing design.

The splitter is arranged between the ID fan and the stack and designed as a splitter silencer.

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B.8.4.6.5. Flue Gas Ducts

Components

This system consists at least the following components:

- flue gas ducts;
- compensators.

Function

The flue gas ducts ensure the gas-tight connection of the thermal oil boiler and all components of the flue gas treatment. Compensators are used when required to prevent the system from thermal stress.

Automation

-

Design

Compensators are fire-resistant and equipped with metal sheets for the protection of the bellow and to prevent dust accumulation.

The ducts are dimensioned for MAXLC (maximum load case, see Section B.8.1.3). Flow grids or baffles are used, in order to avoid vortices, dust deposits and noise emissions.

B.8.4.6.6. Stack and Emission Measurement System

Components

This system consists of at least the following components:

- stack;
- emission measurement system.

Function

The clean flue gas is lead to the atmosphere through the stack. The stack is equipped with the emission measurements to monitor the emission values.

Automation

The emission measurement system ensures an automatic and uninterrupted monitoring of the emission values during all operating conditions of the SSIP.

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Design

The emission measurement system is located inside an air-conditioned and heated container or inside a separate room. It includes all technical equipment and media that are necessary for calibration, test and operation of the system. The measuring instruments are placed in metal cabinets with sight glasses, lighting and 230 V sockets.

The measurements are processed and evaluated by the continuous emissions monitoring system (CEMS) computer. The CEMS-computer is equipped with a tamper-resistant data storage and archive as well as screen and printer. It has the officially prescribed remote monitoring system interface (German: EFÜ) required by the authorities.

All emission data is transmitted to the SCADA system. The following emission values are measured:

- hydrochloride acid (HCl);
- hydrogen fluoride (HF);
- dust;
- total carbon (C_{total});
- carbon monoxide (CO);
- sulphur dioxide (SO₂);
- nitrogen oxides (NO_x);
- ammonium (NH₃);
- mercury (Hg);
- water (H₂O);
- oxygen (O₂).

The measurement equipment is QAL 1 certified according to EN 15267. The design and arrangement meet the European standards and comply with the following rules:

- EN 15259;
- EN 14181;
- EN 15859;
- VDI 4202;
- VDI 3950.

Furthermore, the emission measurement system will be designed in close cooperation with the relevant local authority to comply with the local requirements.

For discontinuous or additional future measurements, spare measurement ports are included. The emission measurement system is equipped with an emergency power supply.

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The stack consists of a free-standing and self-supporting outer duct and the corrosion-resistant and pressure tight inner flue gas duct. It is equipped with a ladder and a platform for the inspection of the measurements and the top of the stack.

The stack is equipped with a condensate and rainwater drainage system.

B.8.4.6.7. Residue System

Components

This system consists of at least the following components:

- operating air system, including:
 - silencer;
 - compressors;
 - compressed air tanks;
- transmitter system, including:
 - collecting vessel;
 - transmitter vessel;
- pneumatic transportation systems, in each case:
 - conveying pipes;
- silos:
 - ash silo;
 - FGT silo;
- big bag filling station.

Function

The pneumatic conveying system transports particulate residues (ashes and FGT residues) to the silos. All transmitter systems shall consist of a combination of collecting vessel and a transmitter vessel. The residues are collected in the collecting vessel. If a maximum level is reached in the collecting vessel, it is filled into the transmitter vessel and transported pneumatically to a silo.

Automation

The silos are equipped with a level control.

Design

The silos are located outside the building and arranged and designed for truck unloading. The capacity is in each case 30 m³. Additionally, the silos can be unloaded with a housed big bag filling station.

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All silos are constructed with the gas tight steel sheets and a chute with a minimum angle of 60 ° to the horizontal and are equipped with manual gate valves below. The silos have a manhole as well as inspection openings and if required, trace heating. The chutes can withstand manual hammering to clear blockages.

The conveying pipe bends are designed with a larger radius (more than 10 times the diameter of the pipes) and basalt lining bends or ball shaped bends are used. If possible, ball valves or equivalent are used.

The entire residue system is equipped with trace heating and temperature measurements to ensure a problem-free transport. The trace heating of each component can be controlled independently depending on its temperature.

The ash silo is equipped with a heating system. It is used when temperatures around freezing point occur. The FGT silo is supplied with a heating system to keep the residues warm to prevent the formation of clumps due to the hygroscopic character of the residues.

B.8.4.7. Ancillary Facilities

B.8.4.7.1. Cooling Water System

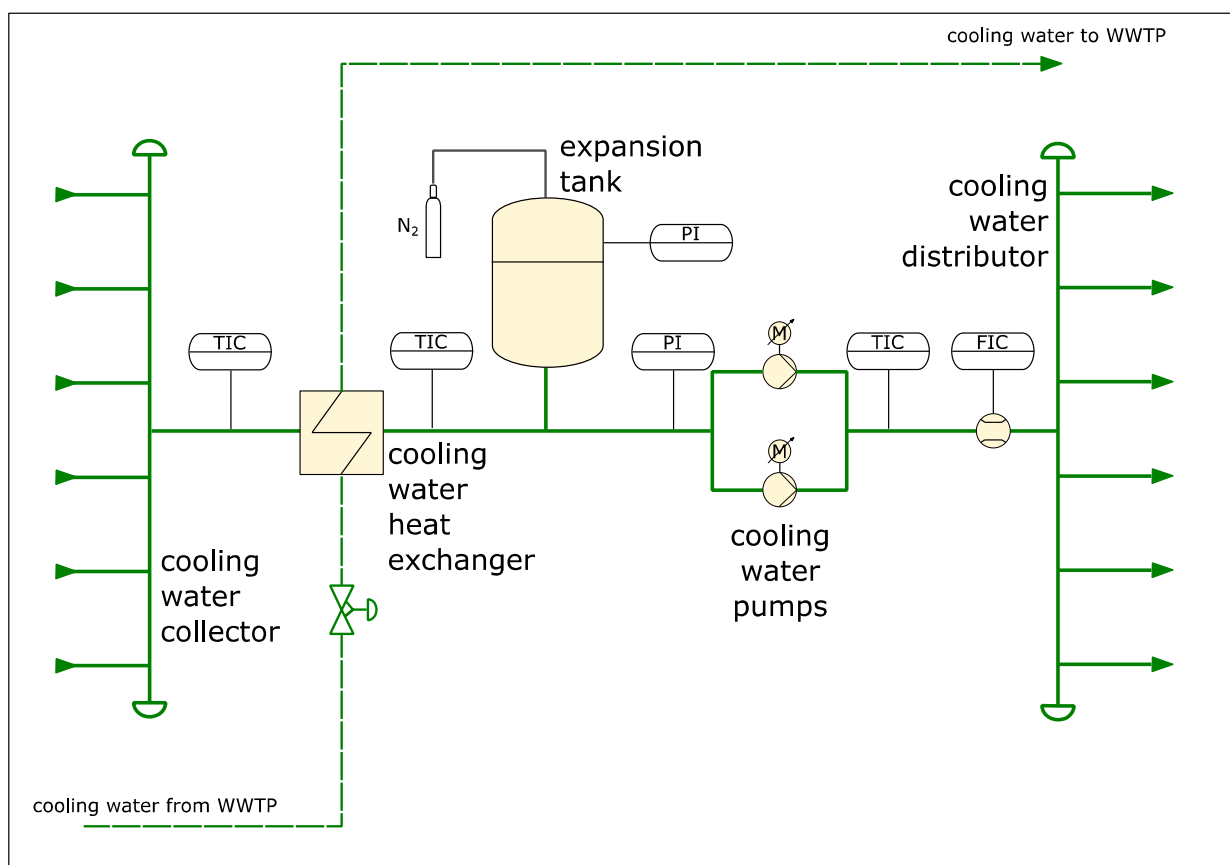


Figure 13: Cooling water system

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Components

This system consists of at least the following components:

- cooling water pumps;
- cooling water heat exchanger;
- expansion tank;
- cooling water collector and distributor;
- pipe network.

Function

The purpose of the cooling water system is the cooling water supply for the SSIP. The main consumers are the following components:

- sludge drying system: exhaust vapour condensation;
- fluidised bed furnace: sludge feeder;
- thermal oil boiler system: water cooler;

The warm return flow is collected by the cooling water collector and further passed to the cooling water heat exchanger. In the cooling water heat exchanger, the heat is transferred to the cooling water from the WWTP. The cooling capacity is controlled by the flow of the WWTP cooling water through the heat exchanger. The outlet temperature of the WWTP cooling water is limited to 30 °C.

The volume flow of the cooling water pumps is controlled to maintain a maximum return temperature of the cooling water.

Automation

The cooling water system operates automatically. An interruption of the cooling water supply has to be identified immediately and a fast pump changeover has to be implemented.

Design

The cooling water system is designed to discharge the thermal power of the SSIP. In case of a failure of the dryer and air preheater, e. g. in a blackout, the thermal capacity of the thermal oil system has to be discharged and a maximum thermal oil temperature has ensured. The design case for the thermal oil system is the MAXLC.

The cooling water pumps are designed as at least two redundant pumps (n-1 criterion) and are connected to the emergency power supply generator.

The expansion tank is equipped with a nitrogen pressure maintenance system.

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B.8.4.7.2. Fuel Oil System

Components

This system consists of at least the following components:

- fuel oil tank;
- pumps.

Function

Fuel oil is used for the start-up / auxiliary burner and fuel lances of the fluidised bed incineration. Fuel oil is used as auxiliary fuel and mainly during start-up. Primarily digester gas is used as the auxiliary fuel. But the use of digester gas decreases the power generation of the CHP plants. As a result, the electricity demand increases and demand peaks may cause higher costs. The use of oil can help to cut these peaks and optimise operation costs.

A fuel tank dedicated for the above described start-up of the SSIP will be installed close to the sludge incineration plant. This tank will also be used to provide fuel for the start-up of the anaerobic digesters (see Section B.7.2), for the heating of the digesters before biogas is produced. In the normal operation of the plant, digesters will be heated with the exhaust heat from the CHP units.

Automation

The level of the fuel oil tank is detected and transmitted to the SSIP control system.

Design

The fuel oil tank shall be sufficient for a cold start-up of the WWTP including the SSIP without the digesters being in operation and therefore no digester gas is available. In addition, the tank shall also have sufficient volume for six weeks of intermittent operation with weekly stand-stills (see Section B.8.2.4). It has a capacity of at least 10.000 l.

B.8.4.7.3. Control Air System

Components

This system consists of at least the following components:

- compressors;
- air dryer;
- compressed air tanks.

Function

The control air system generates the air for the operation of pneumatic actuators.

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Automation

The control air system operates automatically.

Design

Compressors and air dryer are designed with redundancy (n-1 criterion). The air dryer uses adsorption technology for the drying of the air.

The control air produced by the control air system is class 2 air according to ISO 8573-1 with a resting pressure of at 6 - 7 bar_g in the main air pipes.

B.8.4.7.4. Boiler House Crane

The Boiler house shall be equipped with a boiler house crane. The crane can reach all levels via the boiler house crane opening.

The crane should be able to reach the following components:

- centrifuges (SSTP);
- dryer including rotor;
- furnace;
- boiler including bundles.

B.8.4.7.5. Analysis

The following analyses must be carried out regularly and the required analysis and measurement equipment should be available in the WWTP laboratory:

3. Dry mass / water content: The remaining amount of dry sludge after a defined drying process. Determined by subtracting the water content.
4. Loss / residue on ignition (organic / mineral dry matter): Proportion of organic matter. Determined by burning the dried sample in the muffle furnace at 550°C and 800 °C.

These tests are necessary for the analysis of sludge quality. The determination of the loss on ignition of the ash will also be used to determine whether there are sufficient combustion parameters (complete combustion) or organic components are still to be found in the ash.

B.8.5. Electric, Automation and Control

B.8.5.1. Electric

For additional details on the electrical design of the plant, please refer to Section B.10.

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B.8.5.1.1. Power Supply

Transformer

The power supply of the SSIP is realised by two redundant 10/0,4 kV transformers (n-1 criterion) that are both placed in the SSIP in separate rooms.

The transformer is designed at least for a maximum load of 70 % during DLC operation.

Low voltage switchgear

The low voltage switchgear (LV switchgear / MCC4) is depicted in drawing E-0-00-SV-07. The LV switchgear is designed with MCC slide-in modules and is equipped with an automatic switchover in case of a failure of the transformer that is in use.

MV switchgear

The medium voltage switchgear (MV switchgear / MVDB SSIP) is illustrated in drawing E-0-00-SV-07.

B.8.5.1.2. Emergency Power Supply

The following SSIP components and systems are connected to the emergency power supply of the WWTP (Emergency Power Generator):

- thermal oil primary pumps;
- cooling water pumps;
- all automation, control and measurement technology.

B.8.5.2. Electric and Control Rooms

All of the following electric and control rooms are equipped with a double floor. The level of the double floor corresponds to the level of the respective level. Steps are not permitted.

For additional information on the location of the rooms in the SSIP, please refer to the layout plans, floor plans and section in **Drawings M-3-00-FS-01** and Section B.8.4.1.2.

Medium Voltage Room

The Medium voltage room (MV room) is a separate room exclusively for the MV switchgear and related components. The MV room is situated on the same level as the LV room and above the transformer room. Alternatively, the room can be located on the same level as the transformer room and below the LV room. The room is arranged next to an exterior wall. The MV switchgear is equipped with a pressure relief channel, which is led through the outer wall.

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Low Voltage Room

The LV switchgear is situated in the low voltage room (LV room) above the transformer room. The LV room is adjacent to the PLC room with direct access. All low voltage cabinets (e.g. frequency converters, emergency power systems) are placed in this room.

PLC room

The PLC room is located next to the LV room. It is equipped with an operation station (OS). All control technology cabinets (SCADA) are placed in this room.

The PLC room is equipped with a control desk, at least three ergonomic chairs, a meeting table with at least four chairs.

Kitchen

The PLC room is equipped with a small kitchen (pantry) with a stove, coffee maker, fridge, dishwasher, crockery, electric kettle, microwave and hot/cold water kitchen sink. Alternatively, the kitchen can be designed as an extra room accessible from the PLC room and the office.

Office

Connected or next to the PLC room there is an office which can accommodate two employees. The office equipment is similar to the offices of WWTP.

B.8.5.3. Automation and Control

For additional details on the automation and control design of the plant, please refer to Section B.10.

B.8.5.3.1. Control System

The control system of the SSIP is a part of the central control system of the WWTP, hereafter called SCADA (system control and data acquisition). The operation and monitoring of the SSIP takes place in the main control room of the WWTP (administration building).

Black box systems are not used except for systems with safety functions or operation independent periphery components. All measurements values and field signals are transmitted to the SCADA even if they are used in black box systems.

B.8.5.3.2. Combustion Control System

The control system includes an automatic combustion control. The sludge throughput has to be specified as the main set value by the operator.

B.9. SMALL HYDRO-POWER PLANT PROCESS DESIGN REQUIREMENTS

B.9.1. Function

The treated effluent outflow of the wastewater treatment plant (WWTP) shall be used for the generation of electrical energy by means of a water turbine, to take advantage from the significant head difference between the outlet of the WWTP and the River Moraca as receiving water. The effluent shall therefore be captured at the outlet of the UV-Disinfection as last system component of the WWTP and lead towards a powerhouse next to the river Moraca. The produced electricity shall be used directly in the WWTP, thus reducing the amount of electricity purchased for the operation of the plant.

B.9.2. Description and General Design Requirements

The Small Hydropower Plant shall consist of following components, which will be described in detail thereafter:

PART A: Inlet into turbine penstock;

PART B: Penstock pipe between inlet tank (after UV-Disinfection) and powerhouse;

PART C: Powerhouse;

PART D: Machine unit;

PART E: Outlet /stilling basin;

The mentioned components are described independently in the following.

B.9.2.1. Inlet into Turbine Penstock

A receiving tank inlet with two chambers shall be installed downstream of the UV-Disinfection. One chamber shall have an outlet connected to the turbine penstock and the second chamber shall have an outlet to the general by-pass pipe of the WWTP, running parallel to the SHPP penstock. The effluent from the UV-Disinfection shall entirely be lead towards the inlet chamber of the SHPP penstock. To the second chamber (by-pass chamber) shall be connected the general by-pass pipe of the WWTP. The chambers shall be made out of concrete.

The chambers shall be connected via an overflow weir with fixed crest, ensuring a constant water level (29,97 masl in the conceptual design) in the inlet chamber of the penstock. By means of the overflow weir, excess water, which cannot be processed in the turbine, will be discharged towards the second inlet chamber and from there to the river Moraca via the general by-pass pipe. However, in order to reach the highest possible energy output, as much water as possible should be lead towards the turbine under normal operating conditions and the transfer system and the turbine shall be designed to have the capacity to accept at a minimum the dry weather peak flow at the design horizon of the plant.

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In case of failure or maintenance of the turbine unit, all water shall be discharged into the river Moraca via the general by-pass pipe. For this purpose, a sluice gate shall be installed at the outlet of the chamber towards the turbine penstock, so that all water will be lead over the overflow weir into the second inlet chamber. Material and type of the sluice gate shall be chosen by the bidder. The closing time of the gate must be adjusted to the reflexion time of pressure waves within the pipe system in order to avoid pressure shocks. The sluice gate shall be automatically driven and connected to the turbine control system.

The inlet chamber of the pressure pipe shall be designed in such way that hydraulic losses will be minimized. This includes the shape of the inlet itself as well as the length and shape of the chamber in order to minimize turbulences caused by the influent water coming from the UV-disinfection. If necessary, flow-straighteners can be considered for this purpose. In order to avoid the intake of air into the penstock pipe, a minimum water level above the crown of the pipe is required according to the recognized rules of design and technology.

B.9.2.2. Penstock Pipe between Inlet Tank (UV-Disinfection) and Powerhouse

The main function of the penstock pipe is to transport the treated effluent from the UV-Disinfection to the powerhouse. The length of the pipe will be approximately 200 m. To minimize the mechanical exposure of the pipe to heat, frost and other environmental influences, the pipe shall be laid underground in appropriate depth. A proper bearing of the pipe, if necessary in a sand bed to avoid concentrated load on the pipe, must be ensured. At all bends of the pipe, massive bearings (for example made of concrete) shall be built. The pipe should have a minimum slope of 0,5 % to prevent air bubbles from getting stuck within the pipe system.

Since the turbine will be located on the lowest level of the powerhouse, the pipe needs to be led downwards on a level of approximately 10 m below the surface when reaching the powerhouse. To connect the pipe with the turbine inside the powerhouse, a wall lead-through needs to be installed on this level. It has to be emphasized that the water level in the river Moraca and thus the groundwater level around the powerhouse can be higher than the wall throughput during high flow conditions. For this reason the powerhouse and pipe lead-through must be designed and constructed as to be fully watertight.

The nominal diameter of the pipe shall be in the range of DN 700 to DN 1200 and shall be determined by the Bidder. For this purpose, a cost-benefit analysis between material costs and resulting energy output shall be carried out taking into consideration the overall system behaviour and the local availability of pipes. The pipe shall have the capacity to transfer the maximum flow rate which can be processed in the turbine (dry weather peak flow at the WWTP design horizon).

The material of the pipe shall be selected by the Bidder in order to consider the local availability of materials and components. To minimize the hydraulic losses in the pipe and thus maximize the energy output of the plant, materials with long-term low friction coefficients (and

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thus with low chemical interactions) will be preferred. Besides, materials with standardized pipe connections and easy handling (e.g. because of light weight) will be preferred in order to minimize transportation costs and to avoid concerns on the construction site.

B.9.2.3. Powerhouse

The powerhouse shall house all components for energy production in the proper sense. These are the turbine and generator, supply pipe and outlet including all control and isolation valves as well as measurement and control technology.

In order to reduce the outlet section after the turbine and herewith the risk of cavitation, the powerhouse shall be built in close proximity to the river. Nevertheless, for stability reasons, the building shall be far enough from the river bank to ensure a full embedding into the ground. Extensive excavation and earthwork will be required for this purpose. The bottom level of the powerhouse [masl] shall be specified by the Bidders in accordance with the arrangement and the maximum suction head of the turbine. The turbine shall be located at the lowest point of the powerhouse. The entrance to the building shall be from the higher bank, since this is more flood-safe. On this level also the switchgear and control devices shall be installed at a flood safe level.

As indicated before, the water level in the river Moraca can be above the bottom level of the powerhouse (up to approximately 6 m, depending on the bottom level of the powerhouse), which is why a watertight construction made of reinforced concrete is necessary in order to prevent water from entering the machine area. Also pipe lead-through and other possible openings in the concrete structure shall be designed and implemented to be fully watertight for the highest possible water level outside of the powerhouse.

Inside the building, there shall be appropriate equipment to install, operate and maintain the machine unit and all involved components. This includes notably:

- a staircase including handrail to access the machine level, big enough for the maintenance staff to carry necessary tools and equipment;
- an overhead crane, able to carry the weight of the heaviest component installed on the machine level, which cannot be further dismantled. There must be a possibility to park the components on the ground level after lifting them up. The conduction of loads onto the building needs to be considered as part of the structural planning;
- an entrance door big enough for taking out / exchanging the biggest component installed inside the powerhouse, which cannot be further dismantled;
- access road to the powerhouse for heavy vehicle.

In order to reduce the construction costs, the powerhouse should be as compact as possible. Nevertheless, especially the machine level must provide enough space to allow construction and maintenance works around the machine unit and other relevant components. The turbine shall be easily accessible without dismantling the generator. The building needs to meet all standards for operational and work safety.

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All building services, such as climate control, ventilation and illumination shall be included in the design of the powerhouse.

In the scope of the structural design of the building, all relevant loads and load cases need to be considered according to technical directives and the recognized rules of technology. This includes, amongst others, the above mentioned load from the overhead crane, the above mentioned hydraulic pressure from groundwater, the dead-weight of the building, earth pressure, temperature as well as all static and dynamic loads from the hydraulic system including vibration processes.

B.9.2.4. Machine Unit and auxiliary Components

The machine unit shall include all mechanical and electrical parts for power generation including turbine, generator, hydraulic steelwork and switchgear as well as all auxiliary components which are necessary for a safe and economic plant operation. The latter include measurement and control technology, more precisely all components for control, regulation and monitoring of the plant as well as for measuring external and internal data in consideration of all relevant influencing factors. If possible, all mechanical and electrical components shall be provided by a single supplier in order to guarantee a coordinated operation. Otherwise, the Bidder must check and ensure the compatibility of the chosen components.

Generally, different types of turbines can be used for the given application. These are, in particular, Francis turbine, cross flow turbine and reversible pump. The bidder shall select the technology he considers the most suitable including the according system configuration. Depending on the turbine type, one or two machine units can be considered. It has to be emphasized that the turbine has to deal with fluctuating discharge rates from the WWTP throughout the day and with strongly fluctuating tailwater levels in the river Moraca throughout the year. The discharge rates from the WWTP will increase until 2045 (see Section B.9.4).

Depending on the turbine type, a draft tube shall be installed in order to minimize the hydraulic losses in the outlet and to recover pressure from velocity height. The dimensioning of the draft tube shall be done by the Bidder in accordance with the specifications of the turbine, in particular the diameter of the impeller and the local conditions. The overall system configuration shall be such that the risk of cavitation is minimized.

For maintenance purposes, there shall be isolation valves before and after the turbine. The valve on the tailwater-side also has the purpose to prevent water from entering the power house in case of high water conditions in the river Moraca, which is particularly important when using a constant-pressure turbine. Material and type of the valves shall be chosen by the Bidder in accordance with the technical specifications.

The overall system configuration shall be as easy as possible to operate and maintain, with robust and standardized components and only few rigid parts to keep the maintenance effort low. The turbine shall be designed to withstand a life span of > 30 years for moving parts and

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> 50 years for rigid parts. Guide vanes and adaptation mechanism shall be easy to remove for maintenance purposes.

All parts of the machine unit shall be mounted on adequate bearings, which receive all static and dynamic forces from the hydraulic system.

The turbine shall be operated within the grid. Additional equipment for isolated operation is not required. The produced energy shall be used directly to cover parts of the own energy consumption of the WWTP, which means that a transformer and high-voltage-switchgears for grid feed-in are not necessary.

The plant shall run fully automated and shall be equipped to be remote-controlled and monitored from the control room of the WWTP. All necessary control and measurement devices need to be foreseen and planned for this purpose, which includes among others the electrical connection of the components with the control room and, if necessary, camera surveillance and anti-burglar systems of all crucial components.

The fully automated operation is particularly important in case of grid disturbances, in which the machine unit should automatically be transferred into a secure operating mode (usually transferred to halt). For monitoring reasons, the auxiliary measurement and control components as well as the switchgear should be equipped with batteries to further allow the plant to be remote-controlled.

The scope of services concerning the machine unit and its auxiliary components as described above comprises the technical processing, the production, the assembly as well as the commissioning of the plant, including test operation and documentation. The bidder is expected to submit an overall offer for a fully equipped, functioning turbine system.

B.9.2.5. Outlet / Stilling Basin

On the tailwater side of the turbine, the water shall be discharged into an outlet basin, serving as counter-pressure basin with constant water level. The construction shall be made out of concrete. In order to lead the water from the turbine inside the powerhouse towards the outlet basin, a wall lead-through will be necessary. As stated before, the water tightness of the construction needs to be ensured.

The basin fulfils two functions. On the one hand, the risk of cavitation damages inside the turbine can be minimized by applying a counter-pressure. On the other hand, the constant tailwater-level simplifies the dimensioning of the turbine. The water-level in the stilling basin shall be specified in accordance with the optimum operating height of the turbine in the range to be specified by the Bidder (between 14,5 and 16,2 masl based on the Employer's Conceptual Design). During high flow conditions in the river Moraca, the water level in the river will exceed the water level in the stilling basin leading to reduced energy production rates and possibly to lower efficiency rates of the turbine. The optimum height of the basin has to be determined by weighing out these aspects.

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For structural stability, especially in case of high water conditions in the river Moraca, the constructional structure of the stilling basin shall be connected to the power house by means of a continuous bottom plate.

B.9.3. General requirements

All commissioned assignments, including required blueprints, technical evidences and calculations as well as required surveys, have to be planned, carried out or contracted out by the contractor according to relevant regulations, standards, directives, laws and the recognized rules of technology until the day of approval. During the construction and assembly of the plant, all required audits and quality inspections of the mechanical and electrical installations including control technology have to be carried out. The Bidder is responsible for all calculations with regard to a proper plant operation, in particular the hydraulic dimensioning of the pipe system, the turbine and its auxiliary components as well as the static stability calculations.

B.9.4. Design Criteria / provided Data

For the offer, the following design criteria shall be considered. Some of the outlined values have been determined on the basis of preliminary investigations. The bidders will have the latitude to select and propose the technology they consider the most suitable as well as to adapt the key figures. This applies in particular, if by the bidder's concept the overall power generation and herewith the profitability of the plant can be increased in comparison to the values shown below. The choice of technology and materials shall be done considering the local availability of technical components and construction materials. All adjustments and assumptions need to be pointed out in the offer.

Table 12: Design criteria for the SHPP

Component	Unit	Value/Description
Expected life span of the plant	years	50
Inlet		
Type of construction	-	concrete
Number of chambers	No.	2
Water level in the inlet chamber	masl	29,97 (conceptual design value. May be adjusted by the Bidder)
Type of connection between the chambers	-	Overflow weir
Type of gate	-	Automatically driven sluice gate
Penstock Pipe		
Approximate length	m	200
Estimated number of elbows	No.	2
Estimated type of elbows	-	45° elbow piece
Type of installation	-	underground

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Component	Unit	Value/Description
material	-	GRP, steel or comparable
Minimum slope	%	0,5
Nominal diameter	mm	DN 700 – DN 1200
Turbine		
Number of turbine units	No.	1 - 2
Type of turbine	-	Francis-turbine, cross-flow-turbine, Reversible pump or any comparable turbine type
Required peak efficiency	%	> 70
Expected life span	a	> 30 a for moving parts, > 50 a for rigid parts
Upstream Water Level (constant)	masl	29,97 (conceptual design value. May be adjusted by the Bidder)
Absolute maximum Water Level in the River Moraca	masl	21,36
Absolute minimum Water Level in the River Moraca	masl	13,70
Minimum discharge from the WWTP (2023)	m³/s	0,152
Maximum discharge from the WWTP (2045)	m³/s	0,886
Estimated Net head	m	8,2 – 14,9
Estimated Design discharge for turbine	m³/s	0,5 – 0,7
Hydraulic Steelwork		
Number of valves	No.	2
Type of valves	-	Spherical valve, gate valve or comparable
Suction tube	No.	1
Powerhouse		
Type of construction	-	concrete
Outlet		
Type of construction	-	concrete
Tailwater level	masl	14,5 – 16,2

In addition to the above mentioned values, for the dimensioning of the turbine also the annual water level duration curve for the River Moraca as well as the daily wastewater discharge duration curve from the WWTP are relevant. The according data can be seen in **Figure 14** and **Figure 15** and will be provided to bidders in digital format for the dimensioning of the turbine.

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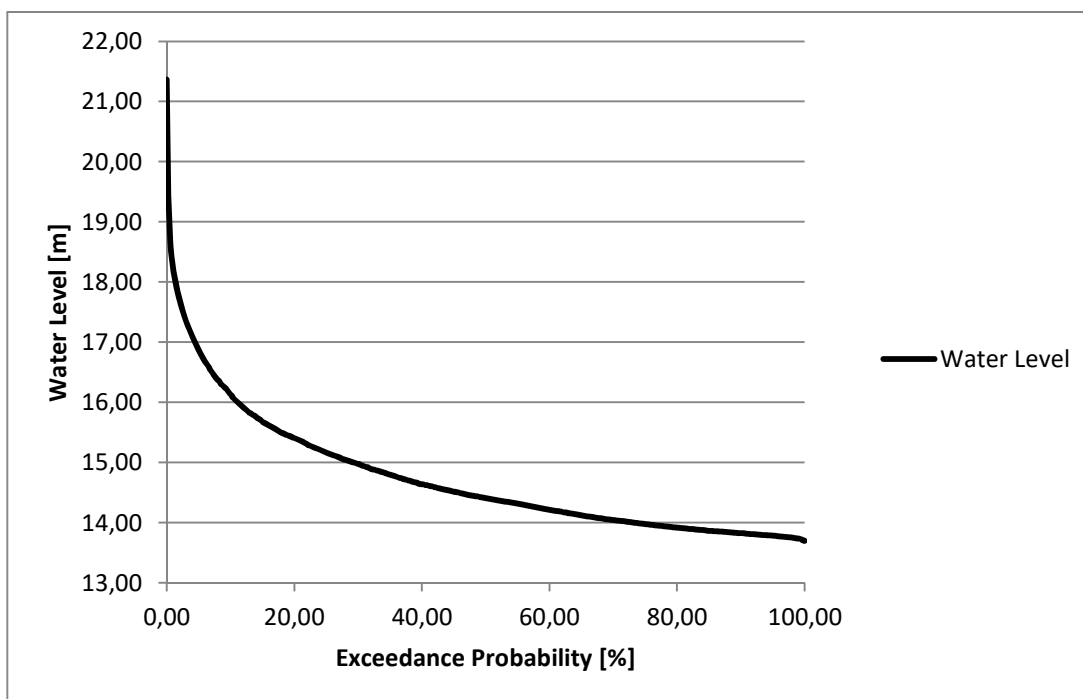


Figure 14: Water Level Duration curve for scenario 2 without weir

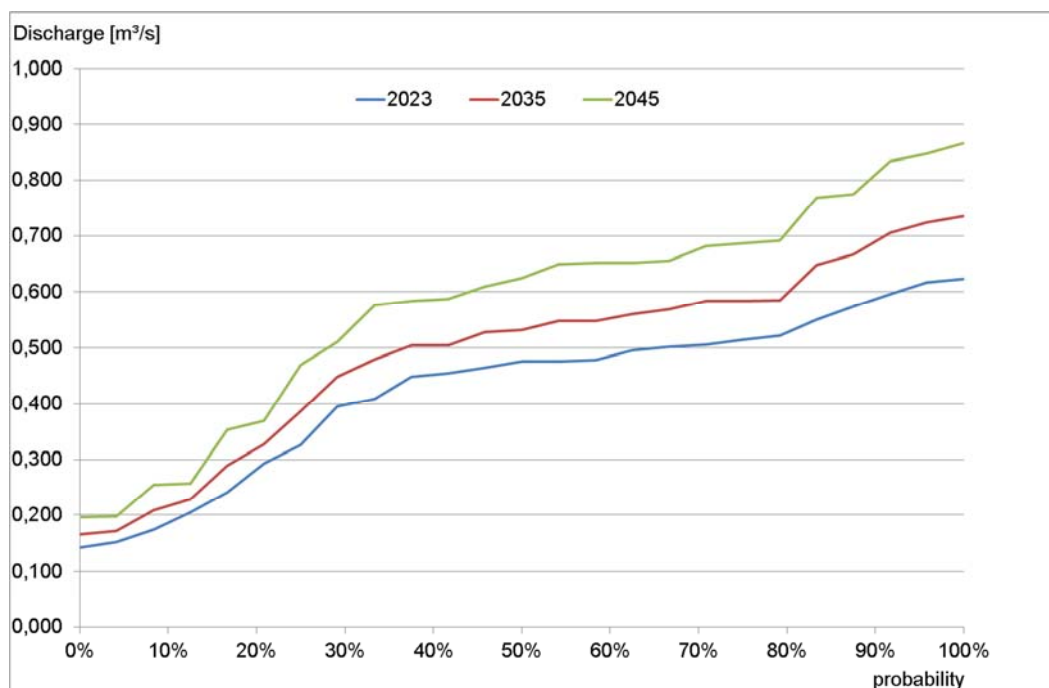


Figure 15: Projected daily wastewater discharge duration curves (dry weather flow)

B.9.5. Guarantee Values

As part of the offer, the bidder needs to indicate several guarantee values, which have to be guaranteed during continuous operation (for operation parameters within allowed range under

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continuous operation) and shall be checked during test-operation as indicated in Volume 2, Section IV, Part A).

B.9.6. Mechanical components

The mechanical components to be supplied and installed shall consist but not be limited to the following.

Table 13: Mechanical components required for the SHPP

Equipment	Number of units	Description
Hydraulic Steelwork		
Sluice gate	1	automatically driven sluice gate in the same dimension as penstock pipe
Isolation valve	2	spherical valve or gate valve
Penstock pipe	1	length approx. 200 m, including elbow pieces , material is to be specified by the bidder
Suction tube	1	According to the specifications of the turbine
Machine unit		
Turbine	1 - 2	Francis-turbine, cross-flow-turbine, Reversible pump or any comparable turbine type
Generator	1 - 2	asynchrone Generator with direct coupling to the turbine
Auxiliary machine components	1	All further required mechanical and electrical components for power generation according to specifications of the turbine
Powerhouse		
Overhead crane	1	able to lift component with highest weight in the powerhouse
Staircase	1	staircase to access machine level in the power house
Entrance door	1	louvred entrance door
Windows	4	louvred windows with break-in protection

B.9.7. Construction works

The construction works to be planned and executed shall consist but not be limited to the following.

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Table 14: Constructions works required for the SHPP

Component	Number of units	Description
Inlet basin	1	Construction made of concrete with two chambers, hydraulically favorable
Outlet / stilling basin	1	Construction made of concrete, structurally connected to the power house
Powerhouse	1	Construction made of concrete, housing of all components for power generation, including housing technology
Wall throughput	2	at in- and outlet of the powerhouse
Foundations	Not specified	Bearings / foundations for penstock pipe and machine unit(s)

B.9.8. Instrumentation

The instrumentation shall be selected in compliance with the selected turbine and the relevant external and internal influencing factors, which have to be measured and monitored for a proper plant operation. Amongst others these typically include:

- Hydrological data from the river (water level);
- Hydraulic parameters within the pipe system (flow rate, flow velocity, pressure...);
- Operational data (status of valves and machines, rotation speed of the turbine, generated power output, temperature of the bearings...).

The required measurement devices will be specified by the bidder and shall be submitted to the Engineer for approval.

B.9.9. Control and Automation

The operation of the turbine will be controlled depending on the hydrologic conditions of the River Moraca, the discharge rates from the WWTP and the operational status of the plant. An individual control technology concept including integration into the control system of the WWTP will be developed and implemented for this purpose by the Bidder. The concept shall be submitted to the Engineer for approval.

B.9.10. Commissioning and Testing

As part of the detailed design, the chosen supplier shall prepare a commissioning and acceptance programme in accordance with international standards, which shall be submitted to the Engineer for approval and should include (but not be limited to) the following steps:

- Dry commissioning: functional tests of all mechanical and electrical components as well as the measurement and control technology with the goal of verifying the unobstructed functioning of all components for the wet commissioning;

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- Wet commissioning including 48-hour test operation: Verification that an unobstructed, safe and dedicated operation of all components and the system as a whole is possible. For this purpose, the turbine shall be rotated for the first time with low rotation speed to check possible noises, vibrations and all operational parameters such as temperature, pressure and flow rate. The 48-hour test-run should include start-up procedures and halts (stationary and instationary operation modes which have to be specified in detail before the commissioning). During this time, the plant must not show any deficiencies;
- Acceptance measurements (performance measurements): The duration of the measurements has to be determined according to contractual regulations but should not be less than four hours;
- Test operation: The test operation serves to verify the complete functionality of the plant and the contractual performance during continuous operation. Performance measurements are being conducted for this purpose with the existent measurement devices and, if necessary, with additionally installed temporary measurement devices. The test operation is conducted as continuous 4-week-long operation, during which modifications in the operation settings are not allowed.

All tests have to be carried out according to relevant regulations and standards and have to be documented.

B.10. ELECTRICAL INSTALLATION DESIGN REQUIREMENTS

B.10.1. General Design Criteria

With reference to the general electrical specification the provided installation and materials shall be designed for the regional climate in Podgorica Capital City.

B.10.2. Power Supply

The WWTP Podgorica including the Sewage Sludge Treatment Plant (SSTP) and the Sewage Sludge Incineration Plant (SSIP) will be connected to the local public electrical network in accordance with technical requirements issued by local power supply authority (CEDIS). The following two independent 10 kV feeders will be provided by CEDIS in order to ensure the safe operation of the plant:

- one 10 kV power supply line from the CEDIS transformer station Podgorica 5, located close to ViK Headquarters at a distance of approx. 8 km from the WWTP site;
- one 10 kV power supply line from the CEDIS transformer station Gornja Zeta south of the WWTP site at a distance of approx. 2 km.

The connection point shall be realized on the medium voltage level at 10 kV. The two 10 kV feeders shall be interlocked to avoid paralleling. The interlock function is scope of supply under this project.

The power supply cable from the grid-substations to the WWTP main station will be installed by Podgorica Capital City and will not be included in the scope of works of the WWTP Contractor.

Two redundant 10 / 0,4 kV transformers for the wastewater and sludge treatment and two redundant 10 / 0,4 kV transformers for the incineration plant shall ensure the low voltage supply to the plant. Each transformer shall be designed to cover 100% of the connected load.

The wastewater treatment plant shall additionally be supplied with power from the two following internal sources:

- two combined heat and power (CHP) units producing heat and power from the biogas produced in the sewage sludge digester;
- one Small Hydro-Power Plant (SHPP) installed at the outlet of the discharge pipe of treated effluents to the Moraca River.

The two CHP units and the SHPP shall generate power to the 0.4 kV low voltage network of the wastewater treatment plant. The produced power shall be used internally at the plant.

To ensure the operation of the plant also during power failures of the public grid, a diesel emergency generator shall be installed. The generator shall provide power to the critical components of the plant, required to run the process. Details of emergency power consumers

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are subject to contractor's design. A load shedding function shall be implemented, realized by SCADA. In case of mains power failure, the load shedding function will disconnect non-essential loads. A start up sequence of the plant after power failure shall also be implemented in the SCADA system.

B.10.2.1. Transformer Station WWTP and SSTP

The following equipment shall be installed in the WWTP and SSTP main station:

1. Medium Voltage Distribution Board 10 kV (MVDB):
 - Incoming panels for connection to public grid (two feeders) with motorized circuit breaker and interlock;
 - One Measuring panel;
 - Transformer feeder panels with motorized circuit breaker;
 - Two transformer feeder panels spare with motorized circuit breaker.
2. Power transformers:
 - Number and rated power according to design requirements;
 - Voltage 10 / 0.4 kV;
 - Oil cooling.
3. Main Low Distribution Board (MLDB):
 - Rated busbar current according to design requirements;
 - incoming panels;
 - Coupling panel;
 - Feeder panels to MCC and electrical distributions.
4. Emergency Diesel Generator:
 - Rated Voltage: 0.4 kV;
 - Rated load according to design requirements;
 - Type: indoor;
 - Network paralleling: yes, for power return.

B.10.2.2. Transformer Station SSIP

1. Power transformers:
 - Number and rated Power according to design requirements;
 - Voltage 10 / 0.4 kV;
 - Oil cooling.
2. Motor Control Centre (MCC) with following characteristics:
 - Rated busbar current: according to design requirements;
 - incoming panel for redundant supply;

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- Coupling panel;
- Outgoing circuits for process equipment.

B.10.2.3. Emergency Diesel Generators

Bidders shall provide an emergency stand-by power generation system including fuel tank, with a capacity sufficient to supply all essential components of the WWTP, SSTP, SSIP and other facilities to ensure that the treatment capacity and treatment efficiency and performances are not compromised.

The fuel tank shall have a storage capacity enabling continuous operation of the emergency power generation system for a minimum of 24 hours, without fuel refilling.

The diesel generator set shall fully comply with general electrical specification in Section H.2.5 of the Employer's Requirements.

B.10.3. Power Distribution

B.10.3.1. Medium Voltage Distribution

The medium voltage switchgear shall comply to the general electrical specification chapter H.2.3 of the Employer's Requirements. The switchgear shall be expandable for future extension.

B.10.3.2. Low Voltage Distribution

The low voltage distribution system of the plant includes distribution panels and MCCs according to requirements of bidder's design. The design shall fully comply to the general electrical specification of this project with special attention to the following main chapters of the Employer's Requirements:

- H.2.6 Low Voltage Switchgear panels
- H.2.7 Motor Control Centre (MCC)
- H.2.8 Reactive power regulation
- H.2.9 Uninterruptable Power supply
- H.3 Installation works

B.10.4. Small power and lighting

The small power and lighting installations shall be designed according to Section H.3.10 of the Employer's requirements and shall be compliant to Montenegrin regulations.

The installation of small power and lighting shall be surface mounted type, except for administration building and office areas with flush mounted installations.

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A low voltage distribution board mainly provided for supply of indoor illumination and small power installation shall be installed in each building. Furthermore one HVAC distribution shall be installed for each building with HVAC installations.

For installations in hazardous areas additional arc fault detection devices (AFDD) shall be implemented.

B.10.5. Earthing, Lightning Protection and Potential Equalization

The earthing and lightning protection installations shall be designed according to chapter H.37 and H.3.8 of the Employer's Requirements.

The design shall be based on a risk report as part of the electrical detailed design. Minimum requirement shall be lightning protection zone III according to IEC 62305. For buildings in hazardous areas, lightning protection zone I shall be realized.

B.10.6. Telecommunication and Network System

B.10.6.1. General

A state of the art network and telephone system shall be provided for the entire plant. The system shall be TCP/IP-based.

B.10.6.2. Telephone System

A sufficient number of telephone sets shall be provided to ensure a convenient internal and external communication.

- Office and administration area;
- Control room;
- Switchgear rooms.

For communication on site a DECT or WLAN system covering the entire plant area shall be available. A number of mobile telephone sets (min. 10 pc) for operators and plant staff shall be available and stored in the control room of the plant.

B.10.6.3. WLAN

For connection of mobile devices for process control, a comprehensive wireless LAN system for industrial areas shall be installed at the plant. The system shall be manageable and comply with following specifications:

- Communication Standard IEE802.11;
- Communication 2,4 and 5 GHz;
- Communication via Ethernet and Profinet;
- Suitable for Hazardous areas (if required);

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- Data rates up to 1.733 Mbps;
- Plug and Play technology;
- Security management
- Manageable network
 - Provision of different WLAN networks with one hardware device shall be possible (Public WLAN, Office WLAN, SCADA WLAN);
 - User and digital rights managements shall be available.

The system shall be available at any place of the plant. The Contractor shall provide and submit to the Engineer's approval a simulation for the radio coverage with the detailed design. A radio field measurement shall be included in the as built documentation.

B.10.6.4. Central Data Server System

The central Server system of the plant shall be installed in the administration building. The system shall be a state of the art Server system for 19" rack installation with the latest server system software and the following tasks and minimum requirements apply:

- Central user management (domain);
- Central digital rights management;
- Central firewall and security system;
- Central network management (LAN, WLAN);
- VPN connection via firewall;
- Central data storage and data backup solution;
- Provision of virtual servers for the different tasks.

The contractor shall install and setup the system according to the Employer's requirements. Therefore the contractor has to submit a functional specification for Engineers approval prior to ordering and installation of the system. All licences and passwords shall be provided to the Employer with the documentation.

B.10.7. Fire Alarm System

The Fire alarm system shall be installed according to Section H.6.1 of the Employer's Requirements. The system shall be designed according to the requirements of the fire safety plan but minimum class II according DIN 14675 (partial protection).

The fire alarm system shall comply with requirements of the Law on Protection and Rescue (Off gazette of MNE No. 54/16) and the Rulebook on technical standard for stable fire alarm installations (Off Gazette of the SFRY No. 87/93)

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B.10.8. Gas Alarm System

The Gas alarm system shall be installed according to the requirements of a risk analysis document and shall be compliant to Section H.6.2 of the Employer's Requirements. As a minimum requirement the gas alarm system shall be installed in the following areas of the plant:

- Screening building;
- Sludge pumping station;
- Gas room;
- CHP room.

B.10.9. Security and CCTV Systems

The contractor shall provide a comprehensive safety and security concept design for the plant. The design shall be discussed with the Employer and shall be subject to Engineers approval prior to ordering and installation works. The following main items shall be part of the security concept:

- Mechanical protection (fences, walls, doors and gates, etc.);
- Security areas and zones;
- Plant access control;
- Plant burglar alarm system;
- CCTV system.

The security design shall be fully compliant to Montenegrin standards and to the Employer's Requirements Section H.6.3, H.6.4 and H.6.5.

The access control for the WWTP shall be based on card reader and security barrier with full access control on the main entrances and buildings. The system shall be based on a central analysing unit connected to the door lock system.

Certain numbers of IP digital cameras shall be provided for process and access control. The IP cameras shall be installed in the field while terminal, supply units, switches, joystick and server shall be located in administration building.

The following areas shall be equipped with video system as a minimum requirement:

- Complete surrounding fence / wall;
- Access gates and roads;
- Parking areas;
- Entrance for each building;
- Corridors of administration building;
- Entrance for control and switchgear rooms.

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The Security system shall comply with the requirements of the Law on Protection of Persons and Property (Off Gazette of MNE No. 43/18) and the Law on Protection and Rescue (Off Gazette of MNE No. 54/16).

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B.11. PLANT CONTROL AND SUPERVISION

The plant control and supervision system shall be designed according to chapter H.5. of the Employer's Requirements and following additional requirements.

One SCADA system shall be implemented to cover WWTP, SSTP, SHPP, SSIP processes as well as common facilities. The system shall be installed in the main control room of the WWTP. For installation of hardware a server room including 19" racks shall be provided. The following equipment shall be provided as a minimum requirement:

- Two Operator stations for the WWTP;
- One Operator Station in the laboratory of the WWTP;
- One Operator station for Incineration plant;
- One Engineering station for WWTP;
- One Maintenance Station / Server;
- Redundant Server system;
- Historical Data Server;
- Internal and external Firewall system;
- External SCADA Access for 10 users (simultaneously);
- Video wall consisting of 4 monitors with a diagonal of 65 inches in the control room;
- 86 inch interactive touch screen in the meeting / conference room

The SCADA program shall be based on prefabricated and tested PLC modules. If contractor specific PLC modules are used, the complete source code and passwords shall be handed over to the client.

The contractor shall provide an engineering license of the SCADA system to the client.

B.11.1. KVM Operator Terminals (OS)

A KVM matrix system shall be installed to allow for the access to the system from the servers of the different operator stations all over the plant, locally and/or remotely. Remote access shall be accomplished in various ways, over:

- CAT cable, 1:1 (distances up to 300 m), indoor;
- Fiber-optic cable (distances up to 10 km), for maximum performance and availability;
- LAN (Local Area Network) or WAN (Wide Area Network) "over IP" for access from any location.

KVM Terminals shall be installed in each PLC control room and in adequate number for process control of the plant. A central KVM Server with adequate number of clients shall be installed.

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B.11.2. Advanced Maintenance System

The SCADA system shall enable online monitoring and diagnostics for all elements of the plant. The software shall give online status information of the equipment and shall be linked to the documentation system of the plant. It shall provide an interface to the ERP (Enterprise Resource Planning) system. Furthermore, the software shall automatically generate maintenance schedules. It shall be possible to implement operating guidelines.

The maintenance station shall be specialized for plant asset, i.e. the management of company assets that are used as fixed assets. Its tasks shall include efficient administration and management of equipment, in particular the I&C equipment, with the objective of maintaining and increasing the value.

The following maintenance strategies shall be supported.

B.11.2.1. Corrective Maintenance

Response to pending error and diagnostics messages:

- Failures are risked or minimized by redundant configurations;
- Maintenance in the form of repair or replacement.

Preventive maintenance

Preventive diagnostics and maintenance:

- Initiation of appropriate maintenance measures before a fault actually occurs;
- Maintenance in the form of time-dependent or status-dependent maintenance (depending on degree of wear).

B.11.2.2. Predictive Maintenance

Predictive diagnostics for timely detection of potential problems and determination of the remaining service life.

With the help of the software tool, the maintenance engineer shall be able to check the hardware of the automation system, evaluate its diagnostics messages and information and derive maintenance measures from them. It shall be supported to plan, control and document the entire maintenance cycle - starting with the arrival of a diagnostics message, continuing with the evaluation of detailed diagnostics information and the planning, initiation and tracking of maintenance measures, all the way to their completion.

The Maintenance software tool shall be fully integrated in the SCADA system.

Parallel to process control, the software provides consistent maintenance information and functions for the system components of the plant (assets):

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- The plant operator receives all process-relevant information via the operator system, as well as an overview of the diagnostics status of the process control system;
- The maintenance engineer checks the hardware of the automation system and processes its diagnostics messages and maintenance requests.

The software shall provide maintenance and service personnel access to:

- Components of the process control system, e.g. intelligent field devices and I/O modules, fieldbuses, controllers, network components and plant buses as well as single stations, servers and clients;
- Assets that do not directly belong to the process control system, such as pumps, motors, centrifuges, heat exchangers (mechanical assets) or control loops. They are represented by proxy objects in which the diagnostics rules are stored;

Plant operators and service personnel shall be able to constantly carry out following actions:

- Service requests;
- Service approvals;
- Placing an asset in "In Service" status;
- Receive information regarding a completed service measure.

B.11.3. Process Device Manager

The Contractor shall provide and install a process device manager. The process device manager is a universal and vendor-independent tool for the configuration, parameter assignment, commissioning, diagnostics and servicing of intelligent field devices (sensors and actuators) and field components (remote I/Os, multiplexers, control-room devices, compact controllers), which in the following sections will be referred to as devices.

Parameters and functions for all supported devices shall be displayed in a consistent and uniform fashion, independent of their communications interface. Even complex devices with several hundred parameters shall be represented clearly and processed quickly. The following main functions shall be realized:

- Uniform representation and operation of devices;
- Uniform representation of diagnostics information;
- Indicators for preventive maintenance and servicing;
- Detection of changes in the project and device;
- Increasing the operational reliability;
- Reducing the investment, operating and maintenance costs;
- Quantity options for:
 - Transfer of parameters between devices;
 - Transfer of parameter sets to the devices;
 - Export and import functions;

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- Diagnostics update;
- Single-point station for point-to-point connection to field devices;
- Local service and parameter assignment station with connection to fieldbus segments;
- Central service and parameter assignment station with connection to plant bus;
- Central HART service and parameter assignment station for HART multiplexers and Wireless HART field devices;
- Integrated into the Maintenance Station;
- Integrated into the process control system and maintenance tool.

Maintenance staff should assign field device parameters at mobile and stationary workstations. Practically every workstation integrated in the production plant can be used for configuration. Service personnel are thus able to work directly at the location of the field device, while data is stored centrally in the engineering station or maintenance station. Device-independent system functions support higher-level maintenance stations for creating progress lists for work and servicing.

A user administration system shall be used to assign various roles with defined function privileges to users (e.g. reading, writing to devices).

On-line and off-line diagnostics shall be provided to assist in system maintenance and troubleshooting. Diagnostics shall be provided for every major system component and peripheral: including controllers, clients, servers and communication devices.

If diagnostics do not exist for particular peripheral devices such as printers and terminals, the system must detect and provide an error indication for the failure of these devices.

It shall be possible to monitor and troubleshoot PROFIBUS devices and HART devices from the control room without having to go out into the field. The system shall be capable of storing calibration information and device status history for each field device. It shall also be possible for the system to upload field device configuration changes implemented in the field. Once the configuration information is stored in the system, it shall be possible to download it to any other similar device, whether a new or replacement device. The system shall provide the capability of communication channel problem / error diagnosis.

B.11.4. SCADA Based Documentation System

The SCADA shall provide a system for documentation, support and project management of industrial plants in the process industry. The software shall enable documentation and revision of process control plants throughout their life cycle.

The tool shall align, in real-time, the plant documentation with the current parameters of the process control system, e.g. limits, control parameters, interlock information, and sequencers. Changes are automatically recorded and revised in change reports.

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The documentation system provides information for system support engineers in standardized form, for example with:

- Shift book function;
- Description of the process tag functionality;
- Limit lists;
- Change logs;
- Version comparison;
- Project documentation: IB/FAT/LoopCheck logs etc.;
- Procedure instructions to support the alarm management;
- Automatic configuration / update of long-term archive systems.

The SCADA based documentation system shall provide following functions:

- Automatic comparison of data in process control system and feature specification;
- Increased plant security;
- Direct availability of the system documentation;
- Integration of feature specification into the operator systems;
- Fast fault identification;
- Efficient help for troubleshooting and training;
- Increased efficiency of the plant personnel;
- Paperless work and quick sourcing of information;
- Efficient documentation / re-documentation of process control;
- Completeness and transparency of change tracking;
- Revision history;
- Ensured timeliness of documentation.

B.11.5. Interface to Third Party Applications

The software shall support an open data interface used for data communication between external systems on e.g. the MES and ERP (Enterprise Resource Planning) levels and the process control system.

The interface shall use a platform-independent communication standard, which enables stable, firewall-compatible TCP/IP communication over configurable, fixed network ports.

The server interface shall offer functions for reading and writing process tags as well as for reading out message archives and the process value archive of the process control system. This allows e.g. job, production, or inventory information to be exchanged, visualized, and edited between an ERP system and the process control system.

The following systems shall be supported:

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- SAP and other ERP systems from the corporate management level;
- Plant Information Management Systems to gather operating data;
- Simulation and optimization tools, e.g. for monitoring of controller performance or for application of Advanced Process Control;
- Analysis tools for alarm management;
- External database applications for long-term archiving and data analysis for more than a single plant;
- Web browser for presentation of production information (online data, message lists, trends, dashboards);
- Generation of reports, e.g. with Microsoft Excel;
- Data exchange between process control systems from other manufacturers.

B.11.6. Change Management

A software tool for version control and change documentation shall be provided as part of the SCADA system providing the following functions:

- Performing all data backups and managing software versions throughout the entire lifecycle of the SCADA;
- Cyclical check of the validated version through automatic data backup and comparison of the saved version to the most recently released, stored version;
- Mapping of the entire configuration of SCADA system including the change history from commissioning to the current time of the plant operation;
- Comparison of the SFCs and CFCs of two versions of an automation project using "SmartCompare" (all differences are highlighted in colour and can be selected);
- Complete documentation of changes in an automation project, for example, audits, validations and certifications;
- Version control of the software for immediate recovery in case of problems (disaster recovery);
- Restoration of optimized software versions.

B.11.7. WEB Access

A central SCADA web server shall provide client access via VNC or RTD connection. The system shall operate via VPN connections secured by a firewall solution.

Each external client shall be authorized by use of certificates. The number of required external connections is scalable. For the project at least five simultaneous external sessions shall be available.

The WEB access shall be limited to monitoring functions. Any control functions shall be disabled.

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B.12. BUILDING REQUIREMENTS

B.12.1. General Requirements

The WWTP shall be provided with following building facilities

- Administration and operation buildings, including:
 - Administration building;
 - Work shop and storage building;
 - Guard / gate house.
- Process / treatment works buildings, including:
 - Power supply and power distribution building (Main Station);
 - WWTP inlet works building housing the grit trap, coarse screens, pumping station, fine screens and Motor Control Centre 1 (MCC 1);
 - Aeration tank blowers and Motor Control Centre 2 (MCC 2) building;
 - Sludge treatment building;
 - Digester service building;
 - Biogas utilization building;
 - Sewage sludge incineration plant (SSIP) building;
 - Building of the Small Hydro-Power Plant.

Minimum requirements with regard to number of rooms and space are given in the following sections.

B.12.2. Architectural Concept

Buildings shall be designed and completed in accordance to national building law under consideration of the relevant structural and architectural requirements. They shall comply with local architectural design style and shall be completed with all necessary landscaping and gardening and parking area for operation staff and visitors.

The Contractor is requested to submit to the Engineer's approval an architectural concept of the whole plant prepared by a licensed and specialised architect. The architectural concept shall consider all buildings in order to have an harmonious and homogeneous whole and include landscaping and development of green areas on all areas within the plant kept free from structures and buildings.

In general, buildings will be constructed with concrete structure and masonry building technique.

All buildings shall be supplied complete and finished, including notably all electrical and sanitary house installations, heating-, ventilation and air-conditioning installation (HVAC), roof

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and rainwater drainage, etc.... All buildings shall be delivered fully and adequately equipped and furnished for the purpose.

All building shall be designed and built in accordance to state-of-the-art requirements regarding energy efficiency.

All buildings shall have to be considered inclusive of all devices needed for their operation and servicing under routine and emergency conditions and adequate safety provisions for the personnel concerning occupational health and physical safety.

This includes, but is not limited to:

- Platforms, walkways, access ways, stairways with guard railings where necessary in a suitable material for the required service with slip-resistant surfaces;
- Lighting suitable for night operation;
- Air conditioning and ventilation systems.

B.12.3. Building Equipment and Furniture

All buildings and process units shall have to be considered inclusive of all devices needed for the adequate operation and servicing under routine and emergency conditions and adequate safety provisions for the personnel regarding occupational health and safety.

B.12.4. Administration Building

The administration building shall include all rooms and facilities for the administration, centralised operation and management of the plant including facilities for the staff.

As visitors and external public will be received at the Administration Building (e.g. schools or students for visits of the plant), the building will be designed as to be fully accessible for disabled people in accordance with the requirements of the Rulebook on Detailed Conditions and Manner of Adaptation of Facilities for Access and Movement of Persons with Reduced Mobility and Persons with Disabilities (Off Gazette of MNE No. 044/15)

The design of the administration building shall consider following minimum requirements on number and type of rooms and space.

Table 15: Minimum requirements for administration building

No.	Description	No. of units	Min area [m ²]	Remark
1.	Control room	1	50	
2.	Conference room	1	50	Meeting room and visitor's room to accommodate min 30 people
3.	Plant Manager office	1	25	
4.	Plant Manager secretary's office	1	20	Adjacent to plant manager's office

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No.	Description	No. of units	Min area [m ²]	Remark
5.	Operator and plant management staff offices	5	15	
6.	Archive	1	10	
7.	Male / Female / disabled toilets	2	--	One per floor
8.	Staff Rest room	1	20	
9.	Staff dining room	1	30	
10.	Kitchen	1	15	
11.	IT service room	1	10	
12.	Laboratory	1	50	
13.	Laboratory office	1	20	
14.	Corridors, hall, entrance as required			

B.12.5. Laboratory Equipment

B.12.5.1. Minimum Requirements

The Contractor shall deliver and install the laboratory with all necessary laboratory equipment for the implementation of all routine physical, chemical, biological and bacteriological analysis for the control of the operation of the WWTP, SSTP and SSIP as required by the applicable local regulations and in accordance with the following requirements.

The scope of supply shall include but not be limited to the following: glassware, scales, refrigerator, drying stove, oven, fume cupboard, demineralised water unit,

A list of analysis to be carried out at the plant's laboratory is given in the following table. The following list is indicative.

Table 16: List of measurement and analysis to be carried out at the plant's laboratory

No	Description	Comment
1. Physical measurements and analysis		
1.1.	Temperature	1 desk + 2 portable combined T°, pH, Redox measurement devices
1.2.	pH	
1.3.	Potential Redox	
1.4.	Conductivity	
1.5.	Disolved Oxygen / temperature	1 desk + 3 portable oxygen / temperaturer measuring devices
1.6.	Suspended solids (SS)	Filtration equipment, drying stove
1.7.	Dry solids (DS)	Drying stove
1.8.	Volatile Suspended Solids (VSS)	Muffle furnace 550 °C and 800 °C
1.9.	Volatile Dry Solids (VDS)	
1.10.	Settleable solids	
1.11.	Gas measurement: O ₂ , CH ₄ , H ₂ S, CO,	Min 3 portable gas measurement devices

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No	Description	Comment
	CO ₂	
2.Chemical Analysis		
2.1.	Chemical Oxygen Demand (COD)	COD measuring reactor with 6 bottles (min 3 units)
2.2.	Ammonium (NH ₄ ⁺)	Laboratory spectrophotometer
2.3.	Nitrate (NO ₃ ⁻)	
2.4.	Nitrite (NO ₂ ⁻)	
2.5.	Total Kjeldhal Nitrogen (NTK)	
2.6.	Total Phosphorous (TP)	
2.7.	Orthophosphate (PO ₄ ³⁻)	
2.8.	Sulfates (SO ₄ ²⁻)	
2.9.	Sulfides (SO ₃)	
2.10.	Alkalinity	
3. Biological Analysis		
3.1.	Biochemical Oxygen Demand (BOD ₅)	Respirometric BOD ₅ measuring device with 6 bottles (min 3 units) including BOD incubator
4. Bacteriological analysis		
4.1.	Total Coliforms (TC)	
4.2.	Faecal Coliforms (FC)	
4.3.	Faecal Streptococci (FS)	
4.4.	Microscopic sludge analysis	Binocular microscope

The scope of supply shall include 2 autonomous refrigerated portable automatic sampler with, 24 bottles for 24 hours, suitable for batch and composition samples and to be connected with influent flow-meter.

The scope of supply shall include a desktop computer with printer for data management.

Bidders shall supply with their offer a complete list of the laboratory equipment included in their offer.

Following minimum requirements apply to the laboratory equipment:

1. Testing methods shall be in accordance with applicable standards and international best practice, making use of the appropriate instruments;
2. All laboratory furniture shall be manufactured according to the relevant international standards, the electrical devices shall be suitable for 230/380 V, 50 Hz. Power supplies shall be in accordance with the relevant IEC regulations;
3. The Contractor shall install, calibrate and connect to water or drainage services as necessary all such equipment to the approval by the Engineer;
4. Fume cupboards shall be connected to exhaust ducts. Control switches for exhaust fans installed inside the fume cupboards shall be built in full conformity to the system;

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5. The Contractor shall supply and assemble parts and materials for adapting the furniture to wall, floor and ceilings and shall deliver detailed layout schemes of service connecting and drainage points as well as schematic wiring diagrams;
6. The Contractor shall submit layout plans for the arrangement of the laboratory furniture in the building to the Engineer for approval;
7. All stainless steel items mentioned below that are used in connection with laboratory tests and operations shall be of special stainless steel type, suitable for laboratory use and highly resistant to corrosion;
8. For comprehensive interchangeability purposes, e.g. spare part stocking, the furniture has to be assembled from standardised components. The widths shall be multiples of 150 mm. The permissible module widths shall be 600, 900, 1200 and 1500 mm for plumbing units, and 450, 600, 900 and 1200 mm for storage cabinets. The laboratory furniture shall consist of self-contained components, which can be assembled together. Working heights shall be 900 mm for standing work and 750 mm for sitting work;
9. The Contractor shall provide and assemble all necessary equipment for cleaning, disinfection, refuse, first aid, fire-fighting, etc., including life vests, life belts and an automatic oxygen life-saving device with casing.

The specified equipment and furniture represents a minimum requirement, which shall be completed by the Contractor under consideration of the monitoring requirements, acc. to his own recommendations and/or local regulations.

The Contractor shall submit a detailed inventory listing the complete laboratory equipment, chemicals, measuring devices, etc. to the Engineer for approval before procurement. The Contractor shall provide the manuals for all laboratory equipment in English and Montenegrin language.

B.12.5.2. Chemicals

The Contractor shall provide a sufficient amount of chemicals for carrying out all the required tests for a period of 3 years after Taking-over.

Chemicals and reagents with storage periods shorter than 1 year shall be supplied in quantities that will be completely used up in the laboratories with the maximum storage life. The Contractor shall submit a complete and detailed list of all chemicals and reagents and the quantities thereof to the Project Manager for approval prior to placing any order.

B.12.5.3. Operator Station

An operator station connected to the central SCADA system shall be installed in the laboratory. The operator station shall provide, but shall not be limited to following functions:

- Visualization of the operation parameters of the WWTP, SSTP and SSIP and especially all on-line measurements;

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- Allow for entry of results of analyses carried at the laboratory.

B.12.6. Workshop and Storage Building

The WWTP shall be provided with a separate workshop and storage building which shall also incorporate the operation staff lavatories, changing room and locker room.

The design of the workshop and storage building shall consider following minimum requirements on number and type of rooms and space.

Table 17: Minimum requirements for workshop and storage

No.	Description	No. of units	Min area [m ²]	Remark
1.	Mechanical Workshop	1	100	
2.	Electrical Workshop	1	100	Adjacent to the mechanical workshop
3.	Mechanical storage	1	100	
4.	Electrical storage	1	70	Adjacent to the electrical workshop
5.	Electronic and I&C storage	1	30	Adjacent to the electrical workshop
6.	Meeting room	1	40	Meeting room to accommodate min 15 people
7.	Offices	4	15	
8.	Medical & first aid room	1	15	
9.	Staff rest, tea and dining room	1	30	
10.	Archive / storage	2	15	One per floor
11.	Locker room, lavatories incl. showers and toilet	2	--	One male + one female.
14.	Corridors, hall, entrance as required			

Locker rooms, lavatories, showers and toilets shall be separate for male and female and have the capacity to accommodate min 40 workers with up to 30 workers being on the site during one shift.

Locker rooms shall be separated in black and white areas with separate access and exit to each area and adjacent lavatories, showers and toilets..

B.12.7. Workshop Equipment

The Contractor shall supply and install in the work-shop and storage building following equipment for the operation of maintenance of the full WWTP:

- Two sets of standard tools for the mechanical and electro-mechanical maintenance;
- Two sets of standard tools for electrical maintenance;

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- One set of firmly installed tools, machines and equipment (workbenches, welding machine, drilling machine, etc.) as required for the operation of the WWTP;
- One set of all special tools required for the maintenance of all equipment installed on the plant;
- All necessary furniture as shelves, boxes, etc. for the adequate storage of the tools and equipment;
- All necessary mobile equipment for maintenance operation, including ladders, lamps, safety belts, tripod, personnel protective equipment;
- 2 sets of hot water industrial high pressure cleaning equipment.

The Contractor shall deliver and furnish the workshop and storage building with sufficient, commercially approved equipment for common electro-/mechanical services, in accordance to the operational requirements of the WWTP in accordance with following requirements:

1. All workshop furniture shall be manufactured according to the relevant international standards, the electrical devices shall be suitable for 230/380 V, 50 Hz. Power supplies shall be in accordance with the relevant IEC (or comparable) standards.
2. The Contractor shall supply and assemble parts and materials for adapting the furniture to wall, floor and ceilings and shall submit layout plans for the arrangement of the workshop furniture in the building to the Engineer for approval;
3. The Contractor shall submit a detailed inventory listing the complete workshop equipment to the Engineer for approval prior to procurement;
4. For comprehensive interchange-ability purposes, e.g. spare part stocking, the furniture has to be assembled from standardised components. The widths shall be multiples of 150 mm. The permissible module widths shall be 600, 900, 1200 and 1500 mm for plumbing units, and 450, 600, 900 and 1200 mm for storage cabinets. Working heights shall be 900 mm for standing work and 750 mm for sitting work.

The Contractor shall provide and assemble all necessary equipment for cleaning, first aid, safety equipment, including life vests, life belts and an automatic oxygen life-saving device with casing, fire-fighting equipment, etc.

Manuals for all main workshop equipment shall be in English and Montenegrin language.

B.12.8. Guard House

The guard house shall be located at the main entrance to the plant and have a minimum area of 20 m², including lavatory and toilet.

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B.12.9. Process / Treatment Works Buildings

B.12.9.1. Main Electrical Station

The main electrical station shall accommodate the main transformers, emergency generator, the Medium Voltage Distribution Board (MVDB) and the Main Low Voltage Distribution Board (MLVDB).

In accordance to the applicable legislation (Rulebook on Technical Standards for the Protection of Power Plants and Devices from Fire ("Official Gazette of the SFRY", No. 74/90)), high voltage power plants must be located in such a way as to prevent the spread of fire to adjacent buildings and facilities. For transformers of individual rated power of above 1.600 kVA, installation in a separate room which is used solely for the accommodation of the electric power plant and separation walls having a fire resistance rating REI 120 min. is compulsory.

The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.12.9.2. WWTP Inlet Works Building

The inlet works building shall accommodate the coarse and fine screens as well as the wastewater pumping station. The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance. Storage of residues (screenings, grit, ...) shall be included in the building.

B.12.9.3. Aeration Tank Blowers and Motor Control Centre 2 Building

The blower house shall accommodate the aeration tank blowers and the motor control centre for the biological treatment process in two separate rooms. The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.12.9.4. Digester Service Building

The digester service building shall accommodate all facilities the sludge thickening with all ancillaries, notably preparation and dosing of polymers. Sludge dewatering units shall be included in the sludge incineration building (see Section B.12.9.7). The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.12.9.5. Sludge Treatment Building

The sludge treatment building shall accommodate the sludge thickening with all ancillaries, notably preparation and dosing of polymers. Sludge dewatering units shall be included in the sludge incineration building (see Section B.12.9.7). The size of the building shall result from

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the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.12.9.6. Biogas Utilisation Building

The biogas utilisation building shall accommodate all equipment relating to the reuse of biogas for production of electrical energy and heat, notably the control cabinet. As a base solution, CHP units shall be of the container type and not installed in a building.

The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.12.9.7. Sewage Sludge Incineration Plant (SSIP) Building

The sludge incineration building shall incorporate the respective facilities of the sludge incineration process as described in Section B.8, including sludge reception and storage bunker, sludge dryer, fluidized bed furnace, flue gas treatment facility, thermal oil boiler, etc. The building shall also accommodate the sludge dewatering unit with all ancillaries, notably polymer preparation and dosing station, as well as:

- one separate control room for the sludge incineration;
- one separate office (min 20 m²) for the SSIP management staff;
- small kitchen (pantry) with a stove, coffee maker, fridge, dishwasher, crockery, electric kettle, microwave and hot/cold water kitchen sink, and
- lavatory / toilet for the operation staff.

The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.12.9.8. Small Hydro-Power Plant (SHPP) Building

The hydro-power plant building shall accommodate all equipment relating to the hydro-power plant, including notably the turbine, the generator and the control cabinet as well as all pipe works, valves and fittings. The size of the building shall result from the space requirements of the proposed equipment plus the required workguard and safety distances for adequate operation and maintenance.

B.13. COMMON FACILITIES DESIGN REQUIREMENTS

B.13.1. Drinking Water Supply System

Drinking water shall be supplied from the public water supply system operated by ViK Podgorica through a connection from the DN 160 pipe installed in the road from Dajbabe to Botun as indicated in Section B.2.12.5.

An internal drinking water supply distribution network shall be installed. This network shall supply:

- The administration building (sanitary facilities, laboratory, kitchen, canteen, ...);
- Sanitary facilities at the workshop and at possible other locations;
- Sanitary facilities at the guard house.

The maximal demand of the drinking water supply system shall be 5 l/s. The internal water supply network shall be designed as a loop system, in such a way that no dead end occur.

B.13.2. Service, Cooling and Firefighting Water Systems

Service water, cooling water (emergency cooling of the SSIP) and firefighting water shall be provided from a separate internal distribution network supplied from a production well to be constructed by the Contractor within the plant.

B.13.2.1. Well

For the supply of the plant with process, cooling, service and firefighting water, a production well shall be constructed inside of the premises of the WWTP. The well shall have a **minimum capacity of 30 l/s**.

B.13.2.1.1. Hydrogeological Situation

On the terrain of the neighbouring KAP Aluminium factory a total of 9 production wells have been constructed in the period between 1970 and 1985. The main characteristics of these wells are as following:

- Well depths: ~50 m;
- Diameter of boreholes: 800 mm;
- Diameter of casings: 600 mm;
- Pumps installed at: 25 - 27 mbgl;
- Static water level: ~13 mbgl;
- Dynamic water level: A drawdown of 2 m has been reported while pumping at a rate of 200 l/s.

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- Aquifer lithology: Gravel and sand, partially cemented, intercalations of fine-grained, impermeable sediments

Existing water analyses from KAP wells are presented in the Supplementary Information (Volume 3, Section VII: Employer's Requirements, Part 3.).

It is assumed that the hydrogeological conditions at the site of the WWTP are very similar.

B.13.2.1.2. Technical Requirements of the Well

Depth and diameter of the well and the casings shall be chosen in order to guarantee the required minimum production capacity of 30 l/s.

- During the drilling, samples of the cuttings shall be taken every 2 m of drilling or at every change of strata. The samples shall not be washed. They shall be displayed on the site on a polythene sheet, in sequence and properly labelled. Photographs of the samples are to be included in the well file;
- If the drilling method involves the use of drilling mud, a biodegradable mud shall be used;
- Filter gravel should be clean, well rounded and of good uniformity. The proportion of quartz grains should be greater 90 %;
- In order to guarantee the verticality of the casings, centralisers of a kind as recommended or provided by the manufacturer of the casing / screens shall be used for proper positioning of the screen section. The centralisers shall be fixed at 5 meter intervals between the upper and the lower edge of the screen section;
- A ¾" PE-piezometer tube shall be strapped to the well assembly and lowered together with it. The piezometer shall be perforated or slotted at its lowermost 3 m, with opening widths not exceeding 1 mm. Its bottom end must be plugged;
- The borehole shall be closed by a concrete slab, which covers the annulus and the surface casing, encompasses and anchors the steel well head. A layer of lean concrete shall be placed before casting the slab;
- A steel well head from a specialised manufacturer shall cover the well casing and serve as a link between riser pipe and well elbow. The well head must be tight.

B.13.2.1.3. Well Development and Testing

Well cleaning and air lifting shall be carried out. Air lifting is followed by development with a submersible pump. The well will be pumped with increasing rates to a rate of approx. 1,5 times the design discharge (1,5 Q_{design}).

After construction and well development the following investigations shall be performed:

- A step-drawdown pump test shall be carried out in order to test the well performance. The step-drawdown test shall consist of at least 3 steps of increasing yields. The last step should be the estimated maximum yield of the well. Each step shall be pumped

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until quasi-steady-state condition is achieved. The test is followed by monitoring the recovery for at least 6 hours;

- Two water analyses shall be taken, at the beginning and at the end of the pump test. The samples will be sent to the laboratory. Parameters to be analysed shall be according to the existing analyses in Supplementary Information (Volume 3, Section VII: Employer's Requirements, Part 3.).

B.13.2.1.4. Reporting

The Contractor shall submit a well file, which shall contain at least:

- A sketch map of the drilling site;
- Lithological log;
- Well design;
- Pumping test results;
- Results of the water quality analyses.

B.13.2.2. Service Water Distribution Network

The internal distribution network shall supply all components of the plant with service water for cleaning as well as all water consumption points within the plant where no drinking water quality water is required. This includes notably the screenings washing units, the grit classifier and the preparation of polymer solution for the sludge treatment.

This network shall also supply the firefighting system in accordance to Section B.13.2.3 below and the green area watering system.

The Contractor shall foresee a sufficient number of tap connections to the service water distribution network at all parts of the plant.

B.13.2.3. Firefighting Systems

The fire fighting system shall be designed and built in accordance to the requirements of the local legislation, notably the Law on protection and rescue (Off Gazette of MNE No. 54/16), the Rulebook on technical standards for fire hydrant extinguishing network (Off Gazette of the SFRY No. 30/91)

In accordance to the applicable legislation, a firefighting water reservoir with a minimum capacity of 150 m³ shall be foreseen to provide for sufficient reserve in case of a failure of the well pump. From this reservoir, two booster stations (one duty + one stand-by) shall supply the internal service water and firefighting water distribution network (see Section B.13.2.2).

A sufficient number of external hydrants, supplied from a min DN 100, pipe shall be adequately placed with a maximum distance between hydrants of 80 m in order to provide adequate fire fighting protection to all parts of the plant, especially the most critical parts (digesters, gas holder, fuel storage, sludge incineration).

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B.13.3. Weigh Bridge

B.13.3.1. Function

The main purpose of the weighing system is to monitor the incoming and outgoing material flows (e.g. sand, screenings, sodium bicarbonate, external sludge, ash and residues) of the waste water treatment plant (WWTP). A truck weighing bridge shall be foreseen for this purpose. The system should be self-operable by the truck drivers and implement at least the following functions:

- automated processing and allocation of the weighing data;
- bidirectional operation of the weigh bridge.

B.13.3.2. Components

The weigh bridge system shall consist at least of the following components:

- one underfloor weigh bridge, including
 - concrete fundament and bridge
 - load cells
- a logistic terminal box;
- a scale automation system;
- a traffic control system.
- additional control and input from the gatehouse

B.13.3.3. Automation

The scale is designed for autonomous operation. Therefore, the weigh bridge shall be equipped with logistic terminals as well as position controls and traffic light systems. The weighing data is registered, processed and allocated by the logistic data processing system. Related weighing procedures are evaluated automatically. The collected data is fully accessible from the superordinate control technology.

B.13.3.4. Design

The truck scale system is located near the access gate of the WWTP, connected with roads and is accessible without reverse driving. The system components are exposed to a rough industrial open-air environment. Hence, they have to meet at least the following general requirements:

- appropriate durability and maintenance features (e.g. revision holes, drainage systems, suitable materials and lightning protection);
- design according to DIN 8119 and EN 45501.

The weigh bridge shall have a wear-resistant road surface. The concrete bridge is provided with lateral upstands or comparable lane-keeping support for the protection of the peripheral

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equipment (e.g. logistic terminals) and avoidance of faulty weighing. The scale is so designed that it can be calibrated. The bridge size shall be of at least 20 x 3 m and the weigh capacity of at least 40 t (according to DIN 8119).

The scale automation system includes a logistic data processing system with a hardware server steel cabinet. The data processing system is connected to the SCADA system including full access and recording of all data. All required software, licenses and services are included in the system.

Each scale is equipped with a logistic terminal. These terminals are designed with automated processes and allow driver self-service. They are designed with a stainless-steel housing, a touchscreen panel and a document output (e.g. delivery note). The terminals are equipped with transponder technology for RFID-identification as well as a barcode or manual data input. The operating panel is provided with language options.

The traffic control system includes signalling equipment and a position control system.

B.13.4. Fuel Tanks

Fuel tanks for the storage of fuel for the emergency generator (Section B.10.2.3) and the start-up of the SSIP (Section B.8.4.4.3) shall comply with the applicable international and local regulations and notably the Law on Flammable Liquids and Gases (Off. Gazette of MNE No. 48/15), the Rulebook on Technical Standards for the Storage of Flammable and Hazardous Materials (Off. Gazette of the SFRY No. 9/81), the Rulebook on the Construction of Flammable Plants liquids and the storage of flammable liquids (Off. Gazette of the SFRY No. 23/71) and the Rulebook on the Construction of Fuel Supply Stations for Motor Vehicles and the Storage and Transfer of Fuels (Off. Gazette of the SFRY No. 27/71

B.13.5. Internal Roads and Drainage

All process units shall be easily reachable by asphalt-paved service roads. All treatment units shall also be accessible for pedestrians by pathways with a minimum width of 1.00 m.

Internal roads shall be asphalt roads with road kerbs. The main internal road, from the main entrance gate to the administration building, workshop and parking, will be a 6,00 m wide two lane road. Other internal roads will be designed as 4,00 m wide single lane roads. Roads shall be designed for the corresponding traffic load (i.e. trucks for supply of chemicals and equipment and for collection of residues: screenings, ashes, FGT residues, etc.). The design of roads shall consider and minimum turning curves and areas for manoeuvring. Manoeuvring areas and curves shall be designed for heavy trucks traffic.

Storm water from the roads, building roofs and other impervious areas shall be collected in a piped storm water drainage network connected to the general by-pass pipe discharging by gravity into Moraca River (see Section B.6.8). Roads and parking area shall be equipped with adequately sized and designed storm water gullies with grit and stone catcher. The parking

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area and other possible critical areas shall be equipped with oil and grease separator in accordance with the applicable legislation.

The stipulations of local authorities have to be considered with regard to traffic signs, lighting, road marking, etc.

B.13.6. Fence and Gate

The whole facilities of the treatment plant shall be surrounded by a concrete wall with a total height of 2,50 m. The higher part of the wall shall be barbed wire on a height of 0,5 m.

The access to the plant shall be provided at a minimum with:

- 1 car gate: motor-driven mono-rail based sliding gate with a minimum clearance of 6 m;
- 1 pedestrian gate with a minimum clearance of 1,20 m.

B.13.7. Landscaping

All free areas within the plant shall be landscaped with appropriate green areas, bushes and trees in accordance to Section D.11 and to a landscape plan to be prepared by a landscape gardening specialist, submitted to the approval of the Engineer.

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

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b) Technical Specifications

General Technical Specifications

Part C: General Requirements

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- b) Technical Specifications
 - Particular Technical Specifications
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- d) Personnel Requirements
- e) Equipment Requirements

2. Drawings

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- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
- f) KAP Well Water Analyses Data.

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List of Acronyms

AFR	Accident Frequency Rate	I/Q/F	Installation / Qualification / Function
ASR	Accident Severity Rate	ISO	International Organisation for Standardisation
CAD	Computer-Aided Design	LAD	Ladder Diagram
CD	Compact Disk	MS	Microsoft
CFC	Continuous Function Chart	MSDS	Material Safety Data Sheet
CPM	Critical Path Method	P&I	Process and Instrumentation
DEM	Digital Elevation Model	PDM	Process Device Management
DIN	Deutsches Institut für Normung (German Standard)	PLC	Programmable Logic Controller,
EMMP	Environmental Management and Monitoring Plan	PO	Process Object
EN	European Norm	QA	Quality Assurance
EXIF	Exchangeable Image File Format	QC	Quality Control
FBD	Function Block Diagram	SCADA	Supervisory Control and Data Acquisition
GPS	Global Positioning System	SFC	Sequential Function Chart
HAZCON	HAZards in CONstruction	SI	Système International (International System of Units)
HSE	Health, Safety & Environment	SPIR	Spare Parts and Interchangeability Record
I&C	Instrumentation and Control	STL	Statement List
ID	Identification (number)	STP	System Test Pressure
IDM	Induktive Durchflussmesser (Electromagnetic Flowmeter)		
IEC	International Electrotechnical Commission		

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

C.1. GENERAL PROVISIONS

C.1.1 General Technical Specifications

The General Technical Specifications define general minimum requirements for design, workmanship and materials for the execution of Works. The General Technical Specifications also describe the framework under which the contractual Works shall be executed and the general activities to be included in the rates for the Permanent and Temporary Works.

The General Technical Specifications shall be observed, as far as they are applicable, for all works. The requirements stated in this Part of the General Technical Requirements are valid for all Parts of the specification, except only where additional and/or special requirements are specified.

These General Technical Specifications are further amended in the Particular Technical Specifications. Whenever there is the conflict between the General and Particular Technical Specifications the latter shall prevail.

C.1.2 Standards

C.1.2.1 Reference Standards

All design, engineering documentation, facilities, materials, equipment and workmanship shall comply with the latest version of the relevant international standards, codes accident prevention regulations and the applicable local standards and regulations.

Local technical regulations take precedence over those of the country of origin of manufactured goods and over the regulations mentioned further down. However, the Standard with the highest quality will regulate where these differ. Overriding standards that the Contractor must comply with are:

- ISO: International Standardization Organisation;
- IEC: International Electrotechnical Commission;
- EN: European Standards;

All materials and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of goods, methods of inspection, specific design features of equipment and parts and acceptances of partial plants shall comply in every respect with the technical codes of the International Organization for Standardization (ISO) and of the International Electrotechnical Commission (IEC).

Unless stated otherwise in the Specifications, the valid version of any reference Standard current at the time of the tender shall be used.

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In the event that any standard referred to in the General and Particular Technical Specifications has been superseded or replaced by another one, such other standard shall be deemed applicable. In any case, always the most recent issue of any standard referred to shall be applicable.

The standards referred to in this Technical Specifications shall not be deemed to be limiting. Standards indicated in these specifications are minimal. The Contractor may offer material and works of higher standard.

The Contractor shall justify compliance with the pertinent ISO, EN or other relevant standard of any single element of the Permanent Works when submitting for approval. The Engineer may reject any element not complying with the relevant standards.

Wherever a national specification, technical standard, building, construction and environmental regulation is more restrictive than the specific standard listed in the Technical Specifications, the national standard and regulations shall take precedence.

Any discrepancy between the standard of design, works or material proposed by the Contractor and the requirements of these specifications shall be submitted to the Engineer's approval prior to ordering material and execution of works.

The Contractor / Tenderer must clearly state his proposals concerning the use of Standards and Codes.

C.1.2.2 Alternative Reference Standards

Wherever throughout this Technical Specification is made reference to certain standards it should be read as "or equal international standard". It is the Contractor's responsibility to provide sufficient evidence that any international standard the Contractor proposes will ensure an equivalent or higher standard as the one used as a reference in this Technical Specification.

Should the Contractor desire to carry out works or to substitute goods and materials in accordance to a standard other than ISO, EN, IEC or those cited in the Technical Specifications, he shall notify the Engineer thereof, and shall submit with his notice a copy in English of the proposed standard (latest version). The Contractor shall demonstrate to the Engineer that the alternative standard is suitable and at least equivalent to the specified standard and shall not order any material or perform any work unless he has obtained the Engineer's approval of such standard. The Engineer will decide and advise the Contractor whether or not such an alternative will be allowed as a Reference Standard.

C.1.3 General Design and Works Requirements

The Works to be supplied shall be new and clean, and designed, manufactured and arranged so that they will have a functional design and a pleasant appearance. All parts of the Works shall be arranged in such a manner as to facilitate surveillance by the operator and to ease maintenance, operation and control.

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They shall be designed, manufactured and put into operation in accordance with the latest recognized rules of workmanship, modern engineering practice and with good standards of prudence applicable to the international standards and codes which would have been expected to accomplish the desired result at the lowest reasonable cost consistent with reliability, safety and expedition.

All parts of the Works shall be suitable in every respect for continuous operation at maximum load as well as part loads and expected transient operating conditions, peculiar to the site and shall be able to safely withstand the stresses arising from the operating conditions without any reduction in its planned life time.

C.1.4 Information on Site Conditions

The Contractor shall be deemed to have inspected and examined the Site, to have verified the site conditions and to have satisfied himself, before submitting the Bid and before the Commencement of the Works, as to all matters relative to the nature of the Site within the specified boundaries, details and levels of existing services and connections to be made, the quantity and nature of the work and materials necessary for the completion of the Works, the means of access to the Site and the accommodation he may require, the supply of water and electricity, the climatic, hydrological and geo-hydrological conditions or such contingencies which may influence or affect his Bid.

Any negligence or failure on the part of the Contractor to obtain reliable information on the Site or elsewhere concerning any matter affecting the Contract Agreement shall not relieve the selected Contractor from any of his obligations or liability arising from the Contract Agreement.

No claim shall be permitted with regard to the effects of these Site conditions on the execution of the Works.

C.1.5 Responsibility for Information

Throughout the Contract Term the Contractor shall inform the Engineer in due time of any circumstance and condition which adversely affect or which may adversely affect the execution of the work or the project in general.

C.1.6 Co-operation and Co-ordination with other Contractors and other Parties

The Contractor shall attend all meetings called by the Employer or the Engineer for the purpose of co-ordination and co-operation. The contents of the minutes of such meetings, after approval by the Employer or the Engineer, shall be binding to the Contractor.

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The Contractor shall co-operate and co-ordinate his operations with all other parties or contractor's executing works on Site / or adjacent to the Site of work in order that the minimum interference inconvenience is caused to the public.

C.1.7 Language

All documents submitted by the Contractor shall be in the English language or accompanied by an English translation and, if otherwise specified, in the local language.

In addition to the requirements of the Conditions of Contract, all meetings and discussions with the Engineer shall be in English. The Contractor's site manager and engineers shall be fluent in spoken and written English.

C.1.8 System of Units

All documents and drawings prepared or submitted by the Contractor in the scope of the Contract shall use the metric international system of units (SI units).

C.1.9 Correspondence

All correspondence shall be addressed to the Engineer and copied to the Employer and shall be written in the English language and, if otherwise specified, in the local language. All correspondence shall be numbered in accordance with a procedure and a numbering system to be agreed with the Engineer.

C.1.10 Project Referencing System

Irrespective of any in-house system used by the Contractor for his own design and construction, a common plant wide referencing system shall be employed. This common project referencing system shall be used on all drawings, technical documents and communications and shall be mandatory. The system to be applied has to be agreed with the Engineer.

C.1.11 Progress Site Meetings

The Contractor shall attend all meetings called for by the Engineer at the Site or in the Engineer's office to discuss the progress of the Works and/or any issues related thereto.

Meetings are to be attended by an authorised representative of the Contractor having the ability to provide all information on the progress of works and to make all necessary decisions, the Engineer and the Employer's representatives and others as necessary. The Contractor's Subcontractors may attend when involved in the matters to be discussed or resolved, but only when requested or approved by the Engineer or Employer.

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On request of the Engineer, site meetings shall include inspection of the Works jointly by the Contractor, the Engineer and the Employer. The Contractor shall make arrangements to facilitate the joint inspection of the Works.

Site meetings shall be held from the commencement date, once each week for general Project monitoring and control purpose and once a month for a detailed review both of work progress and the Contractor's 90 days look ahead schedule. Progress and schedule reviews shall verify:

- Actual start and finish dates for activities completed during the updated period;
- Remaining durations and percentage of completion for all activities not completed;
- Contractor's proposed measures to recover lost time (if any) and place the project back on schedule by measures such as increasing manpower, materials, equipment resources and working extended hours, additional shifts etc.

If during Execution the Engineer considers the progress position of any section of the Works to be unsatisfactory or for any other reason, he will be at liberty to convene a special meeting and the Contractor's Representatives shall attend such meetings.

Requests for additional meetings as required by the Contractor shall be submitted to the Engineer in writing and include:

- the proposed agenda for the meeting;
- the names of all personnel who are required to attend.

In the event that the Contractor fails to attend any meeting at which his presence has been requested, all decisions shall be made as if the Contractor had been present and agreed on subsequent actions and orders.

The Engineer will prepare Minutes of Meeting (MoM) and distribute a copy for comments to both the Employer and the Contractor. Any comments must reach the Engineer within five (05) days after the day of distribution. Beyond this period of time the MoM will be considered as accepted by all parties.

C.1.12 Works included

The remuneration for the various parts of the Works shall be quoted in the relevant items of the Financial Bid, which are deemed to include all Works arising from the general and particular works requirements, the drawings and any other document included in this Bidding Document.

For the Permanent Works to be executed under the Contract, the Contractor shall supply all materials, equipment, temporary Works and labour necessary to perform, test and complete the Works and maintain the Works until issuance of the Taking-Over Certificate.

The Contractor shall also furnish all equipment, materials, specials and labour required to make connections to, to protect, to remove and to rearrange existing services and other structures so

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that the whole of the Works are delivered to the Employer in perfect condition and working order in accordance with the Contract and these Technical Specifications.

The costs of all works, services, supplies and any obligations which are necessary for the execution and completion of works in accordance to the Bidding Documents or required in the Bidding Documents shall be included in the corresponding items for Permanent Works or in the items for Preliminary Works. Where no specific items is included in the Price Schedule, the cost of such services, works and facilities shall be deemed to be included in other items of the Price Schedule.

The contractor confirms with the submission of his bid that he has fully understood and comprehended the scope of works. In the event that details, drawings, technical information or any other technical data are not fully specified in the Bidding Document, the Contractor will submit to the Engineer's review and approval his technical documentation including such details, drawings, technical information or any other technical data.

C.1.13 Contractor's Staffing and Labour Force

When nominating the representatives and the engineers to whom the performance of the Works will be entrusted, the Contractor shall give full information on their educational and professional background. The replacement of any of the Contractor's Representative and/or key staff shall not be allowed without the written approval of the Engineer.

The Contractor shall also submit details of the labour force, which he proposes to employ. Such details shall include Engineers and experts involved; senior staff and specialists, skilled and unskilled labour with indication of the local labour, which the Contractor envisages to employ and the variation in staff and labour levels and their distribution throughout the duration of the Contract. Contractor's staff must have the required qualification and experience and shall be available as required for the appropriate, efficient and uninterrupted implementation of works.

Key staff responsible for the correct execution of works (excavation, concreting, pipe laying, backfilling, road- and footpath reinstatement, concrete works and framing (Shutter Works), etc.), must be available to the Engineer at all times during the working hours ad defined in C.1.15 of these Technical Specifications.

Foremen responsible for above-mentioned works must have significant experience in similar works under similar conditions and must be able to safeguard good workmanship so that the Works are executed according to these requirements.

Persons below the age of 16 shall not be employed and shall have no access to the Site.

C.1.14 Contractor's Representative

The Contractor's representative shall have the authority to act on behalf of the Contractor in accordance with the Contract and is expected to take part in relevant discussions and decision-

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making and be based at the site for the whole duration of the contract. All decisions given by the Contractor's representative shall be deemed to be given by the Contractor and all subsequent actions shall be based on these decisions.

This representative shall, on request of the Engineer, attend all meetings with the Employer, the Engineer or other parties.

C.1.15 Working Hours

The Contractor shall perform his construction work activities only during the standard working hours on construction sites, distributed over 6 days per week, except on public holidays.

Should the Contractor wish to carry out works outside normal working hours or on other public holidays he shall comply with local regulations.

Work during the Defects Notification Period shall be carried out only after the Contractor has given the Employer / Engineer at least 2 working days notice in writing.

C.1.16 Quality Assurance

In addition to the Conditions of the Contract, the Contractor shall establish at the start of the Contract and before commencement of works and maintain and implement during the whole duration of construction works until end of the Defects Notification Period, a quality management system compliant with relevant local regulations and ISO 9001.

The Contractor shall within one month from the Commencement Date submit to the Engineer's approval its complete and detailed Final Draft QA/QC Programme, which shall encompass all works and services to be carried out under the scope of the Contract including those performed by subcontractors. It shall include, in elaborate detail, all policies, procedures and documentation flow procedures to ensure that the Work will be executed in accordance with applicable Standards and, when executed, that the facilities will be capable to be operated in accordance with the Employer's Requirements.

The Contractor shall perform all of its Contractor's Obligations in strict conformity with all policies and procedures set forth in its QA/QC Programme.

The Contractor shall appoint a qualified Quality Assurance Officer, which will be responsible for the correct implementation of all procedures and activities described in the QA/QC Programme from the Commencement Date through to the end of the Contract Period.

The Quality Assurance Officer will report all relevant facts, events and test results to the Engineer and provide to the Engineer with all information and documents he may request in relation to the Contractor's quality management system.

The Contractor must maintain sufficient qualified staff on sites to implement all aspects of the approved Quality Plan.

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Revisions of the agreed QA/QC programme shall be made only for justifiable reasons and must be agreed in advance with the Engineer.

C.2. MATERIALS, EQUIPMENT AND PLANT

C.2.1 Quality of Material, Equipment and Plant

Notwithstanding more stringent or particular prescriptions in the specific parts of these Technical Specifications, all material, equipment and plant that shall become part of the Permanent Works shall be new, of first class quality, from reputed and approved manufacturers and suppliers and shall be manufactured in accordance with the latest relevant local and international standards. Second hand material, equipment and plant are not allowed and shall be rejected.

Nomenclature, classification, symbols, conditions of manufacturing, characteristics and tolerances, conditions for the preparation of specimen, test rules, identification labels and acceptance clauses of materials, equipment and plant are subject to the Engineer's approval and must conform to the latest relevant local and International Standards.

All equipment and plants shall be guaranteed to be suitable for operation under the prevailing environmental and other local conditions and notably:

- Local weather and climatic conditions;
- Environment at the location of use of the equipment (e.g. contact with sewage and its atmosphere, corrosive environment, etc.).

All equipment and plants shall be designed and built:

- Such that routine and occasional maintenance throughout its life shall be a practical minimum and compatible with the preservation of maximum reliability;
- To withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.

C.2.2 Manufacturer and Supplier Requirements

All materials, equipment and plant shall be supplied from approved manufacturers only. The Contractor is requested to submit a list of suppliers that he intends to use, together with his bid. All suppliers for material, equipment and goods that are to be purchased to become part of the Permanent Works shall be ISO 9001 certified.

Equipment of similar design shall be from the same manufacturer. Where more than one component or item is supplied to perform a particular function, all such items shall be identical and interchangeable.

The tenderer shall verify local representative for chosen equipment with full name, contact person, address and telephone. Also the representative's experience, service and spare parts organisation, etc, shall be provided. All supplied equipment must be certified (CE).

C.2.3 Technical Documentation of Manufactured Goods

The Contractor shall submit to the Engineer for approval a complete set of detailed technical documentation of all goods that shall be supplied from manufacturers (equipment, pipes, valves, fittings, etc.) to be incorporated into the Permanent Works, as well as certificates issued by the manufacturers certifying date and place of origin. These documents shall bear the stamp and the signature of the manufacturer. For all items of supply, the Contractor shall submit to the Engineer a certificate of compliance with the specified standards. Where other standards are proposed, they shall be equal or superior to the relevant international and/or local standard.

Each submittal shall be complete in all aspects, incorporating all information and data listed herein and all additional information required to evaluate the compliance of the proposed material with the Contract. Data to be submitted shall include but is not limited to:

- Manufacturer's name;
- Catalogue data consisting of specifications, illustrations and a parts schedule that identifies the materials to be used for the various components and accessories. The illustrations shall be in sufficient detail to serve as a guide for assembly and disassembly;
- Standard to which the item is manufactured;
- Certificates of compliance with the specified standards;
- Weight of all component parts;
- List of spare parts and special tools;
- Manufacturer's instructions for transporting, unloading, storing and installation.

C.2.4 Approval of Materials and Workmanship by the Engineer

Only goods specified in the technical documentation and approved by the Engineer shall be supplied.

As soon as possible after the Contract has been awarded, the Contractor shall submit to the Engineer a list of manufacturers / suppliers from whom he proposes to purchase the materials required for the Works.

The Contractor shall submit for the approval of the Engineer before ordering of materials, all information and data listed in Section C.2.3 and all additional information required to evaluate the compliance of the proposed materials with the Contract.

The Contractor shall provide such samples as the Engineer may require in advance of the execution of Works for approval and, when approved, the quality of materials shall be at least equal to that of the approved samples. This includes also the testing and quality control of aggregates, cement and concrete and other building materials.

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The Contractor shall furthermore provide sample areas and items of finished workmanship for approval by the Engineer as required by him. All workmanship shall be equal to the approved samples.

Before submitting any supplier / manufacturer for approval by the Engineer, the Contractor shall ensure that the plant and/or materials proposed for use fully comply with the Specifications. The Contractor may only make one submission in respect of any particular item of plant or type of material unless specific instructions are received from the Engineer to the contrary. No further submissions will be allowed unless this nominated Supplier is formally rejected.

Approval must be obtained if it is found necessary to change the nominated supplier / manufacturer during the course of the Contract but this approval will only be given in exceptional circumstances. If alternative materials or equipment are proposed, the Contractor shall submit comprehensive details including technical descriptions, drawings, calculations and specifications to demonstrate that the alternative material or equipment:

- complies with the specifications, and
- have at least equal quality and performance of the initially approved material or equipment;

The adoption of such alternative materials or equipment shall be subject to the Engineer's approval.

Where the Contractor maintains an accredited Quality System, conforming to ISO 9000, details of the level of the Contractor's self-certification procedures to be adopted in respect of supplied materials shall be agreed with the Engineer prior to commencement of works. Individual submissions are then restricted to those required by the Quality System.

Where no accredited Quality System exists, the Contractor shall plan all quality management procedures, carry out all quality control testing as required and shall make available records of such testing in the format, numbers of copies, and the timing specified. The Contractor shall submit full details of the proposed quality management system and procedures for the Engineer's approval, who shall have full access to all records, trials and tests.

Unless otherwise authorised in written by the Engineer, no materials, equipment or plant to be supplied under this contract shall be shipped to the Site until all relevant submittals have been approved.

The Contractor shall maintain a neat record of approval / disapproval for all materials and workmanship.

The approval by the Engineer of any material or equipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the Specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective or not conforming to the Specifications.

C.2.5 Inspection by the Engineer

C.2.5.1 General

The Engineer reserves the right to inspect any good, material or equipment supplied by the Contractor or proposed to be supplied by the Contractor, which may become part of the temporary or permanent works. Such inspection may include mill, plant, shop or field inspection, as required. The Engineer shall be permitted access by the Contractor to all parts of the Work, including plants where materials or equipment are manufactured or fabricated.

Inspection or approval by the Engineer of any equipment or materials shall not release the Contractor from any of his obligations under this Contract.

C.2.5.2 Inspection at the Place of Manufacture

The Engineer reserves the right to inspect goods prior to delivery or shipment from the supplier's factory. The Contractor shall, on request, provide all necessary facilities to the Engineer or his representative to carry out such inspection.

To allow possible inspection of materials and equipment in the course of or on completion of preparation or manufacture, the Contractor shall give the Engineer written notice of the work-shops and places where the materials and equipment are manufactured or stored and advise him of the state of progress, so that the inspection may take place at appropriate times and without delaying the dispatch of materials and equipment to the Site.

C.2.6 Identification and Marking of Material, Equipment and Plant

All plant and equipment shall bear distinct and easily legible plates of indestructible material showing manufacturer / brand, date of manufacturing, reference to relevant standard and all relevant technical data required by the standards or in the absence of standards, as generally indicated to describe the characteristics and/or capacity of the plant or equipment.

C.2.7 Testing of Materials

C.2.7.1 General

The Contractor shall provide material test results and certification by independent testing agency / party approved by the Engineer showing that the materials meet the specified requirements. The testing of materials and goods shall be performed well in advance of the time they will be required for use.

Above indicate test certificates will be accepted by the Engineer provided that following conditions are met:

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- The testing agency / party was approved by the Engineer prior to performing the tests, and that all necessary certifications were valid at the time the tests were performed;
- The tests were performed in conformity with the Specifications and applicable standards for the specified materials or items;
- The form and content of the report is as agreed with the Engineer prior to performing the tests.

Information provided by the test certificate shall include but not be limited to the following:

- Sample identification number;
- Sample origin (Sufficient information to identify the lot, group, bin, or silo from which the samples were taken);
- Sampling date;
- Description of tests with reference to the relevant standards;
- Test results (Statement that the material has passed/not passed the requirements);
- Date of tests;
- Reference of laboratory undertaking the tests;
- Conclusion (Satisfactory or Unsatisfactory) with name and signature of the responsible person and stamp of the laboratory undertaking the test.

In the case of standard labelled stock products of standard manufacture, which have a record of satisfactory performance in similar work over a period of not less than 2 years, the Engineer may accept a statement from the Manufacturer certifying that the product conforms to the applicable Specifications.

The Engineer may also accept a certificate from a commercial testing laboratory / agency, satisfactory to him, certifying that the product has been tested within a period acceptable to the Engineer and that it conforms to the requirements of the Specifications.

The Contractor shall maintain a neat record of all tests performed and their results.

The Contractor shall deliver to the office of the Engineer, nominated laboratories or the Site of the Works, such samples and test specimens as the Engineer may require for the approval and/or testing. Samples shall be taken in accordance with the relevant International Standards where applicable or otherwise as directed by the Engineer. Time and location of the delivery will be indicated by the Engineer to the Contractor.

Materials subsequently supplied shall at least be equal to the approved sample in all respects. No source of supply shall be changed without prior written approval from the Engineer.

The Contractor shall promptly remove from the Site of the Works any samples not approved or materials failing to comply with the approved samples. Approved samples shall be kept by the Contractor during the performance of the contract.

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In addition to all tests specified in the Contract or required by applicable standards or quality assurance provisions, the Engineer reserves the right to independently select, test, and analyse, at the expense of the Employer, additional test specimens of any or all of the materials to be used. The Contractor shall provide such samples or assistance in sampling materials at the Site as the Engineer may reasonably require. Whenever any portion of the Work fails to meet the requirements of the Specifications, as shown by the results of independent testing or investigation, all costs of such independent inspection and investigation, and all costs of removal, correction, and reconstruction or repair of any such Work, shall be borne solely by the Contractor.

Testing by the Engineer shall in no way relieve the Contractor of his responsibility to test materials to ensure that they meet all the specified requirements and to control their quality.

C.2.7.2 Testing at the Place of Manufacture

Where the Contractor is specifically required by the Technical Specifications to demonstrate performance of major equipment prior to delivery, a testing procedure must be developed by the manufacturer and approved by the Engineer prior to scheduling the shop performance testing.

In this case, the Engineer and/or Employer wish to witness the performance testing of such major equipment, the Contractor shall make all necessary arrangements, including travel and accommodation, for the participation of the Engineer and any other person stipulated to the Contractor, to the performance testing. Payment of costs relating to the shop performance testing shall be made under a separate item of the Price Schedule.

The Engineer will evaluate performance-testing data and note whether the equipment meets the performance requirements of the Contract. The Engineer will be responsible for releasing the equipment for delivery to the Site. This procedure will also apply to field performance testing required as a condition precedent to acceptance of the equipment.

C.2.7.3 Sampling and Testing of Soils and Fill Materials

Sampling and testing of soils and fill materials includes for trial pits, inspection of excavations and sampling and testing of soils, aggregates and all materials used for backfill and embankments.

C.2.7.4 Sampling and Testing of Construction Materials

Sampling and testing of construction materials includes the provision of samples of materials and workmanship as well as the testing and quality control of aggregates, cement, concrete and other building materials.

C.2.8 Supply of Materials, Equipment and Plant

Supply of materials, equipment and plant, as specified hereunder, shall include the transport from the Manufacturer's plant to the Site, handling, loading, unloading and storage in accordance with the supplier's instructions and good workmanship.

Before shipment from the manufacturer's place, all equipment shall be adequately protected by painting or by other approved means for the whole period of transit, storage and erection, against corrosion and accidental damage.

The Contractor shall be responsible for the supply of all materials in sufficient quantities and shall, prior to placing any order, especially for imported goods, ascertain the required quantities.

C.2.9 Delivery and Storage of Materials, Equipment and Plant

All materials, equipment and plant should be handled and stored in a way to maintain their integrity and to avoid damage and degradation.

The Contractor shall submit to the Engineer a detailed schedule for manufacturing, delivery, transport and installation for each of the various suppliers or sub-contractors. The schedule shall consider the following:

- All equipment and plant arriving ahead of the deadlines shall be stored in a closed compound;
- All electromechanical, electrical and mechanical equipment shall be stored in a closed warehouse under conditions similar to the final ambience, where required in conditioned rooms;
- The Contractor shall remedy any damage of the equipment prior to the delivery to the store;
- The Contractor shall provide insurance and shall be entirely and solely responsible for the security of all plant or equipment stored at the site.

The Contractor shall provide adequate storage and handling areas for the intermediate storage of equipment on the Site in accordance to Section C.3.3.2.3.

C.2.10 Manufacturer's Instructions

The Contractor shall comply with the instructions of manufacturers / suppliers in respect of use, application or installation of any materials, goods, etc., required to complete the Contract. The instructions shall be relevant to the prevailing local climate and environment.

C.2.11 Material Safety Data Sheet

Any product or substance used by the Contractor or its Subcontractors during construction works or during operation and maintenance of the permanent works and which is a toxic or

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hazardous substance shall be identified to the Engineer by the Contractor's submission of a Material Safety Data Sheet (MSDS). The MSDS shall be submitted to the Engineer before the material is delivered on site.

C.3. SITE INSTALLATION AND PREPARATORY WORKS

C.3.1 Site Clearing

The Contractor shall remove overburden and vegetation, fell trees cut down hedges and bushes and grub up roots, all as directed by the Engineer. No trees shall be removed from the site without prior approval from the Engineer and must be in full compliance with the applicable regulations. All rubbish and material unsuitable for reuse must be removed from the site to an approved disposal area in accordance with the Engineer's instructions and the relevant regulations.

C.3.2 Site Installation

C.3.2.1 General

The Contractor shall supply a detail design specifying all temporary facilities and arrangements that he intends to organize on Site – stores, workshops, temporary and access roads, water, power and sewerage supply services etc.- to the Engineer for approval.

All buildings and equipment provided in accordance with this requirement shall be made available within eight (8) weeks following the commencement of the Works at the site and must not be removed without the prior approval of the Engineer.

C.3.2.2 Mobilisation and Site Installation

Mobilisation at Site shall include the erection of all site facilities and the furnishing of all equipment as necessary to carry out the work and/or required in the General and Particular Specifications and the Price Schedule. The site installation shall include all site infrastructure, temporary site offices and yards, safety provisions, accommodation and sanitary facilities, provisions for water, energy and access and the installation of signboards in accordance to the requirements imposed by the Employer's Requirements.

The locations and details of all site installations shall be agreed beforehand with the Engineer. The Contractor shall prepare drawings of all sites selected for the site installation, showing the location of all buildings, stores, offices, temporary roads, etc. The drawings shall be submitted for approval by the Engineer.

Mobilisation at site(s) shall include all site works, the erection of all site facilities and the mobilisation of all equipment and materials as required in the bidding documents and as necessary to carry out the Works under this Contract.

Special attention shall be paid to the safe storage of fuel and lubricants in tanks and safety catchment basins in order to avoid the contamination of soils, subsoil and groundwater. This applies also for the installation of any workshop or other repair facilities.

C.3.2.3 Maintenance of Site Installation

The maintenance of site installation shall comprise, throughout the construction period, the maintaining of all site facilities for the execution of the Works, including but not limited to water and energy supply, the operation and cleaning of site offices, accommodation and sanitary facilities, appropriate solid waste disposal and all temporary works as necessary to ensure access to and proper protection of construction sites, including security, lighting and traffic control and cleaning of public roads.

C.3.2.4 Demobilisation from Site

Following completion or as directed by the Engineer, all site facilities and temporary buildings and equipment, unless otherwise specified, must be removed from the site on the Engineer approval and the site returned to its original state, both above and below ground and all surplus materials and resulting debris removed from the site. This is also applicable to all temporary fences and gates.

The demobilisation also includes the reinstatement of all damaged or worn public and private and access roads and facilities used by the Contractor and the cleaning up of the construction site after completion of the Works.

C.3.2.5 Costs of Mobilisation, Site Installation and Demobilisation

Any costs arising from mobilisation, site installation, demobilisation and other related items shall be included in the Contractor's bid.

C.3.3 Site Facilities

C.3.3.1 General

The Contractor shall provide all temporary site facilities for the proper implementation and completion of works as required and as specified.

The Contractor has to submit to the Engineer the layout and design of his compounds showing areas required for workshops, garages, concrete yards, stores, housing etc., for his approval.

The compounds and their contents shall be dismantled and cleared away by the Contractor at the completion of the contract.

C.3.3.2 Contractor's Facilities

C.3.3.2.1 Site Office

A temporary office or temporary offices for the Contractor, shall be established in proximity to or on the Site, at a location approved by the Engineer. Site offices shall be appropriate to the

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efficient management and control of the project by the Contractor's own staff and adequately furnished, and maintained in a clean, orderly condition by the Contractor for the duration of construction.

C.3.3.2.2 Engineer's Facilities

The contractor shall establish and maintain in a clean and orderly condition for the duration of the construction Works, at a location approved by the Engineer, adequately furnished and equipped office facilities for the Engineer as specified in the Particular Conditions or elsewhere in the Bidding Documents.

C.3.3.2.3 Storage Areas and Yards

The Contractor shall provide all required storage facilities for temporary storage of supplied material and goods. Storage facilities shall be approved by the Engineer. Material and goods shall be stored in a storehouse and in accordance to the Manufacturer's requirements and these specifications. Each storage area shall be fenced and secured by watch guards.

The Contractor shall be responsible for the off-loading, transporting and handling of all the plant and equipment and materials needed for the purpose of the Contract.

The Contractor shall protect all material against corrosion, mechanical damage or deterioration during storage and erection on site. The protection shall be to the approval of the Engineer.

C.3.3.2.4 Staff Facilities

The Contractor shall provide for adequate welfare facilities, including as a minimum drinking water, sanitation facilities, washbasins with warm water, soap and towels and suitable, - clean, dry and warm - shelters and/or mess rooms for his workpeople and engineering equipped with tables and chairs at which food can be eaten.

The Contractor shall at all times provide safe drinking water to the workmen on Site.

C.3.3.2.5 Equipment

The Contractor shall provide all equipment for satisfactory quality of work and a rate of progress which will ensure the completion of the works within the time stipulated in the Tender. If at any time such equipment appears to be inefficient, inappropriate, or insufficient for securing the quality of work required or for the rate of progress, the Engineer may order the Contractor to increase the efficiency, change the character or hire additional equipment and the Contractor shall conform to such order. Failure of the Engineer to give such order shall in no way relieve the Contractor of his obligations to secure the quality of the works and rate of progress required.

C.3.3.3 Sanitary Facilities

The Contractor shall provide and maintain temporary sanitary facilities on the site for the use of all persons connected with the Works and in compliance with applicable regulations and the regulations for groundwater protection and to the approval of the Engineer.

Sanitary facilities shall be provided in suitable numbers and at adequate locations. They shall be made available when the first employees arrive on the site of the Work and shall be maintained throughout the duration of the construction works.

The Contractor shall at all times keep the facilities in a clean and sanitary good condition, and shall post notices and take such precautions as may be necessary to keep the site clean. The Contractor shall carry out any cleaning whatsoever as may be directed by the Engineer to maintain such sanitary conditions.

The Contractor shall be responsible for the adequate treatment or disposal of the sewage resulting from all temporary toilets and ablution facilities.

If the Contractor fails to arrange for adequate precautions and sanitation facilities, the Engineer shall instruct a third party to provide them at the Contractor's expense.

C.3.3.4 Health and Safety Preventive Measures

C.3.3.4.1 General

The Contractor shall be held responsible for all necessary safety measures related to the implementation of the Works and shall strictly follow the safety regulations during the duration of the Contract from the commencement until final acceptance of the Works.

The Contractor shall execute the Works in a manner complying with local and best International Safety regulations and standards. The Contractor shall ensure that his staff and labourers are adequately trained, so that they are familiar and comply with the requirements and are able to carry out their tasks and duties safely and in a manner that will not endanger their own health and safety and those of others.

When first employed on the site, the Contractor's and his Subcontractor's personnel shall be instructed in the hazards inherent in the site, precautions to be taken, the form of construction, and emergency procedures and fire fighting. The Contractor shall maintain a record of all persons instructed and each person shall be required to sign such record confirming that instruction has been received. The Contractor shall prepare a written statement of Safe Systems of Working which shall be issued to all persons at Site.

The Contractor shall propose safety rules for approval. The method statement of any work shall include risk assessment.

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The Contractor shall prepare a Health and Safety Plan in accordance to the applicable local requirements and EU regulations. The Contractor's safety policy (HSE-Manual) shall be submitted for review and approval 8 weeks prior to the start of the site work.

Where applicable, the Contractor shall comply with the requirements of the Employer's safety standards, manuals and Codes of Practice for safe working and those of any authority or body where their services or property are affected by the works.

Should the Engineer consider the Contractor's method of working unsafe or that there are insufficient or inadequate safety barriers or other devices or that there is insufficient safety or rescue equipment, the Contractor shall change his method of working or install or strengthen safety and rescue equipment if so instructed. Such instructions shall not relieve the Contractor of any of his responsibilities under the Contract.

The Contractor shall ensure that all safety and welfare measures strictly comply with the provisions of international standards and codes of Practice and the regulations in force in the Country for health, environment, welfare, and safety.

The Contractor shall appoint a competent Health and Safety Officer to be solely responsible for ensuring the safety and protecting the health of workers, visitors and residents. This person shall be conversant with the hazards associated with the form of construction to be undertaken, corporate policy, management operational instructions, regulations, legislation and current best practice and how these relate to Health, Safety and Welfare. The Health and Safety Officer shall be responsible for ensuring compliance with all management directives, rules and regulations concerning health and safety. Compliance with Health and Safety requirements is the responsibility of managers and individuals at each and every level.

Health and safety measures to be provided by the Contractor shall include but not be limited to the provision on the Site of:

- Welfare and first aid equipment and outfits in accordance to Section C.3.3.4.5 with appropriately trained personnel to administer first aid available at all times, both on the surface and underground, as required by the scale of the Works;
- Equipment for rescue and evacuation of persons underground with persons instructed in its use in accordance to Section C.3.3.4.4;
- All necessary equipment, safety barriers, notices and the like for the protection of persons;
- Proper scaffolding, strutting, sheeting and bracing (including pre-arrangement of the installations when necessary) and protection of slopes;
- Comprehensive fire fighting facilities and fire fighting equipment in accordance to Section C.3.3.4.6;
- Chemical or compressed oxygen self-rescuer sets for underground works;
- Voice communication equipment to link the Site offices and each construction Site;
- Communication with nearest fire brigade station.

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C.3.3.4.2 Relevant Hazards

The Contractor shall identify hazards that are likely to be encountered when carrying out the Works, which could affect the health and safety of the employees and of the general public. The following are examples for areas of work that will likely give rise to serious hazards, and hence appropriate actions should be taken to mitigate the potential health and safety risks as far as practicable:

- Excavations (e.g. support to prevent earth movement, contact with underground/overhead services, physical barriers against vehicles, and warning signs for pedestrians);
- Working at height (e.g. falls, falling materials);
- Confined spaces (e.g. oxygen deficiency, poisonous gases / vapours / fumes, explosive gases);
- Sewerage, sludge in tanks, chambers and pipelines (e.g. leptospirosis / Weill's disease, drowning, poisonous gases);
- Work on roads (e.g. traffic, pedestrians);
- Heavy lifting (e.g. suitable equipment, stable ground, trained driver / slinger);
- Existing operational plant and equipment;
- Storage, handling and use of dangerous substances' (e.g. chemicals, explosives);
- Handling of controlled waste materials;
- Working with electrical equipment; and
- Welding and hot fabrication works.

C.3.3.4.3 Reporting

The Contractor shall submit to the Engineer, as soon as possible after its occurrence, details of any accident arising out of or in connection with the performance of the work whether on, or adjacent to the site, giving full details and statements of witnesses.

If death or serious injuries or serious damages are caused, the Contractor shall report the accident immediately by telephone or messenger to the Engineer. In addition, the Contractor must promptly report in writing to the Engineer all accidents whatsoever.

The Contractors shall maintain records and make reports concerning health, safety and welfare of persons, and damage to property, as the Engineer may reasonably require. The monthly report which shall be submitted by the Contractor shall include accident frequency rate (AFR), accident severity rate (ASR).

If a claim is made by anyone against the Contractor or any subcontractor on account of any accident, the Contractor shall promptly report the facts in writing to the Engineer, giving full details of the claim.

C.3.3.4.4 Safety and Rescue Equipment

The Contractor shall maintain on the Site, safety equipment in accordance to international and local regulations and codes of practice, including any material necessary for the provision of first-aid to injured personnel and shall establish procedures for emergency situations and for the immediate evacuation of any person who may be injured on the Site to a hospital or a doctor's care.

The Contractor shall provide all necessary rescue equipment that shall be regularly checked and maintained. A register of equipment checks shall be kept on site. The Contractor shall ensure that an adequate number of his operatives are fully trained in providing first aid and in the use of breathing apparatus and rescue techniques.

C.3.3.4.5 Site First Aid Post

The Contractor shall establish and maintain on the Site during the whole duration of construction works, site first aid posts, available for the use of all personnel who shall be employed on the site for overall project works. The first aid facilities shall be suitable for the provision of a first aid service to suit the number of personnel in the peak time of the project.

C.3.3.4.6 Fire Prevention

The Contractor shall during the performance of the Contract make arrangements to the satisfaction of the Engineer and/or the relevant authorities for the protection of the works and any adjacent property from fire and if required shall give the Fire Authority all facilities to periodically inspect the fire prevention arrangements.

Particular care must be exercised in connection with the operation of electric arc welding equipment, oxy-acetylene cutting equipment and other processes involving the use of naked lights. Special arrangements shall be made in accordance to applicable regulations and codes of practice for the storage of highly flammable liquids and gases on the site(s).

Site fire protection services shall comply with applicable local regulations and meet the following minimum requirements:

- Provision of fire assembly points at each construction site. The Contractor shall include for the provision of appropriate clear marker posts at locations around all the various project work sites;
- Fire alarms: the Contractor shall include for the provision of manually initiated fire alarm signals at each construction site. This Contract shall also include for the routine checking and maintenance of these fire alarms throughout the project. The Contractor shall maintain a record book in which the routine checks and completed maintenance works shall be recorded;
- Provision of the required number of 10 kg portable dry powder fire extinguishers at each construction site. These shall be placed under a sun shade. The Contractor shall ensure that each extinguisher is tested and maintained in accordance with accepted fire safety

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requirements and details of the routine tests and completed maintenance works shall be recorded in an approved register;

- Fire safety instruction in shall be prepared in English and local language and displayed at each construction Site;
- Appointment of trained firemen. These nominated firemen shall be responsible for maintaining and keeping the designated fire equipment test and maintenance record books for inspection by the Employer and the Engineer.

The construction sites shall be declared as 'NO SMOKING ZONE' and the Contractor shall be liable for the enforcement of this requirement.

C.3.3.4.7 Removal from Site

The Engineer may require the Contractor to remove (or cause to be removed) any person employed on the Works who persists in any conduct that is prejudicial to safety, health or the protection of the environment.

Similarly the Engineer may require the Contractor to remove from the Site any equipment that is unsafe.

C.3.3.4.8 Restricted Areas

Any part of the Site that is designated as a 'Restricted Area' may not be entered without a 'Permit to Work'. All places occupied by live, operational mechanical, electrical or chemical equipment, and 'live' sewers, manholes and chambers will usually be so designated.

The Contractor shall not allow any of his operatives or sub-Contractors to enter such an area until a permit has been issued. Workers being issued such a permit shall comply with any precautionary requirements that may be specified in it.

C.3.3.4.9 Work underground and in hazardous Atmosphere

Where working areas are located within a flammable or toxic gas environment, suitable gas detection, ventilating, and oxygen deficiency equipment shall be provided. Workers shall be equipped with approved breathing apparatus.

The Contractor shall provide the necessary monitoring equipment required for entry to hazardous or potentially hazardous atmospheres. Monitoring of all hazardous or potentially hazardous atmospheres shall be carried out by the Contractor and a suitable register maintained.

Pits shafts, tunnels and any other confined working areas shall at all times be kept ventilated to the standard for safe working and free from potentially explosive or noxious gases, dust and oxygen deficiency.

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Monitoring equipment shall be capable of continuously monitoring the levels of explosive and noxious gases and the oxygen content. The equipment shall give both visual and audible warning of the presence of explosive or noxious gases and where the oxygen content falls below safe working levels. An immediate and effective means of communication warnings to the surface shall be installed. Should the workings be found to contain explosive or noxious gases above a safe level, or of oxygen content below a safe level, all work shall stop and the Works evacuated until a safe atmosphere is established.

C.3.3.4.10 Protection of Slopes and Excavations

Proper strutting, sheeting and bracing, protection of slopes, methods of excavation to reduce risks of slides, etc. shall be deemed to be included in the rates and prices entered in the Price Schedule.

C.3.3.5 Safety of Personnel and Visitors

The Contractor shall observe and instruct his staff to observe health & safety standards commensurate with the nature of the Works and in accordance with the relevant applicable regulations in force in the Employer's country. To this end the Contractor shall provide and ensure his employees wear:

- Overalls;
- Boots or shoes with reinforced toe caps;
- Safety helmets suitable for construction sites;
- Other protective equipment such as gloves, ear muffs, goggles, etc., as are necessary for any particular work.

The Contractor shall further provide helmets and shoes for the Engineer, the Employer and for the use of site visitors up to ten in number.

Visitors to the Site shall receive training in the scope of the Works being undertaken and the relevant hazards that may be encountered. Visitors must be accompanied by a designated person from the Contractor's project team at all times.

No work shall be permitted to be executed unless the Engineer is satisfied that appropriate safety measures are in place and that the Contractor's employees are wearing suitable safety gear.

C.3.3.6 Construction Site Sign Boards

The contractor shall provide, erect and maintain weather resistant signboards / display panels for each site at locations to be approved by the Engineer and as specified in the Particular Specifications, Drawings or elsewhere in the Bidding Documents.

Sign boards shall be in English and, where applicable, in local language.

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Unless otherwise specified, the sign boards shall have a minimum size of 2,0 x 3,0 m and shall bear at least the following information:

- Name of the project;
- Name of the Employer;
- Title of the project;
- Contract amount;
- Location;
- Name of financing agencies;
- Name of the Engineer;
- Name of the Contractor(s);
- Works Implementation Period.

The sign boards shall be easily visible and of a durable type. Where appropriate, signboards shall be of mobile type and suitable for continuous transportation to locations / sections where the actual works are taking place.

C.3.3.7 Access Roads, Site Roads and Footpaths

Design and construction of all Project's roads and footpaths is subject to the Engineer's approval.

Adequate access road shall be provided to each construction Site, site office, construction and storage areas, taking into account type and frequency of traffic. The access road from the public road and main site roads shall be not less than 8 m wide. Roads for occasional use shall be 5 m in width. Turning curves at junctions shall be not less than 10 m.

Sufficient manoeuvring space shall be provided at all sites to facilitate transports. Except for access ramps, road gradients shall not be steeper than 1 in 10.

Parking areas shall be provided for cars at all sites and as required for work execution.

The design of site roads and footpaths will include use of sand and gravel with a top of asphalt paving. Footpaths and pedestrian areas will be of rough pre-cast paving slabs.

Temporary roads shall be designed with an adequate depth of construction appropriate to the vehicle loads anticipated, using an approved design method.

C.3.3.8 Fencing

The Contractor shall provide adequate temporary fencing to all parts of the works, especially around construction sites, open excavations and site facilities and where permanent fencing cannot be erected immediately to allow for adequate protection of all works and to ensure the safety of workpeople, visitors, the public and livestock.

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The Contractor shall have particular regard to the safety of persons and livestock and shall ensure that all open excavations, trenches, access routes and steep or loose slopes arising from the Contractor's operations are adequately fenced and protected to provide maximum safety to pedestrians and vehicles at all times.

Around the working areas safety barriers and portable bridges (for crossing purposes) shall be located along and over excavations / ditches to prevent any accident or injury.

Temporary bridges shall be provided across trenches to maintain reasonable and safe access for pedestrians and vehicles to land and property on either side of trenches. Access shall be provided in the fencing where directed for owners, tenants and occupiers of the adjacent land.

Gaps formed in walls, hedges or fences crossing the route of a pipeline shall be closed during construction, where required, for the proper security of the affected premises and shall be stock-proof where animals are kept in adjoining land.

If temporary fencing is removed for the execution of any part of the Works, it shall be reinstated as soon as possible and, in the meantime, the gap in the fencing shall be patrolled so that no unauthorised entry onto the construction Site takes place.

Temporary fencing shall remain in position until either it is replaced by permanent fencing or where none is required, until completion of the related section of the Works, unless the Engineer permits its earlier removal.

The Engineer may request the Contractor to erect other temporary fencing in specific locations as required.

All fencing shall be neatly and effectively joined to existing fences, walls, etc. All fences shall be regularly inspected and maintained, any defect being immediately made good when noticed by, or brought to the attention of, the Contractor.

C.3.3.9 Cleanliness on Site

The Contractor shall make every effort to keep the Site tidy and in orderly manner and to take at all times every possible precaution against the contamination of subsoil and groundwater. The Contractor shall be responsible for making all arrangements for the proper disposal of solid and liquid wastes from the Site.

The Contractor shall give strict instructions to all persons employed by him to use the waste disposal and sanitary facilities provided at Site and to comply with the regulations for groundwater and environmental protection. The Engineer reserves the right to require the dismissal of any person committing a nuisance on or about the site by failing to use the conveniences provided.

If the Contractor fails to arrange for adequate precautions to avoid any contamination, he shall exchange soils contaminated by him and bear full responsibility for any groundwater pollution.

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If the Contractor fails to keep the Site clean, the Engineer shall instruct a third party to carry out the work at the Contractor's expense.

C.3.3.10 Water and Energy Supply

The Contractor shall be responsible for and shall make all arrangements to provide and maintain adequate supply of water and energy to the construction Site during the entire duration of construction works at his own expense. The Contractor shall be responsible for the supply of all water required for mixing and curing of concrete and for testing of pipelines and structures.

The water supply and power supply systems including the connection to the public system shall be approved by the Engineer.

All temporary connections and installations for electricity shall be subject to the approval of the Engineer. All temporary electrical installations shall be provided, connected, and maintained by the Contractor in accordance with the requirements of the power supply company and local regulations and to the satisfaction of the Engineer.

The Contractor shall provide sufficient electric lighting for the implementation of works with no compromise on the security and quality of works.

The Contractor shall not use any part of the Permanent Works for temporary power supply, illumination, or equal purposes, unless agreed with the Engineer on a case-by-case basis.

C.3.3.11 Traffic Arrangements, Maintenance of Traffic and Access

The Contractor shall provide, erect and maintain on the Site and the access to the Site all traffic signs and traffic control signals and all measures for protection of the public, as necessary and/or may be locally required by the relevant local authorities for the safe direction and control of the vehicular and pedestrian traffic during execution of the Works. He shall maintain safe use 24 hours per day of all roads through or around any part of the work.

The Contractor shall provide all barriers and traffic signs required by the Authorities or instructed by the Engineer. All signs and barriers must comply with standard international practice or as otherwise required by the traffic authorities. All written notices on signs shall be in local language. Such signs and barriers shall be erected by the Contractor immediately before his occupation of the Site, maintained during his occupation and removed immediately after the termination of his occupation.

The location and size of all such signs and the lettering thereon shall be approved by the Engineer before installation.

The Contractor shall relocate, cover or remove signs as required during the progress of the Works.

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Where streets are partially blocked the Contractor shall lay and maintain temporary driveways, ramps, sidewalks, bridges and crossings such as necessary to disturb as less as possible vehicular and pedestrian traffic and accommodate the residents.

No work that will in any way inconvenience the travelling public shall be started until adequate provisions, satisfactory to and approved by the authority concerned and the Engineer, have been made to divert or by-pass traffic in safety and comfort.

All diversion roads shall be to the satisfaction of the Engineer and to the approval of the relevant local authorities. A road shall only be closed with the written permission of the authority concerned. Periods when traffic is being detoured shall be subject to the approval of the authorities and the Engineer. It shall be the Contractor's responsibility to obtain the permissions required. All diversions shall be maintained in good condition by the Contractor and shall be at least 6 metres wide. Where existing private or public roads are used as diversions, they shall be maintained and left in a good condition upon completion of the rerouting activity.

The Contractor shall provide all flagmen, warning lights, signs, and barricades necessary to direct and protect vehicular and pedestrian traffic. Where traffic is diverted via adjacent streets the Contractor shall supply all detour, warning, regulatory or informative signs. Warning or regulatory signs shall be in accordance with to local regulations.

The Contractor shall clean and keep clean the streets, the work and public and private property occupied by him from waste materials or refuse resulting. Trucks hauling excavated materials, cement, sand, stone or other loose materials from or to the site shall be tight so that no spillage can occur on streets. Loads shall be trimmed before trucks leave the Site. If the Contractor fails to comply with the above requirements, the Employer will take the necessary steps to perform cleaning at the costs of the Contractor.

Contractor's vehicles shall all times comply with the applicable regulations and shall not cause spillage and all loads shall be suitable secured. Any vehicle which does not comply with this requirement or any of the local traffic regulations shall be removed from the site.

The Contractor shall in no circumstance be released from his obligations to indemnify and keep the Employer indemnified against losses and claims for injuries or damage to any person or property, which may arise as a consequence of a failure of the Contractor to fulfil his above described obligations.

C.3.3.12 Use of Public Roads and Temporary Roads

The Contractor shall carry out all protective works and strengthening of public roads used by him as necessary to avoid damage from heavy loads and plant moved to the Site. The Contractor shall also construct, maintain and remove at his own expense temporary access roads as he may require for carrying out the works.

The Contractor shall observe all restrictions, which apply to public roads, and he shall comply with all reasonable restrictions which may be imposed by the Engineer, the

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Employer / Beneficiary, or other competent local bodies. This includes safe and secure fencing of the respective site, temporary traffic lights and security guards.

The Contractor shall not run tracked vehicles or tracked plant on any public or private road without the written approval of the responsible Authority or Employer and subject to such conditions as those may require.

Public and private roads and other surfaces used by the Contractor shall be kept free from dirt and rubbish and shall be cleaned with adequate equipment as directed by the Engineer. If the Contractor fails to do so, the Engineer can order a third party to do the cleaning at the Contractor' expense.

Immediately after ceasing the use of any temporary road, the Contractor shall restore the road to the satisfaction of the Engineer and the responsible Authority or the Employer. These provisions shall apply also to shoulders, footpaths, drains, etc. of any existing sealed road used by the Contractor or affected by his operations.

C.3.3.13 Temporary Approaches, Bridges, Gangways etc.

Where any road, path, or right of way is affected by the construction of the Works, and as in the opinion of the Engineer may from time to time be necessary for safe and expeditious access to different parts of the Works, the Contractor shall provide suitable temporary approaches, bridges, gangways, and roads. The Contractor shall notably provide means of access to adjacent occupiers of the land to carry on their normal occupations, and shall indemnify the Employer against any claim for loss of business or amenities.

All such approaches, bridges, gangways and roads shall be maintained in service until all requirements of the Specifications have been fully complied with.

C.3.3.14 Work in existing Roads and Footpaths

Where existing roads shall be crossed or works are performed in existing roads, the Contractor shall obtain instructions from the responsible Authority as to the date and hour for the breaking up of the road and the manner in which traffic is to be diverted to other roads. Such deviations shall be provided and maintained by the Contractor at his expense.

All roads used shall be kept free from dust and mud and unless permission to close certain roads is obtained by the Contractor from the Engineer, at least one half the width of each road (if possible) shall be kept open to traffic.

Men and apparatus shall be provided by the Contractor for pedestrian and for vehicular traffic control when working along or crossing roads. Lamps shall be lighted and warning signboards put up where necessary to ensure, during the progress of work, the safety of traffic using the road, and to prevent unauthorized persons, animals, etc., from straying on to the work.

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The Contractor shall be responsible for liaison, co-ordination and arrangements with the relevant Authorities such as obtaining of consents, payment of fees and all manner of things necessary to comply with the lawful orders of the relevant authorities.

All roads, including shoulders and various kind of drains, ditches and footpaths shall be restored to their original condition and carried out to the requirements of the relevant Authority as soon as the work along or at the crossing has been completed. All restoration works, such as backfilling and road base course and surfacing, shall be performed to the requirements of the Specifications.

C.3.3.15 Maintaining of other Services / Utilities and Structures

The Contractor shall be responsible for maintaining all water-courses, pipes, sewers, drains, electricity and communication cables and other services and structures during the construction of the Works. He shall maintain the flow in all sewers, drains, water pipelines and all water courses which may be met during the execution of the Works, allowing none of the waters to flow in the trenches for pipe laying under this Contract.

The Contractor shall repair to the satisfaction of the Engineer or the concerned Authorities, without any delay, any damage caused by his operations and maintain existing services during the execution of Works.

As soon as an existing service is encountered in the excavation the Contractor shall forthwith call the attention of the Engineer and the appropriate utilities service authority thereto.

Notwithstanding any relevant information furnished by the Employer or the Engineer, the Contractor shall be responsible for ascertaining, from his own inspection of the Site and from the respective utility and other authorities and by excavating and backfilling for trial pits, the position of all mains, pipes and cables whether underground or overhead, within or near the Site.

If an existing utility line is needed to be diverted or demolished, such line shall be diverted or demolished and afterwards relocated and/or repaired as originally found and be approved by the respective utility / Authority.

If any utility intercepts the pipeline route, the Engineer shall have the authority to modify the design and to order deviations from the line and grade..

C.3.3.16 Disruption of Water Supply Services

When and where it becomes necessary for the execution of the Works to interrupt water supply services in order for the Contractor to replace or repair existing facilities, or connect existing facilities to the new system, hereinafter referred to as "Disruption", then the Contractor shall only be permitted to use methods, types and numbers of equipment and levels of staff and labour which shall result in minimum Disruption.

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The Contractor's proposals for the execution of such works shall be subject to the Engineer's approval, and the Engineer shall not be required to consider the costs to the Contractor (including payments for overtime to the Contractor's personnel) or the convenience to the Contractor of particular sequencing of work, where such considerations conflict with the Employer's need to limit the extent of Disruption.

Any shut down periods must (i) be agreed in advance with the Employer, (ii) be limited to a minimum and (iii) under no circumstances may be permitted for a period beyond the point which would endanger the drinking water supply requirements of the downstream service area.

The Contractor shall indicate in the Programme of Works, the approximate dates and durations of Disruption, and shall, during the execution of the Works, notify the Engineer forthwith of any circumstances which arise and may affect the expected dates of such Disruptions.

At least 14 days, prior to any Disruption, the Contractor shall submit to the Engineer for his approval his plan for works associated with the Disruption and details of date and duration intended for such Disruption. The Engineer shall within 7 days of such submission:

- inform the Contractor of the dates and times when such Disruption will be permitted, which shall be not more than 3 days before or 7 days after the dates proposed by the Contractor;
- approve the Contractor's plan or otherwise instruct the Contractor on the methods of work and types and numbers of equipment and labour to be employed on such works; and
- provide the Contractor with the text of a notice by the Employer to the public of the intended Disruption.

The Engineer may otherwise instruct the Contractor that the Disruption shall take place on a date later than 7 days after the dates proposed by the Contractor.

Approval of a Disruption may be withheld at the Contractor's responsibility, if in the opinion of the Engineer, the Contractor's proposal does not prove the adequacy of the measures in terms of quality and safety of the works and the duration of the Disruption. The Engineer shall notify the Contractor of such withholding of approval stating the reasons thereof, and giving instructions to the Contractor how to proceed.

The Contractor shall publish the Employer's notice on one and two days before the commencement of the Disruption in three national newspapers at a minimum of a quarter size.

C.3.3.17 Precautions

The Contractor shall take all precautions to avoid damage to any structure owned by third parties. If damage occurs, the Contractor and the Engineer shall contact the owner of the damaged structure immediately, jointly, and all necessary repairs shall be made by the Contractor at his own expense, to the satisfaction of the Engineer.

C.3.3.18 Cost of Facilities

The costs of all required facilities on Site shall be included in the corresponding items for Permanent Works or in the items for Preliminary Works. Where items are not included in the Price Schedule for required facilities, the cost of such services, works and facilities shall be deemed to be spread over all items of the Price Schedule.

C.3.4 Preparatory Works

C.3.4.1 Project Start Up Programme

Within 10 working days of the Commencement Date, the Contractor shall provide a Project Start Up programme. This program shall be of bar chart format, covering all activities scheduled for the first two (2) months from the contract award. The start-up programme shall be used for progress reporting during the interim period whilst the level 3 CPM programme as per Section C.3.4.2 is being prepared and shall be updated regularly to indicate progress achieved.

C.3.4.2 Programme of Works

Within twenty eight (28) days after receiving the notice for the Commencement Date, the Contractor shall produce and issue for review a level 3 Working Schedule using the Critical Path Method (CPM) method. It shall run on a computer using proprietary software such as MS Project, Primavera or similar and shall include, but not be limited to the following information:

1. Preparatory works;
2. Engineering services and project management;
3. Manpower, equipment and machineries required for the execution of each task;
4. Procurement of goods;
5. Construction works;
6. Operation and maintenance works;
7. Demolish, disconnect, dismantle and abandonment existing facilities;
8. Quality assurance program;
9. Safety precautions for the works; and
10. Required safety equipment and materials which shall be used in conducting the works.

The Programme of Works shall be subject to Engineer review and comment and indicate for each item of the Works the various phases of the work from the commencement of the Contract to its final completion, e.g. design, ordering of materials, manufacture, delivery, erection, construction, commissioning and testing. The Programme of Works shall be deemed to have taken into account the climatic conditions to provide for the supply of the goods and the completion of the Works in the order and within the times specified therein.

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The report on materials procurement shall give the date and details of orders placed and indicate the delivery quoted by the manufacturer. If any delivery has an adverse effect on the Programme of Works, the Contractor shall state the mitigations in place to ensure that delays do not occur.

The Programme of Works shall include but not be limited to the following detailed plans:

- (1) Detailed plan of management progress works such as reports, submittals, manpower categories, inspections requirements, commissioning schedule, testing plan, forms and all other works specified in the Contract requirements
- (2) Detailed plan for mechanical, electrical, instrumental and civil works required by the Contract showing dates of start and completion, equipment, tools and materials needed, pumps, safety equipment, dewatering system, heavy duty mobile equipment or machinery to carry out the works, techniques, methods and procedures of executing works to the satisfaction of the Engineer as specified in the Contract documents.

The Contractor shall carry out the Contract in accordance with the Programme of Works approved by the Engineer. Approval of the Work Program shall in no way relieve the Contractor from his obligations to complete the Works in the prescribed order and by the prescribed Completion Date.

The Contractor shall maintain the Programme of Works to reflect the current state of Contract progress and shall review his progress every month (tracking Gantt chart) and make such amendments to his rate of execution of the Works as may be necessary to fulfil these obligations. The Contractor shall attach a copy of the current Programme of Works to his monthly reports and submit reports as deemed necessary by the Engineer to show the status of project, delayed and critical activities, etc.

The Contractor shall inform the Engineer about any unforeseen difficulty or disturbance which shall have influence on the approved Programme of Works. The Contractor shall advise the Engineer in writing of such occurrences without delay and submit proposals for any necessary remedial measures, for which he shall obtain the Engineer's approval before putting such measures into effect.

The Contractor shall make due allowance in his programme for national holidays, including religious holidays. If at any time during the execution of the Contract it is found necessary to modify the approved programme, the Contractor shall inform the Engineer and submit the modified programme for his approval. Any approval of changes to the approved programme shall not constitute approval of an extension to the guaranteed completion date.

C.3.4.3 Review of technical Documents

The Contractor shall carefully review all technical documents included in the Contract before the start of the Works and the ordering of the required goods. The technical documents are understood to be the following:

- Contract drawings;

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- Data sheets;
- these Technical Specifications;
- Price Schedule.

Any changes on the design of any part, which may become necessary after signing of the Contract shall be submitted by the Contractor in writing to the Employer for approval, being sufficiently substantiated and justified.

C.3.4.4 Tender Drawings

Contract Drawings available at the date of Tender are mentioned in these Specifications. Where applicable, all work shall be performed in accordance with the Drawings furnished, together with the Contract Documents and any such additional drawings as may be issued by the Engineer from time to time during the progress of the work. Additional drawings (if any) will be furnished to the Contractor in due time so as to enable him to perform the work shown thereon in proper sequence and for any advance planning that may be necessary for the efficient performance of such work. The Engineer will decide in such instance whether additional drawings are required for advance planning of the works and determine the time required for doing so.

C.3.4.5 Preservation of Evidence

The existing condition of the areas where the works will be carried out requires a detailed preservation of evidence. This work includes the compilation of the existing state, the detection of any damages visible on the surface like roads, sidewalks, manholes, buildings, walls, etc. This assessment is to be put down in written form including photograph and shall be handed over to the Engineer before the works are commenced.

The Contractor shall provide the Engineer with the details of all properties and facilities that may be destroyed in the course of the execution of the works, four (04) weeks prior to commencing works in the affected areas. This will allow adequate time for the Employer to compensate the owners of the property before the works commence, if applicable. The Employer shall not be held liable for any delays in the works arising from late presentation of this information to the Engineer or delays arising out of inaccuracies of the information presented by the Contractor to the Engineer.

C.3.4.6 General Site Clearance

Prior to the start of survey works as specified in Section C.3.4.7 and before commencing any excavation or fill, the whole construction site shall be cleared of shrubs, roots, bushes, vegetation, fly-tipped waste, rubbish, rocks and all other materials not suitable for reuse in the construction works.

The materials so obtained shall be reserved for further use, when considered suitable by the Engineer, and all rubbish and material unsuitable for further use shall be removed from the Site by the Contractor.

C.3.4.7 Contractor's Survey

C.3.4.7.1 Site Inspection

Before carrying out any works, the Site shall be inspected jointly by the Contractor, the Engineer, the Employer and any other person deemed useful, in order to verify site conditions, to establish the directions for site clearance and to clarify the further proceedings.

The site inspection shall be section-wise and in line with the Contractor's Programme of Works. During such site inspection the detailed alignment shall be defined jointly under consideration of the public right of way, traffic, the actual situation on site, any existing structures and utilities (above and underground) and any other consideration that may be applicable from time to time.

The Contractor shall draft a detailed protocol of the site inspection which is subject to approval by the Engineer.

C.3.4.7.2 Topographic Survey

Before commencing any works but after site clearance, the Contractor shall carry out a thorough topographic survey of the construction site and its vicinity in x, y and z coordinates. The proposed geodetic reference system shall be submitted for approval to the Engineer.

Locations, levels, dimensions and materials of existing works and/or other infrastructure referred to in the Bidding Document are provisional and shall be investigated by the Contractor on his own responsibility, where required for the execution and completion of the works.

The Contractor shall check all distances and levels, bring any errors or discrepancies discovered therein to the attention of the Engineer and shall adjust layout plans, longitudinal profiles and system point drawings if directed by the Engineer. The Contractor shall submit one original and the digital copy of the topographic survey in editable (dwg) format and in (pdf) format to the Engineer for approval.

The detailed topographic survey shall include but not be limited to the boundary of public right of way, limits of pavements, curbs, etc., existing structures and utilities (above and underground), the exact alignment / location / levels of the Permanent Works and any other element that may be applicable from time to time.

The topographic survey results shall be produced in AutoCAD compatible format (*.dwg) and with a structured layer organization to be agreed by the Engineer. The drawings shall be prepared in appropriate scales approved by the Engineer.

All objects shall follow the layer styles (except a few particular exceptions). Using proxies is not allowed. The dwg shall have sufficient labels and an explicit legend.

If required, the Contractor shall produce digital elevation models (DEM) with sufficient break lines.

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The Contractor shall submit a softcopy and two coloured hardcopies of the drawings to the Engineer for approval.

C.3.4.7.3 Record Survey

After clearing the site, the Contractor shall take and record levels in the manner directed by and in the presence of the Engineer of the site and works. Such levels, when approved by the Engineer, shall be recorded by the Contractor on drawings and/or schedules which shall be signed as a true record by the Contractor and the Engineer's Representative and shall form the basis of the measurement of the Contractor's work.

Excavation works shall not commence before such records are certified by the Engineer.

C.3.4.7.4 Setting-out of Works

It shall be the Contractor's responsibility to obtain from the competent authorities before commencing the work coordinates and levels of setting out points which have already been established. The Works shall be set out and tied to the Regional Co-ordinate and Level System, which will be indicated by the Employer to the Contractor.

The Contractor shall set out and establish at suitable locations on the Site of the Works by suitable pegs, additional benchmarks, reference points and grid lines necessary for the setting out of the works. These shall be of a form approved by the Engineer and maintained until the completion of the works. During the progress of the Works the Contractor shall periodically check the levels of the benchmarks and the co-ordinates of the stations against the original points lines and levels of reference given by the Employer. Temporary benchmarks and survey stations shall, unless otherwise approved, be located clear of the construction Works. The Contractor shall seek prior approval from owners for the establishment of bench marks on privately owned properties.

Before commencement of structural works, the Contractor shall establish, in a position to be approved by the Engineer, steel datum pegs which shall be securely concreted in. The level of this peg shall be established and agreed with the Engineer and used as reference datum in the construction of the Works.

The Contractor shall submit to the Engineer for approval, drawings showing the locations and levels or co-ordinates as appropriate of each and every temporary benchmark and survey station used for the setting out of the Works.

The Contractor shall before commencing execution of any given section of the Works submit to the Engineer complete setting out details with supporting calculations and drawings (including drawings showing the locations and co-ordinates of the reference points used) in duplicate for approval.

The Contractor shall identify setting out dimensions for all structures by relating them to existing facilities and by interpretation of the Documentation. The gradients of sewers and pipelines and

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the levels of weirs, inverts of channels and other hydraulic structures shall be as shown on the drawings unless otherwise required or approved by the Engineer.

The locations of structures to be constructed as part of the Works shall be identified by reference to steel pins set in concrete or other approved markers set up by the Contractor, who shall also determine the co-ordinates of the markers and their distances from adjacent existing structures.

The Contractor shall establish reference co-ordinate points at intervals of not more than 250 m along all sewers and major pipelines and these points shall be located and clearly marked at approved locations either on existing buildings or by means of steel pins fixed in concrete.

The Contractor shall set out sections of the Works at such times as may be directed by the Engineer to enable Service Authorities to carry out temporary or permanent alterations to their equipment or buried services. The rate for setting out of works shall include all survey works of Contractor for completion of the works.

The Contractor shall be responsible for accurate setting-out the Works, temporary benchmarks and shall carefully protect and preserve all benchmarks, sight-rails, pegs and other things used in setting-out the Works during entire duration of the construction works and until the end of the Defects Notification Period.

All dimensions and levels shown on the drawings or referred to in any document forming part of the Contract shall be verified by the Contractor on site. He shall be responsible for pointing out promptly any discrepancy or error in such dimensions or levels.

C.3.4.7.5 Geotechnical Surveys and Sample Analysis

Geotechnical surveys at depths prescribed by local seismic standards and norms of construction shall be performed by the Contractor on locations planned for the construction of the works as described in the present Particular Technical Specifications. Soil-mechanical parameters shall be determined after sample analysis.

Based on the results of the geotechnical survey, an expertise on the conditions shall be prepared by a licensed geologist and the detailed and structural design of the treatment works shall be prepared and submitted for approval to the Engineer.

C.3.4.7.6 Survey Staff and Equipment

The Contractor shall provide all staff, labour, instruments and materials as may be required by the Engineer for survey work and measurements in connection with the Works.

C.3.4.8 Removal of Structures

Preparatory Works shall include the removal of all structures and obstructions at such time and to such extent as required by the Engineer. The materials so obtained shall be reserved for

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further use, when considered suitable by the Engineer, and all rubbish and material unsuitable for further use shall be removed from the site by the Contractor at his own costs.

C.3.4.9 Conservation of Existing Structures and Utilities

The Contractor shall take all precautions to avoid damage to any structure owned by third parties. If damage should occur, the owner of the damaged structure should be contacted immediately, jointly by the Contractor and the Engineer, and all necessary repairs shall be made by the Contractor under the direction and to the satisfaction of the owner.

The Contractor shall assume full responsibility for the protection of all buildings, structures and utilities, public or private including poles, signs, services to buildings, utilities in the street, water pipes, hydrants, drains and electric and telephone ducts and conduits, whether or not they are shown on the drawings. The Contractor shall carefully support and protect all such structures and utilities from injury of any kind.

The Contractor shall bear full responsibility for obtaining all locations of under-ground structures and utilities. Services to buildings shall be maintained.

The Contractor shall not demolish or remove any existing buildings, structures or other objects including trees, whether indicated on the Drawings or not, unless on a specific instruction from the Engineer. The Contractor shall take every care and precaution to protect from damage any of these objects, including houses, buildings, fences or trees, which are situated on or near the Site(s).

Any property situated in close proximity to the Works shall be protected against any damage which could be caused by vehicles, subsidence, vibration, etc.

The trunk of trees located close to working areas shall be fully protected with wooden boards.

C.3.4.10 Works in Private Property

Before commencing any site clearance and excavation in private property, the Contractor shall prepare and agree with the owner or occupier of such property a record of the state of the surface and/or structures with particular reference to any features that may require special care, conservation and reinstatement.

The records shall be drawn up in collaboration with the Engineer who shall also be supplied with copies of all such statements and records.

C.3.4.11 Programme of Supplies and Works

The Contractor shall submit to the Engineer full details of his proposed Supply and Working Programme and its milestones within the execution period as stipulated in the Contract.

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The Critical Path Method (CPM) for elaboration of the Programme and shall use MS Project or equivalent software as tool. The Work Programme shall clearly indicate.

- material approval dates before the order of such;
- factory test dates, if witnessed or unwitnessed;
- dates of shipment of material and equipment from abroad;
- periods of customs procedures;
- working drawings submittals;
- time of access to land;
- submittal and approval of road closing;
- periods of civil, mechanical and electrical Works;
- dates of site tests during installation;
- dates of Tests on Completion;
- submittal of As-built Drawings;
- any other event that may concern Employer or Engineer.

The Programme shall be deemed to have taken into account the climatic conditions to provide for the supply of the goods and the completion of the Works in the order and within the times specified therein.

The Contractor shall carry out the Contract in accordance with the Programme agreed with the Engineer but he shall in no way be relieved by the Engineer's approval of the Programme of his obligations to complete the Works in the prescribed order and by the prescribed Completion Date. He shall review his progress every month (tracking Gantt chart) and make such amendments to his rate of execution of the Works as may be necessary to fulfil these obligations.

Once the proposed Programme is approved by the Engineer, the Contractor shall not depart from the Programme without written consent of the Engineer.

In the event of unforeseen difficulties or disturbances which shall have influence on the approved Programme of Works, the Contractor shall advise the Engineer in writing of such occurrences without delay and submit proposals for any necessary remedial measures, for which he shall obtain the Engineer's approval before putting such measures into effect.

The Programme shall clearly indicate the material approval dates before the order of such, the suppliers' customs procedures, the working drawings submittals and the time of access to land, submittal and approval of road closing, the submittal of As-built Drawings or any other event that may concern the Engineer.

When preparing the Programme of Works, as specified, the Contractor shall take account of the priority order prescribed for the various activities of the Works.

If it is necessary for the safety of the Works or for any other reason, the Contractor shall carry out such part of the Works continuously by day and by night when so instructed in writing by the Engineer.

C.3.4.12 Cash Flow Programme

Together with the Work Programme the Contractor shall provide to the Engineer a detailed Cash Flow Programme of all payments to which the Contractor shall be entitled under the Contract. He shall update this Programme with the updates of the Programme of Works, if required to do so by the Engineer.

C.3.4.13 Sub-contractors and Sub-orders

In accordance with the Conditions of Contract, the Contractor shall submit to the Engineer's approval any Sub-contractor he intends to employ for the implementation of part of the works. It is the Contractor's responsibility to provide any requested information sufficiently in advance to allow adequate time for examination and approval.

As soon as practicable after entering into the Contract the Contractor shall, having obtained the Employer's consent, enter into the subcontracts he considers necessary for the satisfactory completion of the Contract Works. No claim shall be allowed if orders have been given by the Contractor without prior approval.

Sub-orders shall include all relevant sections of the Bid Specification, all relevant approved design particulars furnished by the Contractor for the equipment in question, delivery schedule to meet the Programme of Works, all relevant approved drawings, etc. A copy of such order shall be provided by the Contractor to the Engineer and to the Employer. All sub-orders shall be prepared in English.

Each order and drawing shall contain the reference (name of the Employer and Engineer and name of the project) and the instruction that the plant is subject to inspection by the Engineer's representatives.

C.3.4.14 Construction Methods and Method Statements

The Contractor shall submit details of the plant, equipment and labour force, which he proposes to use and employ and shall describe in detail the proposed construction methods for each part of the Works. The details on construction plant shall include the make, type, capacity or rating and the number of units which the Contractor envisages to employ throughout the duration of the Contract.

Special attention shall be paid to:

- the procedure of concrete mixing, transporting, vibrating and curing and whether the concrete is prepared at the Site or elsewhere,

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- the procedure of grouting of any equipment and/or steel structure into box-outs of primary concrete after careful adjustment to line and grade and wrapping into plastic sheets against fouling during grouting;
- the on-site coating, painting and other works serving for corrosion protection;
- the general and particular safety measures to be maintained throughout implementation of the respective Works.

The Contractor shall submit to the Engineer's approval for the respective activity of works, his proposed method statements at least 14 days before his intended commencement date of any new section of works. Such approval of method statements shall in no way relieve the Contractor from his obligations.

Such approvals of working methods shall be obtained for all site activities, including but not limited, as applicable, to the following:

- Excavation / bedding / backfilling including compaction;
- Soil bearing tests;
- Dewatering including diversion of flow and discharge of water from excavations;
- Concrete mix design;
- Concrete testing regarding strength, water penetration, water tightness;
- Any coating / painting / lining works;
- Any shoring works;
- Any pipe laying / installation including leakage tests, flushing and cleaning;
- Any testing and commissioning of mechanical / electrical works;
- Training;
- Maintaining of public traffic;
- Dealing with / crossing of other services;
- Reinstatement of excavated areas;
- Provisions to ensure public safety;
- For any other site activity as requested by the Engineer.

In addition to providing a step by step description of the work (in sequential order) method statements shall also clarify the following:

- Scope of works covered;
- References (procedures or standards);
- Subcontractors assigned;
- Products required;
- Tools, equipment and machinery required;
- Plan of progress works, starting date of the activities and the Period activities to be completed;

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- Personnel required and designated responsibilities;
- Safety Hazards and Precautions to be taken;
- Quality Control Measures;
- Procedure (step by step sequence of work).

Prior to the commencement of any hazardous operation, the Contractor shall submit a Safety / Method Statement to the Engineer for his approval. Where deemed appropriate by the Engineer, a HAZCON study shall be undertaken by the Contractor and agreed with the Engineer prior to the Method Statement being prepared.

The Contractor shall maintain a neat record of method statements, their submission, approval, modification etc.

C.3.4.15 Approval by Authorities and Third parties

The Contractor shall furnish to the Engineer the formal approval of working methods he may be required to obtain from relevant authorities prior to the commencement of any new section of works. Such approval of working methods shall in no way relieve the Contractor from his obligations.

Such approvals of working methods shall be obtained, as applicable, e.g. for the maintaining of public traffic, the dealing with/crossing of other services, the diversion of flow and discharge of water from excavations, the reinstatement of excavated areas and the provisions to ensure public safety.

C.3.4.16 Permits

Unless such permit, license or approval can be issued only to the Employer, the Contractor shall obtain all permits, licenses and approvals necessary for the construction, occupation and use of the Works including work for required temporary measures. The Contractor shall provide any necessary support and assistance to the Employer in obtaining a permit, licence or approval which can be issued only to the Employer.

The Contractor shall comply with all conditions stipulated in any permits granted by third parties, including conditions stipulated in those permits obtained by the Employer. The Contractor shall allow a realistic timescale for dealing with the third parties responsible for permits etc., in his planning and programming of the work.

The Contractor shall not supply material or equipment or start with construction works for works which require approval by local authorities such as the fire protection systems etc., before the necessary approval has been obtained by the Contractor from the relevant authority.

C.3.4.17 Notice and Inspection prior to Excavation

C.3.4.17.1 Notices prior to Excavation

The Contractor shall, before starting excavation in any portion of the Works, give all necessary notices and make timely and reasonable arrangements with:

- The relevant authorities responsible for public roads (approvals for opening, agreements on resurfacing) and the Police (traffic arrangements), where applicable;
- The relevant bodies for water and energy supply and telecommunications (dealing with crossing of, maintaining and reinstatement of the respective services);
- The concerned land owners (approvals of access, reinstatement of surfaces).

C.3.4.17.2 Site Inspection prior to Excavation

Before carrying out any excavation, the Site shall be inspected jointly by the Contractor and the Engineer in order to verify site conditions, to establish the directions for site clearance and to clarify the further proceedings.

Before commencing any site clearance and excavation in private property, the Contractor shall prepare and agree with the owner or occupier of such property a record of the state of the surface with particular reference to any features that may require special care, conservation and reinstatement.

Pre-construction photos shall be taken of the original Site by the Contractor and be submitted to the Engineer in two (2) copies together with the respective digital files. The Contractor shall prepare an inspection report which shall describe the conditions of the buildings, roads, footpaths, etc., in question and shall submit such report to the Engineer.

C.3.4.18 Cost of Preparatory Works

The costs of all preparatory works shall be included in the corresponding items or in the items for Preparatory Works. Where items are not included in the Price Schedule, the cost of such services, works and facilities shall be deemed to be spread over all items of the Bill of Quantities

C.4. REQUIREMENTS FOR PROJECT DOCUMENTATION

C.4.1 General

The Contractor shall prepare and submit to the Engineer's approval all drawings and design documents required for the works execution and future plant operation as indicated in the different parts of the Bidding Documents or required by the Engineer.

Before the submittal of any drawing or document the Contractor is required to submit a detailed list describing the drawings and documents he will produce. Based on this list the Engineer will decide which drawings or documents will have to be submitted for approval, information or for any other purpose.

All information, documentation, calculations, drawings, schedules etc. shall be submitted within such periods or at such dates that are required to guarantee a smooth handling of the project without delays. The Contractor is responsible for submitting all documentation in accordance with a programme to be prepared by him, allowing all participants sufficient time to check, assess, comment and eventually approve the documents. It is the responsibility of the Contractor that all information requested is submitted in sufficient time to allow for adequate time for examination and approval.

The quality of the submitted documents must be in accordance with acceptable international practice and allow a speedy checking procedure.

All information, documentation, calculations, drawings, schedules etc. with respect to the Contract shall be in the metric system and in accordance with the relevant applicable international and local standards and regulations.

The Contractor shall agree with the Employer / Engineer ahead of producing documents on all necessary requirements and finally produce them to the satisfaction of the Employer / Engineer. For electronic copies the Contractor shall agree with the Employer / Engineer the required file format (software version). If documents requiring conformity to specific standards and certification by recognized institutions, it shall be done prior to submission of such documentation.

Drawings shall be to scale and fully detailed. Important dimensions shall be given and the material of which each part is to be constructed shall be indicated. Drawings shall be black lined on a white background with revisions clearly marked. Drawings shall bear the approved Contract references and title block as agreed with the Engineer.

Drawings, performance curves and information shall be supplied in sufficient detail to describe the scope of works and the services offered

All drawings shall be prepared in Auto-CAD or compatible format. All other documents have to be prepared in MS Office or compatible format.

Documents not fulfilling these requirements will be returned to the Contractor for improvement and resubmission. It is solely at the discretion of the Employer or the Engineer to decide whether or not documents are acceptable as per international recognized practice.

C.4.2 Numbering and Titling

The Contractor shall institute a reference numbering system for designs, drawings and documents so that each number used is unique. The numbering and title information on designs, drawings and documents shall be designed so that management, transmittal and communication in connection therewith can be carried out expeditiously.

C.4.3 Minimum Requirements for Drawings

All Drawings submitted by the Contractor to the Engineer for approval shall be on ISO standard size sheets with a maximum size of A1. Every drawing shall have a title box in the bottom right corner indicating:

- Employer's name;
- Identification and number of the Contract;
- Contractor's name;
- Title of scheme;
- Title of works element;
- Subject of drawing;
- Drawing number;
- Date;
- Author;
- Signature of the Contractor (to the effect that the drawing (whether his own, his sub-Contractor's or from any other source) has been checked by him before submission to the Engineer).

Each drawing shall have a separate revision box with space for up to 6 revisions, and including revision number, revision date, and revision description and revision check.

The format and title box of the Drawings shall be approved by the Engineer and, where required, comply with applicable local regulations.

All layout and arrangement drawings submitted by the Contractor shall be drawn to specified scales as are appropriate for clearly detailing and illustrating the works and shall include a graphical scale to aid the use of photographic reproductions. Scales shall generally be 1:2, 1:5, 1:10 or multiples of 10 thereof. The appropriate measuring scales used shall be shown on the drawings.

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Drawings shall include cross-references where appropriate and key information such as vital levels and dimensions. All general layout plans shall show the "north" direction.

Prints of drawings shall show dark and fade-proof linework on a light and non-darkening background. Prints shall be on durable paper of good quality and 80 g/m² minimum weight.

C.4.4 Form of Documents

Designs and documents submitted by the Contractor to the Engineer in the required number of copies but at least in three hardcopies and one electronic copy for approval shall comprise generally:

- contents list;
- scope (description of the contents and purpose of the submission);
- conclusions and recommendations;
- references, specifications requirements, codes, manuals and supporting documents used, drawing numbers, and titles of drawings which are based on the design;
- description of design approach;
- criteria, parameters and methods used;
- test procedures, analyses and results;
- calculations with reference to the used method and/or program and schedules;
- qualitative description and comments on results;
- any other relevant information;
- Appendices.

Designs and documents shall be presented on A4 size paper with every page numbered and bound in order between covers formed of a transparent front and stiff back. The title of the submission shall be given on the front sheet beneath the transparent cover together with a reference number, Employer's name, title of scheme, of Contract, Contractor's name, title of works location, author's reference, date, Contractor's signature, and any other relevant information. Drawings submitted, as part of the design or document shall be folded into pockets at the back.

The Contractor shall bind in as appendices to the designs and documents English language copies or photocopies of any standard, code of practice, manual or other reference in the designs and documents which are not named in the Specification and which have not otherwise been submitted to and approved by the Engineer.

C.4.5 Correspondence, Site Memos and Other Documents submitted by the Contractor

The Contractor shall submit a copy of all correspondence, site memos, requests for inspection in accordance to Section C.6.2, reports, etc. concerning the Contract and of interest for the Employer and/or the Engineer to the Engineer's site office.

All correspondence, site memos, request of inspection, reports, etc. from the Contractor to the Engineer shall clearly indicate:

- Contract Number;
- Contractor's address and communication details; and
- Date and reference number of the correspondence, site memos request for inspection, etc.

C.4.6 Documents and Drawings to be submitted

C.4.6.1 General

The following describes the minimum scope of information, documents, drawings, etc., to be submitted by the Contractor to the Engineer. The Engineer reserves the right to request from the Contractor such additional information, drawings, documents, etc., as may be reasonably required for the proper understanding and definition of the design, engineering and management of the Project.

C.4.6.2 Technical Design Documents

The Contractor shall prepare all required technical design documents.

The design documents shall include all required drawings, calculations, descriptions, specifications, etc. particularly but not limited to the following documents:

- General layout;
- Horizontal and vertical alignment for all underground pipework;
- All schemes for process, piping, electrical installations, instrumentation etc.;
- Details drawings of all structures and buildings;
- General arrangement drawings for equipment;
- Drawings for plant piping, cables, etc.;
- All detail drawings for reinforced concrete structures.

C.4.6.3 Civil Works Design Documents

Where applicable, drawings and documents to prepared and delivered by the Contractor to the Engineer's approval shall include but not limited to the following:

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- Architectural drawings;
- Detail drawings for civil structure including:
 - fills below structures and compaction requirements;
 - concrete and surface finish classifications;
 - position and type of movement joints;
 - water stop details;
 - sequence of construction;
 - special tolerances, e.g., in relation to mechanical or electrical equipment;
- Drawings of Temporary Works;
- Drawings for the performance of the Works as necessary for showing the construction methods;
- Structural calculations and descriptions;
- Detailed drawings of concrete reinforcement as well as bar bending and cutting lists;
- Other drawings necessary for the performance of each part of the Works in accordance with the Contract, and in particular all working drawings;
- As-built drawings of all Permanent Works constructed as required.

Where design beyond that supplied by the Engineer is required to accomplish the works, the Contractor shall perform also the necessary calculations in connection with the required drawings.

The Contractor shall be responsible for the behaviour of the Permanent Works during the various phases of construction. He shall provide all equipment and accessories and all working arrangements necessary to limit stresses on the Works, so that stability of the structures is not threatened and so that stresses and deformation remain within acceptable limits.

In the context of the above-mentioned arrangements, the Contractor may be authorized by the Engineer to reinforce the design of the Permanent Works.

C.4.6.4 Electromechanical Equipment Design Documents

Where applicable, drawings and documents to be prepared and delivered by the Contractor to the Engineer's approval shall include but not be limited to the following:

- Civil Works guide drawings showing the routings and dimensions of conduits, cable trays and pipework, etc.;
- Drawing of recesses to be made in the concrete with the directions and values of stresses transmitted to the concrete by the equipment;
- Drawings of built-in parts;
- Layout drawings of built-in parts in secondary concrete and embedded parts in primary concrete;

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- Overall and detail drawings of the equipment.

The Contractor is responsible for the execution of further needed design documents as e.g. detail drawings, diagrams, design calculations, etc. for the different supplies as required for the implementation of works or by the Engineer.

A list of all further needed drawings, diagrams and design calculations to be submitted to the Engineer shall be drawn up at the start of the implementation stage in agreement with the Engineer. However, the Engineer reserves the right to request further details at a later stage in order to facilitate understanding of equipment functions and installation.

These drawings, or where applicable their technical associated documents, shall include drawings, or, where applicable, their technical associated documents shall include production dimensions, horizontal and vertical tolerances, the values of assembly and operating clearance with the minimum and maximum acceptable deviations, the properties of the materials used in the different parts, the weights of assemblies, parts of assemblies and detailed parts as well as the surface areas to be painted for large structures.

C.4.6.5 Process Design Documents

Where applicable, drawings and documents to prepared and delivered by the Contractor to the Engineer's approval shall include but not limited to the following:

Drawings:

- Layout drawings of works and equipment arrangements, including appurtenant facilities and pipeworks;
- Civil Works guide drawings showing the routings and dimensions of pipeworks;
- Longitudinal profile.
- Layout drawings of equipment arrangements incl. appurtenant facilities and main pipework.
- Hydraulic profiles.

Process design documents:

- Hydraulic calculations incl. surge analysis if required;
- Process calculations for all applicable operational process scenarios;
- Calculations for dimensioning of equipment;
- Process calculations for consumables and electrical demand;
- Description of the control and monitoring concept;
- Description of control and safety circuits ;
- Description of protection against fault conditions;
- Performance diagrams for all equipment;

- Hazardous area classification.

C.4.6.6 Electrical and Instrumentation and Control Works Design Documents

If special forms for entering parameters are provided by device suppliers, they should be used when creating documents (e.g. IDM, level meters, etc.). The capabilities of the PDM (Process Device Management) technology should be used here. If parameterization is carried out using special software, the corresponding data CD shall be included in the documentation.

For all other services, the following content of the documentation applies:

1. Conformity certificate, certificate for insulation measurement and third party acceptance report, if applicable;
2. Lightning protection log with photo documentation of the parts laid underground;
3. Ex certificates (if required);
4. Function description of the plant / control system;
5. Circuit diagrams;
6. Parts lists with the number, reference IDs, manufacturer and general description of the device; I/Q/F reference lists, cable lists / diagrams and terminal diagrams;
7. Parameter lists, measuring ranges, setting values;
8. Automation Technology;
9. Hard ware (HW) structure (production schedule) and program documentation with comments, including program CD, DVD, or hard disk, which is used for the restart test;
10. Control Centre System;
11. Device manuals, programme descriptions and operating manuals, configurators, a description of the user-specific software and hard copies of the process displays and input screens; including printouts of the implemented logs and reports;
12. Equipment lists, operating instructions, system descriptions and installation diagram for the systems with specifications for the required power supply and grounding measures;
13. Function descriptions of the built-in units / meters / plant technology used (divided into all of the individual components);
14. Operating and servicing instructions.

After the contract has been awarded and before carrying out the works, the contractor shall submit the following drawings and documents:

- Dimensional drawings of the parts to be supplied, such as switch and control cabinets;
- Consoles, on-site control centres, etc., incl. the installation dimensions;
- Single-line diagrams for all of the electrical switchboards and control systems;
- Display according to EN 61346, graphical symbols according to EN 60617;

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- Classification and identification of documents for plants, systems and installations according to EN 61335, including the terminal diagrams and shunting diagrams;
- Cables list with cable types, cross-sections, and number of cores;
- Inspection drawings with dimensions;
- Installation diagrams (building technology).

In addition the following shall be provided for the SCADA and I&C systems:

- The overview, layout diagram, single-line diagram, connection (wiring) diagram, installation and connection diagrams for control cabinets and distribution boards and devices according to EN 60617, EN 61346 and EN 61082;
- For the SCADA and I&C system, a detailed order number system shall be used. This system shall be incorporated into the hardware and software description, so that the operator has integrated documentation of all of the systems and subsystems;
- Configuration overview of the hardware components;
- List of measuring points;
- Description of control programmes with explanations, online documentation of the SIMATIC PLC programs according to EN 61131-3 with FBD, LAD, STL in STEP7 and SFC and CFC;
- Function diagrams according to EN 61082, Part 9 for the controllers;
- Information for operating and starting up the system;
- The original licensing key must be submitted before acceptance in the announced performance capability (tags / PO) of the respective software programmes;
- Mimic diagrams and image objects with properties, events, actions, and direct links;
- Tags, properties, and communication links;
- Message classes, message blocks, and messages;
- Archive tags, and configuration data for archives;
- User groups and users;
- Source text of actions / functions;
- Texts of text library;
- Basic Process Control configuration data.

C.4.7 Submission and Approval Procedures

The production, submission and approval procedure for designs, drawings and documents shall comply with the following requirements.

For the purpose of this clause the term drawing shall include diagrams, schedules, performance curves etc. Preliminary copies of the drawings shall be submitted by the Contractor to the Engineer for approval.

C.4.7.1 General

All drawings and documents shall be prepared by the Contractor within the time specified in the approved Programme of Works and shall be submitted for examination and approval to the Engineer. Within his authorities, the Engineer is responsible for examination and approval / rejection of the Contractor's Documents as well as for obtaining the Employer's prior approval / rejection whenever needed.

The Engineer reserves the right to ask the Contractor to submit additional copies of drawings and other documents for approval to the Engineer's head office and / or to the Engineer's site office.

In no case, the Engineer's approval of any documentation shall relieve the Contractor of any of his obligations or responsibilities under the Contract.

Before Submission, the Contractor shall check all designs, drawings and documents submitted by the Contractor to the Engineer for approval, including any prepared by a sub-Contractor or any other source, and certify in each case that he has examined such drawings and that they comply with the requirements of the Contract. For the purpose of this clause the term drawing shall include diagrams, schedules, performance curves etc.

The Contractor shall also ensure that drawings are submitted early enough prior to the date required for approval to permit amendments to be made and the drawings re-submitted for approval without delaying the program.

All amendments to drawings shall be made by the Contractor free of charge. Drawings which have been modified shall be re-submitted for approval.

On receipt of approval by the Engineer, the Contractor shall arrange for the revision column of the drawings to be marked "Approved by the Engineer on (date)" and revise the issue letter or number.

C.4.7.2 Meaning

The following meanings shall apply:

- "Preliminary Drawing" or "Preliminary Document" means a drawing or document which the Contractor submits to the Engineer or other authorized party for approval and any drawing or document returned by the Engineer and not marked "Approved in principle";
- "Approved Drawing" or "Approved Document" means a drawing or a document which the Engineer has marked "Approved in principle" and returned to the Contractor. Approval in this context means that Contractor may proceed with the work described thereon. A drawing, which forms part of an approved design or document, shall not be an approved drawing unless it has been marked "Approved in principle"

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Approval of a design, drawing, or document may be partial or conditional. Such documents will, for example, be marked **"Approved in principle in respect of..."**(certain part as listed) or **"Approved in principle subject to..."**(actions to be taken by the Contractor before he can proceed with the works as listed). In such instances, the Contractor shall carry out the Works only in accordance with approved parts or after the conditional actions have been carried out and confirmed to the Engineer in writing.

The approval from the Engineer for design work does not automatically mean the acceptance of liability for completeness and freedom from errors of the detailed diagrams. Instead, it refers to the basic check to see whether the function requirements in the requirement specifications can be fulfilled. The responsibility for the correctness of the detailed planning from a technical standpoint and especially from a safety-related standpoint remains completely with the Contractor.

C.4.7.3 Submission Procedure

Every drawing or document submitted by the Contractor to the Engineer for review and approval shall be based on and consider previously approved designs or documents. Interrelated drawings shall be submitted at the same time in a complete and self-sufficient set. Copies shall be collated into ordered bundles each with a list of contents.

The Engineer will designate to the Contractor the address of his review office in respect of particular disciplines of work from time to time during the Contract. This address may be in a foreign country other than the country in which Works are to be implemented.

When submitting documents the contractor shall state the purpose of the submittal e.g. "for information" or "for approval" and the Contractor must confirm compliance of the submittal with the construction Contract.

On completion of review, the Engineer will return the submission with one of the following comments:

- Approved in principle to allow work to proceed;
- Approved in principle to allow work to proceed subject to stated amendments and conditions;
- Revised submission required including stated requirements.

Unless specifically stated to the contrary each design, drawing and document submitted by the Contractor to the Engineer for approval shall reach the Engineer's review office in time to allow at least 10 working days (excluding weekends and national holidays) for review by the Engineer before being returned to the Contractor.

Re-submissions by the Contractor to the Engineer of the same design, drawing and document shall reach the Engineer's review office in time to allow at least 10 working days (excluding week-ends and national holidays) for review by the Engineer before return to the Contractor.

C.4.8 Structural Design Work

Structural design work to be prepared by the Contractor shall include all structural engineering and the pertaining shop drawings (formwork and reinforcement) for all in-situ concrete structures.

Furthermore the structural design shall include the stability analysis of all steel and earth structures.

C.4.9 Design Loads

C.4.9.1 Design of Structures

The structures shall be designed to sustain the imposed maximum considered various loads. These include construction loads, dead load, live load, earth and water pressures, seismic impact, etc. Moreover, the structural design shall be carried out to ensure the stability and durability of the structures. The said design shall be based on the standard stated in the Specification. In the absence of a stated standard the applicable local standard shall apply.

C.4.9.2 Loading Conditions

All structures shall be designed to sustain the maximum dead and live loads to which they are subjected including temporary and erection loads occurring during construction, and all the other loads resulting from earthquakes, winds, earth, hydrostatic pressures and others. The value of all loads and combinations of loadings for the design calculations will be taken according to Norms of Loads and Impacts Applied to Buildings and Structures in their actual version.

C.4.10 Contractor's Design

The Contractor shall provide detailed design prior to elaboration of working drawings for all temporary and Permanent Works according to good engineering practice for which such design is required. The design shall not deviate from such details already set forth by the Contract Documents.

The Contractor shall always provide all structural computations or any other computation required to justify the stability of any element of the Works that are required for the execution of the Works. Prior to submitting any structural computations and working drawings, the Contractor shall have reviewed and approved all structural computations and drawings by a licensed structural engineer, agreed upon by the Engineer. Structural designs furnished with the Tender Documents, if any, are only indicative.

The Contractor shall submit for approval to the Engineer, all computations, drawings, mechanical properties of materials, manufacturer's specifications justifying the quality and

design of materials equipment and structures, irrespective of the origin. He shall also submit to the Engineer a copy of the standards and methods used for computations.

C.4.11 Contractor's Working Drawings

The Contractor shall provide Working Drawings for all works (civil, mechanical, electrical etc.) that are required according to good practice for all permanent and temporary works in compliance with the relevant local and international regulations and standards. The Contractor shall elaborate the working drawings in accordance with the Contract Drawings, the Engineer's instructions and the Contractor's design, where such design is required by the Contract.

The Contractor shall prepare and submit for approval by the Engineer a detailed schedule for the elaboration of any working drawings. This schedule shall be closely interlinked with the overall Work Programme.

The Contractor shall carefully verify dimensions and levels on Site, compare such information with the Contract drawings and bring any errors or omissions discovered therein to the attention of the Engineer, who will give the necessary instructions for update.

In public areas the location and/or alignment of mains and related structures shall be determined jointly with the Engineer. Thereafter the Contractor shall carry out such survey as may be required for elaboration of working drawings.

Failure to discover and/or to notify the Engineer of any errors or omissions in the drawings shall not relieve the Contractor from being responsible for unsatisfactory or faulty work resulting thereof or from the obligation to rectify and make good such work at his own expense and to the complete satisfaction of the Engineer.

The Contractor shall submit for approval to the Engineer one original and two copies of the Drawings, as well as a digital copy in editable (dwg) format and (pdf) format.

Additional Drawings, amendments, and/or alterations shall be submitted to the Engineer for approval. Such alterations, which the Engineer may require or which may become necessary during the Works, shall be made by the Contractor without extra charges.

The Engineer will notify the Contractor 14 days after handing over of the soft copies of the Contract Drawings of the format in which all drawings shall be submitted for approval, and which format shall also apply to the As-built Drawings.

The Works shall not commence until the working drawings have been approved by the Engineer. Approval of the working drawings shall not relieve the Contractor from his full responsibility for the design and implementation of works.

C.4.12 As-built Drawings

As the Work proceeds, the Contractor shall prepare record drawings based on the Contractor's reviewed and updated working drawings as to portray the Works actually executed. These record drawings shall become As-built Drawings upon Completion of the Works. These drawings shall clearly show all portions of the Works, in plan, profile and sections and also all deviations from the original drawings.

The complete set of as-built drawings shall comprise at least:

- General layout;
- Layouts and profiles of mains and pipelines;
- Node details for all nodes;
- Drawings of any structures (plan and sections), showing built-in pipes, cables and fittings;
- Architectural and structural drawings;
- Drawings on any facilities in and around structures;
- Mechanical drawings;
- Electrical drawings;
- Detailed process diagrams;
- Any other drawings relevant for the performance of the Works.

Where the Works consist of pumping stations, other plant, reservoirs etc., including hydraulic, mechanical and electrical works, the complete set of as-built drawings shall comprise any civil, hydraulic, mechanical and electrical working drawing, structural and/or any other analysis or computation to justify dimensions, capacities etc. elaborated by the Contractor, all documents updated to reflect the Works as actually executed and taken over, including further amendments in the event such amendments are executed until the end of the Defect Notification Period.

Draft versions of the records drawings shall be submitted to the Engineer for approval and then be completed with any amendments requested by him.

Upon the Engineer's approval but prior to Tests on Completion the Contractor shall supply to the Engineer the complete set of five (05) prints of the approved As-built Drawings. In addition two (02) softcopies shall be handed over on USB flash drive or other adequate data storage approved medium in editable (dwg) format plus two (02) softcopies in (pdf) format, all free of malware.

C.5. WORKS DOCUMENTATION

C.5.1 Progress Reports

C.5.1.1 General

The Contractor shall submit, at the frequency indicated in the Bidding Documents or agreed with the Engineer, reports on the progress of the Works.

The progress reports shall be set out in a format approved by the Engineer, and forwarded promptly so that on receipt the information contained therein is not more than one month prior to the end of the month to which the report relates.

The shipment of each order or part order shall be monitored on the Progress Reports giving the date by which the equipment will be available for shipping, the estimated time of arrival on site and the actually achieved dates.

The sites erection portion of the progress reports shall be segregated into the main and ancillary items of civil, mechanical, electrical, and control and instrumentation work and each item of work shall be monitored giving the percentage completion and the projected completion date of the work. The Contractor shall highlight any delay which will affect the completion, and/or the testing and commissioning dates of any item of plant and he shall state the remedial action taken to ensure that delays do not occur.

The Contractor shall report in respect of the various sections of the Works on any matters arising which may generally affect the progress of the Work.

C.5.1.2 Monthly Report

Within seven calendar days after the end of each month, the Contractor shall submit six copies (2 English and 4 Montenegrin) of its monthly report, which shall at least contain:

- the construction progress of the main facilities, compared to the approved programme;
- the list of the available plant and equipment on the site of the works with their situation;
- the list of all staff and staff available on the site;
- a summary of the works performed during the month with the description of the difficulties met if any and proposed measures to remedy to such difficulties;
- the procurement status report indicating but not limited to the submittal and preparation status of shop drawings, materials, submittals, samples, catalogues of equipment, approval status, procurement of materials and delivery dates to site;
- the report on the monthly progress and status of works related to the Programme of Works, indicating current or anticipated causes of delay and their estimated impact on progress, together with a description of corrective measures taken or proposed;

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- one copy of the latest approved Programme of Works as specified in Section C.3.4.2 or revisions thereof as approved by the Engineer;
- a statement on the climatic conditions;
- a statement on the claims submitted during the month, if any;
- the payment situation including the date of the monthly statements submittals, the interim payment certificates and the actual payment;
- photographs illustrating the progress of works in accordance to Section C.5.2.

The form and content of the Monthly Report shall be approved by the Engineer at the start of the works and shall be maintained throughout the execution of the Contract.

C.5.1.3 Weekly Report

The Contractor's shall prepare and submit weekly progress reports to the Engineer and to the Employer. These reports shall summarize site activities and record any details where difficulties in maintaining the agreed Programme of Works are being experienced or are likely to cause subsequent delay.

The form and content of the Weekly Report shall be approved by the Engineer at the start of the works and shall be maintained throughout the execution of the Contract.

C.5.1.4 Daily Activity Report

The Contractor shall prepare and submit to the Engineer a Daily Activity Report summarizing the main activities carried out each day, the Contractor's equipment and staff available on site, meteorological conditions and any special activities carried out.

The form and content of the Daily Activity Report shall be approved by the Engineer at the start of the works and shall be maintained throughout the execution of the Contract.

C.5.2 Construction Photographs

Starting at the commencement of works, the Contractor shall take regularly and as frequently as required to sufficiently illustrate the progress of construction works at each step of the construction works of each structure and facility, photographs of the works in progress. Photographs shall be taken before commencement, during progress, and at completion of the Work.

Relevant and selected photographs of good quality, illustrating the key works implemented during the month, shall be included in annex to the Monthly Report mentioned in Section C.5.1, with a short description and identification of the view.

All photographs (the ones included in the monthly report annex and others) shall be of good quality and saved in digital format in a way allowing to clearly identify the date and hour of the

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photograph, the location and the photographed object, in accordance to following minimum requirements:

- Indication of the date and hour on the photograph;
- Photograph file with EXIF data (including at least: date, hour, GPS coordinates, accuracy of GPS coordinates);
- Accuracy of GPS coordinates shall be less than 10 m for outdoor photographs;
- Minimum and maximum photograph file size: **300 to 600 kB** (camera shall be set accordingly or files shall be resized);
- Photograph filename with a maximum length of **60 characters** allowing to easily and accurately identify the photographed object and including description of view, picture number and date;
- Photograph files shall be stored and sorted according to a folder structure approved by the Engineer allowing to easily trace a photograph of a specific object and a specific date.

The Contractor shall deliver to the Engineer at his request all or selected photographs in digital format. The Engineer may require the Contractor to take further photographs of the works to record or illustrate specific events. Same requirements as above apply to these photographs.

C.6. INSPECTION AND TESTING

C.6.1 Inspection by the Engineer

The Contractor shall grant access to any and all parts of the Works to the Engineer or the Engineer's Representative at any reasonable time for the purpose of inspecting the works and ascertaining progress of works.

No Work shall be backfilled, buried, cast in concrete, hidden or otherwise covered until it has been inspected by the Engineer and, where required, by the relevant external control authority. Whenever the Contractor is ready to backfill, bury, cast in concrete, hide, or otherwise cover any Work under the Contract, he shall notify the Engineer not less than forty-eight (48) hours in advance to request inspection before beginning any such Work of covering. Failure of the Contractor to notify the Engineer least forty-eight (48) hours in advance of any such inspections shall be cause for the Engineer to require a sufficient delay in the progress of Work to allow time for such inspections and any remedial or corrective work required including its effect upon other portions of the work, shall be the sole responsibility of the Contractor. Any Work so covered in the absence of inspection shall be subject to uncovering. Where uninspected Work cannot be uncovered, such as in concrete cast over reinforcing steel, all such Work shall be subject to demolition, removal, and reconstruction under proper inspection.

The presence and approval of the Engineer or any other external control authority, shall not relieve the Contractor of the responsibility for the proper execution of the Work in accordance with all requirements of the Contract Documents.

C.6.2 Requests for Inspection

The Contractor shall submit in due time requests of inspections of all required works, including but not limited to demolishing, disconnecting, dismantling, excavating, breaking, cutting, dewatering, removing, abandonment, carting away, disposal, delivery, backfill, earth fill, backfill and earth fill materials, calibration and maintenance of laboratory equipment's and devices, renovation works, civil, mechanical, HVAC and electrical maintenance works, maintenance and repair works, preventive maintenance, etc. and other related as specified in this Technical Specification, for the Engineer approval.

Inspection requests shall be developed in a format acceptable to the Engineer and shall include at least the following information:

- Space for serial number;
- Contract or project number;
- Contractor's and Employer's name;
- Discipline (civil, structural, mechanical, electrical, Instrumental);
- Inspection or test description;
- Facility and location;

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- Scheduled time and date for inspection;
- Signature block for contractor with submission time and date;
- Evaluation block for Engineer with date and time inspected results of inspection / test (Approved. Approved as noted, Not Approved) and Engineer's signature block;
- Area for general comments

C.6.3 Scope of Inspection and Testing

The overall testing programme for the Project may include but not be limited to the following:

- a) Shop inspections and testing: these are inspections and tests, at the place of manufacturing which are to be carried out in accordance to Section C.2.7. The manufacturer shall issue the relevant certificates;
- b) Construction inspections and testing at site: these are routine inspections and tests during construction.
- c) Water tightness and pressure tests
- d) Tests on mechanical completion: these tests are performed at the completion of the mechanical and electrical installations;
- e) Tests on part completion: these tests are conducted on completed structures (e.g. leak tests at pumping stations) or parts of the Works (e.g. for a part of the drainage network);
- f) Pre-commissioning tests: these tests are performed before putting the Works or part of them into operation;
- g) Performance tests (Test on Completion): under these tests the Works or part of them shall be operated for a period of 2 days to prove that the specifications and provided performance guarantees are met; and
- h) Reliability test run (Test on Completion): Under this test the Works, or part of them, shall be operated for a period of time as stipulated in the Contract to prove its reliability.

As a general rule, passing successfully tests on mechanical completion and on partly completion shall be the pre-requisite for starting with pre-commissioning tests. Passing successful tests on pre-commissioning shall be the pre-requisite for the commissioning. At the end of commissioning the reliability test run and the performance tests will be carried out.

As a general rule, passing successfully tests on mechanical completion and on partly completion shall be the pre-requisite for starting with pre-commissioning tests. Passing successful tests on pre-commissioning shall be the pre-requisite for the commissioning. At the end of commissioning the performance tests and the reliability test run will be carried out.

After successfully passing the above tests and after submission of the as-built documentation and of the operation and maintenance manuals, and after submission of all test results, the Works, or parts of them at the discretion of the Employer, can be deemed completed and the Engineer will issue the Taking-Over Certificate.

C.6.4 Costs for Testing to be included

The Contract price is deemed to include for all costs of all tests, including temporary works, labour, materials, instrumentation, stores, fuel and power used, as may be required during all inspections and tests and for the provision of certified records and curves whether on site or any other placed deemed appropriate by the Engineer.

C.6.5 Test Instruments and Equipment

The Contractor or the manufacturer as may be the case shall satisfy the Engineer as to the accuracy of all instruments required for the tests and if requested by the Engineer shall produce recent calibration tests, or otherwise have them calibrated at his own expense by an independent authority.

C.6.6 Site Testing and Test Programme

C.6.6.1 General

Site testing includes for both tests during installation and tests at completion.

The Contractor is responsible for carrying out all tests as per the approved programme as specified in Section C.6.6.2 and of additional tests if requested by the Engineer, submission of test reports and test certificates, retest if needed, and for providing all apparatus, assistance, documents, electricity, equipment, fuel, consumables, instruments, labour, materials, and staff needed to carry out the tests. The tests shall be carried out in accordance with the Employers Requirements.

The Contractor shall provide for the tests or provide third party independent inspection agencies or laboratories to do the same:

- All skilled and qualified operating and test staff for the testing of all equipment;
- All equipment and facilities necessary to inspect the work and perform all the tests required by the contract documents;
- All services, lubricants, and fuels and electricity;
- All measuring and testing instruments to demonstrate that the equipment fulfils the requirements, in particular instruments to monitor transient processes such as surges, etc..

The Contractor shall repeat inspections after correcting non-conforming work either if the inspection approved as noted or not approved until all works complies with the requirements.

Inspections and tests conducted by persons or agencies other than the Contractor shall not in any way relieve the Contractor of his responsibility to conform to the requirements of contract documents and referenced standards.

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The Contractor shall prepare and submit to the Engineer reports about Tests and Commissioning, supported by recorded data and calculations, not later than 10 days after the test or commissioning.

C.6.6.2 Testing and Commissioning Plan

The Contractor shall prepare and submit to the Engineer for approval a comprehensive and detailed site Inspection and testing programme of all parts of the Works subject to Site testing as part of his programme to implement the Works.

The Contractor shall submit to the Employer and the Engineer the above mentioned site testing programme at the latest two (2) months after the Commencement Date and one month before start of erection / installation. The site testing programme shall be reviewed and updated as may be required from time to time during implementation of works and shall include:

- a detailed testing programme of each part of the works;
- applicable test standards;
- description of the type of inspection and tests;
- details of tests which are to be witnessed by third parties; and
- quality control procedures.

C.6.7 Tests on Part-Completion

C.6.7.1 General

Tests on part-completion shall include but not be limited to the following:

- Tests on Completion of mechanical and electrical installations;
- Tests of completed parts of the Works (e.g. tightness tests and functional tests, performance tests).

In case of failure of any test, defects shall be made good and tests shall be repeated.

Throughout all the time of Tests on Completion the Contractor shall train Employer staff as set forth in Section **Fehler! Verweisquelle konnte nicht gefunden werden.** below.

C.6.7.2 Tests on Construction Completion for Mechanical and Electrical Works

For complete transmission systems the Tests on Completion shall serve to determine the actual capacities of the various elements through the full ranges of possible operations.

In case that at the time of Tests on Completion connections to the public power supply have not been completed by the public electricity provider, the tests shall be carried out with power generated from the stand-by generating sets.

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For mains, System Test Pressure (STP) shall be deemed to constitute part one of the test at completion, subject to a successful test at normal operating pressures which shall constitute part two of the test at completion of mains. During this second part, the satisfactory function of valves, in particular air valves, washouts, hydrants, shall be tested.

C.6.8 Pre-commissioning Test

Three (3) month prior to the proposed start of commissioning the Contractor shall submit to the Engineer:

- a pre-commissioning and commissioning test programme;
- details of commissioning procedures; and
- details of tests on part completion.

C.6.9 Test on Completion

After successfully passing all pre-requisite tests a) to f) as per Section C.6.3, the Contractor may proceed with the Performance and Reliability Test Run (Test on Completion). A subsequent Phase shall only be launched when the preceding Phase has been accomplished successfully. The Reliability Test Run is scheduled for twenty eight (28) days, while performance tests will last two (2) days.

After successfully passing the above tests, where required, and after submission of the as-build documentation and of the operation and maintenance manuals and after submission of all test results, and after submission of the performance securities related to the Section C Works, the Works or parts of them, at the discretion of the Engineer, can be deemed to be completed and the Engineer will issue the Certificate of Completion or Taking-Over Certificate.

C.6.9.1 Programme of Tests on Completion

The Contractor shall submit a detailed Programme for Tests on Completion at the latest 1 (one) month prior to commencement of Tests on Completion for approval to the Engineer, comprising at least:

- Test programme, clearly distinguishing between the phases above;
- Applicable testing standards;
- Type of inspection and tests;
- Tests which are to be witnessed by third parties;
- Manpower and deployment schedule of the Contractor for performing the tests, forms of test records and report;
- Description of instrumentation to be used, including accuracy, and calibration test results;
- Method of data recording;

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- Method and equations / correction curves used for the adjustment of recorded data to design conditions;
- Quality control procedures.

C.6.9.2 Performance Tests

The performance test can be carried out simultaneously to the reliability test.

The power consumption and consumption of consumables which are subject to liquidated damages shall be tested during the performance tests.

C.6.9.3 Reliability Test Run

During the Reliability Test Run, the Works shall be operated continuously or as required by the Engineer.

The Reliability Test Run will not be deemed to be completed unless the relevant Performance Tests have been made.

In the event of interruptions during the Reliability Test Run, for which Contractor is responsible, the duration of the Reliability Test Run shall be extended by a period equal to the accumulated time of interruptions. If an interruption of operation of the Works lasts more than four (4) hours, the Reliability Test Run shall be restarted, after making good the defect. The Reliability Test Run may be interrupted on a maximum of three occasions, provided that no interruption exceeds four (4) hours and that the Engineer is notified of the interruption in good time.

The Contractor shall provide all skilled personnel required for the Reliability Test Run and operate the system under his sole responsibility.

Upon successful demonstration that the works operate satisfactorily and safely as an integral plant throughout the period specified, and unless otherwise specified, operation shall be taken over by trained personnel of the Employer.

C.6.10 Tests after Completion

The Engineer may, at his own discretion, instruct the Contractor to carry out the Reliability Test Run and the Performance test after Completion of Works (Test after Completion).

During the respective Defects Notification Periods of Section A Works and Section B Works tests shall be carried out to ensure that the plant complies at all time with the guaranteed performances and consumption values in accordance with Section A.11.8 of the Employer's Requirements.

C.7. WORKS COMPLETION

C.7.1 As-built Documentation

Unless otherwise specified, the as-built documentation shall be as follows.

At the latest together with the Contractor's notice for Tests on Completion, the Contractor shall submit as-built documentation in line with the Conditions of Contract and below specifications. As-built documentation is mandatory for proceeding with Tests on Completion. As-built documentation must be approved by the Engineer prior to issuance of the Taking-Over Certificate.

A register for clarity shall separate the various sections. The numeration given above shall be strictly adhered to even if individual sections are not used.

Documentation to be included shall comprise – but not be limited to – the following:

Regarding 1: General Information:

- Numbering and arrangement of the documentation according to the Contractor's bid as well as the Contractor's project number;
- Characteristics of equipment, including a comprehensive list of suppliers and manufacturers of plant and equipment incorporated in the Permanent Works;
- Medium, capacity, delivery head, energy consumption, etc.;
- Details of calculation documents (geotechnical investigations, structural, hydraulic, etc.);
- Details of topographic surveys (benchmarks, protocols, etc.).

Regarding 2: Programme for Tests on Completion:

- A detailed Programme for Tests on Completion shall be elaborated including a chronographic schedule of the tests to be carried out and a detailed, narrative methodology thereof with clear references to relevant standards and norms;
- Input of Contractor's manpower, plant and equipment shall be stated.

Regarding 3: Operating and Maintenance Manual:

The Operating and Maintenance Manual shall be prepared by the Contractor in sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the new infrastructure. They shall describe operation of system as a whole; manufacturers' manuals for individual pieces of equipment shall be annexed in comprehensible order.

The Contractor shall provide all suppliers documentation of the equipment installed in English language.

The documentation shall comply with requirements set forth in Section C.7.6.

Regarding 4: As-built drawings (as approved by the Engineer):

The documentation shall comply with requirements set forth in Section C.4.12.

Regarding 5: Training Documentation:

At the time prior to Tests on Completion, training documentation shall comprise a detailed training programme, methodology, the training manual handed out to trainees and any other documentation required to enable trainees to acquire skills of sustainable and continuous operation of plant and equipment installed. The Contractor shall develop a suitable assessment system allowing to track progress of trainees.

Documentation shall comply with requirements set forth in paragraph **Fehler! Verweisquelle konnte nicht gefunden werden..**

Regarding 6: Test Certificates:

Certificates of all tests during construction / installation until date shall be submitted in this section (e.g. compaction tests, pressure tests for pipelines, concrete delivery notes or tests, tightness, tests and loop impedance, lightning protection, potential equalizing and earthing system etc.) together with the appropriate official test, acceptance and approval documentation and approval permits (e.g. tests at factories premises, cranes, lifts, electrical equipment etc.). Certificates from the respective manufacturers shall be submitted for all equipment and plant.

Regarding 7: Legal Documentation:

The Contractor shall compile in an orderly manner all legal documentation which arose with implementation of the works, such as construction permits, right of way, licenses, etc.

Regarding 8: Miscellaneous

The Contractor shall compile in an orderly manner any other documentation deemed relevant in the framework of works implementation.

C.7.2 Equipment Identification

The Contractor shall establish and maintain throughout the plant and the whole works an equipment identification system. The equipment identification system shall be agreed with the Engineer and shall be in accordance with the Employer's requirements and, where applicable, in accordance with the Employer's own identification system.

A unique ID-number shall be allocated to each equipment of the plant. The ID-number shall be used through all documents of the plant including, but not limited to, drawings, as-built documentation, operation and maintenance documents and SCADA System.

There shall be only one description for any one item of plant and this must be used consistently for plant, electrical and instrumentation designations throughout.

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The Contractor shall supply and install at visible locations and for each equipment, permanent nameplates indicating at least the name and ID-number of each equipment as well as all labels, nameplates, instruction and warning plates necessary for the identification and safe operation of the equipment, plant or facility. All inscriptions shall be in the local and in the English languages.

All labels, nameplates, instruction and warning plates shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self tapping screws or other approved means. The use of adhesives will not be permitted.

Nameplates for plant and equipment identification and record purposes shall be manufactured from stainless steel or aluminium with a matt or satin finish, and engraved with black lettering of a size which is legible from the working position.

Warning plates shall be manufactured from stainless steel or aluminium engraved red white lettering on a white background and sited in the position where they afford maximum safety of personnel.

All equipment within panels and desks shall be individually identified by satin or matt finish stainless steel or aluminium labels, or laminated plastic labels where approved.

Each circuit breaker panel, electrical control panel, relay panel, etc. shall have a circuit designation label on the front as well as on the rear panels engraved with black lettering in accordance with the circuit designation system. Circuit designations must be precise and convey complete information.

Pipe work systems shall be identified with a colour identification systems in conformity with the requirements of the Employer, with colours at the nameplates and, if necessary by colour bands. The direction of flow shall be indicated.

C.7.3 On-site schematic Diagrams

Apart from the P&I-diagrams included in the set of as-built drawings, the Contractor shall install at each place of operation a diagram showing each element to be operated and addressing its purpose. The diagram shall be of rugged and light-proof film and colours, pasted to a plastic board and fixed to the walls as directed by the Engineer. The Contractor shall provide one spare sets of films that shall serve as replacement in case of destruction of the original ones.

C.7.4 Signs

The Contractor shall install where required within the works or the plant, appropriate signs in accordance to international standards and Codes of Practice as well as local regulations. Such signs shall include but be limited to the following:

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Information signs

Information signs should supply the necessary information to acquaint operation personnel with the physical arrangement and structure of site, buildings and equipment, e.g. floor numbers, load-carrying capacities including marking of floor areas, working loads of cranes, lifting gear and lifts, room identification, etc. The routing of underground pipes and cables is to be indicated by substantial marker blocks showing the relevant identification numbers.

Emergency signs

A sufficient number of emergency signs of appropriate size should be installed in accordance to applicable standards and Codes of Practice, e.g. escape routes (including marking of floor areas), emergency exits, fire alarms, fire extinguishers, instructions for special fire-extinguishing agents, warnings against fire-extinguishing agents (CO₂), first aid equipment, first aid points, accident reporting points, telephones, etc.

Obligation signs

Signs indicating obligatory actions must be provided / installed wherever certain action is necessary, e.g. do not obstruct the entrance; keep right, etc.

Signs should also indicate when the wearing of protective clothing and equipment is necessary and obligatory, e.g., protective goggles, protective clothing, helmets, head guards, breathing equipment, ear muffs, etc.

Warning signs

Warning signs should refer to the existence or possible existence of danger, e.g., flammable substances, explosive substances, corrosive or noxious substances, suspended loads, general danger, width / height restriction, steps, risk of trapping, slipping, falling, etc.

In addition to warning signs, appropriate black-yellow strip markings should also be used where necessary.

C.7.5 Spares, Tools, Appliances

C.7.5.1 Spare Parts

Unless otherwise specified, the Contractor shall supply all spare parts to enable the Works to be operated efficiently for a period of two years. The Contractor shall submit with his offer a detailed list of supplied spare parts.

C.7.5.2 Tools and Appliances

The Contractor shall supply in his offer:

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- i) All tools, including special tools and gauges, required for the operation and maintenance of the works;
- j) All special lifting and handling appliances required for the operation and maintenance of the works.

Each tool or appliance is to be clearly marked with its size and/or purpose. The tools and facilities supplied shall not be used for erection purposes by the Contractor and shall be handed over in new condition. The exception to this is the special lifting appliance (if applicable) which may be used provided that when it is handed over to the Employer it has not been subjected to more than normal wear and is still fully suitable for its intended use.

Each set of tools and appliances under category a) shall be suitably arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the layout of the plant and equipment in question and the different qualification of staff in charge of maintenance works (electrical, mechanical, ...). If the weight of any box and its contents is such that it cannot be conveniently carried, it shall be supported on a mobile carriage equipped with tires.

Each cabinet and box shall be painted, fitted with a lock and clearly marked in white letters, in the local and the English language, with the name of the item of equipment for which the contained tools and appliances are intended.

The Contractor shall provide the following:

- suitable storage racks for all portable lifting tackle in this Contract;
- suitable lifting lugs, ears or ring bolts, or tapped holes for lifting rings shall be provided on all equipment with a weight exceeding 15 kg;
- all lifting tackle shall be stamped with a unique identification number and safe working load; and
- A test certificate from an approved authority shall be supplied for each item of lifting tackle.

The Contractor shall provide all runway beams, trolleys, lifting blocks, special slings etc. necessary for the safe and efficient handling and maintenance of the works. Particular attention must be paid to high level equipment such as pump sets etc. Electrically operated hoists and runway trolleys shall be provided for all lifts in excess of two and one half (2,5) tons.

The tools and appliances with the appropriate storage racks, cabinets and boxes shall be handed over to the Employer at the time of Take-Over.

Where the Contract includes site erection, any special tools or appliances required solely for erection shall be provided by the Contractor for his own use and shall remain the property of the Contractor.

The Contractor shall submit with his offer a detailed list of supplied tools and appliances. Before delivery on the site, the Contractor shall provide a schedule of all proposed tools and appliances, for the approval of the Engineer.

C.7.5.3 Lubricants and Greases

Lubricants and greases shall be supplied under this Contract. The Contractor shall supply the first fill of lubricants, and shall provide at the Take-Over sufficient lubricants and greases necessary for the efficient operation and maintenance of the works at full load, 24 hours per day, for a period of 12 months.

All lubricants proposed for the operation of the Works shall be suitable for all operating and environmental conditions that will be encounter on site. In addition, all oils and greases shall, where possible, be readily available in the country of installation.

The number of oils and greases shall be kept to a minimum. For each type and grade of lubricant recommended the Contractor shall list at least three equivalent lubricants manufactured by alternative companies.

C.7.6 Operation and Maintenance Manuals

The Contractor shall prepare and submit for the approval of the Engineer operating and maintenance procedure manuals for the Works and Plant in English and, where applicable and required in the Bidding Documents, local language.

Unless otherwise specified, draft copies of the operation and maintenance manuals shall be submitted not later than two months before commissioning of the respective part of the works or plant. Following successful commissioning and not later than two months after the commissioning was successfully completed, the draft copies, suitably corrected where necessary, shall be assembled into their final form and shall be submitted to the Engineer for approval.

The instruction manuals prepared by the Contractor and manuals relating to equipment by any sub-contractors shall be printed and shall be bound into suitable loose leaf binders A4 size.

The operating and maintenance manuals shall describe the complete functions of the works and the plant and requirements for start-up, operation, system control, water and/or wastewater quality control, maintenance, safety, record keeping, emergency response and shut down.

The manuals shall deal with operation and separately with maintenance and shall cover the Works and each plant as a whole, as well as individual sections. The manuals shall be arranged to provide separate volumes for each principal section of the Works.

All information in these manuals shall apply specifically to the equipment being supplied. The documentation shall be free from irrelevant matters that might be contained in the manufacturer's general literature. Manuals shall relate to as-built conditions and shall include all necessary drawings and diagrams for a proper understanding of the Works and Plant.

The Operating and Maintenance manuals shall include as minimum the following information:

1. Descriptive overview of the whole of the Plant;

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2. Description of all process, with relevant design and operating parameters;
3. Descriptions of all systems installed, including mechanical, electrical, air systems, heating, ventilating and air conditioning, water supply, drainage, sewerage etc.;
4. Description of all equipment supplied including manufacturers' leaflets, which are to be scheduled for easy reference;
5. Schedules and manufacturer's catalogues for all equipment supplied, giving duties, electrical loads, etc.;
6. Schedule of all equipment suppliers (and their local agents) including names, addresses, telephone, e-mail and fax numbers;
7. Start-up, operation, and shutdown instructions for all parts of the Plant. These shall include process control, hydraulic control, power, and auxiliary systems;
8. Procedures to deal with breakdown and emergencies;
9. Repairs and troubleshooting guidelines in sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the new infrastructure;
10. Safety requirements;
11. Full maintenance instructions for all equipment including planned maintenance schedules or charts giving daily, weekly, monthly, quarterly, half yearly, annually and overhaul instructions, together with recommended lubricants and spares. These should also include details of routine maintenance work that will be within the competence of the Plant's maintenance staff, and notification of maintenance work that has to be done by the manufacturer, his agent or other specialist operator;
12. Step by step procedure for the dismantling, repair and re-assembly of all items of equipment which shall be complemented by photographs and exploded diagrams;
13. Schedules of spare parts supplied;
14. Description of required lubricant types, fuels types, and other consumables;
15. Schedules of tools and lubricants supplied;
16. Fault finding charts;
17. Record as-build drawings of all systems installed, including general arrangements, conduit and wiring trunk systems, plant room details, air and water systems flow sheets, wiring diagrams, control schematics and valve charts, etc. to a reduced scale;
18. Certified suppliers drawings of all equipment supplied, which are to be scheduled for easy reference;
19. Site test reports for all electrical, electronic, mechanical and water systems. Site test process reports for proving tests, commissioning reports, and suppliers test certificates;
20. Copies of performance curves;

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21. List of settings of all parameters (operation terminals of the PLC) for Plant automation and control at the time of handing over the Plant to the Employer.

The contents of the operation and maintenance manuals shall be as comprehensive and precise as possible. Every attempt shall be made to use material specific to the Contract. Nomenclature or reference to any one item shall be consistent throughout the manuals. However, information which does not contribute to the understanding of the design, operation and maintenance of the works and plant shall be excluded from the operation and maintenance manuals.

Operation and Maintenance Manuals shall be of a design to be approved by the Engineer and/or the Employer. All documentation forming part of the manuals shall be of a uniform size except where pull-out or folding charts are provided. All printed material shall utilize a uniform type and size. Each folder of any separate volume shall be durably and permanently bound within a stiff binder and a hard cover. They must each permit the subsequent incorporation of revisions to be necessary during the Operation Period.

The Contractor shall provide in addition to the complete set of the operating and maintenance manuals the corresponding computer editable files (AutoCAD, MS Office, etc.) on digital support as instructed by the Engineer.

The timely submission and approval of the operation and maintenance manuals is conditional to any taking over procedure.

Details on the content of the operation and maintenance manuals are given in the following sections.

C.7.6.1 Suppliers' Documents

The Contractor shall provide, together with the supply of the goods, a comprehensive documentation of the equipment installed in English language. The documentation shall comprise at least:

- the complete list of addresses, webpages, email contacts, and phone numbers of all manufacturers and suppliers;
- a complete file of written operation and maintenance instructions obtained from the manufacturers and suppliers;
- explanatory drawings and details of any operation likely to be carried out during the life of the plant (testing, operation, maintenance, dismantling and repair).

C.7.6.2 Detailed Operation Instructions

The Contractor shall prepare and submit to the Engineer a separate comprehensive operating manual giving detailed operating instructions in English and, where applicable and required in the Bidding Documents, in local language. Operation instructions shall give essential functional information of the systems and cover all sequences of various operating steps during the start-

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up, normal operation and shut-down of complete systems as well as all possible ordinary and extra-ordinary cases of operation, including failures of elements, fire, storm, and the like.

Operating instructions shall provide in the simplest and most logical form the necessary information for:

- initial starting and running procedures after various shutdown periods;
- automatic and manual operation of the plant items under normal running conditions, and with all relevant adjustments for safe and efficient operation,
- precautions and observations for the health and safety of the personnel and the safety of the plant and equipment;
- normal and emergency shutdown procedures with relevant safety precautions;
- emergency procedures for all fault conditions in manual and/or automatic operation;
- surveillance, monitoring and data recording;
- periodical tests and checks;
- preservation procedures for long and short term shutdown; and
- commissioning procedures to be implemented following long and short term shutdown.

The instructions shall include both the electrical and the mechanical elements in the proper sequence so that no ambiguity and no omission shall occur. They shall use a logical ID-numbers for each element.

To illustrate the operating principles, the instructions shall contain a brief summary of the technical operating basis of the Works and Plant facilities or equipment, including flow sheets, diagrams, circuit diagrams, piping diagrams and similar. The operating instructions shall be accurate and easy to understand and shall contain the sequence of individual operations required. The information shall be prepared in such a manner that it can be used also for instructing untrained personnel in the operation of the Works, Plant and equipment.

Tables, lists and graphic representations shall be used as far as possible for making the description more readily understood.

C.7.6.3 Maintenance Instructions

The Contractor shall provide for each element of plant and equipment detailed instructions for the inspection, control, maintenance and repair. These instructions shall be in English and, where applicable and required in the Bidding Documents in local language.

The maintenance manuals shall contain a complete and accurate description of the system facilities, their assembly and dismantling, as well as, of all components and accessories.

The Contractor shall furnish to the Engineer complete operating and maintenance instructions of all mechanical equipment. The Operation and Maintenance Manual shall include at a minimum the following:

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- Exploded view or cross sectional drawings;
- Sub-assembly or parts lists with order numbers and addresses;
- Assembly/disassembly instructions, with data and directions for adjustment;
- Lubrication instructions (with indication of lubrication points, lubricants to be employed, draining and filling instructions, details of the required frequency of lubrication, etc.);
- List of potentially occurring problems and methods of remedying them;
- Indication of all makes and method numbers of incorporated parts in a common parts list;
- In addition, manufacturer's service documentation, including maintenance prescriptions and recommendations must be appended.

The maintenance manuals shall be divided into several sections dealing with different maintenance activities. The first page of each instruction manual section shall be a title page.

One section shall concern regular and preventive maintenance and shall indicate the inspection required at regular intervals, the inspection procedure, routine cleaning and lubricating operations, regular safety checks, replacement of wear parts and similar works.

One section shall describe the requirements for the repair and adjustment, the inspection, fitting and dismantling of parts, fault tracing as well as repair and adjustment procedure. For each element of plant and equipment, the Contractor shall provide the Manufacturer's maintenance instructions.

Where the equipment or item is of such a nature that local repair cannot be undertaken and the item is usually returned to the factory as a unit for overhaul, specific information concerning its repair and parts breakdown shall be provided.

One independent section shall describe requirements for the entire testing and adjustment procedure for the system or equipment supplied after overhauls and to be observed during operation.

One section shall contain the spare parts list with necessary data for ordering spare parts, list of lubricants, lists of packing, seals and gaskets, list of chemicals and consumable materials and list of special tools.

The Contractor shall provide to the Employer all information, document and support he may require to allow the Employer to enter data into a computerized maintenance management system.

C.7.6.4 Maintenance Plan

The Operation and Maintenance Manuals shall be supplemented with a Maintenance Plan. This Maintenance Plan shall consist at least of the following:

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1. **Maintenance Schedule:** schedule of routine maintenance activities for a period of one year of operation. This plan shall show daily, weekly, monthly, quarterly, half-yearly and yearly maintenance activities for each component of the Plant. These activities shall be based on particular equipment maintenance instructions as described in Section C.7.6.3;
2. **Maintenance Database:** with the purpose to enable archiving and QA/QC of all routine and emergency maintenance activities for each component of the Plant. The Maintenance Database shall be prepared in a Hard Copy version and as a digital database. The filing system shall be organized in way which enables that a unique Maintenance Card is provided for each component of the Plant.

All Maintenance Plan documents should be prepared in way which shall enable flexibility in changes based on Plant operation experience. Managing of the Maintenance Plan shall be part of the overall Training Program.

C.7.6.5 Amendments to the Operation and Maintenance Manuals

If it shall emerge during the erection, commissioning or maintenance period of the equipment that the operating and maintenance instructions are inadequate or faulty, the Contractor shall carry out and supply the necessary corrections and supplements.

C.7.6.6 Stock-keeping Lists

The Contractor shall establish an electronic Spare Parts and Interchangeability Record (SPIR) or similar system for recording and stock keeping control of all spare parts, wear and tear parts, chemicals, lubricants and other consumables based on the plant and equipment identification system or any other system to be decided by the Employer.

The spare management system shall provide the availability of the necessary spare parts, material and consumables in the required quantity and quality and making sure that ordering can be effected in good time without interruption of operation, particularly with regard to unforeseen defects.

C.7.7 Hand Over Certificates

In addition to the requirements of the corresponding clauses of the conditions of Contract on Employer's Taking Over, the Contractor shall prepare and deliver to the Employer hand over certificates for documents, goods and materials other than those incorporated in permanent works erected on site and which are to be handed over to the Employer. Such documents, goods and materials shall include but not be limited to construction documents, consumables, chemicals, lubricants, spare parts, as built drawings, O&M manuals, special tools and handling equipment, etc.

C.8. SITE REHABILITATION AND REINSTATEMENT

Upon issue of the Taking-Over Certificate for the whole of the Works the Contractor shall apply to the Engineer for approval to demobilize the Site installations and on obtaining such approval, shall remove from the Site all plant, equipment, stockpiles, temporary buildings, installations and all other facilities and things such as are no longer needed for the performance of any outstanding obligations under the Contract.

If the Contractor refuses to carry out such removal and rehabilitation to the standards specified within 28 days after the issue of the Taking-Over Certificate for the whole of the Works, the removal and rehabilitation works may be undertaken at the discretion of the Employer at the Contractor's expenses.

All existing drainage ditches and culverts shall be reopened and graded and natural drainage restored. Broken or damaged culverts shall be restored to their original condition and location.

Upon completion of pipe laying and backfilling operations, all former grassed and planted areas shall be hand-raked and dragged, leaving all disturbed areas free from rocks, gravel, clay, or any other foreign material. Unless instructed or specified otherwise, the finished surface shall conform to the original surface, and shall be free draining and free from holes, ruts, rough spots, or other surface features detrimental to a seeded area.

C.9. ENVIRONMENTAL REQUIREMENTS

C.9.1 Compliance with Laws and Regulations

The Contractor shall comply with all applicable national environmental protection laws, orders and regulations and relevant international and local environmental standards. All site works on the project shall be ISO 14000 compliant.

C.9.2 Environmental Management and Monitoring Plan

The Contractor shall prepare and implement during the whole duration of the Contract an Environmental Management and Monitoring Plan (EMMP) in compliance with current legal national and international laws and regulations and the recently completed Environmental and Social Impact Assessment (ESIA).

The EMMP describes the environmental issues associated with the construction of the works included in the Contract and outlines corresponding management strategies that will be employed to mitigate potential adverse environmental effects. The Contractor shall assign for the preparation and monitoring of the Environmental Management Plan a qualified and accredited Environmental Expert for the whole duration of the Contract.

C.9.3 Landscape Preservation

The Contractor shall exercise care to preserve the natural landscape and shall conduct his construction operations so as to prevent any unnecessary destruction, scarring, or defacing of the natural surroundings in the vicinity of the work. Except where clearing is required for Permanent Works, approved construction roads, or excavation operations, all trees, native shrubbery, and vegetation shall be preserved and shall be protected from damage by the Contractors construction operations and equipment. The edges of clearings and cuts through trees, shrubbery, and vegetation shall be irregularly shaped to soften the undesirable visual impact of straight lines. Movement of labour and equipment within the right-of-way and over routes provided for access to the work, shall be performed in a manner to prevent damage to grazing land, crops or property.

The Contractors workshops, offices and yard area shall be located and arranged in such a manner as to preserve trees and vegetation to the maximum practicable extent. On abandonment, all temporary buildings, including concrete footings and slabs, and all construction materials and debris shall be removed from the site. The area shall be removed, as required, so that all surfaces drain naturally, blend with the natural terrain, and are left in a condition that will facilitate natural vegetation, provide for proper drainage and prevent erosion.

C.9.4 Prevention of Water Pollution

The Contractors construction activities shall be performed by methods that will prevent entrance, or accidental spillage of solid matter, contaminants, debris and other pollutants and wastes into surrounding stream / swamp, flowing or dry watercourses, lakes and underground water sources. Such pollutants and wastes include, but are not restricted to refuse, garbage, cement, and concrete, sanitary waste, industrial waste, radioactive substances, oil and other petroleum products, aggregate processing tailings, mineral salts and thermal pollution.

C.9.5 Abatement of Air Pollution

The Contractor shall comply with applicable national laws and regulations concerning the prevention and control of air pollution.

Notwithstanding the above in conduct of construction activities and operation of equipment, the Contractor shall utilise such practicable methods and devices as are reasonably available to control, prevent and otherwise minimise atmospheric emissions or discharges of air contaminants. Equipment and vehicles that show excessive emissions of exhaust gases due to poor engine adjustments, or other inefficient operating conditions, shall not be operated until corrective repairs or adjustments are made.

Burning of materials resulting from clearing of trees and brush, combustible construction materials, and rubbish will be permitted only when atmospheric conditions allow and when authorised by the Engineer. In lieu of burning, such combustible materials may be disposed off by other methods as approved by the Engineer.

Where open burning is permitted, the burn piles shall be properly constructed to minimise smoke and in no case shall unapproved materials, such as tires, plastics, rubber products, asphalt products or other materials that create heavy black smoke or nuisance odours, be burned.

C.9.6 Dust Abatement

During the performance of the work required by these specifications or any operations appurtenant thereto, whether on site of Works or elsewhere, the Contractor shall furnish all the labour, equipment, materials and means required and shall carry out proper and efficient measures wherever and as often as necessary to reduce the dust nuisance and to prevent dust which has originated from his operations from damaging crops, orchards, cultivated fields and dwellings or causing a nuisance to persons. The Contractor will be held liable for any damage resulting from dust originating from his operations under these specifications on the public access roads or elsewhere. The Engineer may direct sprinkling of water or other measures for dust abatement of necessary to obtain adequate control.

C.9.7 Clean up and Disposal of Waste Materials

The Contractor shall, at all times, keep the construction area, including storage areas, free from accumulations of waste materials or rubbish.

All waste water and sewage from office, residential and mobile camps shall be piped to soak pits or other disposal areas constructed in accordance with local government regulations, and where and when such regulations require, the Contractor shall obtain a permit or other appropriate documentation approving the disposal methods being used. All used fuels, other plant or vehicle fluids, and old tyres and tubes shall be collected to a central disposal point, on a regular basis and disposed as specified below.

All household, office, workshop and other solid waste shall be collected to a central disposal area on a daily basis and disposed in accordance to local regulations and in a manner approved by the Engineer.

Servicing of plant, equipment and vehicles shall whenever possible be carried out at a workshop area. This workshop area shall be equipped with secure storage areas for fuels oils and other fluids constructed in such a way as to contain any spillage's which may occur and similar where used fluids can be stored securely prior to their disposal.

When servicing of plant, equipment and vehicles is carried out away from the workshop area, it shall be done at locations and in such a manner as to avoid spillage and contamination of streams and other drainage courses.

Prior to completion of the Work, the Contractor shall remove from the vicinity of the work all plant facilities, buildings, rubbish, unused materials, concrete and other like materials belonging to him or used under his direction during construction.

All work areas shall be graded and left in a neat manner conforming to the natural appearance of the landscape.

Any residue deposited on the ground from washing out transit mix trucks or any similar concrete operations shall be buried or cleaned up in a manner acceptable to the Engineer.

In the event of the Contractors failure to perform the above work, the work may be performed by the Employer, at the expense of the Contractor.

C.9.8 Measurement and Payment for Environment Protection and Waste Disposal

Except as specifically included in the Price Schedule or otherwise provided, no separate measurement or payment will be made for any work included in this Clause, the relevant cost of all these requirements being included by the Contractor in his rates.

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

1. Specifications

b) Technical Specifications

General Technical Specifications

Part D: Civil Works for Facilities

Content of Volume 3:

Section VII: Employer's Requirements

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- a) Scope of Supply of Plant and Installation Services by the Contractor
- b) Technical Specifications
 - Particular Technical Specifications
 - General Technical Specifications
- c) Specifications for Project Area Environmental, Social, Health and Safety Management (ESHS)
- d) Personnel Requirements
- e) Equipment Requirements

2. Drawings

3. Supplementary Information

- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
- f) KAP Well Water Analyses Data.

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List of Acronyms

ACV	Aggregate Crushing Value	ETA	European Technical Assessment
AL	Alignment Load	FEM	Fédération Européenne de la Manutention (European Materials Handling Federation)
ASHTO	American Association of State Highway and Transportation Officials	FI	Flakiness Index
ASTM	American Society for Testing and Materials	GRP	Glas fibre Reinforced Polyester
BS	British Standard	HS	High Sulphate resistance
BSt	Type of rebar	ISO	International Organisation for Standardisation
		LAA	Los Angeles Abrasion
CAPWAP	Case Pile Wave Analysis Programme	LL	Liquid Limit
CBR	California Bearing Ratio	MC	Medium Curing
CEM	Cement	OD	Outer Diameter
CESMM	Civil Engineering Standard Method of Measurement	PES	Polyester
		PI	Plasticity Index
CFA	Continuous Flight Auger (piles)	PP	Polypropylene
CPT	Cone Penetration Test	PV	Prefabricated Vertical (drains)
DIN	Deutsches Institut für Normung (German Standard)	PVC	Polyvinyl Chloride
		QA	Quality Assurance
DL	Design Load	QC	Quality Control
DN	Nominal Diameter	RC	Rapid Curing
DVGW	Deutscher Verein des Gas- und Wasserfaches (German Association for Gas and Water Industry)	SPT	Standard Penetration Test
		SSS	Sodium Sulphate Soundness
EN	European Norm	w/c	Water / cement (ratio)
ENV	Euro Norm Vornorm (Pre-standard)	WEAP	Wave Equation Analysis of Piles

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

D.1. GENERAL

D.1.1 Scope of the Specifications

This sub-section outlines the general requirements for civil works and civil works for construction of facilities to be carried out by the Contractor. Specific requirements for civil works for pipe works are given in Part C and for civil works for building in Part D. The work required under this sub-section shall include all labour, materials, equipment, remedy of deficiencies, site clearance and all other appurtenant works required to complete all civil works and facilities specified herein. Not mentioning any specific material or plant does not necessarily imply that such specific material or plant is not included in the works.

The Contractor shall, unless otherwise specified herein, supply all materials, equipment, temporary works and labour necessary to perform, maintain and complete the works.

All Civil Works, unless otherwise specified, shall comply with the provisions of this Section. The names of the manufacturers of materials proposed for incorporation in the Works, shall be furnished by the Contractor when so requested by the Engineer who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specification.

D.1.2 Standards and Rules

All design, facilities, materials and workmanship shall comply with the relevant latest ISO, EN or equivalent international and local standards and codes of practice.

Materials supplied and work performed shall comply with these standards and regulations as a minimum. If manufacturers offer material to other standards, the standards shall be equal or superior to those specified and full details of the difference shall be supplied to the Engineer.

Wherever a national specification, technical standard, building, construction and environmental regulation is more restrictive than the specific standards listed in these specifications, the national standard or regulation shall take precedence .

The designs shall be carried out in accordance with:

- EN 1990 Eurocode 0: Basis of structural design;
- EN 1991 Eurocode 1: Actions on structures;
- EN 1992 Eurocode 2: Design of concrete structures;
- EN 1997 Eurocode 7: Geotechnical design;
- EN 1998 Eurocode 8: Design of structures for earthquake resistance.

D.1.3 Scope of Works

The civil works comprise all works in connection with the construction works such as soil investigations / soil replacement, site installations, temporary works, civil structures below or above ground, reinforced concrete structures and masonry, structural steel and iron works in connection with civil and concrete structures, interior and finishing works, building equipment for installations, infrastructural and environmental works, etc.

The Contractor shall provide all the installations, temporary buildings, temporary site infrastructure and services etc., which make his site operation feasible and enable him to start, to execute and to complete the works in due time and to the satisfaction of the Engineer.

The Contractor shall be entirely responsible for the design, safety, stability and sufficiency of the works in accordance with local regulations.

D.1.4 Approval of Materials and Workmanship

The supply of all materials and items shall be subject to the prior approval of the Engineer. The Contractor shall provide such samples as the Engineer may require for approval and, when approved, the quality of materials and workmanship shall be at least equal to the approved samples.

D.1.5 Design Loads, Structural Design and Analysis

Structural design work to be furnished by the Contractor shall include all structural engineering and the pertaining shop drawings (formwork and reinforcement) for all in-situ concrete structures. Furthermore the structural design shall include the stability analysis of all earth structures.

All structures and parts thereof shall be designed to withstand the maximum loads from within the plant and its components, including dynamic effects where they occur. These include dead and live loads to which they are subjected including temporary and erection loads occurring during construction, earth and water pressures and all the other loads resulting from earthquakes, winds, earth, hydrostatic pressures and others. Such loads shall be clearly indicated in the design calculations. Moreover, the structural design shall be carried out to ensure the stability and durability of the structures.

Loads shall be taken as stated in Eurocode and the relevant local standard.

In his QA/QC Programme, the Contractor shall define the procedures for preparation and approval of the structural designs. During the Final Design, detailed design calculations for each individual structure, together with general arrangement drawings, reinforcement drawings and bar schedules, are subject to the checking and approval procedures as laid down in the QA/QC Programme.

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A statement explaining the principles of the design shall preface the detailed calculations and the type of analysis adopted and any design references on which the design is based.

For a concrete structure, the class into which the structure has been placed for design purposes shall be stated.

For a superstructure framework, a separate statement shall be included explaining how overall stability has been achieved and whether reliance has been made on walls, whether of brick, concrete or other material to provide stability.

All loads and structural wall sizes, including positions and sizes of any significant chases and openings shall be clearly indicated in the design calculations.

Design shall allow for the effects of ambient temperatures and temperatures of contained liquids as well as the effect of direct sunlight.

D.1.6 Special Loads

Roof and Wind Loads

Roof and wind loads shall be in accordance with EN and local standards.

Crane load

Crane loads shall generally be in accordance with the design principles as described by the Federation Européenne de la Manutention (European Materials Handling Federation, FEM) in the "Rules for the design of Hoisting Appliances.

Floor Load

Floor slabs in operating areas shall be designed for all permanent loads and other loads, which could take place during maintenance or repair work, but not less than 5 kN/m^2 over their total area. Maintenance walkways shall be designed for more than $2,5 \text{ kN/m}^2$.

Water load

Structures shall be designed to resist water loading due to uplift. Forces on pump wells, tanks, channels, culverts and pipes shall be calculated according to the assumption that they are empty; the factor of safety against flotation shall not be less than 1,1 for this condition.

No reliance shall be placed upon side drains or under drains to lower the natural level of ground water locally in the vicinity of structures. Where structures are constructed above the natural groundwater level and this is relied upon in the design, positive means of drainage shall be provided to prevent accidental uplift arising from leakage of contents or percolation of surface water into the backfill. In the case of structures, which are partially submerged, drainage shall be similarly provided above the designed maximum water level.

Where additional amounts of concrete beyond the normal structural design needs are introduced, for example for the purpose of gaining dead weight to counter the effects of buoyancy, any such addition to the concrete shall, as far as possible, be uniformly distributed among the substructure members.

The Contractor shall determine the maximum design external water level. Structures that may be water tested before backfilling shall also be designed for no external pressure from water or backfill together with maximum internal water pressure.

The design of walls for tanks, wet wells and the like shall allow for accidental filling of freeboard by water to the tops of the extended walls.

D.1.7 Foundations Design

The Contractor shall carry out his own detailed foundation conditions investigation to make himself fully aware of all the subsoil conditions affecting the construction and maintenance of the plant as well as the safe bearing capacity of the foundation soil adopted in the design with no restriction to the given recommendation. The Contractor shall investigate the amount of sulphate and chlorides contained in the subsoil in order to check the necessity for providing corrosion protection for underground structures.

Suitability of materials on site for filling shall be checked and the Contractor shall carry out tests, investigations to determine the best method for utilisation of excavated materials as fill.

D.1.8 Method of Construction

All structural element containing or conveying sewage, sewage sludge, effluent or water shall be constructed in reinforced or pre-stressed concrete, including tanks, channels, culverts and chambers.

Storage tanks for process chemicals should be made of concrete, lined with a protective membrane as necessary, or prefabricated from corrosion-resistant materials, e.g., PVC, GRP.

D.1.9 Architectural Design

Buildings intended to house process machinery as well as those intended for administrative purposes, should be made of reinforced concrete foundations, framing, floors and roofs, with infield masonry panels or prefabricated cladding.

The architecture of the surface buildings and general all visible surface structures shall present a pleasing external appearance but having clean and simple lines combined with good weathering and low maintenance properties. The appearance shall be similar to existing structures and buildings which are located at the construction site or its vicinity. Materials shall be selected for a long life, taking into account the exposed nature of the site.

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The architectural design for buildings and structures exposed above finished ground level shall be submitted to the Client with the Preliminary Design for approval before commencing the final designs.

Rainwater disposal shall be provided such that no roof or overhang water runs down the face of the building. Effective drains shall be incorporated in all overhanging elements.

Buildings containing heavy and or voluminous items requiring handling by mechanical means shall be provided with doors suitable for trucks. The door height shall be not less than 3 metres. Separate personnel access doors shall be provided in addition to the equipment doors.

Buildings for chemical and fuel storage shall conform to all respective safety standards requirements.

D.1.10 Rooms for Electrical System

Generally, water, sewage, drain, gas or other kinds of pipe or duct, which are not related to the room, shall not enter areas and rooms where electrical equipment is installed. The floor shall be levelled, dust-free and not slippery.

Walls between rooms for electrical systems and other rooms can be made from light concrete or other kinds of masonry. Walls and ceilings shall have surfaces, which do not cause peeling or falling particles. Walls, ceilings and floors shall be painted with dust-binding paint.

All rooms with electrical equipment shall be fire-retardant and resist fire for at least 60 minutes.

Exits from rooms with switchgear shall be provided with doors, which open outwards. The exit doors shall emerge to platforms or other rooms with an area of at least 1,5 m² and be located at the same level as the floor of the actual Switchgear rooms. From the platform or the escape areas evacuation shall be possible.

D.1.11 Thermal Performance

Heated and air conditioned buildings shall be designed to utilise minimum energy consumption. Windows shall be designed in such a way that in the summer months there will be little or no direct sunlight into the rooms. Wall and roof construction shall be designed to prevent condensation within the building elements (interstitial condensation).

D.2. DEMOLITION AND PROTECTION OF WORKS

D.2.1 General

Existing buildings and structures on site which the Engineer may order to be demolished or may be required to be removed for the construction of the permanent works shall be demolished to the extent necessary to construct the various units of work but at least to a depth of 1,5 meter.

The demolition of structures includes the demolishing of all kinds and grades of bricks, wooden structures, plain concrete and reinforced concrete, pipes, all requisite shoring and strutting or other supports incidental to demolition works, the removal of debris from site, final site clearance and making good of disturbed parts.

Details of the buildings and structures to be demolished by the Contractor shall be ascertained by the Contractor prior to the commencement of any demolition work during the construction of the Works and shall be to the approval of the Engineer. The Contractor shall be obliged to complete his survey in order to obtain any outstanding information

The Contractor shall, amongst other risk investigations; examine the features of the structures, and ensure whether any shock or vibration could damage surrounding executed work, fixed equipment or any existing buried services and investigate the existence of any toxic or flammable substances or asbestos.

The Contractor shall be obliged, prior to the commencement of any demolition work, to disconnect all affected existing live services according to the directions and instructions of the Engineer and any relevant Statutory Authority. In this respect the Contractor shall be obliged to obtain on time all necessary permits and provide the necessary notices to all parties concerned.

The work shall be carried out in such a manner as to cause as little inconvenience as possible to the occupants of adjoining premises and the public. The debris shall be sprinkled with water to prevent dust arising. The Contractor shall provide all requisite shoring and strutting or other supports incidental to the demolition work, remove debris from site and finally clear the site and make good all parts of the work which are disturbed.

D.2.2 Permission

The Contractor shall not demolish or remove any existing buildings, structures or other objects including trees, whether indicated on the Drawings or not, without the approval of the Engineer.

Permission for demolishing existing buildings and structures shall be applied in writing to the Engineer and shall be accompanied with a demolition programme. No demolition shall take place before obtaining the Engineer's permission and the area has been provided with all necessary relevant temporary works and/or diversions which have been either requested or authorised by the Engineer.

Demolition works shall be carried out using approved methods and in accordance with any safety regulations of the local municipality and Authorities. The Contractor should note that a Building Permit might be required for demolition works.

D.2.3 Workmanship

The Contractor will submit for the Engineer's approval the methods applied for demolishing and the proposed temporary safety measures before moving equipment into the site and commencing operations. The method statement for demolition shall include the proposed method that is such that any nuisance arising from dust, noise, and vibration are kept to an acceptable level and ensure the safety of structures adjacent to those to be demolished. The use of explosives is strictly prohibited.

Underground structures shall be broken out to a depth required for removal of them. Sumps, pits, chambers and the like shall be properly cleaned out and filled with clean demolition hard-core (if required or instructed by the Engineer), excluding any wood, plastic, sheet metal, loose reinforcement steel and the like. Demolition of walls, tanks, and plates inside building to be rehabilitated will be performed with the required care, without damaging the stability of the structure.

Where required or directed by the Engineer, the existing structure will be temporary reinforced to assure the stability. The Engineer's approval shall not relieve the Contractor of any of his responsibilities under the Contract.

D.2.4 Ownership and Disposal of Demolition Materials

The Employer shall have the option of retaining ownership of any materials arising from demolition and may remove them at his own expense. In the absence of the Employer giving reasonable notice of his intention to take possession of such materials, ownership shall revert to the Contractor who shall become responsible for removal from the site and disposal.

If becoming property of the Contractor, all materials arising from the demolition and clearance of water lines, buildings, structures and other objects mentioned shall be removed from the site promptly and disposed of in a place and in a manner acceptable to the local municipality and Authorities.

D.2.5 Refilling and Finishing

All voids shall be re-filled with soil compacted to the same density as the surrounding soil and the surface shall be finished to the existing ground level and to the satisfaction of the Engineer.

Where existing sewers are connected to the new systems, the sewer downstream to the connection, which is not incorporated into the new system, shall be abandoned.

Buried pipelines to be abandoned shall be sealed with mass concrete plug of minimum length 1 m at either ends and between manholes. Manholes on abandoned pipelines shall be demolished to a depth of 1,5 m below final ground level and the void filled with hard core or other approved fill material and surface reinstated to a finish similar to that of the surrounding area.

D.2.6 Protection of Existing Objects

Existing objects, including buildings, structures, fences and other objects including trees which are situated on or near the site(s) and which shall be maintained, shall be protected from damages during implementation of works.

The Contractor shall:

- Protect benchmarks, existing structures, fences, roads, sidewalks, paving and curbs against damage from equipment and vehicular traffic;
- Protect aerial, surface, or underground utility lines or appurtenances, which are to remain;
- Repair any damage caused during the works to facilities which shall be maintained.

Any property situated in close proximity to the Works shall be protected against any damage that could be caused by vehicles, subsidence, vibration, etc. The Contractor shall either repair any damage caused or the Contractor shall pay for the works to be repaired to the condition of the property prior to damage and to the satisfaction of the Engineer.

Construction works and trench excavation at utilities, along existing supporting walls, at dams and embankments shall be executed under strict avoidance of settlements. The contractor has to apply a suitable method for pit/trench sheeting and bracing with low vibration and low concussion.

D.3. CLEARING AND GRUBBING

D.3.1 Clearance of Sites

All areas of the site, marked on drawings for clearance or from which material has to be excavated or upon which fillings have to be deposited shall be levelled and be cleared from all debris, all obstructions and all vegetation except trees marked for conservation. Excess materials obtained from site clearance shall be disposed of the site at locations proposed by the Contractor and approved by the Engineer.

Site clearance shall also include the inspection of the construction site, the record of existing status by photo documentation and levelling.

The Contractor shall clear the reservation widths for pipelines, road facilities and the sites of structures free of all vegetation, trees up to 0.5 m girth measured 1.0 m above ground level, and all superficial obstacles such as road surfaces, kerbs, bricks, debris, rubbish and/or other objectionable matter.

When ordered by the Engineer, the Contractor shall also clear the sites of trees over 0.5 m girth, buildings and/or structures.

The extent of Contractor's clearing and grubbing operations shall be the minimum practicable necessary for the construction of the Works.

D.3.2 Removal and Replacement of Trees and Hedges

Where directed by the Engineer, trees shall be uprooted or cut down as near to subsoil level as possible. Branches and foliage shall be disposed of the site at locations proposed by the Contractor and approved by the Engineer. Stumps or roots whether existing or remaining after the felling of trees shall, where directed by the Engineer, be grubbed out and disposed of the site at locations proposed by the Contractor and approved by the Engineer. The resulting hole shall be filled with approved material and well compacted.

Any damage to the canopy of trees of girth greater than 900 mm shall be treated by an approved tree surgeon as promptly as possible after the damage occurring or on any instruction from the Engineer. Replacement trees and hedges shall be planted in the appropriate season and shall be replaced by the Contractor.

D.3.3 Protections

Trees and/or other vegetation designated on the Drawings or directed by the Engineer for preservation shall be kept free from clearing operation and be protected from damages during execution of the Works.

D.3.4 Road Furniture

The Contractor shall re-install any road furniture (such as street lighting, traffic sign or traffic lights) that has to be removed during the progress of the Works.

Installation of the road furniture shall take place at its original location, in a condition at least equal to that prior to removal and as soon as practicable after completion of construction works at a particular location.

D.3.5 Disposals

Trunks arising from the clearing and grubbing operations shall pass to the ownership of the Contractor and shall be dumped at a depot to a location directed by the Engineer.

Other remnants of vegetation, including trees, stumps and roots, shall be disposed of site by the Contractor unless otherwise directed by the Engineer.

D.3.6 Blasting

No blasting shall be carried out without the written permission of the Engineer. When necessary, blasting for clearing boulders and/or rock masses will be permitted only on written approval of the Engineer and when proper precautions are taken for the protection of all persons, the Works and public and private properties.

Blasting shall be carried out in a controlled manner and to the required depth, amount and extent necessary and only with explosives of such quantity and strength and in such locations as will not structurally damage the material to be blasted outside the prescribed limits. Any damage to the Works or properties arising from the blasting shall be repaired by the Contractor to conform to the condition existing prior to damage.

Before any blasting is carried out, the Contractor shall ensure that adequate measures that are necessary for the safety and protection of persons and property against injury or damage has been provided and warning signs and signals has been installed all to the satisfaction of the Engineer and other Authorities concerned with safety and public order.

Explosives and detonating caps shall be stored, handled and used as prescribed by the local regulations. Only qualified and authorised personnel shall handle and use explosives.

D.3.7 Notice of Commencement

The Contractor shall give to the Engineer written notice of his intention to commence the clearing and grubbing and/or blasting operations. The works shall not be commenced until written approval has been received from the Engineer.

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The Contractor shall ensure that all clearing, grubbing and blasting are carried out far enough in advance of other construction operations within the relevant areas in order to avoid delays.

D.4. EARTH WORKS

D.4.1 General

D.4.1.1 Works included

Earth Works as specified hereunder shall include the location of underground structures, the preparation of the site including protective fencing, excavation including strutting, sheeting, bracing and protection of slopes, trimming, disposal of excavated materials off site, backfilling including delivery of backfill material and site clearance including disposal of surplus material.

D.4.1.2 Standards

The Contractor shall carry out the works or provide materials in accordance with the appropriate local or approved similar international standards (ISO, EN and others), provided their requirements are superior or equivalent to the quality described by the standards cited in the Specifications. These include, but are not limited to, the following:

- ISO 14688-1 Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description
- ISO 14688-2 Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification
- ISO 14689 Geotechnical investigation and testing — Identification, description and classification of rock
- ISO 17892 Geotechnical investigation and testing — Laboratory testing of soil — Part 1 to 11.
- ISO 22475 Geotechnical investigation and testing — Sampling methods and groundwater measurements — Part 1 to 3
- ISO 22476 Geotechnical investigation and testing — Field testing — Part 1 to 15
- ISO 22477 Geotechnical investigation and testing — Testing of geotechnical structures
- EN 1610 Construction and testing drains and sewers
- DIN 4124 Building pits and trenches
- DIN 18300 General technical codes for earthworks
- DIN 18303 General technical codes for excavation lining.

D.4.1.3 Classification of Soils

The following terms shall apply to Specification Clauses in which reference is made to the excavated materials in accordance to international approved Standards mentioned above (DIN 18300, ISO 14688 Part 1 and 2)

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Topsoil	means any surface material suitable for use in soiling areas to be grassed or cultivated (Class 1, DIN 18300).
Subsoil	any material other than topsoil and rock shall be classified as "subsoil" (Class 2-6, DIN 18300).
Rock	is defined as material occurring in solid un-weathered banks or layers which, in the opinion of the Engineer, can only be removed by blasting, percussion drilling, wedging or splitting. Boulders exceeding 1 m ³ in volume shall be classified as "rock" (Class 7, DIN 18300).

D.4.1.4 Excavation Methods

The Contractor shall prepare a method statement of his proposal for earthworks operation for each particular part of the Works to be constructed at any one time, detailing the location, programme of excavation, temporary supports, placing and handling of the spoil, and ground stabilisation.

The Contractor shall submit for the Engineer's approval his proposed method statement at least 14 days before his intended date to commence earthworks on each particular part of the Works.

The following terms shall apply to Specification Clauses in which reference is made to excavations:

Normal Excavation	means excavation in open cut (excluding trench excavation) down to levels specified on drawings or otherwise as being the general levels after completion or excavation other than incidental excavation.
Trench Excavation	means excavation to levels and limits specified on drawings or otherwise of trenches in which pipes or the like are to be laid.
Incidental Excavation	means excavation in small quantities below or outside the limits of normal excavation and trench excavation but excluding excess excavation.
General Excavation	means excavation, whether normal or incidental, required for structures, roadwork and borrows areas.
Excess Excavation	means excavation outside the limits specified for normal, trench or incidental excavation. Excess excavation shall not qualify for any extra payment.

D.4.1.5 Backfill Materials

The following terms shall apply to Specification Clauses in which reference is made to backfilling of excavations:

Unsuitable Material	means material not suitable for backfilling including materials from swamps, organic and perishable materials, clay and soils with high

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plasticity indices such as liquid limit (LL) > 80 and plasticity index (PI) > 55.

Rock Fill shall consist of hard un-weathered material of suitable size for deposition and compaction and may comprise broken stone, hard brick, concrete or other hard inert material.

Selected Fill for backfilling trenches and foundations shall comprise well graded readily compactable material free from roots, vegetable matter, building rubbish and clay lumps.

D.4.1.6 Notice of Commencement

The Contractor shall give to the Engineer at least 7 days written notice of his intention to commence earthworks on any part of site and shall furnish the Engineer with all ground levels, site photographs showing the existing conditions and levels and other particulars he may require for the purpose of carrying out measurements.

Earthworks shall not be commenced until written approval has been received by the Contractor from the Engineer.

D.4.1.7 Stripping of Soil

Where ordered by the Engineer topsoil shall be stripped from the whole or part of the site to a depth of 25 cm or to such other depths as indicated in the Contract Documents or such other depths and over such areas as the Engineer may direct, and set aside for reuse as a separate operation prior to any further excavation which may be required.

The work includes transport on site and storage of soil on stable and well-drained stockpiles within the area affected by construction operations.

Topsoil shall include any surface material capable of supporting vegetation and suitable for use in areas to be grassed or cultivated.

The Contractor shall not dispose of surplus topsoil without the written permission of the Engineer.

D.4.2 Excavation

The Contractor shall examine the site and familiarise himself with the nature of ground, the excavation methods to be applied and physical obstructions that may affect the work. The use of explosives will not be permitted.

The Contractor shall not execute any excavation without having the Engineer's prior approval to the methods which he proposes to employ. The Contractor shall not modify such methods thereafter without the Engineer's consent.

D.4.2.1 General Excavation

General excavation, whether normal, mass or incidental excavation, required for structures and roadwork shall be carried out to the grade of the bottom of the structure.

General excavation will be carried out after site clearance and the stripping of topsoil.

In the working drawings, the Contractor shall indicate the limits of excavations to be made for the construction of the individual structures.

The prices quoted for general excavation shall be fully inclusive and contain all incidental works as:

- Excavation of any type of ground including rock, whether this excavation has to be made by hand or by machine;
- Location, maintaining and reinstatement of existing services, where required;
- Supporting excavations and temporary support of the sides of excavations;
- Keeping the excavation free from surface and ground water;
- Trimming, compacting and protecting of formation levels;
- Any additional excavation to accommodate temporary supports and all working space to carry out the work;
- Disposal of excavated material whether it shall be reused for backfilling or removed as surplus material off site, including formation of all temporary spoil heaps and all double handling necessary;
- All works related to pipe laying in parallel or crossing existing cables and pipe.
- Protection of the works and all additional measures necessary to ensure that the excavations are maintained in a safe and workmanlike manner.

Demolition of existing surfaces and underground structures shall be paid for separately. Excavation shall be carried out in a safe manner to suitable lengths, widths, depths and profiles required for the construction of the works shown on the drawings or to such other dimensions that the Engineer may direct. Excavations in open cut are to have stable side slopes.

Area excavated to levels lower than the designed levels approved by the Engineer prior to commencement of work shall be back-filled to the approved level and to the Engineer's satisfactions.

Every precaution shall be taken by the Contractor to prevent slips or falls during the excavations. In the event of slips or falls occurring, or in the event of excavation being made in excess of the minimum necessary or practicable for the construction of the Works, the voids so formed shall be filled. In all cases where the voids so formed when backfilled would provide support for the permanent Works or adjacent structures and services then such voids shall be filled solid with concrete Class E at the Contractor's expense. In all other cases the voids shall

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be packed with selected excavated material or approved fill material and thoroughly compacted to the Engineer's approval

D.4.2.2 Trench Excavation

Trench excavations shall be carried out in accordance with EN 1610.

Trench Walls

Trench excavations for pipes and interconnections shall be open-cut trenches (i.e. with vertical walls). Shoring shall be implemented in accordance with section D.4.2.7. Excavation with sloping sidewall shall be subject to the approval of the Engineer. In this case, there shall be no extra payment for all related additional earthworks.

Trench Width

The trench width is defined as the width between the trench walls or between the shoring walls in case of shoring.

The trench width shall be deemed sufficient to permit the pipes to be laid and jointed properly and to place and compact the backfill as specified.

Minimum trench width depending on the trench depth as per EN 1610:

Trench depth	Minimum trench width in m
< 1,0 m	No minimum specified
≥ 1,00 m and ≤ 1,75 m	0,80 m
> 1,75 m and ≤ 4,00 m	0,90 m
> 4,00 m	1,00 m

Minimum trench width depending on the pipe outer diameter as per EN 1610 in case of circular pipes and shored trenches:

OD in mm	Minimum trench width in m
≤ 225	OD + 0,40
> 225 and ≤ 350	OD + 0,50
> 350 and ≤ 700	OD + 0,70
> 700 and ≤ 1,200	OD + 0,85
> 1,200	OD + 1,00

In case of multiple and parallel pipe laying, distance between pipes shall be sufficient to allow for reaching the compaction targets. Other criteria shall also be considered as deemed required by the Engineer.

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In the event of any trench for pipelines exceeding the maximum allowable widths as specified or shown on the Drawings the Engineer will order the restoration of the trench width or the use of an alternative bedding material or such other remedial action as in his opinion is necessary. The Contractor shall then carry out the measures so ordered by the Engineer and shall have no claim against the Employer for any additional costs resulting from such instructions.

Trench Depth and Bedding

The trench shall be excavated to such depths as necessary to permit placing pipe bedding material or concrete encasement as required and to allow the pipe to be laid at the required elevations, slopes and depths. Trench bottoms shall be cleared of projections such as rocks stones roots and the like. All pipes, sewers and cables shall be laid in trenches excavated in undisturbed soil.

Trench bedding shall be carried out in accordance to Section D.4.4.9.

Crossings

There shall be extra payment only for crossings of rivers, streams, channel or canal of more than 1 meter width. The width is defined as the bottom width at the crossing between axis of pipe and axis of rivers, streams, channel or canal.

D.4.2.3 Further and Excess Excavation

When the specified levels or limits of excavation are reached and approved by the Engineer, he will inspect the subsoil exposed and may, if he considers any part of the subsoil unsuitable, direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with approved imported material or concrete class C 8/10.

Any excess excavation outside the specified "payment limits" and any further excavation which has not been ordered by the Engineer shall be held to be excess excavation which will not be paid for.

The Contractor will not receive payment for the excavation or backfilling of over break, or measures necessary as a consequence of such over break except otherwise approved by the Engineer. Over break means an excavation carried out outside the designated lines.

The Contractor shall remove from the Site all material resulting from excess excavation and shall make good the same with such kind of fill material or concrete as may be reasonably required by the Engineer having regard to the circumstances.

D.4.2.4 Keeping Excavations free from Water

The Contractor shall keep all excavations free from water and sewage, whether caused by floods, storms or otherwise, so as to construct the works in dry conditions.

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The Contractor shall keep infiltrating or accumulated water at a level lower than the bottom of the permanent work for such a period as required by the provisions of the Specification and the Contractor's method of construction.

The mode of drainage proposed by the Contractor is subject to the approval of the Engineer. Any sub-drainage below the permanent works shall, if left in place, be sealed with concrete or other approved material. Sub-drains underneath permanent concrete structures shall be covered with waterproof membranes.

D.4.2.5 Trial Holes

The Engineer may direct that trial holes shall be excavated well ahead of excavation to such depths as he shall order to determine the location of existing works.

The Contractor shall arrange for the refilling and reinstatement of trial holes to be carried out immediately after the required information is obtained. The reinstatement of the surfaces of trial holes shall be carried out to the approval of the Engineer.

D.4.2.6 Supporting Excavations

The Contractor shall support the sides and the ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation.

The Contractor shall provide, install and maintain all materials necessary to provide such support.

If, for any reason, any portion of the bottom, sides and ends of any excavation shall give way, the Contractor shall take all necessary remedial measures including the excavation and removal of all the subsoil thereby disturbed at both inside and outside the nominal limits of excavations. The Contractor will stop the works until the Engineer inspects them. The work will not be proceeding until the Engineer has approved a solution. The contractor will perform the earthworks at his own cost if the slides are caused by him.

Where the Contractor proposes to perform excavations with sloping faces and without shoring, the excavated faces shall be to stable slopes and heights. Full details of the execution shall be submitted to the Engineer for prior approval.

D.4.2.7 Shoring

Trench Excavation - Shoring

Shoring is mandatory for trenches with depths of more than 1,25 m.

For lower depths, depending on specific factors, such as the soil type, rain, etc., the Engineer shall decide during excavation works whether shoring is also required or not.

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During excavation works without shoring, if slipping or collapsing of the trench walls involve a health risk, the Contractor shall immediately suspend the works and inform the Engineer of the occurrence.

Other Excavation Methods - Shoring

In its methods of statement, the Contractor shall indicate where and how shoring is to be implemented. The Engineer shall decide whether shoring is also required or not. During excavation works, depending on specific factors, such as the soil type, rain, etc., the Engineer shall decide whether shoring is also required or not.

During excavation works without shoring, if slipping or collapsing of the trench walls involve a health risk, the Contractor shall immediately suspend the works and inform the Engineer of the occurrence.

Shoring Method

The method of shoring to be used is at the discretion of the Contractor but subject to the approval of the Engineer with regard to safety. The Contractor will be fully responsible for the stability and the effectiveness of the shoring. All costs for shoring shall be included in the excavation rates and prices offered.

The method statement shall include engineering calculations for the sheeting, shoring and piling for different excavation depths.

D.4.2.8 Existing Cables and Pipes

The Contractor shall take all steps necessary to find, protect and safeguard any drains, pipes, cables and similar services encountered, already installed or to be installed, for the duration of the Contract in order to keep them in good working condition. Should the services become damaged during the course of the works, then the Contractor shall be responsible for liaising with the responsible utility companies or organizations and arranging for the repair of that service and bear all costs associated with the repair of the service.

Information as may be given in the Contract in relation to the present condition and character of the existing structures, roadways, embankments and the like and in relation to the dimensions of various parts of the existing structures, the position, extent and particulars of drains, pipes, cables and the like, is given without guarantee of accuracy and the Employer will not be liable for any discrepancy therein.

The absence of such information shall not relieve the Contractor of this liability for the cost of any repair work necessitated by damage caused by him to such mains and services in the course of his work and for the cost of all losses arising from their disruption.

The Contractor shall obtain all available information, assistance, full permission and approval of all relevant utility companies or organizations regarding the positions and/or relocation of mains

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and services, serving notices of intent to start work as may be necessary in accordance with all the local laws and regulations. He shall make this information available to the Engineer as soon as he obtains it. He shall agree with the Engineer any trial excavations, which may be necessary to confirm or establish these locations. All costs for executing trial holes shall be deemed to be included in the Contract. All relocating works shall be carried out two weeks in advance of execution of the relevant work.

Any temporary or permanent diversion and/or relocation of mains and services shall only be permitted after agreement with the appropriate utility companies or organizations and the approval of the Engineer.

There shall be no extra payment for pipe laying works in parallel to or crossing or cables and pipes from other utilities.

During excavations, if unknown cables/pipes are discovered or if cables/pipes are not located where foreseen, the contractor shall immediately suspend the works and inform the Engineer.

D.4.2.9 Tests on Ground Water

During the course of the excavation work the Engineer will require samples of the ground water to be taken for testing to ascertain the presence of harmful substances.

The tests shall be performed in a suitable laboratory before starting any concrete work. The results concerning adverse affects on concrete shall be evaluated according to ISO 22475.

D.4.2.10 Disposal of excavated Material

All material obtained from the excavation (surplus material or material not approved by the Engineer for reuse) shall become the property of the Contractor. The Contractor shall dispose such material off-Site at locations to be determined by the Contractor and to be approved by the relevant authorities.

Storage on site

Excavated material shall be stored at the Site in any of the following ways:

- Transporting and placing in temporary stockpiles and backfilling to excavations including any double handling of materials; or
- Transporting and placing of approved materials in permanent stockpiles, including the shaping and drainage of such tips; or
- Transporting of selected excavated materials to locations within the site for embankments and filling around structures including tipping for spreading and compaction.

Stockpiles on site

Only such materials approved by the Engineer shall be placed in the various stockpiles. No tree trunks, stumps, roots, foliage or rubbish of any kind shall be placed in stockpiles.

Temporary stockpiles to store excavated materials shall be arranged by the Contractor. Such stockpiles shall be shaped as to maintain stability and good drainage at all times. Topsoil stripped from the Site shall be stored in separate stockpiles for later use in reinstatement and landscaping.

D.4.3 Geotextiles

D.4.3.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. Applicable standards for the material shall be, but not be limited to the following:

- ISO 10319 Tensile strength (wide width)
- ISO 10320 Identification of geotextiles at construction site
- ISO 10321 Tensile test on seams and joints by wide width method
- ISO 10722 Damage to geotextiles during installation in grained material
- ISO 11058 Water Flow (normal to plane)
- ISO 12236 Static puncture strength (CBR)
- ISO 12956 Characteristic opening size
- ISO 12957 Friction values
- ISO 12958 Water flow capacity (in plane)
- ISO 12960 Resistance against liquids
- ISO 13427 Abrasion test
- ISO 13431 Tensile creep test
- ISO 13437 Sampling and testing of geotextiles at construction site
- ISO 13438 Resistance against oxidation

D.4.3.2 Application

The applications of geotextile fabrics are divided into the following three main classes:

Drainage: under all rubble rip-rap, including cyclopean stone and under gabions; wrapped around drains, pipe joints, and edge-drains; filter behind walls, etc.;

Erosion Control: silt fence and staked silt barrier;

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Stabilisation: separator between embankment and soft subsoil, reinforcement and pipe bedding.

D.4.3.3 Material Requirements

The geotextile shall be the type appropriate for the intended use. The geotextile fabric shall be a woven or non-woven fabric consisting of long-chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamides or polyvinyl chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The base plastic shall contain stabilisers and/or inhibitors to make the filaments resistant to deterioration due to ultra-violet light (except for subsurface and stabilisation classification), heat exposure and potential chemically damaging environment. The fabric shall be free of any treatment which may significantly alter its physical properties. The edges of the fabric shall be selvaged or otherwise finished to prevent the outer yarn from pulling away from the fabric.

Synthetic filter fabric used for reinforcing grades (in water environments under block or rock covers) shall conform to the following specifications:

The Contractor shall furnish two certified copies of a test report from the manufacturer certifying that the geotextile to be incorporated into the completed project meets the requirements of this Specification. The certified test reports shall be attested to be a person having legal authority to bind the manufacturing company. The Contractor shall also furnish two 100 x 100 cm samples of the geotextile for product identification and any onsite testing. In addition, the manufacturer shall maintain test records as required by this Specification. These records shall be made available to the Engineer on request.

D.4.3.4 Execution and Workmanship

The fabric shall be wrapped in a protective covering which is sufficient to protect it from sunlight, dirt, and other debris during shipment and storage.

After placement, the geotextile shall not be left uncovered for more than 2 weeks.

Traffic or construction equipment will not be permitted directly on the geotextile.

Geotextile which becomes torn or damaged shall be replaced or patched. The patch shall extend 1 m beyond the perimeter of the tear or damage.

Overlaps shall be as specified by the manufacturer or as directed by the Engineer. In order to reduce overlaps, the geotextile fabric may be sewn together. Seams of the fabric shall be sewn with thread meeting the chemical requirements and minimum seam strength requirements given for the fabric and application. Sewn seams shall be lapped a minimum of 10 cm and double sewn.

Non-sewn seams shall have a minimum overlap of 50 cm except where placed under water where the overlap shall be a minimum of 100 cm.

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All seams shall be subject to the approval of the Engineer.

The geotextile shall be placed and anchored on a prepared surface approved by the Engineer. The geotextile shall be laid loosely so that placement of the overlying materials will not stretch or tear the geotextile. Where geotextile is placed above water, the backfill placement shall begin at the toe and proceed up the slope.

Where geotextile is placed under water, the long dimension shall be placed parallel to the direction of flow. Successive geotextile sheets shall be overlapped in such a manner that the upstream sheet is placed over the downstream sheet. As the geotextile is placed under water, the backfill material shall be placed on it to the required thickness. The geotextile placement shall not progress more than 15 m ahead of the backfill placement.

Rip-rap, stone filling (heavy) or stone filling (medium) shall not be dropped onto the geotextile from a height greater than 0,3 m. Slope protection and smaller sizes of stone filling shall not be dropped onto the geotextile from a height exceeding 1 m.

If the above conditions cannot be met, a protective layer shall be placed on top of the geotextile (i.e. wire mesh, steel wire fabric used for concrete reinforcement, etc.)

The surface upon which the geotextile is to be placed shall be within reasonable conformity to the proposed grade. The geotextile shall be laid loosely so that placement of the overlying material will not stretch or tear the geotextile. The overlying course shall be placed in one lift and compacted as approved by the Engineer.

The geotextile shall be placed to conform loosely to the shape of the trench.

After placing the filter material, the geotextile shall be folded over the top of the filter material to produce a minimum overlap of 30 cm. The geotextile shall then be covered with the subsequent course.

D.4.4 Backfilling

D.4.4.1 Materials

Backfill Material

Selection of backfill material is subject to the approval of the Engineer. Fill material shall be, if not specified otherwise, selected and/or crushed so that the maximum grain shall not exceed one half of the thickness of the layer for compaction and that it shall have a continuous gradation allowing for easy compaction. For trenches, the maximum grain size shall not exceed 50 mm.

Fill material shall be free of organic, soluble or other deleterious materials.

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Should the material selected as backfill become unacceptable to the Engineer for any reason including exposure to weather conditions, contamination and segregation during the progress of the Works, the Contractor shall remove such damaged, softened or segregated material and replace it by fresh approved material.

Sand Embedment

Any kind of pipes and cables shall be laid on and embedded in compacted bed of sand or approved excavated material in accordance with EN 1610. Sand and/or approved backfilling materials from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction without the permission of the Engineer.

D.4.4.2 Graded Aggregates

Graded aggregates shall be used for the backfill of the top of trenches below paved areas. Except where otherwise specified that aggregate shall have the following gradation:

Sieve size (mm):	37,5	25	19	4,75	2,0	0,425	0,075
Per cent passing by weight:	100	60-100	55-85	35-60	25-50	15-30	8-15

D.4.4.3 Drainage Fill and Filter Materials

Free drainage fill and filter material shall be formed of hard durable grain and shall be free from clay, silt, soluble or organic matter. The particle size distribution shall be in accordance to the filter rules.

The Contractor shall provide for free drainage materials from approved sources. The Contractor may use material from excavation, provided it is suitable and processed in compliance with the specification of free drainage material.

D.4.4.4 Rip Rap

Riprap material shall be sound, un-weathered and with low water absorption capacity in order to avoid cracking, bursting and dripping as a result of weather influences.

The rock shall mainly consist of large pieces with lateral lengths from 150 to 400 mm and smaller parts to secure the boulders against sliding and to provide stability to the fill structure. The distribution of the size of the riprap material should be:

- 150 – 225 mm: 20% in weight;
- 225 – 325 mm: 60% in weight;
- 325 – 400 mm: 20% in weight.

The density of riprap material shall be not less than 2,2 t/m³ (solid volume without voids) and each piece of riprap shall have its greatest dimension not larger than twice its least dimension.

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The material delivered shall be dumped and graded off to a uniform surface up the lines and grades shown on approved drawings. No pockets of rocks and clusters of large blocks will be permitted.

The Contractor shall submit full details of the proposed source, certified test results and samples to the approval of the Engineer.

D.4.4.5 Stone Pitching

The material used in stone pitching shall be obtained by the Contractor from sources approved by the Engineer.

The stone shall be sound, durable and hard. It shall be free from laminations, weak cleavages and undesirable weathering and shall be of such properties that it will not disintegrate from the action of air, water or in handling and placing.

The dimensions of stones shall range between 200 and 400 mm. The minimum plane dimensions shall be of less than two thirds of the maximum plane dimension for each stone. The density of stones shall be not less than 2,2 t/m³ (solid volume without voids).

The stones shall be roughly dressed so that they fit reasonably close together. They shall be laid to a true and even surface, the spaces between the stones being clinched with spalls.

D.4.4.6 Reuse of excavated Material

Where, in the opinion of the Engineer, excavated materials are not suitable for refill without resorting to sieving or other special means, the Engineer may instruct the Contractor:

- to sieve out stones as may be necessary to meet gradation requirements;
- to transport suitable materials from trench excavation at distances exceeding 200 m from the section to be backfilled (overhaul); or
- to import material from suitable borrow pits to the section to be backfilled.

D.4.4.7 General Backfill

Backfilling materials and methods are generally subject to the approval of the Engineer. The approved materials shall be placed in layers, not exceeding 200 mm in depth before compaction and shall be well compacted as specified in the following:

- The layers of fill material shall be placed in such a manner as to maintain adequate drainage and to prevent accumulation of water.
- The timing and rate of placing of fill material around or upon any completed or partially completed structure shall be arranged in such a way that no part of the works is overstressed, weakened, damaged or otherwise endangered.

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- Around structures the material shall be placed as to exert a uniform pressure and each layer shall be placed with a fall to prevent the accumulation of water.
- Where necessary, the moisture content of the backfill has to be adjusted to an optimum either by drying out or by adding water. After such treatment the backfill shall be thoroughly mixed until the moisture content is uniform.
- Placing the backfilling, due allowance for any settlement that may occur before the end of the Defects Notification Period shall be made. Where necessary, the Contractor shall at the end of the Defects Notification Period remove any excess material or make up any deficiency of backfilling to specified levels.

D.4.4.8 Backfill adjacent to completed Structures

The Contractor shall start backfill only after the walls, floors and slabs have been completed and have attained their full strength. Backfill around the walls of tanks and reservoirs shall not commence before successful completion and testing and after having the Engineer's approval.

The layers of backfill material shall be placed in such a manner as to maintain adequate drainage and to prevent accumulation of water. The material shall be placed with particular care for insulation and watertight paints and all other protective or conserving surfaces and as to exert a uniform pressure around the walls of a structure and each layer shall be placed with a fall to prevent the accumulation of water.

Special attention shall be paid to the compaction of material laid immediately adjacent to concrete walls as to ensure that the material is well compacted. Hand operated vibrating plate compactors, vibro-tampers or power rammers shall be used. The compacting shall be carried out in such a way as to avoid in any case direct contact of the compacting machinery and the building.

In other cases vibrating compactors or pneumatic tyre rollers of types approved by the Engineer may be used for compaction.

D.4.4.9 Embedding of Pipes

Embedding method

Trench bedding shall be in accordance with EN 1610, pipe material and manufacturer, and soil conditions. The Contractor shall submit for approval a method of statement for all representative typical cases including structural pipe computations according to EN 1295-1 or equivalent.

Embedding of pipes and cables includes for the supply of bedding material, preparation of the bed, placing of embedding layers (not more than 0,1 m compacted thickness) and compaction either by hand or with appropriate machines to the specified density below and around the pipes. The embedding works shall be carried out in compliance with EN 1610.

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The bedding material for plastic pipes (GRP, HDPE, PVC) shall be in accordance with the manufacturers requirements.

The bedding material for concrete and steel pipes shall consist of sand-gravel, graded 0/25 mm.

The bedding material for cable conduits and cables shall consist of sand, graded 0/2 mm.

Approval of embedding

Formal approval of embedding shall be obtained from the Engineer prior to the testing of pipes.

D.4.4.10 Main Backfill of Trenches

Backfilling of trenches shall be carried out in accordance with EN 1610.

From the top of the bedding layer up to the finished ground level, the trench shall be backfilled with approved selected material, compacted by mechanical methods approved by the Engineer in layers with a thickness of not more than 150 mm.

Each layer shall be compacted separately. Compaction shall be not less than 95 % modified proctor density. Where necessary, the Contractor shall adjust the moisture content of the refill material to assist the compaction either by drying out or by sprinkling with water.

The Contractor shall provide adequate number of power tampers or other compaction equipment subject to the approval of the Engineer and sufficient water on site for moistening.

The Contractor shall, when placing the backfill, make due allowance for any settlement that may occur before the end of Defects Notification Period. Where necessary, the Contractor shall at the end of this period remove any excess material or make up any deficiency of backfilling to specified levels.

In the event that excavated material is insufficient or unsuitable for backfilling, the Contractor shall use imported fill material from approved borrow pits.

Where directed by the Engineer, trench excavations shall be backfilled with concrete, class C 8/10. Likewise, the Contractor shall use cement stabilised backfill where shown on the drawing or as directed by the Engineer.

D.4.4.11 Tolerances for filling

The fill shall be placed and compacted to a tolerance of – 10 mm / + 15 mm for a final surface. Where further works will be carried out above the fill the tolerance shall be – 25 mm / + 0 mm.

D.4.4.12 Control and testing of the fill

Control testing shall be carried out by members of the Contractor's staff competent to perform the required tests. Additional testing may be carried out at the discretion of the Employer.

Soil compaction tests shall be carried out according to the relevant standards.

D.4.4.13 Allowance for settlement

The Contractor shall make due allowance for consolidation and settlement of fill and compacted fill such that the levels and dimensions of the finished surfaces at the end of the Contract (Defects Notification Period) are within the tolerances specified.

D.4.4.14 Disposal of surplus Material

The disposal of surplus backfill material shall be deemed to be included in the rates for the respective backfilling operations.

The Contractor shall make his own arrangements to dispose of all surplus backfill and unsuitable excavated material from any part of the Work. The material shall become the property of the Contractor and the Contractor shall dispose such material off-Site at locations to be determined by the Contractor and to be approved by the relevant authorities.

The Contractor shall clean the Site and the surrounding ground immediately after completion of works and leave the construction sites clean and tidy to the satisfaction of the Engineer.

D.4.5 Backfilling Sundries

D.4.5.1 Backfilling under paved Areas

When excavation is made in highways, roads, sidewalks or any other paved area, the trench shall be backfilled and thoroughly compacted up to the bottom of the sub base of the surrounding pavement.

The remaining top of the trench shall be filled with graded and well compacted aggregate up to the top of the base of the pavement.

The further reinstatement of surfaces shall correspond to the existing pavements.

D.4.5.2 Backfilling around Chambers

Backfilling around chambers and material used for it shall meet the specifications set out for the backfilling of adjacent trenches.

In roads with a width over 3 m, the material around chambers shall be selected and compacted to meet the requirements of base and sub base.

D.4.5.3 Backfilling in agricultural Land

If pipe alignments cross agricultural land, the trench shall be backfilled to the top of adjacent land; whereby the top 30 cm of the trench shall be filled with the agricultural top soil originally found before excavation.

D.4.5.4 Backfilling in Water Courses

In riverbeds the pipes shall be fully encased with reinforced concrete and the top of the excavation shall be covered with gabions, laid by hand and extending 1 m on either side of the excavated trench; likewise in ditches clad with masonry, the masonry shall be reinstated after completion of backfill with concrete and in small ditches without any surface cladding the trench shall be backfilled to the invert of the ditch with concrete. Concrete shall be reinforced with 80 kg/m³ steel. Concrete shall be of class C 20/25.

D.4.5.5 Field Drains

Should any existing subsoil or field drains be uncovered during general excavation, the Contractor shall either carefully replace them when backfilling, or, if this is impracticable, shall divert them to new drains or ditches, or otherwise relay them as the Engineer may direct.

D.4.6 Embankments

D.4.6.1 Embankments in General

The term “embankment” includes the construction of embankments around structures, hard or other backfill, embankments for road works and the like.

Backfilling to general excavations, the forming of soil tips and the re-filling of trenches are specified and included in the clauses dealing with backfill.

D.4.6.2 Materials for Embankments

Excavated material (including material from borrow pits) to be used as fill material for embankments shall be free from clods and lumps and shall be approved by the Engineer.

If not otherwise directed, cohesive soil shall be placed in layers not exceeding 200 mm in compacted thickness; cohesionless soil shall be placed in layers not exceeding 300 mm in compacted thickness.

Material for hard filling shall be as specified below.

Should the material being placed as filling, while acceptable at the time of selection, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or become puddled soft or segregated during the progress of the works, the Contractor shall

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remove such damaged, softened or segregated material and replace it with fresh approved material.

D.4.6.3 Filling with Hardcore

All fill under structures, unless indicated otherwise on approved drawings or instructed by the Engineer, shall be constructed with hardcore obtained from sources approved by the Engineer.

Hardcore shall be hard inert material passing a 75 mm sieve and be free from clay, silt, soil and vegetable matter and shall not deteriorate in the presence of water.

Hardcore shall be placed in layers not exceeding 150 mm thickness after consolidation and each layer shall be compacted by mechanical means. The final surface of hardcore shall be blinded with fine crushed stone and thoroughly compacted.

D.4.7 Reinstatement and Maintenance

D.4.7.1 Reinstatement of paved Surfaces

The Contractor shall restore all pavements or other surface structures removed or disturbed as a part of the work to a condition suitable and satisfactory to the Engineer.

No pavement shall be restored unless and until, in the opinion of the Engineer, the condition for backfill is given in such a way as to properly support the pavement.

The reinstatement of road surfaces and other pavements will be commenced upon approval of the Engineer of the completed backfill and shall be done, if not otherwise stated, as follows:

- The top of the pipe trench (below the top of the base) shall be filled with graded aggregate (0 - 60 mm of natural stabilized material), watered, placed in layers of max. 15 cm thickness and compacted to not less than 95 % of maximum dry density according to modified proctor test.
- At pipeline crossings, the top 30 cm of the trench shall be filled with plain concrete C 12/15.
- At the top of the base, the width of the trench shall be increased for 15 cm on each side. In order to ensure appropriate adjustment of the surfaces the Contractor shall use such methods as will ensure the breaking of the pavement along straight lines, preferably by cutting. The face of the remaining pavement shall be approximately vertical.
- The surface shall be restored in accordance with the existing pavement and/or instructions of the Engineer.

D.4.7.2 Reinstatement of unpaved Surfaces

Gravel roads and unpaved roads shall be reinstated to their original condition. If the original road construction cannot clearly be applied, then 100 mm approved large gravel and 150 mm well-graded gravel compacted to 95 % of maximum density shall be provided.

D.4.7.3 Surface Reinstatement in agricultural Fields

After the Contractor has completely backfilled the trenches in fields and grass verges to the level specified, he shall replace all topsoil previously removed and it shall be evenly distributed and levelled over the full extent of the stripped area.

Such working area occupied by the Contractor as was originally grown with grass shall be sown with grass seed of equivalent quality and maintained until the new grass is properly established.

Other areas not originally down to grass shall be dressed with suitable fertilisers harrowed in so as to restore the original level of fertility.

D.4.7.4 Reinstatement of existing Services

Where excavation is carried out close to or across the line of sewers, pipes, cables or other services, whether underground or overhead, the Contractor shall, where necessary, provide at his own cost temporary supports or slings and where such services are temporarily disturbed, they shall be replaced.

D.4.7.5 Reinstatement of Hedges, Fences and Walls

Where excavation disturbs features such as hedges, fences and walls, the Contractor shall, as a temporary measure, provide temporary fencing for any such parts of such barriers.

After excavation has been reinstated, the Contractor shall carry out such work as approved by the Engineer for permanent restoration of such barriers.

In case of hedges, saplings of the appropriate species and on both sides shall replace the section removed by providing an adequate post and barbed wire fence.

During the Defects Notification Period all hedges replanted in the above manner shall be inspected and any dead sapling replaced by the Contractor.

The reinstatement of the backfilled surface shall include (1) the re-excavation of the top surface, base and sub base, (2) compacting the backfill in the trench, (3) backfilling the base and sub base with graded aggregate and (4) reinstatement of the surface according to surface conditions met before.

D.4.8 Auxiliary Works

Unless otherwise specified, all and any kind of works, materials, services, safety measures, etc., as well as, and if so requested by the Engineer, all tests and samples required for the Completion of the Works shall be included in the unit rates offered. Hence, the auxiliary works comprise, but are not necessarily limited to, the following:

- Removing and storing of boundary stones, bench marks, etc., protection of surveying points and designation by means of boards, survey and protection of all secondary survey points, profiles, etc.;
- Difficulties to be overcome where excavation may have to be carried out in layers by hand;
- Keeping off or diversion of water, any pumping required, difficult work caused by water, etc.;
- Removal of any groins, buried pipes, wattle work, fascines and the like that might interfere with excavation profiles;
- Difficulties resulting from the specifications relating to fills, compaction tests, eliminating unsuitable material from fills, and, if necessary, mixing of different soil materials;
- Transport of excavated material to fill or deposit, placing and spreading in layers according to conditions and drawings, and careful compaction;
- Difficulties in transport due to existing subsoil conditions;
- Grading of intermediate and top fill surfaces and slopes to lines and levels required;
- Sorting of excavated material which, if necessary, is to be used for special purposes;
- Any expenditure for providing, maintaining and later removal of drive ways and roads, providing, placing, maintaining and later removal of conveying and dumping equipment that might be required.

D.4.9 Dewatering

Dewatering applies for all filling works to be carried out below the groundwater level. Dewatering shall be done by pumping out the water from drains, pits and trenches or by other dewatering means, all subject to the Engineer's approval.

The Contractor shall maintain all earthworks surfaces in a way that no water coming from any source can penetrate into it to soften and destroy the achieved compaction. Hence all works shall be implemented above the water level and be considered as earthworks in a dry and maintained environment.

Furthermore, dewatering should avoid any erosion of filled material. This applies especially for surfaces and slopes. In case surfaces have to be reinstated because of erosion, the Contractor shall bear all costs connected to it. The Contractor shall keep the site reasonably free from water, as long as work is being performed within them. In case, the presence of water is

considered endangering the works, dewatering operation shall continue until elimination of the danger.

It is recommended that the final layers of built platform should be compacted to show a roof shape of which the lowest parts are supplied with temporary drains.

D.4.10 Top Soil

So far as practicable, topsoil shall be obtained from material emanating from excavations and separately stored in temporary spoil tips as specified or directed by the Engineer.

If, in the opinion of the Engineer, the Contractor cannot reasonably obtain sufficient topsoil in this way, the Engineer may order the Contractor to provide extra material from an approved source off the Site.

Topsoil shall be evenly spread and trimmed over embankments and filled excavation to the slopes and levels as shown on approved drawings. The depth after spreading and trimming shall be 250 mm measured perpendicular to the surface. All clods and lumps shall be broken up and any rubbish, large stones, roots and weeds shall be removed.

Where the upper layer of natural soil is poor in organic matter, it shall be improved to a minimum depth of 25 cm by adding either clay or sand or silt to create a loamy soil texture consisting of 40 % sand (size > 0,05 mm), 30 % silt (size 0,05 to 0,002 mm) and 30 % clay (size < 0,002 mm).

A shallow ripping will be required before adding clay or sand or silt which shall be mixed properly by using a disk harrow. If it shall be necessary for topographical reasons, levelling shall be carried out before mixing clay, sand or silt.

D.4.11 Grassing

Where the topsoil shall be sown with grass seed, the top 75 mm of the previously laid topsoil shall be brought to a fine tilth suitable for seeding, and sowing shall be carried out as soon as practicable after completion of top soiling, having due regard to the season and the weather conditions. If ordered by the Engineer, subsoil lime and fertiliser shall be applied in accordance with his directions.

After the seed has been sown uniformly, the surface shall be raked and lightly rolled. The young grass shall be kept free from weeds and any bare patches shall be re-seeded until an even close turf is established. The grass shall be watered, mown and rolled as required and maintained in good condition until the expiry of the Defects Notification Period.

The Contractor shall replace, at his own cost, any damaged area where the grass has dried up or has not adhered to the slope surface, which contains undesirable plants or which has an irregular or unattractive appearance in the Engineer's opinion.

D.4.12 Shrubs and Trees

Shrubs for borders and hedges shall have a minimum height of 0,6 m. A selection of 2 plants per m² are to be planted to create an evenly dense area.

Trees to be supplied and planted shall have a minimum height of 1,5 m.

For the plant holes, vegetable soil is to be used. Stabilization of freshly planted trees against wind actions shall be provided. Shrubs and trees shall be suitable for the climatic conditions on Site. The Engineer shall approve the species the Contractor intends to plant.

Growth of shrubs and trees shall be guaranteed for one year from the day of planting. Any shrubs and trees which have died within the guarantee period must be substituted without extra payment.

D.4.13 Dressing of Topsoil

After planting of lawn, shrubs or trees, the topsoil shall receive a dressing of fertiliser. As minimum requirements, dressing of topsoil shall be done with lime, potash and super-phosphate, as applicable.

Dressing of topsoil shall only be carried out after watering. The surface of the soil shall be kept wet until fertilisers have dissolved.

D.5. PILING

D.5.1 General

The piling works required to include all materials, labour, equipment, testing and all operations under this item to complete the work indicated on drawings and described in these specifications.

The Contractor has to submit the system he will be using for construction to be approved by the Engineer.

The Contractor is not obliged to use the proposed design for piles. In case he has another alternative, he must submit this alternative to the Engineer to be checked and approved. The loads acting on piles are given in the drawings.

The Contractor is responsible for the setting out of piles. He has to obtain written agreement of the Engineer to the setting out. This agreement does not remove the responsibility of the Contractor for the correctness of work.

D.5.2 Materials and Workmanship

The lengths of piles may be varied by instructions of the Engineer as a result of data derived from the driving and/or test loading of driven, cast-in situ or bored piles, or as a result of further detailed information obtained as to the soil characteristics.

Piles shall be installed using approved piling plant appropriate to the ground conditions and the design loads.

Installation of piles must not affect in any way the stability of the neighbouring structures.

Bored piles shall be formed by methods approved by the Engineer and shall comply with EN 1536 and/or other equivalent applicable standards.

The quality of production of bored piles and cast in situ concrete shall be

Drilling	if bored using stabilizing suspension: $\geq 1\text{m}$ excess pressure by suspension if bored using a piping: $\geq 1\text{m}$ excess pressure by water
Using a stabilizing suspension:	the contractor has to prove that the stabilisation of the suspension will not collapse
Groundwater	groundwater has to be investigated with respect to concrete aggressiveness acc. to ISO 22475-1/2. Appropriate corrective measures shall be taken in the mix design to counteract any deleterious properties of the ground water.

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Mix design	The concrete has to be a watertight concrete. The mix design has to be submitted to the site supervision for approval, at least 4 weeks before starting the production of piles
Exposition Class	XA2, if investigation of groundwater does not demand higher exposition class
Limitation of cracks	$\leq 0,3$ mm in case of exposition class XA3 $\leq 0,2$ mm
Concrete Class	according to statical requirements, but $\geq C 25/30$,
Cement	sulphate resisting cement, HS
Cement content	≥ 375 kg/m ³
Water-cement ratio	$< 0,6$
Aggregates	pile diameter 0,4 m: 0/16 pile diameter $> 0,4$ m: max grain size 22 mm is proposed favourable range of grain sizes:
Longitudinal reinforcement	$d \geq 16$ mm
Spacing of longitudinal bars	≥ 10 cm
Secondary (spiral) reinforcement	$d \geq 6$ mm
Coverage	dependend on exposition class ≥ 50 mm if borehole is cased, in case of drilling using stabilizing suspension the theoretical coverage is ≥ 75 mm

After production the quality of the production of all piles has to be tested by accepted testing method (integrity checking: Low-Strain, High-Strain, Down-Hole or equivalent).

The piles shall be reinforced in their full length. Reinforcement of piles shall extend sufficiently to be incorporated with the capping reinforcement with at least the minimum laps specified. The details of all capping arrangements shall be subject to the Engineer's approval.

Piles shall be driven or cast truly vertical or to the required rake and piles inaccurately driven or positioned, or piles damaged shall be rectified as required by the Engineer.

A record of the pile installations work and associated observations shall be submitted to the Engineer at the end of each day of work.

The records shall contain description of penetrated deposits and measurement of the associated interface levels of each type of deposit.

In additions the records shall include information on date, operator, piling equipment, duration of work in the different strata, type of pile, water level before and after the installation, toe level, water jetting, if any, and the name of the foreman or supervisor in charge.

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Before installation all piles shall be marked per m in the whole length with clear indication of the figures from toe to top.

All piles shall be subject to approval by the Engineer before and after installation. Piles may be rejected by the Engineer if they appear to have been damaged, cracked, located out of the line or tolerance, incorrectly fabricated, marked, stored or handled, or they have been lengthened in a way that is not approved. Rejected piles shall be substituted by other piles as directed by the Engineer, and rejected piles, not left embedded in the soil, shall promptly be removed from the site as directed by the Engineer.

Where, in the opinion of the Engineer, incorrectly placed, inaccurately installed or damaged piles can result in the necessity for installing additional piles or altering the capping arrangement, all such additional material, labour, plant, etc, as may be required, shall be provided to the Engineer's satisfaction.

Piles selected by the Engineer shall be test loaded to 1,5 times their working load. The number of all piles justifies a number of at least 3 pile load tests. The charges have to be included in the unit rates.

The Contractor shall provide all necessary apparatus and assistance for the testing of piles as required by the Engineer.

D.5.3 Concrete Pile Foundations

D.5.3.1 Standards

In addition to the standards as listed, the following standards shall apply:

- ASTM D 1143 Piles under static axial compressive load
- ASTM D 3689 Test method for individual piles under static axial tensile load
- ASTM D 3966 Test method for piles under lateral loads
- ASTM D 4945 Test method of high strain dynamic testing on piles
- ASTM D 5882 Test method of low strain dynamic testing on piles
- EN 1536 Bored piles
- ENV 1997 Eurocode 7: geotechnical design
- EN 12699 Displacement piles

D.5.3.2 General

Pile foundation may be necessary for supporting structures where the subsoil is considered to have insufficient bearing capacity. The Contractor shall carry out detailed design of these structures in accordance with the Contract Conditions and technical specifications and shall

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determine the type of foundation required, the number of piles and their working loads and the optimum arrangement of piles required for supporting the structures.

Excavation, concrete steel reinforcement and steel casing where applicable shall conform to the relevant Clauses of the technical specifications.

At least 21 days before the Contractor intends to commence piling work on the site the Contractor shall submit for the Engineer's approval full details of his proposed piling system including the type and dimensions of piles, reinforcement details and full details and full design and driving calculations. The details to be submitted shall include the Contractor's proposals for equipment, temporary works and construction methods.

No work on piling shall commence on the site until the Engineer's approval to the Contractor's proposal has been received.

D.5.3.3 Types of Piles

Bearing piles shall be driven reinforced concrete, precast concrete or cast in-situ concrete piles. All concrete shall be in sulphate resisting cement.

D.5.3.4 Design of Piles

Piles shall be generally designed in accordance with appropriate standards and the materials and work shall conform to the requirements of the technical specifications. Piles shall be designed to sustain the specified loads with settlements not exceeding those specified. Allowance shall be made in the design for the incidence of negative skin friction where appropriate and for resisting the necessary tensile forces due to the swelling and heave of any soil stratum. Piles shall be designed to have a bearing capacity of at least 2,5 times the working load.

The permissible load of piles shall be modified where necessary to allow for particular conditions: piles in close proximity or in groups, soil strength, groundwater level, and other relevant factors.

The piles shall be of sufficient cross-section and length to sustain loads specified without settlement exceeding the following:

- 1,0 x working load Allowable settlement 8 mm
- 1,5 x working load Allowable settlement 10 mm
- 2 x working load Allowable settlement 12 mm

These settlements shall include both permanent and elastic deflections. Measurement of the settlement shall be made on first achieving the specified load. Measurement of the settlement shall be made at the point of application of the load.

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Where piles in place are subjected to handling, stacking and pitching or bending moments and/or shear forces, these shall be combined with the vertical loads (either in compression or tension) to satisfy the design requirements.

The average compressive stress in the concrete of bearing piles under working load shall not exceed 25 % of the characteristic cube strength at 28 days, calculated on the total cross-section area of the pile shaft.

D.5.3.5 Preliminary Test Piles

After the Engineer has approved the Contractor's proposals and calculations for the proposed piling system, preliminary test piles shall be constructed as instructed by the Engineer. These shall be loaded to 2,0 times the working load to prove the design and system and to demonstrate that the safe load requirements can be achieved by the piling method proposed.

The preliminary test piles shall be located in places proposed by the Contractor and approved by the Engineer. The Engineer shall be given at least 48 hours notice before commencement of construction of the preliminary pile which is to be test-loaded.

The preliminary test piles shall be constructed / installed in a manner similar to that to be used for the construction of the working piles by the use of similar equipment and materials. Any variation will only be permitted with the prior approval of the Engineer.

The pile shafts shall be extended where necessary above the cut-off level or working piles so that gauges and other apparatus to be used in the testing process will not be damaged by water or failing debris and to permit exposure of the reinforcement.

Where the pile shaft is extended above the cut-off level of the working piles in soils which would influence the load bearing capacity of the pile a sleeve shall be left in place during testing to eliminate friction which would not arise in working piles.

If the cut-off level is below ground level and the shaft is not extended and there is a risk of the borehole collapsing, a sleeve shall be left in place or inserted above the pile shaft or other means satisfactory to the Engineer shall be employed. Adequate clearance shall be given between the top of the pile shaft and the bottom of the sleeve to permit unrestricted movement of the pile.

For piles that are tested in compression the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile sufficiently large to accommodate the loading and settlement measuring equipment and shall be adequately reinforced or protected to prevent damage due to the concentrated application of load from the loading equipment.

The pile cap shall be concentric with the test pile and the joint between the cap and the pile shall have a structural strength equivalent to that of the pile.

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A sufficient clear space shall be made under any part of the cap projecting beyond the part of the pile so that at the maximum anticipated settlement, load is not transmitted to the ground except through the pile.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide a strength equal to the maximum load which is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

If the preliminary test pile fails to meet the requirements of the technical specifications, the piling system proposed will be considered unsatisfactory. The Contractor shall then submit revised proposals and calculations to the approval of the Engineer. Unless otherwise agreed by the Engineer any test pile which has failed the preliminary test will be rejected and the Engineer may instruct the Contractor to provide one or more further test piles and tests to prove his modified system at no additional cost to the Employer.

D.5.3.6 Lengths and Tolerances

The Contractor shall determine the approximate lengths of piles by examination of the available geo-technical information including information obtained from any additional site investigations carried out by the Contractor. The final length of piles shall be decided by constructing the piles to a minimum depth on the basis of the geo-technical information.

Precast piles shall be constructed within the following tolerances:

- in plan, at the working level of the piling rig $0,15 \times B$ in any direction from the designed position. B = pile dimension (diameter or side)
- $1/75$ from the vertical for a vertical pile

The cross-sectional dimensions of the pile shall not be less than those proposed by the Contractor nor should they exceed them by more than $0,015 \times B$ (B = pile dimension, diameter or side). No face of a precast pile shall deviate by more than 6 mm from a straight edge 3 m long laid on the face. The centroid of any cross-section of the pile shall not deviate by more than 12 mm from the straight line connecting the centroids of the ends.

D.5.3.7 Sequence for Constructions

The sequence of construction of piles shall be to the approval of the Engineer and shall be arranged so as to minimise the vertical and lateral displacement of piles already installed. Levels of the tops of adjacent piles or the structures founded upon them or any other structure shall be measured at intervals while a pile is being installed. Driven piles driven which have risen, shall be re-driven or forced down to the original resistance.

D.5.3.8 Driving Piles

The Contractor shall submit for the Engineer's approval details regarding the suitability efficiency and energy of his driving equipment.

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Precast (prestressed) concrete piles shall not be driven until the concrete has achieved the specified characteristic strength.

Cast-in-situ driven piles with steel casing shall be bottom driven by using a casing which shall not distort or buckle during driving. Concrete casing shall be driven on the pile shoe using a mandrel.

Each pile shall be driven continuously until the approved set and/or depth has been reached except that the Engineer may permit the suspension of driving will be substantially re-established on its resumption or if he is satisfied that the suspension of driving was beyond the control of the Contractor.

A follower (long dolly) shall not be used except with the approval of the Engineer who will then require the set to be revised to take into account the reduction in the effectiveness of the hammer blow.

The final set of each pile shall be recorded either as the penetration in mm per 10 blows or as the number of blows required to produce a penetration of 25 mm. When a final set is being measured, the following requirements shall be met:

- a) The exposed part of the pile shall be in good condition without damage or distortion;
- b) The dolly and packing if any shall be in sound condition;
- c) The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check driving resistances. A set for the purposes of the Contractor shall only be taken in the presence of the Engineer unless otherwise agreed.

At the start of the work and in new areas or parts, sets shall be taken at intervals during the last 3 m of driving to establish the behaviour of piles.

The Contractor shall inform the Engineer without delay if an unexpected change in driving characteristics is noted. A detailed record of driving resistance over the full length of the nearest available pile shall be taken.

Redrive checks if required shall be carried out by a procedure to be agreed by the Engineer.

Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of the ground.

Measurements shall be taken to determine the movement of ground or any pile resulting from the driving process when required by the Engineer.

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Where piles have risen or moved out of plumb as a result of driving adjacent piles the Contractor shall submit to the Engineer his proposals for correcting such faults and their avoidance in subsequent work.

Where pre-boring is required by the Contractor each pile shall be pitched into a hole pre-bored before driving to the required depth.

Jetting may be carried out only when approved by the Engineer and the Contractor shall submit detailed proposals and it shall not normally be undertaken over the last 3 m of penetration.

D.5.3.9 Repair and Lengthening of Piles

In preparation for repairing the head of a pile, the concrete shall be cut off square at sound concrete to expose the reinforcement and all loose particles shall be removed by wire brushing followed by washing with water.

If the pile is to be subjected to further driving the head shall be replaced with concrete of an approved class.

If the pile has been completely driven but the sound concrete is below cut-off level the pile shall be made good to cut-off level with concrete of a class not inferior to that of the concrete of the pile.

In preparation for lengthening a normal reinforced pile, the concrete shall be cut off square to expose a sufficient length to ensure that the full strength of the bars will be developed across the joint.

Welded joints shall be made in accordance with ISO 17660, ISO 10809, ISO 5817 or equivalents and before welding the main longitudinal reinforcing bars in the head of the pile shall be exposed for at least 300 mm below the position of the weld.

For lap or splice joints sufficient link bars shall be provided to resist eccentric forces.

If the pile is to be subjected to further driving the additional length shall be of an approved grade of concrete. Piles shall not be driven until the added concrete has reached the specified characteristic strength of the concrete of the pile.

D.5.3.10 Reinforcement

Unless otherwise stipulated by the design, cast in situ piles shall be reinforced over the whole of their length. The minimum longitudinal reinforcement shall be 1,0 % of the gross concrete area in the top 3 m of the pile and 0,8 % of the gross concrete area in the remainder of the pile. Lateral ties shall be provided to maintain the alignment of the longitudinal reinforcement at centres not closer than 150 mm.

Concrete cover in-situ piles to the outermost reinforcement, including binding wire shall not be less than 60 mm measured to the inside of the casing.

D.5.3.11 Pile Shoes

Driven piles shall be provided with flat or pointed co-axial shoes of cast iron if driving is liable to damage the concrete at the tip of the pile.

Cast iron pile shoes shall be made from "chill hardened" iron of the grade used for making grey iron castings. The chilled iron point shall be free from major blow holes and other surface defects.

D.5.3.12 Records

The Contractor shall maintain a complete record of all piling works which shall include the following, where relevant:

- Pile type and number;
- Nominal diameter or dimension and pile length;
- Date concreted and date driven;
- Depth from ground level to toe of pile;
- Depth from ground level bearing stratum;
- Final set, weight and drops of hammer;
- Details of any obstructions observed.

All records shall be accurately kept in duplicate as the work proceeds and one copy shall be handed to the Engineer at the completion of each day's work.

D.5.3.13 Precast Reinforced Concrete Piles

D.5.3.13.1 General

Precast reinforced concrete piles shall be designed cast and cured to develop the strength necessary to withstand the transporting, handling and driving stresses without damage. Square piles shall have chamfered corners. Manufacturing and curing shall be in accordance with International standards.

D.5.3.13.2 Handling of Precast Piles

Precast (prestressed) concrete piles shall be handled, transported, and stored by methods that will not injure the pile. The piles shall be supported while being handled, transported, and stored, at the pick-up points shown on the plans, or else shall be supported along their full length. Piles damaged in handling or driving shall be replaced by the Contractor.

D.5.3.14 Cast-In-Situ Piles

D.5.3.14.1 Driven or Bored Cast-In-Situ-Piles

Driven or bored cast-in-situ piles shall comprise a temporary or permanent casing of steel, or a permanent casing of precast concrete, augered or driven to a set and completely filled with dense concrete reinforced with steel bars.

All joints in the casing and between the casing and shoes where applicable shall be watertight during driving and completion of driven cast-in-situ piles. Permanent casing shall be inspected, e.g. by using a light lowered from the top after installation to ensure that the casing is neither damaged nor deformed and that all loose soil has been removed from the bottom of bored piles.

Drilling mud shall not be used unless otherwise approved by the Engineer.

D.5.3.14.2 Casing for Cast-In-Situ Piles

The casing shall be suitable for the method of installation and for the purpose of jointing piles. The casing shall either be permanent or temporary.

Steel casing shall be delivered to site in lengths as long as can be conveniently handled. Ends shall be prepared for butt welding and designed to maintain true alignment of the pile.

Joints between steel casings shall be made by butt welding according to ISO 17660, ISO 10809, ISO 5817 or equivalents so that the full strength of the original part is developed. Welded joints shall be watertight.

D.5.3.14.3 Concrete Cast-In-Situ Piles

The slump for the concrete shall be agreed with the Engineer prior to concreting preliminary test piles. Concrete filling in cast-in-situ piles shall be placed continuously. Removal of temporary casings must be completed before the placed concrete loses its workability, but placing of concrete shall keep in advance of withdrawal of casing to prevent 'necking'.

Pile heads shall be stripped down and bonded into the pile caps as specified for precast concrete piles.

D.5.3.15 Pile Load Tests

Pile load tests shall be carried out in the following situations:

- When using a type of pile or installation method that is outside comparable experience and which has not been tested under comparable soil and loading conditions;
- When using a piling system which is outside the experience of the operatives carrying out the work;

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- When the piles will be subject to loading for which theory and experience do not provide sufficient confidence in the design. The pile testing procedure should then provide loading similar to the anticipated loading;
- When observations during the process of installation indicate pile behaviour that deviates strongly and unfavourably from the behaviour anticipated on the basis of the site investigation or experience and when additional ground investigations do not clarify the reasons for this deviation.

Load test can be static or dynamical.

If a load test is carried out, it shall normally be located where the most adverse ground conditions are believed to occur. If this is not possible, an allowance shall be made when deriving the characteristic value of the bearing resistance.

If load tests are carried out on two or more test piles, the test location shall be representative of the site of the pile foundations, and one of the test piles shall be located where the most adverse ground conditions are believed to occur.

Between the installation of the test pile and the beginning of the load test, adequate time shall be allowed to ensure that the required strength of the pile material is achieved and the pore pressures have regained their initial values.

D.5.3.15.1 Static Load Tests

Loading Procedure

The pile load test procedure, particularly with respect to the number of loading steps, the duration of the loading steps and the application of load cycles, shall be such that conclusions can be drawn about the deformation behaviour, creep and rebound of a pile foundation from the measurements on the pile. For trial piles, the ultimate loading shall be such that conclusions can also be drawn about the ultimate failure load.

Static load tests shall be carried out in accordance with the respective standard. In case of different wording, the text in this technical specifications shall be valid prior to the above mentioned recommended procedure.

Devices for the determination of forces, stresses or strains and displacements shall be calibrated prior to the test.

In general, pile load tests for the purpose of designing a tensile pile foundation should be carried out to failure. Extrapolation of the load-displacement graph for tension tests should normally not be used, especially in the case of transient loading.

Trial Piles

The number of trial piles required to verify the design shall be selected based on the following aspects:

- the ground conditions and their variability across the site;
- type of structure;
- documented evidence of the performance of the same type of pile in similar ground conditions;
- the total number and types of piles in the foundation design.

The ground conditions at the test site shall be investigated thoroughly. The depth of borings or field tests shall be sufficient to ascertain the nature of the ground both around and beneath the pile tip. It shall include all strata likely to contribute significantly to pile deformation behaviour, at least 5 times the diameter beneath the pile tip, unless sound rock or very hard soil is found at a lesser depth.

Working Piles

The number of working pile load tests shall be selected on the basis of the recorded findings during construction.

The selection of the working test piles should be prescribed in the contract documents.

The load applied to the working test piles shall be at least equal to the design load governing the design of two foundations.

D.5.3.15.2 Dynamic Load Tests

Dynamic load tests shall be carried out in accordance with the respective standards.

The results of dynamic load tests may be used for design, provided an adequate site investigation has been carried out and the method has been calibrated against static load tests on the same type of pile, of similar length and cross-section, and under comparable soil conditions.

Dynamic load tests may be used as an indicator of the consistency of the piles and to detect weak piles.

In a dynamic load test the pile is instrumented with accelerometers and strain gauges. The gauges are connected to a recording and data processing device. During blows on the pile signals from the gauges are recorded and processed for assessment of pile bearing capacity. The data processing will be one of two kinds, either simple or signal matching (CASE or similar program). The simple method gives instant results while signal matching is more time consuming (hours).

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In the CASE method or similar the following data shall be registered and reported:

- bearing capacity;
- toe resistance and skin friction;
- maximum compression stress, acceleration, velocity and displacement;
- maximum tension stress in pile;
- pile structural integrity; extent and location of damage;
- maximum energy transferred to the pile;
- blows per minute for hammer check;
- blow number;
- input and reflection of force, velocity, upward and downward force waves;
- load versus deflection of cushions and of pile toe bearing.

CAPWAP or similar programs determines that set for soil resistance parameters which produces the best match between measured and computed pile top force and velocity. After CAPWAP analysis additional information than above for CASE is accomplished as:

- deformation properties, ultimate capacities and soil damping parameters for each soil segment of normally 1 m length;
- unit skin friction for each segment and end bearing;
- maximum of tension and compression forces and stresses;
- pile structural damping;
- dynamic pile toe displacement;
- graph on bearing capacity and pile stresses versus blow count.

An introductory program (WEAP) can be utilised before pile driving to assess preliminary combinations of sets and bearing capacities for specified pile, driving equipment and soil conditions.

The data processing shall be carried out by well experienced experts.

Dynamic Load Test Procedure

The Contractor shall notify the Engineer at least two weeks prior to dynamic testing.

The Contractor shall submit a qualified testing Consultant and his experience to the Engineer for approval.

The Engineer shall determine if the test is to be performed or if some pile waiting periods at the proposed site is required before a decision will be made.

The Engineer will establish a date for the tests and will also determine the location of all piles to be dynamically load tested.

Dynamic Load Test Procedure on Driven Piles

The Contractor shall supply all personnel and equipment needed to strike the test pile with the hammer.

The Contractor shall provide the hammer (drop, diesel, etc.) or the mobile crane to lift a steel ram weight by a single non-twisting cable and be able to strike to the pile top by mean of full-gravity-fall.

The instrument for the dynamic load test shall conform to the standards, e.g. ASTM D 4945.

Approximately two driven piles will be tested in one day. The testing Consultant personnel will drill holes into the pile to be tested so that transducers (two accelerometers and two strain gauges) can be attached. Testing procedures shall be conformed to e.g. ASTM D 4945.

When the transducers have been placed in position and the recording and processing equipment has been made ready to receive the acceleration and strain measurements, the Engineer will instruct the Contractor regarding the drop height and the Contractor shall strike the driven pile with the hammer as many times as is required to obtain adequate measurements as determined by the Engineer.

The Engineer may ask the Contractor to provide surveying instrument to monitor the pile set after each strike.

After the dynamic testing measurements have been obtained and analysed and a report has been submitted, the Engineer will provide instructions for the results.

Dynamic Load Test Procedure on Bored Piles

The Contractor shall prepare the pile top and if necessary improve the structural integrity of the pile top to resist a sharp impact force. All loose concrete at the pile top shall be removed. The top portion of the bored pile shall be extended to a length of at least two times the diameter of the bored pile with the same diameter as the bored pile. The extended portion of the bored pile shall be cast with concrete having a minimum compressive strength of 40 MPa.

Additional shear reinforcement such as spiral hoop at the pile top is recommended for the impact force. The Contractor shall provide the windows for the installation of instrument by burning an opening 0,35 x 0,35 m² to the steel casing using a cutting torch.

On top of the bored pile a timber cushion under steel plate as a hammer cushion shall be mounted. Adhesive material may be applied between the pile top and the timber.

The Contractor shall provide an additional steel casing inserted into the pile top. This casing is acting as a guide for the steel ram weight, having the length not less than the summation of the drop height and the length of the steel ram weight. It is important to secure and stabilise the steel casing by means of a vibratory hammer.

The Contractor shall supply all personnel and equipment needed to strike the test pile with the steel ram weight. The Contractor shall provide a mobile crane which has the ability to lift the steel ram weight by a single non-twisting cable and be able to strike to the pile top by mean of full-gravity-fall.

The instrument for the dynamic load test shall conform to e.g. ASTM D 4945.

Approximately one bored pile will be tested in one day. The testing Consultant personnel will drill holes in the windows of the left-in-place steel casing into the pile to be tested so that transducers (two accelerometers and two strain gauges) can be attached.

Testing procedures shall be conformed to e.g. ASTM D 4945.

The Engineer may ask the Contractor to provide surveying instrument to monitor the pile set after each strike.

After the dynamic testing measurements have been obtained and analysed and the report has been submitted, the Engineer will provide instructions for the results.

Load Test Report

The Contractor shall submit a complete record of each pile test to the Engineer 24 hours after completion of the tests. Where appropriate, this report shall include:

- a description of the site;
- the ground conditions with reference to ground investigations;
- the pile type;
- a description of the loading and measuring apparatus and the reaction system;
- calibration documents of the load cells, the jacks and the gauges;
- the installation record of the test piles;
- photographic records of the pile and the test site;
- test results in numerical form;
- time settlement plots for each applied load when a step loading procedure is used;
- the measured load-settlement behaviour;
- justification of the reasons for any departures from the recommendations;

D.5.3.16 Piles in Compression

D.5.3.16.1 Ultimate Bearing Resistance from Static Pile Load Tests

Trial piles to be tested shall be installed in the same manner as the piles which will form the foundation and shall be founded in the same stratum.

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In the case of a very large diameter pile, it is often impractical to carry out a load test on a full size trial pile. Load tests on smaller diameter trial piles may be considered provided that:

- the ratio of the trial pile / working pile diameter is not less than 0,5;
- the trial pile is instrumented in such a manner that the base and shaft resistance can be derived separately from the measurements.

When deriving the ultimate characteristic bearing resistance R_{cc} from R_{cms} values measured in one or several static pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installations, at minimum, both conditions (a) and (b) of the table below shall be satisfied using the equation:

$$R_{cc} = R_{cms} / \gamma_{ns}$$

Factors γ_{ns} to deduce R_{cc} :

Number of Load Tests	1	2	> 2
γ_{ns} on average R_{cms}	1,5	1,35	1,3
γ_{ns} on lowest R_{cms}	1,5	1,25	1,1

In order to derive the ultimate design bearing resistance, the characteristic value R_{cc} should be divided into components of base resistance R_{cbc} and shaft resistance R_{csc} such that:

$$R_{cc} = R_{cbc} + R_{csc}$$

The design bearing resistance R_d shall be derived from:

$$R_d = R_{cbc} / \gamma_{bs} + R_{csc} / \gamma_{ss}$$

where: γ_{bs} and γ_{ss} are taken from the table below.

Values of γ_{bs} , γ_{ss} and γ_{ts}

Component Factors	γ_{bs}	γ_{ss}	γ_{ts}
Driven piles	1,3	1,3	1,3
Bored piles	1,6	1,3	1,5
Continuous flight auger (CFA) piles	1,45	1,3	1,4

In general, the load test only provides the pile load test versus settlement and time versus settlement diagrams, without distinction between point and shaft resistance. Therefore, it is often not possible to distinguish between partial factors for the assessment of the design value of base resistance and shaft resistance. Instead a partial factor on the ultimate characteristic pile resistance R_{cc} may be taken as the γ_{ts} values given in the table above.

D.5.3.16.2 Ultimate Bearing Resistance from Pile Driving Formulae

If pile formulae are used to assess the ultimate bearing resistance of individual compression piles in a foundation, the validity of the formulae shall have been demonstrated by previous experimental evidence of good performance or static load tests on the same type of pile, of similar length and cross-section, and in similar ground conditions.

Pile driving formulae shall only be used if the stratification of the ground has been determined.

In the design, the number of piles to be re-driven shall be specified. If re-driving gives lower results, these shall be used as basis for ultimate bearing resistance assessment. If re-driving gives higher results, these may be taken into consideration.

Re-driving should usually be carried out in silty soils, unless local comparable experience has shown this to be unnecessary.

D.5.3.16.3 Ultimate Bearing Resistance from Dynamic Load Tests

Dynamic load tests and their evaluation can be used to assess pile bearing resistance of individual compression piles. The validity of the evaluation shall have been demonstrated by previous evidence of acceptable performance or static load tests on the same pile type of similar length and cross-section and in similar soil conditions. The input energy level during the dynamic load testing shall be high enough to allow for an appropriate interpretation of the pile capacity at a correspondingly high enough strain level.

When deriving the ultimate characteristic bearing resistance R_{cc} from R_{cmd} values measured in two or several dynamic pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installations a minimum, both conditions (a) and (b) of the table below shall be satisfied using the equation:

$$R_{cc} = R_{cmd} / \gamma_{nd}$$

Factors γ_{nd} to derive R_{cc}

Number of Load Tests	2	4	> 4
γ_{ns} on average R_{cms}	1,5	1,35	1,3
γ_{ns} on lowest R_{cms}	1,5	1,25	1,1

In order to derive the ultimate design bearing resistance, the characteristic value R_{cc} should be divided into components of base resistance R_{cbc} and shaft resistance R_{csc} such that:

$$R_{cc} = R_{cbc} + R_{csc}$$

The design bearing resistance R_{cd} shall be derived from:

$$R_{cd} = R_{cbc} / \gamma_{bd} + R_{csc} / \gamma_{sd}$$

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Where γ_{bd} and γ_{sd} are taken from the table below:

Values of γ_{bd} , γ_{sd} and γ_{td}

Component Factors	γ_{bd}	γ_{sd}	γ_{td}
Driven piles	1,4	1,4	1,4
Bored piles	1,7	1,4	1,6

In case R_{cbc} and R_{csc} are not known the design bearing resistance R_{cd} is derived from:

$$R_{cd} = R_{cc} / \gamma_{td}$$

D.5.3.17 Piles in Tension

Pile load tests to determine the ultimate tensile resistance R_{tc} of an isolated pile shall be carried out in accordance with the international standards.

When deriving the ultimate characteristic resistance R_{tc} from values R_{tm} measured in one or several static pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installation. As a minimum, both conditions (a) and (b) of the table below shall be satisfied using the equation:

$$R_{tc} = R_{tms} / \gamma_{nt}$$

Number of Load Tests	1	2	> 2
γ_{ns} on average R_{cms}	1,5	1,35	1,3
γ_{ns} on lowest R_{cms}	1,5	1,25	1,1

Normally when piles are loaded in tension, more than one pile shall be tested. In the case of a larger number of tension piles, at least 2 % shall be tested.

The design tensile resistance, R_{td} , shall be derived from:

$$R_{td} = R_{tc} / \gamma_m$$

Where $\gamma_m = 1,6$

D.5.3.18 Supervision of Construction

A pile installation plan shall be the basis for the construction work. The plan should give the following design information:

- the pile type with designation if standardised or technical approval otherwise;
- the location and inclination of each pile and tolerances on position;
- pile cross-section;

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- pile length;
- number of piles;
- required pile load carrying capacity;
- pile toe level or the required penetration resistance;
- installation sequence;
- any other constraints on piling activities.

The installation of all piles shall be monitored and records shall be made at site and as the piles are installed. A record signed by the supervisor of the work and the pile manufacturer shall be kept for each pile.

The record for each pile shall include the following, where appropriate:

- pile type and installation equipment;
- pile number;
- pile cross-section, length and (for concrete piles) reinforcement;
- data and time of installation (including interruptions to the construction process);
- concrete mix, volume of concrete used and method of placing for cast-in situ piles;
- pumping pressures of the grout or concrete, internal and external diameters, pitch of screw and penetration per revolution (for continuous flight auger piles or other injection piles);
- for driven piles, the values of driving resistance measurements such as weight and drop or power rating of hammer, blow frequency and number of blows for at least the last 0,25 m penetration;
- the power take-off of vibrators (where used);
- the torque applied to the drilling motor (where used);
- for bored piles, the strata encountered in the borings and the condition of the base, if performance of the base is critical;
- obstructions encountered during piling;
- deviations of positions and directions and as-built elevations.

Records shall be kept for a period of at least 5 years after completion of the works. As built record plans shall be compiled after completion of the piling and kept with the Drawings.

If site observations or inspection of records reveal uncertainties with respect to the quality of installed piles, additional investigations shall be carried out to determine the as-built conditions of the piles and whether remedial measures are necessary. These investigations shall include either re-driving or pile integrity tests, in combination with soil mechanics field tests adjoining the suspected piles, and static pile load tests.

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Tests shall be used to examine the integrity of piles for which the quality is sensitive in a reliable way.

Dynamic low strain integrity tests can be used for a global evaluation of piles that might have severe defects or that may have caused a serious loss of strength in the soil during construction. Since defects, like insufficient quality of concrete and thickness of concrete cover, affecting the long term performance of a pile, often cannot be found by dynamic tests, other tests such as sonic tests, vibration tests or coring may be needed in supervising the execution.

D.5.4 Permanent Steel (Sheet) Piles

D.5.4.1 Standards

In addition to the standards as listed the following standards or equivalent international standards shall apply:

- EN 1537 Grout anchors, design, execution and testing
- EN 12063 Sheet pile walls
- ENV 1997 Eurocode 7: geotechnical design

D.5.4.2 General

The work covered by this Part consists of furnishing and driving of steel (sheet) piles which are to be left in place so that they become a part of the permanent work, all in conformity with the requirements shown on the Drawings or in these specifications.

Application shall be retaining walls and pile foundation, only.

The Contractor shall carry out detailed design of these structures in accordance with the Contract Conditions and technical specifications and shall determine the type of foundation or supporting wall required, the number of piles and their working loads and the optimum arrangement of piles required for supporting the structures or walls.

Excavation and steel shall conform to the relevant Clauses of the technical specifications.

At least 21 days before the Contractor intends to commence piling work on the site the Contractor shall submit for the Engineer's approval full details of his proposed piling system including the type and dimensions of piles, reinforcement details and full details and full design and driving calculations. The details to be submitted shall include the Contractor's proposals for equipment, temporary works and construction methods.

No work on piling shall commence on the site until the Engineer's approval to the Contractor's proposal has been received.

D.5.4.3 Material Quality

The following strength classes shall apply:

- EN 10027-1
- EN 10027-2
- S275JO 1,0143
- S355JO 1,0553

D.5.4.4 Cutting and Welding

No cutting or welding of piles shall be carried out without prior written approval from the Engineer. All such cutting shall be carried out by means of oxyacetylene, oxypropane or other approved method. The remaining pile shall be of clean and even appearance with grinding tools being employed to remove splatter. Cut-offs shall be marked so that it is clear from which pile they came and after agreement from the Engineer will be disposed of in the pre-agreed manner. Cutting must be carried out in such a way as to prevent damage or distortion to adjacent piles. The finished level of the cut pile shall be within 20 mm of the theoretical level.

Only welders who are qualified to the international standards and have a proven record over the previous 6 months, or who have attained a similar standard, shall be employed on the works. Proof of welder proficiency shall be made available to the Engineer on request.

Defective welds shall be cut out and replaced. Where steel sheet piles are to be spliced by butt welding, the interlocks shall not be welded unless a sealing weld is required. Butt welding should only be carried out if the component ends have been matched together to ensure best possible fit.

D.5.4.4.1 Cutting Sheet Piles

When it is necessary to form holes in the sheet piles, they shall be drilled or burnt using a template, and subsequently dressed flush. The hole size shall be of sufficient clearance and will include allowance for bolt / tie coatings and inclination if not horizontal. All holes not required in the finished works which are not sealed in the pile cap or other such detail, shall be sealed by welding a plate of the same grade, of thickness not less than the pile thickness to the pile. The minimum plate overlap shall be 40 mm and the minimum continuous fillet weld size shall be 6 mm.

All holes shall be within a positional tolerance of ± 10 mm.

Holes formed as weep holes to avoid water build up behind the wall shall comply with the above details.

D.5.4.5 Retaining Walls

D.5.4.5.1 Design

Design of the retaining wall structure shall consider ultimate and serviceability limit states.

Ultimate limit states shall include instability of the structure as a whole including the soil mass, failure of the structure by bending or shear and excessive deformation of the wall or soil to the extent that adjacent structures or services are affected. Serviceability limit states shall include limited deformation of the structure and movement of the ground.

Surcharges and externally applied loads on each side of the wall: a minimum surcharge of 0,01 MPa on the retained side of the wall shall be used in design.

A minimum unplanned depth of excavation in front of the wall of 0,5 m or 10 % of the retained height of a cantilever or 10 % of the distance below the lowest support in a supported wall shall be included. In the case of a retaining structure with services buried in the passive zone, allowance shall be made for future excavation to replace or maintain the cables or pipes.

In permanent structures, the long term performance of the steel used must be considered.

Weep holes shall be provided behind the wall for drainage.

Sheet piles parts shall consider stresses caused by driving forces

The design shall consider full hydrostatic pressures behind the wall where this can occur.

D.5.4.5.2 Profiles

The steel sheet piles shall be LX or Larssen, in new condition and shall have an appropriate combined part modulus and mass to be submitted to the Engineer for approval.

The corners, junctions and special piles indicated on the working drawings shall be fabricated at the manufacturer's premises under workshop conditions or similar approved facility with quality assurance systems operative. All such work shall comply (within the tolerances) to the standard dimensions quoted by the manufacturer, or for non-standard fabrications to the approval of the Engineer.

If during the course of the works a requirement for extra fabricated piles occurs, the contractor shall submit to the Engineer for approval, the proposed type and method of manufacture. Piles of the same steel grade and part size as the neighbouring plain piles shall be used, unless otherwise approved.

All materials shall comply with the appropriate standards.

D.5.4.5.3 Tolerances

Width of single pile shall not deviate more than 2 % from nominal width.

Width of interlocked piles shall not deviate more than 3 % from nominal width of interlocked piles.

Maximal bow shall not exceed 0,2 % of total pile length.

Profile height may vary ± 4 mm for profiles heights below or equal 200 mm. Profile height may vary ± 5 mm for profiles heights above 200 mm.

Flange thickness may vary $\pm 0,5$ mm for flange thickness below or equal 8,5 mm. Flange thickness may vary ± 6 % for flange thickness above 8,5 mm.

Web thickness may vary $- 0,5$ mm for web thickness below or equal 8,5 mm. Web thickness may vary $- 6$ % for web thickness above 8,5 mm.

Profiles ends shall be cut plane and perpendicular to profile axis.

D.5.4.5.4 Coating

Steel sheet pile coating protection shall receive the following surface preparation and take the following form:

Sand blast clean to ISO 8501-1, grade 2, then application of high-build isocyanate cured, epoxy pitch (special coal tar pitch, modified with epoxy resins, cured with isocyanate adducts) in coat thicknesses of up to 400 μ m or similar approved by the Engineer.

Due care and attention shall be given to the offloading, storing and installation of protected piles to prevent damage to coatings.

Any remedial work to coatings shall be carried out in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer.

D.5.4.5.5 Capping

The top of the steel sheet pile shall be protected with a cap beam made of reinforced concrete, cross Part not less than 40 cm x 40 cm.

D.5.4.6 Ground Anchors

Pre-stressed ground anchors shall consist of high-strength bar or strand tendons grouted into an inclined hole drilled behind the face of the excavation. The ground anchors shall be installed and tensioned as the excavation progresses downward.

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Wale beams shall be secured to each pair of piles with anchor bolts, washers and bearing plates. All splices, if welded or bolted, shall be at the fifth spacing between ground anchors and splices in wale beams and shall be staggered by a minimum distance of 5 m.

Tendons shall not be used for earthing purposes and will be protected against welding splash. Tendons shall be assembled with necessary taper washers, washers and bearing plates in accordance with the manufacturer's recommendations.

Tendons and fittings shall be protected against corrosion by appropriate and approved means.

D.5.4.6.1 Working Drawings

The Contractor shall submit to the Engineer working drawings and design submittals that shall include the following:

- Ground anchor schedule giving:
 - Ground anchor number
 - Ground anchor design load
 - Type and size of tendon
 - Minimum total anchor, bond, tendon bond, unbonded length
- Drawing of the ground anchor tendon and the corrosion protection system including details for the following:
 - Spacers, centralises, anchorage and trumpet and their location
 - Corrosion protection system for the bond and unbonded length and anchorage
- Certificates of Compliance for the following materials, if used. The certificate shall state that the materials or assemblies to be provided will fully comply with the requirements of the Contract, including:
 - Pre-stressing steel, strand or bar
 - Portland cement
 - Pre-stressing hardware
 - Bearing plates
 - Corrosion protection system

D.5.4.6.2 Tendon Bond Length Encapsulations

When the Drawings require the tendon bond length to be encapsulated to provide additional corrosion protection, the encapsulation shall be fabricated from corrugated HDPE with adequate wall thickness.

D.5.4.6.3 Heat Shrinkable Sleeves

Heat shrinkable sleeves shall be fabricated from a radiation crosslinked polyolefin tube internally coated with an adhesive sealant. Prior to shrinking, the tube shall have an adequate wall thickness.

D.5.4.6.4 Sheath

A sheath shall be used as part of the corrosion protection system for the unbonded length portion of the tendon. The sheath shall be fabricated from a PE tube pulled or pushed over the pre-stressing steel.

D.5.4.6.5 Bondbreaker

The bondbreaker shall be fabricated from a smooth plastic tube or pipe being resistant to chemical attack from aggressive environments, grout, or corrosion inhibiting compound; being resistant to ageing by ultraviolet light; being fabricated from material non detrimental to the tendon; being capable of withstanding abrasion, impact, and bending during handling and installation; and shall enable the tendon to elongate during testing and stressing; and shall allow the tendon to remain unbonded after lock-off.

D.5.4.6.6 Corrosion Inhibiting Compound

The corrosion inhibiting compound placed in either the free length or the trumpet areas shall be an organic compound (i.e. grease or wax) with appropriate polar moisture displacing, corrosion inhibiting additives and self-healing properties. The compound shall permanently stay viscous and be chemically stable and non-reactive with the pre-stressing steel, the sheathing material, and anchor grout.

D.5.4.6.7 Grout Tubes

Grout tubes shall have an adequate inside diameter to enable the grout to be pumped to the bottom of the drill hole. Grout tubes shall be strong enough to withstand the grouting pressure

D.5.4.6.8 Drilling

Drilling methods shall be left to the discretion of the Contractor, if not specified in the contract documents. The Contractor shall be responsible for using a drilling method to establish a stable hole of adequate dimensions, within the tolerances specified. Drilling methods may involve, amongst others, rotary, percussion, rotary / percussive or auger drilling; or percussive or vibratory driven casing.

Holes for anchors shall be drilled at the locations and to the length, inclination and diameter shown on the approved working Drawings. The drill bit or casing crown shall not be more than 3 mm smaller than the specified hole diameter. The ground anchor hole shall not be drilled in a

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location that requires the tendon to be bent in order to enable the bearing plate to be connected to the supported structure.

At the point of entry the ground anchor shall be installed within ± 3 degrees of inclination from horizontal shown on the approved working Drawings. At the point of entry the horizontal angle made by the ground anchor and the structure shall be within ± 3 degrees of a line drawn perpendicular to the plane of the structure unless otherwise shown on the approved working Drawings. The ground anchors shall not extend beyond the right-of-way or easement limits shown on the contract Drawings.

D.5.4.6.9 Tendon Insertion

Tendons shall be placed in accordance with the approved working Drawings and details and the recommendations of the tendon manufacturer or specialist anchor contractor. The tendon shall be inserted into the drill hole to the desired depth without difficulty. When the tendon cannot be completely inserted, the Contractor shall remove the tendon from the drill hole and clean or re-drill the hole to permit insertion. Partially inserted tendons shall not be driven or forced into the hole.

Each anchor tendon shall be inspected by Engineer during installation into the drill hole or casing. Damage to the corrosion protection system shall be repaired, or the tendon replaced if not repairable. Loose spacers or centralisers shall be reconnected to prevent shifting during insertion. Damaged fusion-bonded epoxy coatings shall be repaired in accordance with the manufacture's recommendations.

The rate of placement of the tendon into the hole shall be controlled such that the sheathing, coating, and grout tubes are not damaged during installation of the tendon. Anchor tendons shall not be subjected to sharp bends.

D.5.4.6.10 Grouting

The Contractor shall use a neat cement grout or a sand-cement grout with Portland cement (CEM I) class CE I 32.5, 42.5 or 52.5 in accordance to EN 197. The cement shall not contain lumps or other indications of hydration. Admixtures, if used, shall be mixed in accordance with the manufacture's recommendation.

The grouting equipment shall produce a grout free of lumps and undispersed cement. A positive displacement grout pump shall be used. The pump shall be equipped with an appropriate pressure gauge to monitor pressures. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The mixer should be capable of continuously agitating the grout.

The grout shall be injected from the lowest point of the drill hole. The grout may be pumped through grout tubes, casings, hollow-stem-augers, or drill rods. The grout can be placed before or after insertion of the tendon. The quantity of the grout and the grout pressures shall be

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recorded. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing.

After the tendon is installed, the drill hole may be filled in one continuous grouting operation except that pressure grouting shall not be used in the free length zone. The grout at the top of the drill hole shall not contact the back of the structure or the bottom of the trumpet.

If the ground anchor is installed in a fine-grained soil using drill holes larger than 15 cm in diameter, then the grout above the top of the bond length shall be placed after the ground anchor has been tested and stressed. The Engineer will allow the Contractor to grout the entire drill hole at the same time if the Contractor can demonstrate that their particular ground anchor system does not derive a significant portion of its load-carrying capacity from the soil above the bond length portion of the ground anchor.

The grout tube may remain in the hole on completion of grouting if the tube is filled with grout.

After grouting, the tendon shall not be loaded for a minimum of 3 days.

D.5.4.6.11 Anchorage Installation

The anchor bearing plate and the anchor head or nut shall be installed perpendicular to the tendon, within ± 3 degrees and centred on the bearing plate, without bending or kinking of the pre-stressing steel elements. Wedge holes and wedges shall be free of rust, grout and dirt.

The stressing tail shall be cleaned and protected from damage until final testing and lock-off. After the anchor has been accepted by the Engineer, the stress tail shall be cut to its final length according to the tendon manufacturer's recommendations.

The corrosion protection surrounding the unbonded length of the tendon shall extend up beyond the bottom seal of the trumpet or 10 cm into the trumpet if no trumpet seal is provided. If the protection does not extend beyond the seal or sufficiently far enough into the trumpet, the Contractor shall extend the corrosion protection or lengthen the trumpet.

The corrosion protection surrounding the unbonded length of the tendon shall not contact the bearing plate or the anchor head during testing and stressing. If the protection is too long, the Contractor shall trim the corrosion protection to prevent contact.

D.5.4.6.12 Corrosion Protection

The corrosion protection systems shall be designed and constructed to provide reliable ground anchors for temporary and permanent structures.

All stressing anchorages permanently exposed to the atmosphere shall receive a grout-filled cover, except, for re-stressable anchorages, a corrosion inhibiting compound must be used. Stressing anchorages encased in concrete at least 5 cm thick do not require a cover.

The trumpet shall be sealed to the bearing plate and shall overlap the unbonded length corrosion protection by at least 10 cm. The trumpet shall be long enough to accommodate movements of the structure and the tendon during testing and stressing.

The trumpet shall be completely filled with grout, except re-stressable anchorages must use corrosion inhibiting compounds. Compounds may be placed any time during construction. Compound filled trumpets shall have a permanent seal between the trumpet and the unbonded length corrosion protection. Grout must be placed after the ground anchor has been tested and stressed to the lock-off load. Trumpets filled with grout shall have either a temporary seal between the trumpet and the unbonded length corrosion protection or the trumpet shall fit tightly over the unbonded length corrosion protection for a minimum of 10 cm.

Corrosion protection of the unbonded length is described above.

D.5.4.6.13 Testing - General

Each ground anchor shall be tested. No load greater than 10 % of the design load can be applied to the ground anchor prior to testing. The maximum test load shall be no less than 1,33 times the design load and shall not exceed 80 % of the specified minimum ultimate tensile strength of the pre-stressing steel of the tendon. The test load shall be simultaneously applied to the entire tendon. Stressing of single-element tendons shall not be permitted.

The testing equipment shall consist of:

- A dial or vernier scale capable of measuring accurately enough shall be used to measure the ground anchor movement;
- A hydraulic jack and pump shall be used to apply the test load. The jack and two calibrated pressure gauges shall be used to measure the applied load. The jack and all pressure gauges shall be calibrated by an independent firm as a unit. Testing cannot commence until the Engineer has approved the calibration;
- An electrical resistance load cell and readout to be used when performing an extended creep test;
- The stressing equipment shall be placed over the ground anchor tendon in such a manner that the jack, bearing plates, load cells and stressing anchorage are axially aligned with the tendon and the tendon is centred within the equipment;
- The stressing equipment, the sequence of stressing and the procedure to be used for each stressing operation shall be determined at the planning stage of the project. The equipment shall be used strictly in accordance with the manufacturer's operating instructions;
- Stressing equipment shall preferably be capable of stressing the whole tendon in one stroke to the specified test load and the equipment shall be capable of stressing the tendon to the maximum specified test load within 75 % of the rated capacity. The pump shall be capable of applying each load increment in less than 60 seconds;

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- The equipment shall permit the tendon to be stressed in increments so that the load in the tendon can be raised or lowered in accordance with the test specifications, and allow the anchor to be lift-off tested to confirm the lock off load;
- Stressing equipment shall have been calibrated, within an accuracy of $\pm 2\%$. The calibration certificate and graph shall be available on site at all times.

Dial gauges shall bear on the pulling head of the jack and their stems shall be coaxial with the tendon direction. The gauges shall be supported on an independent, fixed frame, such as a tripod, which will not move as a result of stressing or other construction activities during the operation.

Prior to setting the dial gauges, the Alignment Load (AL) shall be accurately placed on the tendon. The magnitude of the AL depends on the type and length of the tendon.

Re-gripping of strands, which would cause overlap wedge bites, or wedge bites on the tendon below the anchor head, shall be avoided.

Stressing and testing of multiple element tendons with single element jacks is not permitted.

Stressing shall not begin until the grout has reached adequate strength.

The anchor testing program shall consist of two parts, namely, performance tests and proof tests.

Anchor installations for performance testing within each area shall be as directed by the owner's representative. One anchor per wall area shall be tested in accordance with the performance test procedures. These anchors should be located in the area of soil borings if possible. These anchors are to be installed, tested, and approved by the owner's representative prior to the installation of production anchors within that area. All anchors which are performance tested shall be used as production anchors and incorporated into the retention structure.

Upon completion and approval of the performance tests in an area, the installation of production anchors may proceed.

Proof tests shall be performed on all production anchors which are not performance tested. Proof tests results are subject to the approval of the owner's representative.

D.5.4.6.14 Performance Test Procedures

Two production anchors shall be performance tested. These tests should be located near soil borings if feasible.

The anchors which are performance tested may be completely unloaded prior to adjusting to the lock-off load, if so warranted by the construction sequence. Final loading to the lock-off load does not require further movement readings.

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Anchors shall be performance tested in accordance with the following schedule:

Cyclical load increments (% DL / 100)

	AL	AL	AL	AL
0,25 DL	0,25 DL	0,25 DL	0,25 DL	0,25 DL
0,50 DL	0,50 DL	0,50 DL	0,50 DL	0,50 DL
		0,75 DL	0,75 DL	0,75 DL
			1,00 DL	1,00 DL

AL = Alignment Load (10%-15% DL)

DL = Design (Working) Load

The load shall be maintained at each load increment for a sufficient period of time to allow for accurate movement readings to be recorded. This applies to all load increments except the 1,25 DL increment.

The 1,25 DL load increment shall be held for 10 minutes. The 10 minute observation period shall commence as soon as the 1,25 DL load is applied to the anchor. Movements shall be recorded at 0,5, 1, 2, 3, 4, 5, 6, and 10 minutes. If the anchor movement between the 1 minute and 10 minute readings exceeds 1 mm, then the 1,25 DL test load shall be maintained for an additional 20 minutes. Movements shall be recorded at 15, 20, 25, and 30 minutes. If the acceptance criteria given below is not satisfied, then the anchor test shall be continued for an additional 30 minutes. Movements shall be recorded at 45 and 60 minutes. If the acceptance criteria is not satisfied after this extended observation period, then the contractor shall exercise one of the options as referenced below.

Throughout the 1,25 DL observation period, the load shall be held constant by adjusting the hydraulic pressure. Care must be taken so as not to exceed the 1,25 DL test load.

D.5.4.6.15 Proof Test Procedures

All anchors which are not performance tested shall be proof tested.

Anchors which are proof tested may be completely unloaded prior to adjusting to the lock-off load, if so warranted by the construction sequence. Final loading to the lock-off load does not require further movement readings.

Anchors shall be proof tested in accordance with the following schedule:

Loading Schedule

Observation	
Increment	Period
[% DL / 100]	[min]

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Observation	
Increment	Period
[% DL / 100]	[min]
AL	0,0
0,25 DL	2,0
0,50 DL	2,0
0,75 DL	2,0
1,00 DL	2,0

AL = Alignment Load (10 % - 15 % DL)

DL = Design (Working) Load

The load increments from AL to 1,0 DL shall be maintained for a period not to exceed 2 minutes. The 2 minute observation period shall begin when the pump begins to load the anchor to the next load increment. Movement readings shall be taken at the end of the two minute observation period. This does not apply to the 5 minute observation period at 1,25 DL test load.

The 1,25 DL test load shall be maintained for 5 minutes. This 5 minute observation period shall commence as soon as the 1,25 DL is applied to the anchor. Movement readings shall be recorded at 0,5, 1, 2, 3, 4, and 5 minutes. If the movement between the 0,5 and 5 minute reading exceeds 1 mm, then the 1,25 DL test load shall be maintained for an additional 5 minutes. Movement readings shall be recorded at 6 and 10 minutes. If the acceptance criteria given below is not satisfied, then the anchor test shall be continued for an additional 20 minutes. Movement readings shall be recorded at 15, 20, 25, and 30 minutes. If the acceptance criteria given below is not satisfied after this extended observation period, then the contractor shall exercise one of the options as referenced below.

Throughout the 1,25 DL observation period, the load shall be held constant by adjusting the hydraulic pressure. Care must be taken so as not to exceed the 1,25 test load.

D.5.4.6.16 Acceptance Criteria

The net movement for the performance and proof tests shall not exceed 3 mm during the final log cycle of time (examples, 3-min. to 30-min. for performance tests; 1-min. to 10-min. for proof tests).

If the above criteria is exceeded, then the test shall be continued for an extended period of time as defined for the performance test and for the proof test. If the final log cycle of time movement at the end of the extended observation period exceeds 0,12 then the contractor shall have the following options:

- a) Extend the observation period for an additional 60 minutes for the performance test with movement readings taken at 80, 90, 100, and 120 minutes. Extend the observation period for an additional 30 minutes if the proof test is involved with movement readings taken at

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45 and 60 minutes. The net movement shall not exceed 3 mm during the final log cycle of time.

- b) Install the anchor deeper so as to increase its average installation torque, provided that the maximum torque capacity of the anchor will not be exceeded. This anchor shall be proof tested.
- c) Remove the anchor and reinstall an anchor with larger diameter and/or additional helices. If this anchor is reinstalled at the same location, then the last helix of this reinstalled anchor shall penetrate at least 1,5 m beyond the length of the original anchor. This anchor shall be proof tested.
- d) Reduce the design load of the anchor. This anchor shall be performance tested at the reduced design load. This option will require one or two additional anchors be installed adjacent to this reduced design load anchor. The number of additional anchors to be installed is a function of the reduced design load. Adjacent anchor(s) shall be installed at least 1,2 m from the reduced design load anchor. Design loads on adjacent anchor(s) shall be adjusted accordingly based on the revised horizontal spacing.

D.5.5 Steel Pile Foundations

D.5.5.1 Profiles

Bearing piles shall be H-Part bearing piles, Larssen box piles or tubular piles.

D.5.5.2 Design, Testing, Driving

For design of piles, preliminary test of piles, lengths of piles, sequence for constructions, and driving piles the relevant Standards shall apply.

D.5.5.3 Repair and Lengthening

In preparation for repairing the head of a pile the profile shall be cut off plane and perpendicular to the profile axis.

If the pile is to be subjected to further driving or the pile has been completely driven but the end is below cut-off level the new profile part shall be welded onto the driven profile Part.

D.5.5.4 Piling

D.5.5.4.1 Method Statement

Before the commencement of any piling works, the contractor shall submit 3 weeks before starting the works to the Engineer for approval a safety policy and a method statement which shall include the following information:

- Program of the works detailing sequence and timing of individual portions of the works.

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- Maximum proposed lead at any stage of driving between a pile and its neighbour and the limitations of same if hard driving is encountered.
- The height, spacing, stability and type of piling guidance system and the number of piles in each panel if applicable.
- Full details of installation plant to be utilised including manufacturers information, proof of servicing/recent upkeep and assessment of actual input energy to the piles and a definition of driving refusal for each type of plant proposed.
- Proposed phasing of excavation/filling operations such that designed stresses in the piles and frames/supports are not exceeded.
- Contingency plan in the event of encountering obstructions or reaching driving refusal to minimise disruption/delay especially when using pitch and drive methods.
- Details of the envisaged noise production and the Contractor's intended method of noise minimisation.
- Details of the estimated vibration levels created by the works and the Contractor's intended method of noise minimisation.

D.5.5.4.2 Handling

All piles shall be stacked in accordance with the manufacturer's recommendations.

The Contractor shall ensure that operations involving loading, transporting, offloading, handling, stacking and pitching the piles, are carried out in such a manner as to prevent damage to the piles or their coating.

Any damage that does occur shall be drawn to the attention of the Engineer and the Contractor shall submit his proposals for remedial works for approval prior to commencement. The Engineer's approval of the completed remedial measures will be required before inclusion into the structure can take place.

Holes shall not be burnt / drilled nor lifting brackets welded to the sheet piles without the prior approval of the Engineer. All such modification shall be made good after use.

Wherever possible the same pile parts, lengths and steel grades shall be stored in separate stacks clearly marked / colour coded to avoid errors in placement.

D.5.5.4.3 Pitching & Driving

The selection of the driving and extracting plant shall be made having due regard to the ground conditions and pile type.

The Engineer shall be notified of the contractor's intention to pitch and drive piles at least 24 hours prior to commencement of the installation works. Prior to interlocking sheet piles the contractor shall ensure that the locks are undamaged clean and free from deleterious materials.

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Pitch and drive techniques shall be permitted if the following criteria are met:

- The rig has sufficient height to adequately support the entire pile during driving;
- The driving will be relatively easy, without hard bands or obstructions which would dictate the requirement for full support afforded by panel driving techniques;
- The Contractor can satisfy the Engineer that the sheet pile structure can be built to conform with the specified tolerances for verticality and alignment.

In all cases the piles shall be guided and held in position during pitching and driving. All piles shall be fully interlocked without exception. Overlapping of piles will not be accepted as a substitute for interlocking piles.

Taper piles shall not be introduced to correct piles which have developed a lean, unless the approval of the Engineer is first obtained.

Piles which reach refusal before achieving the design penetration shall not be cut off without the approval of the Engineer. In difficult driving conditions a lead in excess of 1 m shall not be allowed to develop between the toe level of the pile being driven and the level of its neighbouring pile.

The contractor shall do all within his power / experience to avoid driving damage or declutching. The Engineer shall be notified immediately if any of these occur.

Percussive piling hammers shall be either freely suspended in which case they will have suitable leg guides / inserts in sound working order, or leader mounted in which case the leader must be of suitable rigidity and strength to keep the hammer stable during driving and moving operations. In all cases the hammer shall be held in position over the pile such that each blow is directed axially down the centreline of the pile / pair. (When driving high modulus units the centreline of the hammer blow shall be positioned as close to the centreline of the combined unit or between that position and the centreline of the beam unit).

The anvil block shall be of sufficient plan area to cover at least 90 % of the pile or piles being driven and of sufficient thickness to adequately transfer the heaviest hammer blow evenly to the pile heads. The anvil shall be flat and level, without substantial wear such that the blow is transferred axially and distributed evenly over the pile head.

Where sheet piles are driven to a set to indicate vertical load carrying capacity this shall always be calibrated by maintained load testing on a representative sample of the piles. The set shall be recorded with a hammer of well defined input energy such as a gravity drop hammer or a hydraulic drop hammer. Where it is unavoidable to use hammers of less certain input energy, i.e. air hammers and diesel hammers, then the maximum losses must be used in the set calculation i.e. assuming approximately 30 % hammer efficiency.

D.5.5.4.4 Driving Tolerances

The following tolerances are suitable for general site practice for permanent structures. However more lenient limits may be applied if difficult driving conditions are encountered i.e. obstructions or the works are only temporary:

- Deviation perpendicular to theoretical line ± 50 mm;
- • Deviation of verticality normal to and along the line of the piles, 1 in 100;
- • Top of finished pile level ± 20 mm.

Deviation from these tolerances will not be acceptable without written agreement from the Engineer. Forcible correction will not be permitted.

The above tolerances are included for guidance purposes only and should be altered depending on site specific requirements

D.5.5.4.5 Driving Records

The Contractor shall keep complete and accurate piling records. Two signed copies of these records shall be submitted to the Engineer not more than 48 hours from the date of the works detailed therein. The pile records shall always be submitted with sufficient time for the Engineer's approval prior to the piles becoming inaccessible due to further operations.

The records shall contain the following information:

- Pile reference number (correlated to previously accepted works general arrangement drawing showing each pile position and reference).
- Pile type and steel grade.
- Pile length.
- Commencing surface level and final toe level.
- Depth driven, type of construction plant and times and dates when piles were driven.
- Where required the number of blows to drive each 250 mm over the last 2,5 m shall be recorded.
- Comments regarding unusual/ unexpected driving conditions (both harder, e.g. obstructions, or easier, i.e. increased penetration rates) should be included.
- Where changes in the pile length have occurred due to lengthening or cutting, all relevant information including off-cut length or extension length, reason for change and on what authority the change was made shall be included.

D.6. GROUND TREATMENT

D.6.1 General

Any ground treatment proposed by the Contractor to improve the bearing capacity and/or settlement characteristic of the soil must be supported by a full method statement and design calculations with a statement of the minimum performance to be achieved.

In the selection of the ground improvement method, the time limitations of the Contract shall be taken into consideration. The method is subject to the approval of the Engineer. Where directed by the Engineer, the Contractor shall carry out a field trial of the proposed treatment to demonstrate that it meets the stated performance criteria.

All in-situ verification of ground improvements shall be made by CPT or SPT test after ground improvement works.

D.6.2 Soil Replacement

Soil replacement involves excavating the soil that needs to be improved and replacing it. Excavated soil shall be replaced with compacted granular soil (sand and gravel) with suitable properties for the proposed application.

Methods and material for soil replacement shall be approved by the Engineer.

D.6.3 Admixture Stabilisation

Admixture stabilisation consists of mixing or injecting admixtures, such as cement, lime, fly ash or bentonite into a soil, to improve its properties. Admixtures can be used to increase the strength, decrease the permeability or improve the workability of a soil. Admixtures can fill voids, bind particles, or break down soil particles and form cement. The general process of admixture stabilisation consist of (1) excavating and breaking up the soil, (2) adding the stabiliser and water, if necessary, (3) mixing thoroughly, and (4) compacting the soil and allowing it to cure.

During stabilisation of soils with admixtures, the most important observations are the amount of admixtures and water mixed into the soil, the amount of mixing performed and the amount of compactive effort used on the fill. The moisture content and density of the fill can be determined in the field. The curing time and conditions should also be recorded. Samples should be taken for laboratory testing.

Method of admixture stabilisation shall be approved by the Engineer.

D.6.4 Jet Grout Columns

The Contractor is required to test several jet grout column sections prior to construction, to determine the geometry and quality of treated material that can be obtained.

For assessing the geometry, excavation of coring shall be made. Wet grab samples shall be taken for strength and permeability testing. If piezometers are installed for later hydraulic conductivity measurements, the construction details of the piezometers shall be recorded.

During construction, it shall be monitored and the Contractor is required to note if the grouting parameters and materials are consistent with the approved test section. The ability to erode the soil with the jets is an important factor in successful jet grouting. There shall be a continuous flow of spoils to the ground surface during jetting. If there is no spoil return, it is possible that hydrofracturing is occurring. The rate of rotation and removal of the grout pipe and the rate of material consumption shall be monitored.

Method of jet grouting shall be approved by the Engineer

D.6.5 Prefabricated vertical Drains (wick drains – strip drains)

The Contractor is required to prepare a method statement for preloading with wick drains based on the geotechnical report. This method statement shall include the following data:

1. Materials;
2. Monitoring equipment;
3. Spacing and depth of wick drains (drain layout drawings);
4. Spacing and depth of settlement gauges (monitoring system layout drawings);
5. Height of pre-loading fill;
6. Time required for achieving design settlements;
7. Record keeping
8. Expected vertical displacements (swell / settlements) during trial loading, preloading, excavation for foundations and in long term (for centres and edges of foundations).

First stage in the application of the prefabricated drain, shall be removing the topsoil, installing surface settlements plates, laying the separation geotextile and placing the drainage layer according to the thickness stated in the Method Statement and extend this drainage layer to the drainage trenches around.

Later, the vertical drain locations shall be marked. Prefabricated wick drains shall be installed down to the depth stated in the Method Statement using a special steel mandrel mounted on the service crane. The mandrel shall be pushed into the soil using a vibratory hammer.

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Wick drains shall be placed at constant load and high speed in order to avoid disturbance of soil. Vertical misalignments shall be avoided by checking with a water balance.

A drainage ditch shall be excavated around the perimeter of the wick drain fields. This drainage trench will collect the discharge coming from the granular drainage layer over the wick drain field.

Finally, another separation geotextile shall be laid over the granular drainage layer over the wick drain field. Before any preloading fill material is placed, settlement columns and magnetic extensometer shall be installed according to the Method Statement, in order to find out the future settlements. The settlements shall be measured and recorded until the displacements have reached the desired level.

Preloading fill materials shall be laid around the perimeter of the large structures and the base of the fills shall be extended at least 4 meters outside the structure's borders. Then the fill will be placed with 1H : 1V side slope, to a maximum height of 4 meters.

Fill material will be laid uniformly in 200 - 300 mm thick layers and spread uniformly. No compaction tests are required and compaction will be achieved by the truck traffic over the fill construction. Therefore it is mandatory to place the fill homogeneously and uniformly.

Surface settlement measuring plates will be buried in natural ground at the preloading area and these will be protected and extended as described in the Method Statement.

A working platform shall be formed to support drain installation equipment. Drainage payer may be used for this purpose; however, thickness of the drainage layer may need to be increased to support the equipment as required.

The drain capacity could be the limiting factor in cases where PV drains are designed for sites where there are deep compressible layers with surcharge loading. When PV drains are designed to function near their maximum capacity, the installation shall be monitored carefully. Before using wick drains below a depth of 45 m, a specialist shall be consulted.

Wick drains shall be composed of two parts: inner core and filter material. These may be manufactured as a single material or the filter may be wrapped around the core, and overlapped to keep the core closed inside.

Wick drains shall be 100 mm wide, 6 mm thick polyester (PES) or polypropylene (PP), or similar, with the approval of the Engineer.

Wick drains shall be flexible, capable of being rolled to a 300 mm diamtere drum without damage. The wick drain must be strong enough so it will not break, tear or lose ist drainage properties during installation. The core of the drain shall resist crushing or formation of kinks when bent.

The position of the wick drains shall be at most 100 mm away from the coordinates shown on the drain layout drawings.

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Vertical deviation of the drains shall be at most 1 Horizontal in 50 Vertical.

Wick drains shall be cut at least 150 mm above the working platform.

Daily reports shall be written for the drains installed. A copy of these reports shall be presented to the Engineer within two days after installation. The records shall include:

- Date;
- Reference area and grit for each drain;
- Depth of installation of each drain ;
- Obstacles and delays;
- Reading of the installed instruments.

Any unexpected conditions experienced and reported will be briefly mentioned in these records.

After all field works are completed, two (2) copies of the Final Report will be presented to the Engineer within two (2) weeks after removing the preloading fill.

Method of preloading with wick drains shall be approved by the Engineer.

D.6.6 Flood Protection

D.6.6.1 General

The main aims of the flood protection works are:

- To avoid flooding water into the facility, protecting in this way its structural stability;
- To protect the building and roads of the facility site from erosion caused by flooding.

The flood protection works of the site consist in the following:

- Ditches for the protection of the facilities;
- Ditches for the protection of internal road network;
- Well for the drainage of the ditches and sewers.

The ditches aim at interception and transporting the rainwater from the outside basins and internal sub-basins. The flooding protection will be succeeded via perimetric insulated ditches outflow wells through which the water will be lead to the natural recipient.

The hydrologic calculations should be made for a minimum return period of 20 years. A safety factor has to be adopted for the maximum discharge that the ditches can convey.

It is clearly stated that rainwater that will occur throughout the facility will be collected separately from washing and similar wastewaters.

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If new construction of structures or facilities are to be located in a floodplain, accepted flood proofing and other flood protection measures shall be applied to new construction or rehabilitation. To achieve flood protection, Contractors shall, wherever practicable, elevate structures above the base flood level rather than filling in land.

D.6.6.2 Earth Dikes

Dikes shall be high enough to prevent the 100-year flood. Existing dikes at the plant area shall also be investigated. These shall be reshaped or rebuilt where necessary and repaired in areas of the dikes where erosion has occurred.

Design requirements for earth dikes include:

- Preconstruction surveys required for design;
- Soil sampling and soil tests for dike embankments fill borrow areas;
- Design of local drainage improvements (including culverts with flap gates and/or manual control gates).

D.6.6.3 Mortared Stone Walls and Slabs

Mortared stone walls and slabs shall be built at locations shown on Drawings or specified by the Engineer, with the sections and stone sizes shown on the details or specified by the Engineer.

Before the stones are placed, ground surface shall be arranged smooth and parallel to the finished surface considering the stone thickness and wall slope. Wall thickness shown on the Drawings or specified by the Engineer must be achieved with a single stone layer, and two stone layers on top of each other will not be accepted.

The void between the stones shall be filled completely with mortar and stones shall be hammered after laying to get a strong bond between stones.

Larger stones shall be used at the edges of the stone surfaces, especially at the skirts of sloped surfaces. Stones shall be laid from bottom to the top. Mortar, cement and water shall be in accordance with the technical specifications regarding concrete and steel works.

D.7. CONCRETE WORKS

D.7.1 General

D.7.1.1 Scope

This section covers the technical requirements for the concrete Works as specified in the Contract including the supply of materials, mixing of concrete, formwork, reinforcement, placing, compaction, and curing of concrete...etc.

D.7.1.2 Standards and Rules

The Contractor shall carry out the works described in this Section in accordance with the appropriate standards ISO, EN or equivalent international standards.

The main standards include, but shall not be limited by, the following:

- ISO 22965 Concrete;
- ISO 19595 Natural aggregates for concrete;
- ISO 22966 Execution of concrete structures;
- ISO 16311 Maintenance and repair of concrete structures;
- ISO 20290 Aggregates for concrete — Test methods for mechanical and physical properties;
- ISO 19596 Admixtures for concrete;
- ISO 1920 Testing of concrete;
- EN 206 Concrete - Specification, performance, production and conformity;
- EN 934-2 Admixture for concrete, mortar and grout;
- EN 12350 Testing fresh concrete. Slump test;
- EN 1992-2 Design of concrete structures. Concrete bridges;
- EN 13791 Assessment of in-situ compressive strength in structures and pre-cast concrete components;
- EN 1008 Mixing water for concrete;
- EN 10080 Steel for the reinforcement of concrete;

D.7.1.3 Concrete Specifications

Concrete **specifications shall be in accordance with ISO 22965 and EN 206**. The Contractor shall submit to the Engineer for approval the proposed concrete specifications for the various concrete works. This includes in particular:

- compressive strength class;
- exposure classes;
- D_{upper} and D_{lower} .

D.7.1.4 Organisation of Concrete Production

Upon Contract commencement, the Contractor shall submit for approval of the Engineer a method statement detailing his proposal for the organisation of concreting activities at the Site. The concrete production plant shall preferably be placed on Site.

The method statement shall at least include:

- Plant proposed and layout of the production facility;
- Proposed method of organisation of the production facility;
- Quality control procedures for concrete and concrete production;
- Method of transport including heat protection and placing of concrete;
- Striking times for formwork and procedure for temporary support of beams and slabs;
- Curing of concrete and ways to assure an optimum curing.

D.7.1.5 Aggregate Samples

Before work on trial mixes is commenced, the Contractor shall submit for approval 50 kg samples of each aggregate which he proposes to use.

The source of each aggregate shall be clearly marked on the container of each sample.

At the same time certified test results, demonstrating compliance with relevant quality standards such as ISO 20290 and EN 12620 shall be submitted.

Samples approved by the Engineer shall be preserved at Site for reference.

D.7.1.6 Records of Concreting

The Contractor shall keep accurate and up to date records of concreting for each day when sections of the works were concreted showing at least:

- Date, time, weather and temperature;
- Results of all concrete tests including identification for which parts of works the sampled material are representative;
- Number of batches produced, weight and kind of cement used, volume of concrete placed, number of batches wasted or rejected;
- Class of concrete, volume of concrete placed and number of batches used for each location.

The laboratory where concrete tests have to be carried out shall be approved by the Engineer and be accessible at any time. The laboratory shall preferably be placed on Site.

D.7.1.7 Concrete Mixes

At the commencement of the works the Contractor shall design a mix for each class of concrete which will be required for use in the works and shall submit full details of the mix designs to the Engineer for approval (also see D.7.3.7). Each mix design shall be according to the requirements of the respective specification (see D.7.3.1).

D.7.1.8 Construction Joints and Lifts

The Contractor shall submit to the Engineer, not later than 3 weeks prior to the commencement of concreting, drawings showing his proposals for placing concrete and the position of all construction joints which have to be located as not to impair the strength of the structure.

No concreting shall start until the Engineer has approved concrete placing and the position and form of construction joints.

Rebates, keys or notches shall be formed and water stops inserted as the Engineer may require.

The position of construction joints and the size of formwork panels shall be so coordinated that where possible the line of any construction joint coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series.

For all exposed horizontal joints and purposely-inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat joint line.

D.7.2 Materials

D.7.2.1 Cement

All cement used on the Work shall be standard brand Portland cement from a single approved source conforming to the requirements of Portland cement class CEM I 32.5 R or class CEM I 32.5 HS in accordance to ISO 679, ISO 9597, EN 196 and EN 197 or equivalent.

Cement used in the works for structural parts underground or in contact with wastewater shall be sulphate-resisting Portland cement, class CEM I 32.5 HS.

The source of cement shall not be changed without prior approval of the Engineer.

Samples of cement, water and fine and coarse aggregates called for in the foregoing sections shall be provided to the Engineer. Cube tests shall be completed before work is due to start.

Cement has to be delivered to the Site in the original sealed and branded bags.

No cement shall be used which has been manufactured 6 months prior to its proposed use on Site or which has been in storage for more than 3 months, whichever is shorter.

The Contractor shall provide from each consignment of cement delivered to the Site such samples as the Engineer may require.

D.7.2.2 Storage of Cement

Immediately upon arrival on Site, the cement shall be stored in silos or in dry, weather tight and properly ventilated structures with adequate provisions to prevent absorption of moisture.

All storage facilities shall be subject to the approval by the Engineer and shall be such as to permit easy access for inspection and identification.

Each consignment of cement shall be kept separately and the Contractor shall use the consignments in the order in which they are received.

D.7.2.3 Aggregates

Aggregates shall be hard, durable and clean and shall not contain deleterious material in such form or quantity as to adversely affect the strength of concrete. The aggregates shall be obtained from an approved source, shall be washed clean and shall conform to the requirements of ISO 20290, EN 206 and EN 12350.

The aggregates to be supplied shall not give rise to any alkaline reaction with the cement, weathered silica or carbonate. In addition, the soluble chloride and sulphate content of the aggregates shall be such that the concrete mix as a whole complies with the specified limits of the salt content. For limits of soluble chloride and sulphate contents see D.7.3.4.

Proof of chloride and sulphate contents for aggregates shall be given by certified / recorded history of aggregate testing, or certificates from an approved concrete supplier.

If no proof for this can be given, tests for chlorides and for potential alkaline reaction may be carried out by the Contractor upon the Engineer's request.

D.7.2.4 Storage of Aggregates

The Contractor shall provide storage facilities for aggregates which shall comply with following requirements:

- Each nominal size of coarse and fine aggregates shall be kept separate at all time;
- Contamination of aggregates by the ground or other foreign matter shall be prevented effectively at all times;
- Each heap of aggregate shall be capable of draining freely;

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- Aggregates are kept as cool as possible by shading and provision of water sprinkling if required.

The Contractor shall ensure that graded coarse aggregate is not segregated during tipping, storing and removal from storage.

Fine aggregate shall not be used unless approved by the Engineer, and it is conditioned to acceptable and uniform moisture content. If necessary to meet this requirement, the Contractor shall protect the heaps against weather, and shall condition fine aggregate in accordance with the applicable standards and approved procedures.

D.7.2.5 Water

Water for washing aggregates and for mixing of concrete shall be in accordance with ISO 22965 and EN 206, and shall be clean and free from objectionable quantities of organic matter, alkali, salts and other impurities.

The water shall enter the mixer at the lowest possible temperature and shall not exceed 30° C.

During the execution of works, the Contractor shall ensure that sufficient quantities of water for production and curing of concrete are available on Site at all times.

D.7.2.6 Admixtures

Admixtures shall not be used unless approved by the Engineer.

By instructions from the Engineer, or at the request of the Contractor and approved by the Engineer, an admixture may be added to the concrete in order to control the set, to effect water reduction and to increase workability. Such admixture shall not contain calcium chloride and it shall be used in accordance to the manufacturer's instructions and be in accordance with ISO 19596.

D.7.3 Concrete

D.7.3.1 Proportioning of Concrete Materials

Concrete shall be composed of cement, aggregates, water and, when unavoidable, of admixtures. These materials shall be of the qualities specified and their proportioning shall be determined in accordance with all requirements imposed by ISO 22965 or EN 206 and be subject to the approval of the Engineer.

In general, the mix shall be designed to produce concrete capable to be placed so as to obtain maximum density and strength and smoothness to the surface.

The proportions may be changed if instructed or approved by the Engineer.

D.7.3.2 Impermeable Concrete

All concrete for underground works (e.g. chambers) shall be of impermeable concrete according to ISO 22965 or EN 206.

D.7.3.3 Water-Cement Ratio and Compressive Strength

The minimum compressive strength and cement content shall be not less than required in the appropriate approved international Standards.

If necessary to obtain the required strength, the Engineer may instruct that the cement content of any class to be increased over the quantity specified in the standard.

The maximum water-cement ratio shall be no greater than 55 l of water per 100 kg of cement.

D.7.3.4 Limits of Salt Contents

All concrete mixes shall contain less than 0,6 % total chlorides (as chloride ions) and less than 4,0 % total acid soluble sulphate (as sulphite ions). Tests shall be carried out in accordance with the applicable approved international Standards.

D.7.3.5 Consistency

The quantity of water added to a batch of concrete shall be in accordance with ISO 22965 or EN 206, just sufficient to produce a concrete which, in the judgment of the Engineer, can be placed properly without segregation and which can be compacted by vibration to give the desired density and smoothness of surface. Also see D.7.1.7.

Water content of aggregates shall be monitored at all times and adjustments made during batching to ensure that w/c ratio does not exceed the specified limits.

The consistency of the concrete shall be determined in accordance with EN 12350.

D.7.3.6 Mix Design

Samples of coarse and fine aggregates and cement proposed to be used in the works shall be tested. Tests shall be made at a laboratory accepted by the Engineer.

From analysis and test of samples furnished, the laboratory shall design a concrete mix to meet the requirements for each class of concrete required for use in the works.

The laboratory shall prepare 2 test cylinders of each design mix from the samples furnished and test them after 7 and 28 days, respectively.

Three copies of the test results shall be submitted to the Engineer for approval.

D.7.3.7 Trial Mixes

As soon as the mix designs are approved by the Engineer, 3 batches of concrete for each grade shall be made on site under full scale production conditions using the same means and the same plant the Contractor proposes to use and approved by the Engineer.

The portions of cement, aggregates and water shall be carefully determined by weight in accordance to the approved mix design and sieve analyses shall be made in accordance with EN 12620 of fine and coarse aggregate used. In accordance with EN 12350 three test cubes from each of the three batches shall be made by the Contractor in the presence of the Engineer from each trial mix.

The cylinders shall be made, cured, stored and tested as described in EN 12350.

If the average value of the compressive strength of the nine cylinders taken from any trial mix is less than the target mean strength or any individual cylinder test result falls below 85 % of the target mean strength, the Contractor shall redesign the mix and make a further trial mix.

D.7.3.8 Mixing of Concrete

All concrete prepared on site shall be mixed in accordance with EN 206 with batch mixers in accordance with approved international Standards.

The mixing of each batch shall continue not less than 1,5 minutes after all materials including water are in the mixer.

Hardened concrete or mortar shall not be permitted to accumulate on the inner surfaces of the mixer. Re-tempering will not be permitted.

D.7.3.9 Ready-Mixed Concrete

Ready mixed concrete shall not be used in any part of the works without the written approval of the Engineer.

If ready-mixed concrete is accepted, the Contractor shall certify to the Engineer that the ready-mixed concrete complies with the Specifications in all respects, and that the manufacturing and delivery resources of the proposed supplier as well as traffic conditions are adequate to ensure proper and timely completion of each concreting operation.

D.7.4 Reinforcement

D.7.4.1 Submissions and Approvals

In addition to other submission requirements in the Contract the following submissions are required:

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- Manufacturer's test certificates for each delivery of reinforcing steel, showing the country of origin and tests;
- Manufacturer's data on accessories;
- All reinforcement drawings and bending schedules prepared by the Contractor.

Before concrete is placed against any formwork, the reinforcement shall be inspected by the Contractor and offered for inspection and approval by the Engineer.

In no case shall concreting be commenced prior to the inspection of the reinforcement by the Engineer and his written approval to proceed with concreting.

The approval procedure shall be supported by a 'pour-card' system.

D.7.4.2 Steel Reinforcement

Steel reinforcement bars shall be hot rolled untreated bars conforming to the requirements of ISO 15698, ISO 6935-2019 and EN 10080. Only plain round bars type BSt 220 / 340 GU (minimum yield strength 220 N/mm²; tensile strength 340 N/mm²) and BSt 420 / 500 S shall be used. Steel wire reinforcement shall conform to the requirements of ISO 1569, ISO 10144 or EN 10080 and shall be type BSt 500 / 550 M.

D.7.4.3 Accessories

The Contractor shall supply, use and install all necessary accessories such as reinforcing steel supports, hold-downs, spreaders, hangers, tie wire and all other incidentals necessary to complete an acceptable installation of all concrete reinforcement.

All accessories shall be of steel with the exception of spacers to maintain concrete cover.

If not otherwise directed by the Engineer, the concrete spacers shall be in the form of a truncated cone or pyramid and shall be used with the larger face towards reinforcing steel.

D.7.4.4 Cutting and Bending of Reinforcement

Bars shall be cut and bent in accordance with the provisions of ISO 22965, ISO 15835 and EN 206.

All bending shall be done cold with an approved bending machine.

Cut and bent bars shall be bundled and labelled for identification until they are incorporated into the work.

Re-bending or straightening of bars shall not be permitted.

D.7.4.5 Storage of Bars and Mesh

The Contractor shall stack separately and label the various type of reinforcement for identification.

Steel reinforcement shall be kept clean and free from pitting.

Loose rust, mill scale, oil, grease, earth paint or any other material impairing the bond between the concrete and the reinforcement have to be removed thoroughly before fixing.

Reinforcing steel shall be stored under cover on wooden supports, elevated from the ground surface.

D.7.4.6 Fixing of Reinforcement

All reinforcement shall be securely and accurately fixed in positions shown on the approved drawings using approved spacer blocks and chairs. The Contractor shall ensure that all reinforcement is maintained in position at all times, particular care being taken during placing of concrete.

Reinforcement in slabs shall be maintained in position by means of stirrups at 90 cm centres maximum. Reinforcement in walls with two layers of reinforcement shall be maintained in position by means of 6 mm U- or Z-shaped spacers at 180 cm centres maximum.

No part of the reinforcement shall be used to support formwork, access ways, working platforms or the placing of equipment.

Welding of reinforcement is subject to the permission of the Engineer.

D.7.4.7 Concrete Cover

Except as otherwise shown in approved drawings, reinforcement shall be installed with clearance coverage as follows:

- All surfaces in contact with water or placed against soil: 5,0 cm;
- Bottom of slabs over water and beams and columns not exposed to soil or water: .. 4,0 cm;
- Surfaces exposed to air and all interior surfaces in buildings: 3,0 cm.

D.7.4.8 Tolerances

Tolerances in placing reinforcement shall be:

- For members 60 cm or less in depth: $\pm 0,5$ cm;
- For members more than 60 cm in depth: $+ 1$ cm / $- 0,5$ cm.

D.7.4.9 Approval by Engineer

In no case shall any reinforcing steel be covered by concrete until it has been inspected by the Engineer and his permission given in writing to proceed with the concreting.

D.7.5 Formwork and Concrete Finishes

D.7.5.1 Submissions

Before concrete is placed against any formwork, the formwork shall be inspected by the Contractor and offered for inspection and approval by the Engineer. In addition to submission requirements in these Technical Specifications the Contractor shall submit following documents:

- Design and shop drawings for formwork
- Layout of panels

In no case shall concreting be commenced prior to the inspection of the formwork by the Engineer and his written approval to proceed with concreting.

D.7.5.2 Requirements

Formwork shall be constructed of timber, sheet metal or other approved material, but meeting the surface finishing requirements.

The Contractor shall furnish all struts, braces and ties to withstand the placing and vibrating of concrete.

Except when otherwise expressly approved by the Engineer, all material brought on the Site as forms, struts or braces shall be new material.

The class of concrete finish is specified in Clause D.7.5.6. For each class of finish the Contractor shall present sample panels to the satisfaction of the Engineer. Sample panels shall not be less than 2 m² in area.

D.7.5.3 Form Ties

D.7.5.3.1 General provision

The maximum diameter of removable cones for rod ties, or of other removable form tie fasteners having a circular cross section, shall not exceed 40 mm and all such fasteners shall be such as to leave holes of regular shape for reaming.

Holes left by the removal of fasteners from the end of snap-ties or form ties shall be reamed with suitable toothed reamers so as to leave the surfaces of the holes clean and rough before being filled with a chemical mortar such as Sikadur 31 from SIKA or equivalent approved product.

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Wire ties for holding forms will not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete; nor shall any tie be removed in such manner as to leave a hole extending through the interior of the concrete member.

The use of snap-ties, which cause spalling of the concrete upon form stripping or tie removal, will not be permitted.

If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste.

Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 50 mm back from the surface in the case of reinforced concrete and 150 mm in the case of un-reinforced concrete.

D.7.5.3.2 Watertight Ties

For concrete structures that shall be watertight, watertight ties shall be used (WÜRTH or H-BAU pentaflex opti or approved equivalent). These ties shall not require mortar sealing after removal of the formworks.

D.7.5.4 Number of Forms

A sufficient number of forms of each kind shall be provided to permit the required rate of progress to be maintained in accordance with the Contract and the approved Programme.

The design of concrete forms, false work and shoring shall comply with applicable standards.

D.7.5.5 Design of Formwork

All formworks must be adequate, safe and compliant with the Specifications and applicable standards:

- All forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete.
- Concrete construction joints will not be permitted at locations other than those shown on approved shop drawings. When a second lift is placed on hardened concrete, special precautions shall be taken in the location and tightening of ties at the top of the old lift and the bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete.
- All exposed arises and exterior corners shall be chamfered (20 x 20 mm), unless specifically shown otherwise in the drawings or directed by the Engineer.
- All vertical surfaces of concrete members shall be formed, unless placement of the concrete against the ground is called for and explicitly authorised by the Engineer.

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Permission for placing concrete against trimmed ground in lieu of forms will be granted only for members of limited height and where the properties of the ground allow for it.

- Top formwork shall be used on any inclined concrete surface steeper than 15° to the horizontal.

D.7.5.6 Formed Surfaces

Finishing to formed surfaces shall be fair finish according to CESSM 4 and defined as follows. Finish for surfaces which are exposed to view but where the highest standard of finish is not required. Forms shall be faced with wrought boards with square edges arranged in a uniform pattern or, alternatively, with plywood or metal panels, which are free from defects, disturbing the general appearance.

Remark: the specifications of this section also apply to surfaces that are not resulting from the use of formworks.

D.7.5.7 Erection of Formwork

All formwork shall be constructed, firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete. Formwork shall not be tied to or supported by reinforcement.

Faces of formwork in contact with concrete shall be free from adhering matter, projecting nails and the like, split or other defects, and shall be clean and free from stagnant water, dirt, shavings, chippings or other foreign matter. Joints shall be sufficiently water tight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete.

Formwork in contact with concrete shall be treated with suitable non-staining mould oil prior to reinforcement and concrete placement to prevent adherence of the concrete. Care shall be taken to prevent the oil from coming into contact with the reinforcement or with concrete at construction joints. Surface retarding agents shall not be used unless approved by the Engineer.

Where ties are built into the concrete for the purpose of supporting the formwork, the whole or part of any such support shall be capable of removal in such a way that no part remains embedded nearer than 5,0 cm from the surface. Holes left after the removal of such supports shall be neatly filled according to specification under D.7.5.3.

D.7.5.8 Tolerances

The permissible tolerances in the finished faces of shuttered concrete shall, if not otherwise directed, shall not exceed the following values:

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Type of concrete works:	Buried concrete	Exposed concrete
Deviation from alignment	50 mm	10 mm
Deviation from grades	10 mm	10 mm
Deviation from dimensions	+10 / -5 mm	+10 / -5 mm

D.7.5.9 Removal of Formwork

Formwork shall be designed as to permit easy removal without resorting to hammering or levering against the surface.

The period of time elapsing between the placing of the concrete and the striking of the formwork shall be as approved by the Engineer and shall be in any case not less than the period stated in EN 206. If not otherwise directed, the striking times for formwork shall be as follows:

- Side formwork for beams, walls, columns: 3 days
- Formwork for floor slabs: 8 days
- Formwork for beams, frames and long span slabs: 20 days

D.7.5.10 Dry Pack Mortar

D.7.5.10.1 Dry-Pack Mortar for Concrete Structures not in Contact with Water or Sludge

Dry-pack mortar for filling holes and repairing surface blemishes shall be from one part by weight of cement and three parts fine aggregate passing a 1 mm sieve and an expanding agent approved by the Engineer. Additives to improve workability may be added to the approval of the Engineer. The colour of the mortar shall match that of the surrounding concrete. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.

The dry-pack material shall be placed and packed in layers having a thickness not greater than 15 mm. The compaction shall be carried out by use of hardwood stick and hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. Holes shall not be over filled and the surface shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

D.7.5.10.2 Dry-Pack Mortar for Concrete Structures in Contact with Water or Sludge

Special dry-pack mortar for filling holes and repairing surface blemishes for concrete faces designed for contact with water or sludge shall be mixed of aggregates and cement as prescribed by the manufacturer. The colour of the mortar shall match that of the surrounding concrete. Placing shall be in accordance with the manufacturer's instruction.

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Special dry-pack mortar shall have the following characteristics and shall be approved by the Engineer before being applied:

- Applicable under water;
- Persistent to wastewater or sludge or their ingredients harming concrete;
- Good workability;
- Good adhesion to the concrete surface;
- Low invariance and deviation in dimensions;
- Modulus of elasticity and heat expansion coefficient similar to concrete, and
- Compression, tensile, and bending tensile strength equal or higher than of the concrete to be applied.

Epoxy resin based mortars shall be used as bonding agent.

The Contractor shall provide material catalogues and method of application to the Engineer for his approval.

D.7.5.11 Remedial Treatment of Concrete Surfaces

D.7.5.11.1 General

Any remedial treatment to concrete surfaces shall be agreed with the Engineer following inspection immediately after the stripping of formwork and shall be carried out without delay.

Any minor surface blemishes as air or rock pockets, gravel streaks, sand streaking, dusting, surface scaling etc. shall be repaired to the satisfaction of the Engineer immediately after completion of curing. Subject to the Engineer's approval, remedial measures may include, but shall not be limited to, the following:

1. Holes left for formwork ties supports shall be thoroughly cleaned out to remove all loose material and the sides shall be roughened, if necessary, to ensure a satisfactory bond. They shall then be filled with appropriate dry-pack special mortar to be approved by the Engineer;
2. Air or rock pockets, Fins, pinhole bubbles, surface discoloration and minor defects may be repaired rubbed down with sacking and cement immediately the formwork is removed. with special repair mortar;
3. Abrupt and gradual irregularities like gravel or sand streaks may be rubbed down with carborundum and water after the concrete has been fully cured. Loose and/or sticking out aggregates shall be broken out, the defect places shall be repaired with special repair mortar;
4. Small defects and minor honeycombing shall be chipped out perpendicular to the face of the concrete to a depth of at least 25 mm and filled with special repair dry-pack mortar as specified in Sub-clause D.7.5.10;

5. Fissures shall be repaired according to Sub-clause D.7.5.12.

D.7.5.11.2 Repair Workmanship

The repair mortar shall be pre-shrunk by mixing it to a plastic consistency as far in advance of its use as possible. Trial mixes shall be made and aged to determine the longest period the mortar's use can be delayed while retaining sufficient plasticity to permit good workmanship.

Immediately prior to the application of the mortar, the damp surface of the area to be repaired shall be scrubbed thoroughly with a small quantity of neat cement ground, using a wire brush. Remaining loose sand particles shall be swept away immediately before application of the mortar.

In applying the mortar, it shall be compacted into the space to be filled, care being taken to eliminate air pockets and to secure bond at the edges. The surfaces shall be shaped and finished to correspond with adjacent surfaces of the pipe.

The newly repaired surfaces shall be kept damp for 24 hours after the repair is completed. A membrane coating of an approved white-pigmented sealing compound shall then be applied.

Epoxy resin as bonding agent shall be used as a in the manner prescribed by the manufacturer. The prepared area shall be primed with the epoxy resin compound, care being taken to insure intimate contact with the base material. Mortar shall be applied before the epoxy resin compound sets.

D.7.5.12 Concrete Injection

To repair cracks in concrete and if in the Contractor's opinion normal concrete repair methods as described above are deemed not to succeed, upon the Engineer's approval epoxy injection resin may be applied in order to effectively seal the crack to protect the reinforcement and to monolithically weld the structure together.

Before any injection application the cracks to be injected shall be to examined carefully to find the best injection method and material.

Injection material shall have the following characteristics:

- Low viscosity;
- High modulus;
- High penetration ability;
- High tensile and bond strength and durability;
- Non-shrinkable;
- Creating permanent, high-strength bonds between concrete surfaces when fully cured;
- Allowing for the normal transfer of loads designed into the original structure;

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- Creating an impervious seal to air, water, chemicals;
- Good workability.

D.7.5.12.1 Equipment

For the equipment used to inject the resin, the Contractor shall meet the recommendations of the approved resin injection material manufacturer and the following requirements:

1. Equipment shall have the capacity to automatically proportion the material components within the mix ratio tolerances set by the resin materials manufacturer.
2. Equipment shall have the capacity to automatically mix the resin component materials within the pump and injection apparatus. The Engineer will not allow batch mixing.
3. Equipment shall have the capacity to inject the resin under controlled variable pressures up to 1.4 MPa, with a pressure gauge mounted at or near the nozzle to indicate the actual working pressure.

D.7.5.12.2 Injection Personnel Qualifications

Only personnel trained in performing injection work similar to that works required for the project shall carry out the resin injection of cracks in concrete. The Contractor shall provide an on-site supervisor for the resin injection work who is sufficiently qualified certified by the manufacturer of the resin injection material as having the necessary competence to accomplish the epoxy injection work in a satisfactory and safe manner in compliance with these Specifications.

D.7.5.12.3 Crack Surface Preparation and Cleaning Requirements

The area surrounding the cracks shall be cleaned of all deteriorated concrete, efflorescence and other contaminants detrimental to the adhesion of the surface sealing resin compound. Clean the interiors of the cracks with air under sufficient pressure to remove loose materials entrapped within the crack including efflorescence.

D.7.5.12.4 Sealing Cracks for Epoxy Injection

After cleaning, injection port holes shall be drilled using a swivel drill chuck and hollow drill bits, including a vacuum attachment which will remove dust and debris generated during drilling. The spacing of the injection port holes shall be determined by the size of the crack and the depth of the crack in the concrete substrate. The actual spacing of injection ports shall be determined by field trials. The holes shall be drilled to the necessary depth, exercising care in aligning the hole along the plane of the crack so that the hole follows the crack for the full depth. Injection ports shall be inserted in the drilled holes, allowing for a small reservoir below the injection port.

After cleaning the cracks and drilling the injection port holes, the crack surface and the injection ports shall be sealed with approved suitable epoxy.

D.7.5.12.5 Epoxy Injection

The resin shall be injected in accordance with the approved resin manufacturer's instructions and chosen equipment. The actual injection procedures and pressures shall be determined in field trials, based on crack widths and depth into the substrate and sufficiency of the results.

The injection pressure shall be limited in order to avoid additional stressing of the crack, hydraulic lifting, rupturing of the cracked substrate, or further elongation of the crack.

Injection on very cold or hot concrete substrate or injection during cold or extremely hot weather shall be avoided.

When injecting resin against a head of water the cracks shall be sealed special high-mod epoxy gel adhesive to prevent water blowouts while injecting.

D.7.5.12.6 Cleaning after Epoxy Injection

The concrete surface areas shall be cleaned of excess epoxy materials and injection ports after completing the epoxy injection work. Cleaning shall be accomplished in a manner which will not damage the concrete by scraping, light sand blasting, grinding, use of solvents, or any other appropriate method approved by the Engineer. Excess materials shall be cleaned so that no epoxy material or injection ports extend beyond the plane surface of the concrete.

D.7.5.12.7 Acceptance

Failed injection work shall be corrected as necessary to the Engineer's satisfaction. Additional injection ports shall be installed as required to achieve satisfactory reinjection of epoxy resin.

After the epoxy injection work is completed and accepted, the core holes shall be filled with an epoxy mortar consisting of one part by volume epoxy injection resin and four parts by volume clean, dry sand.

D.7.6 Joints

D.7.6.1 Construction Joints of Watertight Concrete

D.7.6.1.1 Definition:

A construction joint is defined as a joint in the concrete introduced for the convenience of execution and at which special measures have to be taken to achieve subsequent continuity without provision for further relative movement.

Any and all construction joints shall be fitted out with central waterstop, and with sealant fillet in a groove if required elsewhere (H-BAU PENTAFLEX KB or approved equivalent).

D.7.6.1.2 Material of bonding Agent

The Contractor shall submit specifications for approval to the Engineer. Primer and bonding agent shall be from the same family of products offered by the same manufacturer.

D.7.6.1.3 Material of Sealant for Grooves

Prior to ordering the sealant material, the Contractor shall submit to the Engineer for approval sufficient data to demonstrate general compliance with the specification requirements. Primer and sealant shall be from the same family of products offered by the same manufacturer.

The sealant shall be two-pack polyurethane polymer specially designed for bonding to concrete continuously submerged in water and shall meet the following requirements:

Work life 45-90 mins. Time to reach "All hardness" (at 25°C, 200 gr quantity): 20 hours max.

- Ultimate hardness: 20 - 40 shore "A".
- Tensile strength: 16 kg/cm² min.
- Tear resistance: 120 kg/cm of thickness.

Alternatively a two-part polysulphide, gun grade, compliant with BS 4254 or similar may be used as a sealant subject to the Engineer's approval.

Certified test reports from the sealant manufacturer on the actual batch of material being supplied indicating compliance with the above requirements shall be furnished to the Engineer before the sealant is used on the works.

The primer and sealant shall be placed strictly in accordance with the recommendations of the manufacturer, taking special care to properly mix the sealant prior to application. Before any sealant is placed, the persons carrying out the work shall be carefully instructed as to the proper method of application.

All sealant shall cure at least 7 days before the structure is filled with water.

D.7.6.1.4 Material for PVC or Polymer central Waterstops

Central waterstops shall have 10 mm thick webs and be extruded from an elastomeric Polyvinylchloride compound containing the necessary plasticisers, resins, stabilisers and other materials necessary to meet the requirements of these Specifications.

The Contractor shall furnish to the Engineer current test reports and a written certification that the material to be supplied meets the following physical requirements:

Physical property, sheet material

• Tensile strength - min	[kg/cm ²]	120
• Ultimate elongation - min	[%]	350

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- Stiffness in flexure - min [kg/cm²] 28

Accelerated extraction

- Tensile strength- min [kg/cm²] 105
- Ultimate Elongation - min [%] 300

Finished waterstop:

- Tensile strength - min [kg/cm²] 100
- Ultimate elongation - min [%] 280

H-Bau Pentflex KB (galvanized iron water stop sheet with resistant coating, 30 mm installation depth, up to 50 m water pressure) or approved equivalent with ETA certificate shall be used.

Prior to use of the waterstop material in the field, a cross section sample of a fabricated waterstop of each size or shape to be used shall be submitted to the Engineer for approval.

D.7.6.1.5 Field Splices of central Waterstops

Field splices and joints shall be made in accordance with the waterstop manufacturer's instructions using a thermostatically controlled heating iron. These samples shall be fabricated so that the material and workmanship represent in all respect the fittings to be furnished under this contract. When tested, they shall have a tensile strength across the joints equal to at least 42 kg/cm².

Horizontal waterstops shall be held in place with continuous supports to which the top edge of the waterstop shall be tacked.

Vertical waterstops shall be held in place with light wire ties at 45 cm centres, which shall be passed through the edge of the waterstop and tied to the two curtains of reinforcing steel.

D.7.6.1.6 Execution

Concrete placed to form the face of a construction joint shall have all laitance removed and the large aggregate exposed prior to the placing of fresh concrete.

The laitance shall wherever practicable be removed when the concrete has set but not hardened by spraying the concrete surface with water under pressure or brushing with a wire brush sufficient to remove the outer mortar skin and expose the large aggregate without being disturbed.

Where the laitance cannot be removed due to hardening of the concrete, the whole of the concrete surface forming the joint shall be treated by high pressure water jet, sand blasting, use of a needle gun or a scaling hammer to remove the surface laitance.

When placing concrete around waterstops, concrete shall be worked under the waterstops by hand so as to avoid the formation of air and coarse aggregate pockets.

Where grooves are to be provided, the profiles used for forming the grooves shall be left in the grooves until just before the grooves are cleaned, primed and filled with joint sealant. After removing the form from the grooves, all laitance and fins shall be removed and the grooves shall be sandblasted.

The grooves shall be allowed to become thoroughly dry, after which they shall be blown out, immediately thereafter, they shall be primed and filled with the construction joint sealant.

D.7.6.2 Expansion and Contraction Joints, General

D.7.6.2.1 Definition

An expansion or contraction joint serves to absorb the relative movements of adjacent structures and is described on the drawings. Any expansion or contraction joint shall be fitted out with a central waterstop, a joint filler and sealant finish that can follow the relative movement.

Such joints for expansion and contraction shall be constructed in accordance with the details and to the dimensions shown on the approved drawings or where otherwise ordered by the Engineer and shall be formed of the elements specified.

The Contractor shall pay particular attention to the effects of climatic extremes about the works on any material which he may desire to use in any movement joints and shall submit for approval by the Engineer his proposals for the proper storage handling and use of the said materials having due regard to any recommendations in this connection made by manufacturers.

D.7.6.2.2 Material of Bonding Agent

Same as under D.7.6.1.2.

D.7.6.2.3 Material of Waterstops

Central Waterstops shall be of PVC exclusively and conform to the requirements specified before and elsewhere. All waterstops in one structure shall be of the same material.

Waterstops shall be supplied by the longest practical units from the supplier's works and shall be continuous throughout the structure below highest water level. Intersections and joints shall be factory made where possible.

Waterstops shall be carefully maintained in the position and supported on accurately profiled stop boards to create rigid conditions.

D.7.6.2.4 Material of Joint Filler

Joint filler shall be either cork / bitumen joint filler or cellular joint filler. Cork / bitumen joint filler shall be waterproof and rootproof and shall not extrude as a result of compression. Cork joint filler shall compress to less than 50 % of its original thickness with immediate recovery to 80 % or more of its original thickness.

Cellular joint filler shall be used only for joints of low horizontal loading and shall be a pre-formed low compression joint filler made from foam rubber. Cellular joint filler shall recover to its original thickness after each loading and unloading.

D.7.6.2.5 Execution

Preparation of concrete surfaces shall be applicable as under D.7.6.1.6.

The joint filler shall be fixed to the required dimensions of the joint cross section and shall provide a firm base for the joint sealer. Where the depth of joint between the concrete surface and the water stop does not exceed 500 mm filler shall be placed in single depth sections.

Sealing of expansion joints shall be carried out only when adjacent concrete surfaces are perfectly dry and as long after the concrete has been set as possible. Immediately before the application of the joint sealer the groove protection batten shall be removed in such lengths as represent a single day's work for sealing the joints.

The joint grooves shall be cleaned, adequately primed and filled with approved sealer strictly in accordance with the manufacturer's instructions and on joints of 25 mm and larger with a shape factor of 2:1 (width to depth).

On permanently exposed areas of structures joint sealing is to be carried out with the aid of masking tape to form neatly defined surface limits to the sealer.

D.7.6.3 Sliding Planes

Sliding planes on the concrete and joint blinding layers shall consist of a bitumen sand mixture 1 to 4 by volume spread evenly 3 mm thick over the carpet coat or of building paper either of which shall be applied immediately before the structural floor is concreted and shall be at all times suitably protected. Where building paper is used the concrete formation carpet shall be finished with a steel trowel to give a smooth surface.

Sliding joints shall consist of two layers of purpose made preformed plastic membrane which when in contact shall give a coefficient of friction of not more than 0,2 when subjected to a load of 270 kg/m². Where formed in concrete structures, the lower joint bedding surface shall be steel float finished to a smooth true surface.

D.7.7 Concreting

D.7.7.1 Preparing for Concreting

For the preparation of concreting, the following shall apply:

- No concrete shall be placed until all provisions and related aspects (such as formwork, installation of reinforcement and parts to be embedded and preparation of surfaces involved in the placing...etc.) have been approved by the Engineer;
- Each surface shall be free from mud and debris and be thoroughly wetted by sprinkling prior to the placing of any concrete;
- For watertight structure all slabs, beams and walls shall be concreted in one batch.

Before any lift of concrete is placed, the Contractor shall carry out an inspection to ensure that all preparations are complete, including the provisions of the necessary equipment and personnel and shall ensure that sufficient materials are available to complete the works proposed.

D.7.7.2 Transporting and Placing

Concrete shall be transported from the mixer to its place in the works as rapidly as possible by approved methods which will prevent segregation or drying out and ensure concrete of the required workability at the time of placing:

- Concrete shall not be placed when unsuitable wind and temperature conditions prevent proper placement and curing as determined by the Engineer;
- Concrete shall be placed by hoppers and chutes and, if necessary, by vertical ducts;
- The free fall of concrete after chutes and ducts shall in no case exceed 1,5 m;
- Concrete shall not be dropped through any reinforcement or into any deep form in order to avoid segregation;
- Concrete shall be placed and compacted before the initial set has occurred and, in any event, not later than 45 minutes from the time of mixing.

The concrete shall be placed in the presence of the Engineer, unless agreed otherwise. The Contractor shall notify the Engineer in writing 24 hours prior to the placing of any concrete.

The order of placing in all parts of the work shall be subject to the approval of the Engineer.

In order to minimise the shrinkage, the concrete shall be placed in units as bounded by construction joints. The placing of the units shall be done in such a way that each unit shall have cured for at least 7 days before the contiguous units are placed, with the exception of walls which shall be placed not before the wall footings or adjacent wall panels have cured for at least 14 days.

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Whenever a run of concrete is stopped or completed, the surface of the concrete shall be levelled with a trowel and all laitance shall be removed.

D.7.7.3 Compaction

As concrete is placed in forms or in excavations, it shall be thoroughly settled and compacted, throughout the entire depth of the layer which is being consolidated, into a dense, homogenous mass, filling the form completely, thoroughly embedding the reinforcement, eliminating air and aggregate pockets and bringing only a small amount of excess water to the surface of concrete during placing.

For compaction the Contractor shall use power driven vibrators supplemented by hand spading and tamping, except as otherwise approved by the Engineer.

A sufficient number (including stand-by) of appropriate sizes vibrators shall be available on Site at all times.

D.7.7.4 Attendance of Steel Fixer and Carpenter

When concreting reinforced concrete, a competent steel fixer and carpenter shall be in attendance on each concreting gang to ensure that the reinforcement, formwork, spacers and embedding fittings are kept in position as works proceed.

D.7.7.5 Concreting in Hot Weather

The temperature of concrete as placed shall not exceed 30°C in order to prevent rapid drying of the newly placed concrete. To achieve this, the Contractor shall provide sunshades over aggregate stockpiles, cement silos and mixing water tanks and preferably place concrete during the night hours.

With the approval of the Engineer, also the following procedures may be applied:

- Cooling of mixing water by chipped ice;
- Sprinkling of stock piles with water;
- Shade or wet the outside of the formwork.

The fresh concrete shall be shaded and cured as soon as the surface of fresh concrete is sufficiently hard.

D.7.7.6 Concreting in Cold Weather

Cold weather is defined as the situation existing at the Works, where either or both of the following conditions exist:

- The air temperature at the time considered is below 2°C;

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- The mean daily air temperature over three or more successive days has dropped below 5°C.

Under no circumstances may concrete be placed in contact with frozen ground or formwork, or in contact with ice, snow or frost on the ground or on formwork or reinforcement. Concrete shall not be made with frozen materials.

Concreting may proceed in cold weather provided that special precautions approved by the Engineer are taken to ensure that the surface temperature of the concrete at the time of placing is not less than 5°C for a succeeding period of at least:

- 4 days when the cement used in the concrete is ordinary Portland cement;
- 2 days when the cement used in the concrete is rapid hardening Portland cement.

Such precautions may include the following:

- Warming the aggregates and heating the water, provided that the temperature of either does not exceed 60° C. Water and aggregates shall be mixed for a period sufficiently long for them to acquire a uniform temperature before cement is added;
- Completely surrounding the freshly placed concrete with a cover and heating the enclosed air, which shall be kept moist. Draughts of hot or dry air shall not be directed at surfaces;
- Insulating the formwork and finished concrete surfaces;
- Providing screens to protect the concrete from air currents.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to protect the concrete from the effects of low temperatures and with details of the methods he proposes to use assess the correct timing at which such protection may be removed.

No concreting shall be done in cold weather prior to the approval the Engineer for the proposed measures.

D.7.7.7 Concreting in unfavourable Weather

Concreting shall not be permitted during heavy rain or snowfall, or when the air temperature falls below 2 °C, or when the concrete temperature rises above 30 °C. When the air temperature exceeds 25 °C, concreting shall only be permitted after special precautions, approved by the Engineer, have been taken to prevent early setting of the concrete, such as lowering the temperature of the water to be used in the mix or by means of a cooling-system, keeping the aggregates and shutters continuously sprayed with water and erection of temporary sun shades over the working area. During concreting operations the temperature of the placed concrete shall be recorded.

D.7.7.8 Curing of Concrete

All concrete shall be cured by protecting the surface from the effects of sun, drying winds, rain, running water or mechanical damage for a continuous period of at least seven days by:

- Keeping wooden formwork wet until it is removed;
- Covering the concrete surface with burlap mats and keeping them wet;
- Covering the surface with moist earth (not before 4 hours and not longer than 24 hours after concreting);
- Spraying the surface with water or a liquid curing compound.

D.7.7.9 Care and Repair of Concrete

The Contractor shall protect all concrete against injury or damage from excess heat, lack of moisture, overstress or any other cause until final acceptance by the Engineer.

Any concrete found to be damaged, which may have been originally defective, which becomes defective prior to the final acceptance of the completed work or which does not conform to the Specification, shall be repaired or removed and replaced by the Contractor to the Engineer's satisfaction.

Repair of concrete must be made by a proper mortar which is designed for only repair purposes; e.g., Sika Monotop 610–604–620 (or equivalent approved products).

Mortar for concrete repair works must be approved by the Engineer prior to the commencement of any repair works.

D.7.7.10 Finish of Concrete Surfaces

Workmanship in formwork and concreting shall be such that concrete does not require making good, i.e. surfaces are perfectly compacted, smooth and with no irregularities. Surfaces shall be free from fins, bulges, ridges, offsets, honeycombing or roughness of any kind.

Except if otherwise provided, unformed top surfaces of concrete shall be brought to a uniform surface and worked with suitable tools to a smooth wood-float finish. Excessive floating of surfaces while the concrete is plastic will not be permitted.

As soon as forms are removed, all exposed surfaces shall be carefully examined and any irregularities shall be immediately rubbed or ground in a satisfactory manner in order to secure a smooth and uniform surface.

Plastering or coating of surfaces shall not be permitted. No repairs shall be made until after inspection by the Engineer and then only in strict accordance with his instructions.

D.7.7.11 Prefabricated Concrete Members

Prefabricated concrete members shall be obtained from an approved manufacturer or prepared by special skilled employees upon Engineer's approval, and shall be true to dimension and shape, with true arises and with perfectly smooth exposed faces free from surface blemishes, air holes, crazing or other defects, whether developed before or after building-in.

The prefabricated concrete members shall comply in every respect with the provisions of the contract whether such units are manufactured on the site or obtained from approved manufacturers.

All cement, aggregate and other materials for precast concrete units with faces which are exposed whether internally or externally, shall be from the same sources throughout.

Exposed surfaces of the units shall be uniform in colour and in texture.

Formwork and unformed surfaces for prefabricated concrete members shall comply generally with the accuracy grade "C".

D.7.7.12 Pre-stressed Concrete

Pre-stressed concrete work whether prefabricated or cast in-situ shall be as detailed on the approved drawings and the Contractor shall submit to the Engineer for approval full details of his proposed method of carrying out all operations connected with pre-stressing including:

- Design of concrete mix; description of concrete casting and curing operations;
- Procedure for pre-stressing and method of checking and recording the pre-stressing wire extension and anchorage slip;
- Procedure for handling, hoisting and placing of any pre-cast units;
- Grouting of ducts.

All tendons, duct forming devices, anchorages and other components shall be kept free of mud, oil paint, retarders, loose rust or other foreign matter. They shall be placed with a tolerance of ± 3 mm in concrete dimensions of 300 mm or less or ± 6 mm in concrete dimensions over 300 mm.

The bearing surfaces between anchorages and concrete shall be normal to and concentric with the tendons and the line of action of the pre-stressing force.

D.7.7.13 Concrete for Benching

Concrete benching in chambers and works structures shall consist of concrete with adequate consistency and aggregate sizes. It shall be placed with low workability to the approximate shape required and, while still green, shall be finished with not less than 50 mm of concrete to a steel trowelled finish and to the contours indicated on the drawings.

D.7.7.14 Pumping Concrete

Where pumping of concrete is permitted to be used, no relaxation of the requirements of this Specification will be permitted.

Particular attention shall be paid to the proper grading of aggregates to prevent bleeding and/or segregation during the pumping operations.

The inclusion of water-reducing additives or other materials such as fly ash, to improve the flow characteristics of the concrete will only be permitted upon Engineer's approval.

D.8. ROAD WORKS

D.8.1 General requirements

This section covers the technical requirements for the road works, as specified in the Contract including the construction or reinstatement of roads and pavements as shown on the drawings or as directed by the Engineer.

All materials shall be new and shall comply with standard quality and dimension provisions. Non-standardised materials and building components shall be subject to the Engineer's approval and the Contractor shall, at the request of the Engineer, provide samples, details and name of manufacturer...etc. to the Engineer's satisfaction.

Mineral materials shall be weatherproof, of adequate hardness and of sufficient adhesion to bind. They shall not contain any swelling, weathering, loamy, clay or organic components in harmful quantities.

Bituminous mixes shall be blended so as to be suitable for the purpose of application. Special consideration shall be given to climatic conditions, volume and type of traffic.

D.8.1.1 General Road Layer Structure

D.8.1.1.1 Top or Wearing Course

Top courses shall fulfil the following requirements in generally: good evenness, good grip, good sealing against lower layers against precipitation, low void content, high resistance against deformation:

- Minimum layer thickness: 3 cm (for bituminous wearing course) respectively 14 cm for concrete wearing course;
- Material: bituminous concrete, hot mix asphalt, asphalt mastic, concrete;
- Grading: 0/5, 0/8, 0/11, 0/16 (for bituminous wearing course).

D.8.1.1.2 Binder Course

Binder courses shall fulfil the following requirements in generally: high resistance against deformation, good equalisation of unevenness of substratum, good shear acceptance:

- Minimum layer thickness of bituminous binders: 4 cm;
- Material: bituminous concrete with high void content;
- Grading for bituminous binders: 0/11, 0/16, 0/22.

D.8.1.1.3 Base courses

Base courses shall ensure a regular force distribution, be frost proof and fulfil the following requirements:

- Minimum layer thickness: 8 cm;
- Material in case of bituminous binders and top layers: bituminous base course, hydraulically bound base course;
- Material in case of concrete top layers: hydraulically bound base course;
- Grading: 0/22, 032.

D.8.1.1.4 Roads to be Reinstated

The roads and pedestrian access pavements to be reinstated may include the following types of surfacing:

- Asphalt concrete pavement on a macadam base;
- Asphalt concrete pavement on a cement stabilised gravel base;
- Double bituminous surface treatment on a cement stabilised base;
- Double bituminous surface treatment on a selected gravel base;
- Natural cobblestones;
- Gravel roads and foot paths;
- Tiled pavements.

For the precise details of materials to be used and thickness of construction, the Contractor shall refer to the Technical Requirements of the Local Road & Highway Authority and international standards.

D.8.2 Maintenance and Reinstatement of Existing Roads and Footpaths

The Contractor shall maintain existing roads and footpaths within the Site. He shall reinstate the pavements, curbs and other parts of the roads after execution of works to its original state.

Temporary reinstatement of public roads shall be carried out as soon as is practical after completion of the Permanent Works and before the Part of the road or pavement is re-opened for public use. Temporary reinstatement shall be maintained by making good any subsidence, shrinkage, defect, imperfection or fault a period as directed by the Engineer but at least 3 months prior to final reinstatement.

The Contractor shall remedy any settlement occurring after execution of works immediately upon notification by the Engineer.

Such remedy of pavement shall be done to the Engineer's satisfaction and may include the re-excavation of the top surface, base and sub-base, the backfilling of base and sub-base with graded aggregate and the reinstatement of the surface.

D.8.3 Sub Grade

Sub grade shall be graded and compacted to the levels, falls, cambers as required by approved international standard and shall be compacted so that the dry density of the upper 15 cm of the ground or fill is not less than 95 % Proctor of the maximum dry density determined by tests. Where the sub grade is the natural soil, compaction shall be carried out at or near to the natural moisture content of the ground.

Material not suitable to reach the required density shall be removed and replaced with material for granular sub base.

Surface of sub grade shall be kept free of standing water at all times and drains shall be provided so that it will drain quickly and effectively during rain.

Any irregularities or depressions that develop during compaction of the sub grade or any area which becomes muddy, broken-up or loosened due to weather conditions shall be corrected by loosening the surface of these places and adding, removing or replacing these materials and re-compacting so that the surface is smooth and uniform to the Engineer's satisfaction.

D.8.4 Pavement

D.8.4.1 Sub-base and Road Base

The sub base and road base shall be graded and compacted to the levels, falls, cambers and densities as required by approved international Standards and as shown on drawings.

The materials for sub-base and road base shall be laid in layers, each not exceeding 15 cm or being less than 10 cm. The total compacted thickness of sub-base and road base shall nowhere be less than the specified nominal thickness. If not otherwise directed by the Engineer, the sub-base and base in roads shall have each a thickness of 20 cm, in footpaths a thickness of 15 cm.

The sub-base and road base materials shall be deposited in such a manner that there is no segregation and the materials require the minimum of blading or spreading. Each layer of material shall be compacted immediately after spreading in accordance with international Standard. If any of the sub grade material is worked into the sub base material during spreading, profiling or compaction, all the sub base material in the affected area shall be removed, the sub-grade compacted again and fresh sub base material shall be placed to the Engineer's satisfaction.

On completion of compaction and before commencing the next operation, the surface of the granular sub base and road base shall comply with a surface tolerance of ± 1 cm.

D.8.4.2 Surfacing, General

Wherever possible, the operations of final trimming of the formation, compaction of the sub grade and placing and compaction of the granular sub-base and road base shall be carried out immediately one after another.

The Contractor shall take all necessary steps to prevent damage to the previously completed layer or layers by excessive wetting or drying out due to weather conditions or by traffic or any other cause. If the contractor considers it as advisable or if so instructed by the Engineer, the completed layers shall be sealed using bitumen road emulsions.

In any case, the completed surface of the road base shall be sealed with suitable emulsion (M.C. 70) at a rate of 1,5 to 2,0 kg/m² immediately when it has been completed and checked for compliance with the specified tolerances.

D.8.4.3 Flexible Pavement

Unless otherwise specified or instructed by the Engineer, materials for flexible pavement shall be bituminous concrete and asphalt, in a quality corresponding to the approved international standards and applicable local regulations. The surface on which each course of coated bituminous material to be laid shall be free from standing water and any loose or deleterious material and shall be tested for accuracy.

Before laying commences in any area, a tack coat of bitumen road emulsion shall be applied to the whole area of the preceding course and any other surfaces with which the coat will be in contact.

The top of the base shall be sprayed with suitable emulsion (M.C. 70) at a rate of 2,0 kg/m²; the surface of the bituminous coat shall be treated with asphalt tack coat (RC-250) at a rate of 0,5 kg/m². The emulsion shall be allowed to break completely before the subsequent bituminous layer is laid on it.

Heaters used for bitumen shall conform to BS 1676 and the heated bitumen shall be applied by self-propelled pressure distributors with spray bars complying with BS 1707 or BS 3136. Where different grades of bitumen are used, heaters and distributors shall be thoroughly cleaned before the grade of bitumen is changed. Flushing from heaters and distributors shall be drained to disposal pits and not discharged into drains, ditches or watercourses. Any bitumen heated above the maximum specified temperature shall be removed from the Site and replaced by the Contractor. Hand spraying shall only be used if approved by the Engineer.

Where spraying is commenced or stopped, metal sheets or building paper shall be spread across the width of area to be sprayed to produce a clean sharp edge to the area. The sheets shall be cleaned daily and the building paper properly destroyed after use.

During spraying, all kerbs, headwalls and other road furniture shall be protected from bitumen splashing.

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During the course of the work only essential construction equipment shall be allowed into the area and not allowed to stand on completed work. The road shall not be opened to general traffic until directed by the Engineer.

Coated macadam material shall be delivered to site in clean vehicles and shall be covered to minimise loss of heat in transit and against contamination by dust or other deleterious matter.

Binder for surface dressing shall only be applied upon completion of the priming and when any defect to the primed surfaces have been repaired. No binder shall be applied until primed surfaces have been approved by the Engineer.

Aggregate shall be spread, by mechanical chip spreaders, immediately following the spraying of the binder and no work are to commence until sufficient supplies of aggregate are at hand. Manual spreading of aggregate shall only be permitted when approved by the Engineer. After applications of aggregate, the surface shall be lightly broomed to give a uniform coverage with no areas having an excess or deficiency of aggregate. Within 20 minutes of application and brooming of the aggregate, the surface shall be rolled with a self-propelled pneumatic-tyred roller, weighing not less than five tons, until a smooth, well-compacted surface is obtained.

Upon completion, all loose aggregates shall be removed from the surface for proper disposal off the site.

Bitumen binder shall be straight run 80/100 penetration grade bitumen and the first seal coat shall consist of bitumen sprayed at the rate of 1,2 l/m² of surface area and 19 mm aggregate spread at the rate of 70 m²/m³ of aggregate. The second seal coat shall consist of bitumen sprayed at the rate of 1,2 l/m² of surface area and 12 mm aggregate spread at the rate of 100 m²/m³ of aggregate.

Aggregate grading shall be as follows:

Sieve (mm)	20	14	10	6,3	5	3	2	0,5
First seal	100	85 - 100	0 - 30	0 - 7	-	-	0 - 2	-
Second seal	-	100	85 - 100	0,30	0 - 10	-	0 - 2	

and should have the following aggregate requirements:

- Los-Angeles Abrasion (LAA): max. 35
- Aggregate Crushing Value (ACV) max. 26
- Sodium Sulphate Soundness (SSS) max. 12
- Flakiness Index (FI) max. 25

The rate of delivery to the site shall be regulated so as to enable the material to be laid with a minimum of delay and so that the paver can operate continuously.

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The coated thickness of individual layers shall be not less than the minimum compacted thickness specified or as shown in drawings. If not otherwise directed, the bituminous base course shall have a thickness of 10 cm, the wearing course of 5,0 cm.

D.8.4.4 Rigid Pavement

Rigid paved areas shall be constructed in concrete in accordance with approved international Standards and with the relevant requirements of the Specification for Concrete Works.

Concrete shall be in accordance with ISO 22965 and EN 206 and it shall include an exposure class of at least XM1.

Concrete for rigid pavement shall be of class C 20/25. The use of additives shall be subject to the approval of the Engineer. Concrete courses shall be never less than 100 mm thick.

Transport and placing of the concrete shall be co-ordinated so that the concrete can be completely placed before setting.

Expansion joints shall be executed at the required intervals and shall enable expansion to the concrete slabs and be fixed. The expansion joints shall be 20 mm wide. The strength of the concrete and the properties of the concrete surface shall not be influenced by the execution of joints.

The concrete shall be protected against harmful influences until correct setting, i.e. against drying out, especially due to sun and wind, against washing out due to rain, against heat or quick cooling. The concrete surfaces shall be cured and kept moist for 7 days.

D.8.4.5 Kerbs

Kerbs shall comply with the following Standards:

- EN 1343 Kerbs of natural stone for external paving – Requirements and test methods;
- EN 1340 Concrete kerb units - Requirements and test methods.

Kerbs shall be laid true to line and level. Kerbs found to be more than 1 cm out of line or level at either end shall be lifted and relaid.

Kerbs shall be bedded on a layer of 3:1 sand / cement mortar, minimum 10 cm thick on a grade C 8/10 concrete foundation and shall be backed with concrete shaped up to the required cross section. Kerbs shall be jointed with cement mortar except at expansion joints which shall be made with joint filler, 10 mm thick.

D.8.4.6 Footpaths

Footpaths shall be surfaced with coated macadam, concrete, pre-cast concrete slabs or natural stones. The base for footpaths shall be formed from flexible surfacing, laid and compacted to a

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minimum thickness of 100 mm using a roller of at least 2 tons mass or other approved equipment allowing for equivalent compaction.

Where footpaths receive coated macadam surfaces, the construction shall be as follows:

- pre-cast concrete edging in accordance with the appropriate Standards as mentioned above shall be bedded and backed with in-situ concrete C 8/10;
- the base shall be constructed as specified above and shall then be sealed;
- the surfacing shall consist of a single course of coated macadam and be compacted to minimum thickness of 25 mm.

Pre-cast concrete slabs shall be bedded on a layer of sand, of thickness not less than 50 mm, and tamped into place.

Natural stones shall be sound, durable, hard and free from undesirable weathering and shall be of such properties that they will not disintegrate from the action of weather in handling and placing.

The density of stones shall be not less than 2,2 t/m³ (solid volume without voids).

The dimensions of stones shall range between 150 and 200 mm.

The stones will be rough hammered dressed so that they fit reasonably close together.

They shall be laid to a true and even surface on a layer of sand, approximately 100 mm thick and tamped into place.

Concrete footpaths shall be surfaced with concrete C 20/25, at least 10 cm thick with mortar topping, constructed on a prepared bed as specified above and in accordance to the Specification for Concrete Works.

D.8.4.7 Disposal of surplus Material

Unless otherwise directed by the Engineer, the Contractor shall make his own arrangements to dispose of all surplus backfill and unsuitable excavated material from any part of the Work.

The material shall be disposed off-site and shall become the property of the Contractor who will be entirely responsible for its removal from the Site and its ultimate disposal.

The Contractor shall clean the Site and the surrounding ground immediately and leave the construction sites clean and tidy to the satisfaction of the Engineer.

D.9. DRAINAGE WORKS

D.9.1 Piped Systems

Specifications for sewers shall apply (see section General Technical Specifications Part C).

D.9.2 Open Channels

Open channels shall be constructed either as earth channels, in stone work or with pre-cast concrete elements in half-round or rectangular sections.

Open channels adjacent to buildings, basins or other structures and channels with longitudinal slope steeper than 1:100 shall be constructed with pre-cast concrete or stone work, depending on soil conditions. Channel sections, which are subject to scouring, shall be protected with stone pitching.

Structural design of pre-cast concrete channels shall be submitted to the Engineer for approval. All backfilling shall be with selected approved material. If the soil is unsuitable for laying of channels, the Contractor shall place a bedding layer of approved granular material or concrete C 8/10 under the channel.

All road crossings of channels shall be constructed such that vehicular traffic is not exposed to danger.

The Contractor shall provide for the installation of pipes and culverts or grating over the channel.

D.10. FENCING AND GATES

D.10.1 General

Internal fencing shall be of the standard type and fencing around the perimeter of the site shall be of the security type. Security fences shall be anti-intruder type.

All items of material for fencing shall be standard products of specialized manufacturers. Posts and struts shall be either reinforced concrete or galvanized steel sections. Timber posts shall not be used. Steel posts shall be closed at the top with plastic or cast zinc alloy caps.

The distance between the posts shall be maximum 3.0 . The posts are to be set in stable C 20/25 concrete foundations. This applies also to the required cross braces for the corner poles.

Intermediate straining posts are to be installed to max.20 m intervals and at changes in line or direction. They shall have two diagonal struts and shall be provided with 3 double ratchet winders for the strain line wires and one joint clamp to fix the struts to the post. Strut foundations shall be cast in concrete C 20/25 and in sufficient size.

All wire shall be galvanized wire with plastic coating. The length of the sides of the chain link mesh shall be 50 mm. Sufficient straining wires, winding ratchets, joining clamps and other fittings required shall be provided for all end, corner and gate posts.

The steel mesh shall be secured to the posts at 0.30 m intervals along the height of the posts and the chain link fence shall be supported by fixing to 3 wires strung from post to post.

All posts and struts shall be anchored in rigid concrete C 20/25 foundations of sufficient depth. In the vicinity of gates, structures and fence openings, adequate provisions to fix the fences shall be provided.

D.10.2 Standard Fencing

Standard fencing shall consist of a 1.0 m high mesh wire fencing with steep posts of circular tubing of high tensile steel as approved by the Engineer.

The posts shall be galvanized inside and outside and plastic coated and closed at the top with plastic or cast zinc alloy caps. End, intermediate, corner and straining posts shall be 1.5 m long, gate posts 1.5 m long.

Corner and end posts shall either be supported by struts as for intermediate straining posts or by a horizontal bracing. Sufficient straining wires, winding ratchets, joining clamps and other fittings required shall be provided for all end, corner and gate posts.

Three rows of straining wires are to be installed for 1.0 m high fences.

D.10.3 Security Fencing

Security fencing shall be constructed as described for standard fencing, but with posts provided with barbed wire holders inclined outwards along the top edge.

The total fence height shall be 2.5 m. Six rows of straining wires are to be installed. The post length shall be 3.0 m minimum. Posts shall be anchored in foundations of a width/length 40 x 40 cm and a depth of at least 40 cm, filled with concrete class C 20/25.

Three rows of galvanized and plastic coated 2 strand, 4 point barbed wire shall be fixed to the cranked top section of the post. Sufficient ratchet, winders and clamps are to be provided to assemble and to secure the barbed wire.

D.10.4 Gates

Access gates shall be made of:

- a steel frame consisting in rectangular or round hollow parts of sufficient strength, width and height or diameter not less than 5 cm, wall thickness not less than 3 mm. The frame shall be 2.0 m in height;
- filling rods placed vertically into the frame in a distance not less than 10 cm and consisting in rectangular or round hollow parts of sufficient strength, width and height or diameter not less than 3 cm, wall thickness not less than 2 mm.

The whole frame including filling rods shall be factory welded, hot-dip galvanised and 2-layer coated.

The tops of the gate frames shall be levelled with the tops of adjacent fencing (excluding barbed wire holders). All gates shall be surmounted with galvanized plastic coated barbed wire to match the fencing.

Man-gates shall be hinged single-entrance gates with a clearance of 1 m.

Car-gates shall be motor-driven mono-rail based sliding gates with a clearance of at least 6 m. Motor, gearbox and drive wheel / pinion shall conform to the requirements. Sliding gates shall be provided with roller support tracks.

The gate shall be equipped with an automatic emergency stop mechanism to avoid persons to be shut between gate end and limit stop. Furthermore an additional emergency stop push button shall be installed. The gate shall be lockable with a key control switch.

Motor control shall be as follows:

- Gate opens automatically for cars leaving the plant by means of an inductive loop placed below the road surface in an appropriate distance from the gate. Gates closes automatically controlled by free adjustable timer;

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- Higher-ranking manual remote and key switch open-close control to be operated by the Security Staff;
- Higher-ranking emergency stop.

The Contractor shall submit to the Engineer's approval the detailed specifications of the gate system (gate, motor-drive, control).

Each man-gate shall be supplied with a padlock and three keys all to the Engineer's approval.

The gates shall be complete with all fittings such as drop bolts, back catches, locking bars, lock plates and locks including three keys per lock, etc.

D.10.5 Installation

Fences shall be installed in accordance with the fence manufacturer's drawings and written installation instruction and to the Engineer's satisfaction. Each line of fencing shall be erected so that it is plumb, taut, true to line and grade, and complete in all details. The outside face of the fabric shall be on the property line where the fence runs along the property boundary. Posts shall be suitably braced during concreting to ensure that they remain in the correct line and level during placing of concrete and the concrete shall be cured for 3 days before any further work is done at the post.

D.11. LANDSCAPING

D.11.1 General

All areas of the Site not occupied by treatment units, buildings, roads or footpaths, etc. shall be evenly graded to a uniform surface and shall receive an extensive greening. The vegetation of these areas shall correspond to the vegetation presently encountered on and around the Site, be suitable for local conditions and require minimal maintenance.

Areas near buildings shall be covered with lawn, bushes and trees.

The Contractor shall prepare and submit to the Engineer's approval prior to the start of the landscaping works, a landscaping scheme shown in a plan at a scale of minimum 1:1000 and including the proposed species of grass, trees and shrubs.

D.11.2 Topsoiling

So far as practicable, top soil shall be obtained from material emanating from excavations and separately stored in temporary spoil tips as specified and directed by the Engineer. If deemed necessary by the Engineer, he may instruct the Contractor to provide extra material from an approved source off the site for this purpose.

Topsoil shall be evenly spread and trimmed over embankments and filled excavation to the slopes and levels as shown on approved drawings. The depth after spreading and trimming shall be 250 mm measured perpendicular to the surface. All clods and lumps shall be broken up and any rubbish, large stones, roots and weeds shall be removed to the Engineer's satisfaction.

Where the upper layer of natural soil is poor in organic matter, it shall be improved to a minimum depth of 25 cm by adding either clay or sand or silt to create a loamy soil texture consisting of 40 % Sand (size > 0.05 mm), 30 % silt (size 0.05 - 0.002 mm) and 30 % clay (size < 0.002 mm).

A shallow ripping will be required before adding clay or sand or silt which should be under mixed properly by using a disk harrow. If it should be necessary for topographical reasons, levelling may be carried out before mixing clay, sand or silt.

D.11.3 Grassing

Where the topsoil shall be sown with grass seed, the top 75 mm of the previously laid topsoil shall be brought to a fine tilt suitable for seeding, and sowing shall be carried out as soon as practicable after completion of topsoiling having due regard to the season and the weather conditions. If ordered by the Engineer, subsoil lime and fertilizer shall be applied in accordance with his directions.

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After the seed has been sown uniformly, they shall be raked and lightly rolled into the surface. The young grass shall be kept free from weeds and any bare patches shall be re-seeded until an even close turf is established. The grass shall be watered, mown and rolled as required and maintained in good condition until the expiry of the period of maintenance.

The Contractor shall replace any and all damaged areas where the grass has dried up or has not adhered to the slope surface, which contains undesirable plants or which has an irregular or unattractive appearance in the Engineer's opinion.

D.11.4 Shrubs and Trees

Trees and shrubs shall not be planted at locations where roots may destroy or infiltrate buried pipes or cables or where lapsed leaves may fall or blown into open tanks. Number, species and location of trees and shrubs shall be approved by the Engineer before planting.

Trees and shrubs shall be of the species proposed by the Contractor, approved by the Engineer, of the best quality and free from disease and suitable for the climatic conditions on site. They shall be young stock or in the case of shrubs may be established seedlings or cuttings. All must be sufficiently mature to survive transplanting from the supply nursery.

The root systems of all plants shall be maintained intact in the soil in which they have been grown and may be supplied in containers.

All trees and shrubs and other plants shall be supplied by a nursery approved by the Engineer.

Prior to planting, holes for trees and shrubs shall be prepared and filled twice with water. Plants shall be watered in their containers so that the soil and the roots are kept in a moist condition. Plants shall then be removed from their containers and their root ball complete with soil set in place and the holes backfilled and the plants firmly trodden in.

Soil shall not be allowed to rise above the original container level and the ground level around the trunk or stem shall be set below adjacent ground to retain irrigation water.

All species of trees and shrubs where required shall be provided with supports during planting. These shall take the form of timber stakes of adequate strength driven into the ground adjacent to the trunk or stem without damage to roots. Wide hessian strips shall be used to tie the plant securely but not tightly to the support.

Where shrubs are to be planted in groups to provide ground cover, individual plants shall be spaced as follows:

Size	Height	Spacing
Small	less than 1 m	50 - 60 cm
Medium	1 to 2 m	90 – 120 cm
Large	over 2 m	180 cm

Shrubs for borders and hedges shall have a minimum height of 0.6 m. A minimum of 2 plants per m² are to be planted to create an evenly dense area. Trees to be supplied and planted shall have a minimum height of 1.5 m. For the plant holes vegetable soil is to be used. Stabilization of freshly planted trees against wind actions shall be provided if the Engineer deems it necessary.

D.11.5 Support for Climbing Plants

Training wires shall be pegged to brickwork walling where required to support climbing plants. Wires shall be horizontal fixed to every four courses of brickwork with pegs at 1,500 mm maximum centres.

Climbing plants shall be secured to wire with sisal string as required.

D.11.6 Irrigation

After planting of native tree and shrub species they shall be irrigated regularly until hand over to the Employer.

Grassed areas shall be irrigated immediately after planting and regularly thereafter until handing over. Watering of grass shall preferably be by night time sprinkler system. If watering is carried out during the daytime the area should be flooded.

D.11.7 Maintenance

All new plants and grassed areas shall be protected to prevent damage from workmen, builders plant and equipment and animals, by the use of temporary fencing or other suitable means. All new plants and grassing shall be maintained for not less than 12 months after planting. This shall take the form of irrigation, restaking, pruning, weeding, tilling, etc. to ensure sufficient growth is achieved by all plants up to hand over to the satisfaction of the Engineer.

Once grassed areas are sufficiently established they shall be kept cut or mown to provide a uniform depth growth. Edges of grassed areas shall be trimmed as necessary.

D.11.8 Replacement

Growth of shrubs, trees and grass shall be guaranteed for one year from the day of planting. Any trees, shrubs or areas of grass which fail to show satisfactory growth or that wither and die shall be replaced by the Contractor.

The responsibility for the irrigation and maintenance of these replacement plants shall remain with the Contractor until such time as they exhibit satisfactory growth.

D.11.9 Dressing of Topsoil

Prior to planting of lawn, shrubs or trees, the topsoil shall receive a dressing of chemical fertilizer or manure approved by the Engineer at a rate of 7.5 kg/m^2 . As minimum requirements, dressing of topsoil shall be done with lime, potash and super-phosphate, as applicable. After being spread uniformly on the surface the manure shall be thoroughly mixed into the top soil.

Dressing of topsoil shall only be carried out after watering and raining. The surface of the soil shall be kept wet until fertilizers have dissolved.

D.12. INSPECTION AND TESTING OF CIVIL WORKS

D.12.1 Testing of Earthworks

D.12.1.1 General

The Contractor shall furnish all equipment and materials necessary for collecting samples and carry out field laboratory tests on materials for earthworks. Laboratory equipment shall be housed in a suitable building on Site, which shall also incorporate adequate space for the storage of field test equipment.

D.12.1.2 Main Tests and Standards

The Contractor shall carry out all tests in accordance with local and international standards. For the below tests the following DIN standards shall apply:

- DIN 18121 Moisture Test
- DIN 18122 Consistency Test
- DIN 18123 Grading Tests
- DIN 18124 Density Test (solid volume without voids)
- DIN 18125 Density Test for Soils (including voids)
- DIN 18127 Proctor Test
- DIN 18134 Loading Test

D.12.1.3 Compaction of Soils

The Contractor shall carry out the compaction to safely achieve the specified dry density and control soil compaction during backfilling and filling operation.

Where the sub grade or layers of soil material require being moisture conditioned before compaction, the Contractor shall uniformly apply water to the sub grade or layer of soil to attain the optimum moisture content required. The application of water shall be carried out in a manner to prevent free water appearing on surface during compaction operations.

The Contractor shall replace soil material that is too wet for compaction to the specified densities.

D.12.1.4 Testing of Compaction

The Contractor shall inspect, perform and report all testing and retesting as to ensure that the works conform to the specified requirements. In order to test the degree of compaction, the Contractor shall carry out field density tests in accordance to DIN 18127 or BS 1377.

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For each compacted backfill of trench the required number of field density tests to ensure compliance with specification shall not be less than three passing tests between each 2 chambers or 100 linear meters (whichever is smaller) of filled and compacted trench.

If, in the opinion of the Engineer, the sub grade, backfill and fill layers have been placed and compacted to densities below the specified limits, the Contractor shall provide additional compaction and testing until satisfactory results are attained or remove certain sections of the work and reconstruct them according to the Specifications.

All holes made for the purpose of tests shall be restored by the Contractor to conform to the characteristics of the adjacent layers.

The compaction required for various fills shall be as follows:

Item of Works	Materials Prescribed	% of Max. Density acc. to ASTM D698
Backfill for over-excavation	Granular material	100 %
Formation and bedding layers	Fine granular material	95 %
Crushed stone supporting layers	Crusher runs	95 %
Final backfill of trenches under roads	Fine granular material	100 %
Backfill of trenches in general	Fine granular material	98 %
	Sandy material	95 %
	Clayey material	93 %
Backfill below structures	Fine granular material	100 %

D.12.2 Inspection and Testing of Structural Works

D.12.2.1 Inspection prior to Commencement of Works

Buildings and other structures in close proximity to the Construction Site that might be damaged by excavation or other work shall be inspected before work is commenced. All parties concerned shall be invited by the Contractor to participate in the inspection.

The Engineer and the Contractor shall make the inspection jointly and the Contractor shall set out an inspection report, including "preconstruction photos". The report shall describe the conditions of the buildings, roads, footpaths etc. in question.

Any failure or damage caused by excavation or other works, shall be repaired and maintained by the Contractor without any delay.

D.12.2.2 Testing of Concrete Works

D.12.2.2.1 Concrete Works, Test Certificates

Unless otherwise directed by the Engineer, the Contractor shall supply and submit to the Engineer:

- Manufacturers test sheets with each consignment of cement and admixtures certifying the compliance with the relevant standards;
- Certification of the calibration of weighing and dispensing equipment on the batch mixing plant;
- The certified test results for all tests carried out on aggregates, water fresh and hardened concrete.

In case of doubts, new tests shall be executed upon the Engineer's direction at the Contractor's expense.

D.12.2.2.2 Concrete Works, Inspections

No concrete shall be placed until the Engineer has inspected and approved the surfaces upon which the concrete is placed the formwork and the reinforcing steel.

If requested by the Engineer to do so, the Contractor shall institute a "pour card" system in which a card is made out for each lift of concrete and is initialled by the Contractor and the Engineer confirming that the inspections have been carried out.

The "pour card" shall include spaces to identify the concrete being placed and to signify the completion of the inspections by the Contractor and the Engineer in regard to:

- Preparation of surfaces on which concrete is to be placed;
- Formwork;
- Reinforcement;
- Readiness for concrete placing;
- Striking time of formwork;
- Inspection after removal of framework (remedial work directed);
- Curing procedures;
- Completion of remedial work (if any).

D.12.2.2.3 Sampling and Testing of Aggregates

The Contractor shall sample and carry out mechanical analysis of the fine aggregates and each normal size of coarse aggregate in use, employing the method described in ISO 19595 and ISO 20290 at least once a week when concreting is in progress and at such more frequent intervals as the Engineer may require.

The grading of all aggregates shall be within specified limits. Should the fraction of aggregate retained on any sieve differ from the corresponding fraction of aggregate in the approved mix by more than 5 % of the total quantity of fine and coarse aggregate, the Engineer may instruct the Contractor to alter the relative portions of the aggregates in the mix to allow for such differences.

D.12.2.2.4 Sampling and Testing of Concrete

The Contractor shall provide the equipment necessary to determine the compacting factor of freshly mixed concrete at each place where concrete is being prepared and shall determine the compacting factor of the freshly mixed concrete by the method described in DIN 1048 on each location where a set of test cubes is made and not less than once a day or as the Engineer may direct.

Unless particularly specified, for each grade of concrete works test cubes shall be made whenever required by the Engineer but not less frequently than one set of cubes per 25 m³ or part thereof concreted at least one set per day.

Each set of cubes (six cubes per set) shall be made from a single sample of a concrete batch taken by random. Each three cubes shall be tested 7 and 28 days after manufacture.

When requested by the Engineer, additional set of cubes shall be made for testing 3 days after manufacture. Test reports shall be submitted to the Engineer in duplicate.

D.12.2.2.5 Compliance with specified Requirements

When determining a concrete mix design such design shall be deemed satisfactory provided that:

- a) The average 28 days strength f_{cm} determined from every group of three (3) consecutive test cubes (edge length 150 mm) is not less than $f_{ck, cube} + 4 \text{ N/mm}^2$ (i.e. for grade C 25 / 30 concrete the average strength is not less than 34 N/mm²);
- b) The minimum strength of any cube must be f_{ci} (i.e. for grade C 20 / 25 concrete the strength of each cube is not less than 30 N/mm² minimum);

If one cube result fails to meet the second requirement (b) the result may be considered to represent only the particular cube, provided that the average strength of the group satisfies requirement (a);

If more than one cube in a group fails to meet the second requirement (b) then all the concrete in all the batch shall be deemed not to comply with strength requirements;

During execution of the concrete works such concrete shall be deemed satisfactory provided that:

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- c) The average 28 days strength f_{cm} determined from every group of four (4) consecutive test cubes is not less than $f_{ck,cube}$ (i.e. for grade C 25 / 30 concrete the average strength is not less than 30 N/mm²).
- d) The minimum strength of any individual cube f_{ci} is not less than $f_{ck,cube} - 4$ N/mm². (i.e. for grade C 25 / 30 concrete the strength of each cube is not less than 26 N/mm²).

If one cube result fails to meet the second requirement (d), the result may be considered to represent only the particular batch of concrete from which the cube was taken, provided that the average strength of the group satisfies the first requirement (c).

If more than one cube in a group fails to meet the second requirement (d) or if the average strength of any group of four (4) consecutive test cubes fails to meet the first requirement (c), then all the concrete in all the batches represented by such cubes shall be deemed not to comply with strength requirements

D.12.2.2.6 Non-compliance with specified Requirements

When the average strength of four consecutive test cubes fails to meet the first requirement, no further concrete from that mix shall be placed in the work and the Contractor shall establish the cause of the failure and apply such remedies as are necessary.

The Contractor shall demonstrate by trial mixes and test cube results that the revised mix is in accordance with the specified requirements.

The Contractor shall, within 24 hours of the date of testing, make proposals for agreement with the Engineer about actions to be taken in respect of any concrete represented by the test cubes which fail to meet either of the requirements. These proposals may include, but shall not be limited to, cutting and testing cores.

Concrete, which is ultimately not found to comply with any of the requirements of the Specification, shall be broken out and replaced or otherwise dealt with as instructed by the Engineer.

The Engineer may order additional cement to be added to the mix immediately. The mixes used may also be changed whenever, in the opinion of the Engineer, such change is necessary or desirable to secure the required workability, density, tightness, surface finish and strength.

D.12.2.2.7 Cutting and Testing of Core Samples

As and where directed by the Engineer, cylindrical core samples shall be taken normal to the surface of the hardened concrete for examination and testing.

The procedure for drilling, examination, measurement and testing shall be in accordance with DIN 1048.

Prior to the preparation for testing, the specimen shall be made available for examination by the Engineer.

If the crushing strength of the specimen determined in accordance to DIN 1048 is less than the characteristic strength at 28 days for the grade requirements in other aspects, that concrete in that part of the Works of which it is a sample shall be considered not to comply with the specified requirements.

D.12.3 Testing of Water Retaining Structures

Tightness test shall be carried out before any backfill around the structure subject to test takes place. All outside surfaces of the structure must be cleaned, smoothened and be completely visible and accessible. Each tank of a multi-tank reservoir shall be subject to a separate test.

Water filling of the structure shall start during daylight to allow for continuous inspection during filling. The structure shall be filled up to the maximum operating water level or as otherwise instructed by the Engineer.

Concrete structures or clay sealed structures shall be maintained full over a period of 7 consecutive days prior to the test to achieve saturation of the lay and concrete exposed to water.

For structures completely made of steel such saturation period is not required, and the Contractor shall maintain the tank / reservoir full one day prior to start of test.

A visual check of all concrete wall surfaces shall then take place. If such inspection does not identify visible leakages or wet spots, the test can continue. If such inspection however identifies leakages and wet spots, the test will be terminated and the Contractor shall proceed with repairs of the respective parts as instructed by the Engineer.

Thereafter the procedure shall be repeated according to DVGW W 300 up to successful completion.

After having successfully passed the visual inspection of the external surfaces, the main test shall be undertaken. The main test shall last 48 hours. During that period of 48 consecutive hours the structure shall be tightly sealed. Water level shall be measured at the beginning and end of the main test period. If water level drop does not exceed one (1) cm or 0,3 % of the testing water depth, whichever is less, the test shall be considered as successful. The Contractor shall supply all water required for the test.

From the start of filling until completion of the test, the Contractor shall monitor the water level decrease through precision levelling as directed by the Engineer.

From start of filling until completion of the test, the Contractor shall monitor the settlements of the tanks through precision leveling on the benchmarks grouted into the concrete as directed by

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the Engineer, particularly at the four corners of rectangular tanks and every 90° at the circumference of round tanks.

Frequency of levelling and recording formats shall be as instructed by the Engineer.

D.12.4 Tests on Completion for Civil Works

In the event tests carried out earlier on the respective parts of the Works have not been successful or if necessary to proof the tightness between two sections of the Works that have been tested before separately additional Tests on Completion shall be carried for any such parts of the Works.

D.12.5 Site Testing

D.12.5.1 General

Site testing includes for both tests during installation and tests at completion. The Contractor shall prepare and submit to the Engineer a comprehensive and detailed site testing programme of all parts of the Works subject to Site testing. This programme shall be submitted to the Engineer one month before start of erection / installation and be reviewed and updated as may be required from time to time.

D.12.5.2 Composite Hydraulic Systems subject to Test during Installation

Site testing includes tests during construction and installation, Pre-commissioning and Commissioning.

All joints, pipe foundations and the like shall be inspected during testing and pressure shall be maintained until such inspections are completed and as specified by EN 805 for the duration of testing, which ever lasts longer.

In the event that pressure loss encountered during test is higher than acceptable and/or any visible leak occurs or any foundation or puddle flange is found to have moved or cracked or appears damaged in any way, or if any pipe barrel or flange shows deformation, the test shall be declared as being unsuccessful.

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

1. Specifications

b) Technical Specifications

General Technical Specifications

Part E: Civil Works for Pipe Works

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List of Acronyms

AC	Asbestos Cement		standard)
AISI	American Iron and Steel Institute	EPDM	Ethylene Propylene Diene Monomer
ANSI	American national Standards Institute	FBE	Fusion Bond Epoxy
ASME	American Society of Mechanical Engineer	FBPE	Fusion Bond Polyethylene
ASTM	American Society for Testing and Materials	FCAW	Flux Cored Arc Welding
ATV-DVWK	Abwassertechnischen Vereinigung e.V. (ATV) - Deutschen Verbandes für Wasserwirtschaft und Kulturbau e.V. (DVWK), now DWA	GI	Galvanised Iron
BS	British Standard	GMAW	Gas Metal Arc Welding
BSI	British Standard	GRP	Glas fibre Reinforced Polyester
CCD	Charge-Coupled Device	GTAW	Gas Tungsten Arc Welding
CEM	Cement	HDD	Horizontal Directional Drilling
CEN	Comité Européen de Normalisation (European Committee for Standardization)	HDPE	High Density Polyethylene
CI	Cast Iron	HV	High Voltage
CP	Cathodic Protection	ISO	International Organisation for Standardisation
CTE	Coal Tar Enamel	J&B	Jack and Bore
DC	Direct Current	LCP	Lined Cylinder Pipe
DCI	Ductile Cast Iron	LDPE	Low Density Polyethylene
DI	Ductile Iron	LPE	Layer Polyethylene
DIN	Deutsches Institut für Normung (German Standard)	LPP	Layer Polypropylene
DN	Nominal Diameter	MAG	Metal Active Gas Welding
DVGW	Deutscher Verein des Gas- und Wasserfaches (German Association for Gas and Water Industry)	MIG	Metal Inert Gas Welding
DWA	Deutsche Gesellschaft für Abwasserwirtschaft, Abwasser und Abfall e. V. (German Association for Water, Wastewater and Waste)	MRS	Minimum Required Strength
ECP	Embedded Cylinder Pipe	MT	Microtunneling
EF	Electrofusion	MTBM	Microtunneling Boring Machine
EN	European Norm	NACE	National Association of Corrosion Engineers
ENV	Euro Norm Vornorm (Pre-	NBR	Nitrile Rubber
		OD	Outer Diameter
		PE	Polyethylene
		PEHD	Polyethylene High Density
		PFA	Pression de Fonctionnement Admissible (allowable operating pressure)
		PN	Nominal Pressure
		PP	Polypropylene

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PU	Polyurethane	SDR	Standard Dimension Ratio
PUR	Polyurethane	SMAW	Shielded Metal Arc Welding
PVC	Polyninyl Chloride	SN	Nominal Stiffness
PVC-U or uPVC	Unplasticized Polyvinyl Chloride	STP	System Test Pressure
PWHT	Post-Weld Heat Treatment	TIG	Tungsten Inert Gas Welding
QC	Quality Control	T/R	Transformer Rectifier (Unit)
RC	Reinforced Concrete	TS	Technical Specification
RP	Recommended Practice	UNS	Unified Numbering System for Metals and Alloys
RPM	Rotation per Minute	UP	Unsaturated polyester (resin)

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

E.1. STATIC CALCULATION OF PIPELINES

The static calculation shall be carried out in accordance to applicable standards.

The static calculation of sewer pipes shall be carried out in accordance to EN 1295-1 and/or ATV-DVWK A 127 "Static Calculation of Drains and Sewers" or similar technical guidelines.

The contractor shall make the calculation for each pipe material, pipe diameter for all occurring pipe depth intervals (interval range shall not exceed 0,5 m) and for the different soil conditions and for other different conditions, which may vary due to working methods etc.

The calculation shall be systematised and presented in a form, which can be approved by the Engineer and indicate:

- strength on transverse loading;
- criteria on cracks;
- resistance against forces arising from fabrication, transportation, storage and application of the concrete pipes and
- soil conditions and location of the pipes.

The followings details shall be indicated for each diameter of pipe to be used in the Works.

- the spigot and socket;
- circumference of the sealing ring in non-stretched position;
- thickness and shape of the sealing ring;
- the allowable angular deviation;
- the type of bedding required for the different loading and soil conditions;
- the type of pipe surround required for the different loading and soil conditions.

The calculations must be approved by the Engineer before production or ordering of pipes shall be executed. The contractor is fully responsible for his calculations.

E.2. LAYING OF PIPELINES AND INSTALLATION OF PIPEWORKS

E.2.1 Definitions

The following words or expressions shall have the meanings hereby assigned to them except where the context otherwise requires:

"Pipeline"	shall mean a line of pipes having an appreciable length; it may have branch lines; it does not include piping system such as process piping system within factories or treatment plant;
"Pipework"	shall mean all pipes excluded from the definition of pipeline;
"Pipes"	shall mean straight tubes having plan ends or ends shaped to form joints;
"Pressure pipeline"	shall mean pipelines, in which the nominal internal working pressure exceeds 0,3 bar and such other pipework as may be designated;
"Gravity pipeline"	shall mean a pipeline, in which the liquid being conveyed through the pipe is geared by the force of gravity only;
"Sewer"	shall mean the pipelines draining wastewater and/or storm/rain water;
"Sewerage system"	shall mean all the pipelines, chambers, pumping stations etc., which comprise complete system which drains wastewater to a treatment plant or which drains storm/rain water;
"Regime or working pressure"	shall mean the pressure necessary in a hydraulic system to obtain the normal operating conditions;
"Fittings"	shall mean bends, junctions, reducers, tapers, joint adapters, couplings and similar items which are not joints or flow control equipment;
"Internal"	shall mean those parts of pipes and fittings, which are to be in contact with the liquid being conveyed;
"Flexible joints"	shall mean joints made with factory made joint materials, loose collars, rubber joint rings and the like, which permit angular deflection between adjacent pipes;
"Chambers"	shall mean structures on the pipeline that can house pipes, fittings, valves, including fittings through chamber walls;
"Manhole"	shall mean a structure on the pipe with a cover, where access to the pipe is possible;
"Wastewater" or "sewage"	shall mean polluted water, discharged into a sewerage system by domestic and industrial sources;
"Sewerage system"	shall mean all the pipelines, manholes, chambers, pumping stations etc., which form the complete system which leads untreated waste water from houses / industries to a treatment plant;
"Rain or storm water"	shall mean water that originates during precipitation events, runs off;

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"Sludge"	shall mean wastewater with high solid content (above about 10 g/l);
"Faecal sludge"	shall mean sludge that originates from septic tanks or pit latrines.

E.2.2 Ruling Standards

All design, facilities, materials and workmanship shall comply with the relevant latest ISO, EN or equivalent international and local standards and codes of practice. Main applicable standards are, but shall not be limited by the following:

- EN 805 Water supply - Requirements for systems and components outside buildings;
- EN 752 Drain and sewer systems outside buildings;
- EN 476 General requirements for components used in discharge pipes, drains and sewers for gravity systems;
- EN 1671 Pressure sewerage systems outside buildings;
- EN 1610 Construction and testing of drains and sewers;
- EN 1295-1 Structural design of buried pipelines under various conditions of loading - Part 1: General requirements;
- ISO 13470 Trenchless applications of ductile iron pipes systems — Product design and installation;
- ISO 11296-3 Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 3: Lining with close-fit pipes;
- EN 124 Gully tops and chamber tops for vehicular and pedestrian areas – Design requirements, type testing, marking, quality control;
- EN 1092 Flanges and their joints: Circular flanges for pipes, valves, fittings and accessories, PN designated;
- EN 12889 Trenchless construction and testing of drains and sewers;
- EN 13380 General requirements for components used for renovation and repair of drain and sewer systems outside buildings;
- ISO 4633 Rubber seals - Joint rings for water supply, drainage and sewerage pipelines - Specification for materials;
- EN 681 Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications;
- EN61386 Conduit systems for cable management.

Wherever a national specification, technical standard, building, construction and environmental regulation is more restrictive than the specific standards listed in these specifications, the national standard or regulation shall take precedence .

E.2.3 Pipe, Fittings, Joints and Valves – General

E.2.3.1 Scope

Pipe laying works, as specified hereunder, shall include the supply, laying and testing of pipes including manholes, fittings, joints, accessories and house connections. The bid prices shall fully include the value of works described under the several items and shall cover the cost of all labour, subsidence, travelling, supplies, materials, fittings, tools, equipment, temporary works, testing, re-testing (if applicable), watching, lightening, overhead charges and any other expenses whatsoever together with all risks, liabilities and obligations set forth or implied in the Contract Documents.

Flexibility shall be provided in the pipework at joints in the main structures to allow differential settlement and thermal stresses which shall not be transferred to the anchor blocks. Flexible joint or collars and cut pipes shall also be incorporated in pipework where necessary to allow for some margin of error in the building work. The pipework system shall be so designed to ensure the anchorage at blank ends, bends, tees and valves may be kept to a minimum. The Contractor shall indicate on his detailed drawings the blocks required to anchor pipework supplied by him.

E.2.3.2 Quality of Materials

All pipes, specials, fittings, valves, accessories and all materials and other equipment supplied under the Contract shall be new and shall be manufactured in accordance with the latest relevant local and International Standards.

The Contractor shall submit documentation on the details of the delivered goods. These documents shall bear the stamp and the signature of the manufacturer. For all items of supply the Contractor shall submit to the Engineer a certificate of compliance with the specified Standard. Where other Standards are proposed, they shall be equal or superior to the relevant International and/or EN Standard.

Pipe and fittings materials shall be of the best quality of the class most suitable for working under the conditions specified and shall withstand traffic loads, operating pressure, corrosion and abrasion, and the variation of temperature and climatic conditions without distortion or deterioration or the setting of undue stresses in any part of the works and without affecting the strength or the suitability of the various parts for the work which they have to perform.

Where corrosion or abrasion may be expected from contact with water, sediments or from any other cause, the Contractor shall supply suitably resistant materials.

Any material showing signs of corrosion, distortion or pitting before expiry of the Defects Notification Period shall be replaced with material approved by the Engineer, at the Contractor's own expense.

E.2.3.3 Marking

All pipes, fittings, specials, valves, accessories and other important components shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure and that normal storage, weathering handling, installation and use shall not affect the legibility of the marking.

The marking shall display the following information:

- Manufacturer's name or mark;
- Material identification such as ductile iron;
- Material grade;
- Identification of the date of manufacture;
- DN and/or outside diameter and wall thickness;
- PN rating when applicable;
- Reference to relevant Standard.

E.2.3.4 Supply of Materials

Supply of material, as specified hereunder, shall include the transport from the Manufacturer's plant to the Site, handling, loading, unloading, intermediate storage and storage beside the trench in accordance with the supplier's instructions and good workmanship.

All materials shall be supplied from approved manufacturers only. The Contractor is requested to submit a list of suppliers that he intends to use, together with his bid.

The Contractor shall submit for the approval of the Engineer before ordering of materials, all information and data listed herein and all additional information required to evaluate the compliance of the proposed materials with the Contract. Data to be submitted shall include but is not limited to:

1. Catalogue data consisting of specifications, illustrations and a parts schedule that identifies the materials to be used for the various components and accessories. The illustrations shall be in sufficient detail to serve as a guide for assembly and disassembly;
2. Standard to which the item is manufactured, details of specials, adapters, fittings and joints;
3. Complete assembly drawings of fittings etc. with clearly marked dimensions. This information shall be in sufficient detail to serve as a guide for assembly and disassembly and for ordering parts;
4. Weight of all component parts;

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5. Tabulated pipe schedule, which shall include the following information for all pipe and fittings: dimensions, thickness, lengths, working pressure, shape, weight, class, tolerance limits and quality;
6. Coating and lining methods;
7. Manufacturer's instructions for transporting, unloading, storing and installing pipes, fitting and other pipe accessories.

No material to be supplied under this contract shall be shipped to the Site until all submittals have been approved.

Uniformity of materials shall be maintained throughout the manufacturing process for each pipe size to the end, so that the test samples are representative. All supplies shall be new; second hand material will be rejected.

Nomenclature, classification, symbols, conditions of manufacturing, characteristics and tolerances, conditions for the preparation of specimen, test rules, identification labels and acceptance clauses of pipes and pipe-fittings must conform to the latest relevant local and International Standards.

Only materials approved and accepted by the Engineer shall be supplied and installed. Materials which are rejected shall immediately be removed from the Site at the cost of the Contractor.

Pipes shall be ordered in the maximum lengths available to minimize the number of joints. The Contractor shall be responsible for the supply of all materials in sufficient quantities and shall, prior to placing any order, especially for imported goods, ascertain the required quantities.

E.2.3.5 Inspection by the Engineer

The Engineer reserves the right to inspect goods prior to delivery or shipment from the suppliers factory. The Contractor shall, on request, provide all necessary facilities to the Engineer or his representative to carry out such inspection.

Inspection or approval by the Engineer of any equipment or materials shall not release the Contractor from any of his obligations under this Contract.

E.2.3.6 Method Statement

The means of storing, handling and laying, together with the chosen material and construction methods for manholes and the method for compacting the pipe surrounding and the backfilling of pipe trenches and around manholes, shall be subject to the approval of the Engineer.

At the commencement of the Contract, the Contractor shall submit for the approval of the Engineer a method statement detailing his proposal for pipe laying and related activities at the Site. The method statement shall include:

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- a) location, size and security arrangements of all proposed storage areas for pipes;
- b) methods of loading, off-loading and transporting pipes and precast concrete sections from the point of production or point of importation to the storage area;
- c) methods of loading, transporting and stringing out of pipes from the storage area to the pipeline routes;
- d) method of excavation of pipe trenches including plant to be used and methods of trench dewatering to be employed;
- e) material to be used for bedding and surrounding of pipes and backfilling of pipe trenches together with plant to be used and methods of compaction to be employed;
- f) details of the proposed order of work incorporating the specified checks and hydraulic testing.

The methods for pipe laying, jointing, bedding and backfilling recommended by the pipe manufacturer shall be strictly adhered to. In cases of conflicts between the manufacturer's recommended methods and this Specification, the decision of the Engineer will prevail.

E.2.4 Pipes, Fittings and Joints – Water Supply

E.2.4.1 Potable Water Certification

All pipe and coating materials for water distribution pipes shall not contain any ingredients that might migrate into water in amounts that are considered to be toxic or otherwise dangerous to health. Compliance with this requirement shall be certified for each of the various kinds of materials by independent institutions approved by the Engineer.

Joint lubricants for sliding joints used for jointing water supply pipes shall not impart to water taste or colour, shall not have any effect known to be injurious to health and shall be resistant to bacterial growth.

E.2.4.2 Toxic Materials

The Contractor shall not import or use any toxic or poisonous grouts for use in piping, its accessories, lining, sealing, etc., or in various kinds of concrete, soils or whatsoever.

E.2.5 Pipes, Fittings and Joints - Sewer

E.2.5.1 General Requirements

Laying shall be in accordance with the manufacture's recommendations.

All non-flanged sewer pipes shall have a gasket-type joint used in conjunction with an integral bell which shall be a homogeneous part of the pipe.

E.2.5.2 Gravity Sewers

If not otherwise specified in the particular specifications, the minimal nominal stiffness of pipes and fittings shall be SN 4 (4 kN/m²) according EN ISO 9969 when the height of filling up layer is between 0,8 and 6,0 m. If the height of filling up layer is up to 0,8 and more than 6,0 m, pipes with ring stiffness 8 kN/m² (SN 8) shall be used.

E.2.5.3 Internal Lining of Ductile Iron and Steel Pipes for Wastewater

Ductile iron and steel pipes for sewage have to be lined with an inner sulphate resistant cement lining according to EN 10928 and DIN 2880.

E.2.5.4 Pressure Sewers

If not otherwise specified in the particular specifications, all supplied and installed pressure sewer pipes, fittings and joints shall be at least PFA = 6 bars.

E.2.5.5 HDPE pressure Sewers

If not otherwise specified in the particular specifications, HDPE pressure pipes and fittings shall be of PE 100 quality.

Pipes of diameters less than OD 180 mm shall be joined with electro-fusion (EF) couplers of PE-HD. If approved by the Engineer, small diameter pipes (OD < 63 mm), pipes within structures and pipes connecting to metal fittings can be jointed using mechanical jointing techniques, such as compression or push-fit joints of HDPE or another appropriate approved plastic material with bronze adaptor or flanged joints. Pipes of diameters equivalent or larger than OD 180 shall be joined by butt fusion.

E.2.6 Handling, Storage and Stringing of Pipes

E.2.6.1 Transport and Handling of Pipes

Shipping, packaging and protection of material and equipment shall be in accordance with the manufacturer's recommendations and approved international Standards. Any vehicle on which pipes are to be transported shall have a body of such length that the pipes do not overhang. The stacking height for the various items shall be as recommended by the manufacturer and approved by the Engineer but should not exceed 2,0 m for thermoplastic pipes. Each load shall be secured by ropes or other lashing arrangement so that the pipes do not move or chafe and suitable padding shall be used to ensure that the pipe is not damaged by these lashings. Pipe specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during transport.

The Contractor shall be responsible for obtaining all necessary permits for transporting the pipes. Wherever necessary, the Contractor shall ensure that any weight restrictions on public

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roads are not exceeded. The Contractor shall be responsible for making good any damage caused to these roads.

When pipes are collected from a storage site, the Contractor shall secure the remaining pipes against slippage. When a storage site is emptied of materials the Contractor shall clean the site and any access road and reinstate both to their original condition.

Pipes, fittings and appurtenances shall be handled with utmost care in such a way that damage is avoided. The Contractor shall provide appropriate machinery for loading and unloading (e.g. cranes, forklift with wide forks, etc.) and other appliance approved by the Engineer wherever it is necessary to lift or lower pipes or pipe specials. All equipment necessary for loading, transport to construction sites or storage sites and unloading shall be supplied by the Contractor.

Pipes shall only be lifted with straps of a material and a form which protects the pipes and their coating from damage. For the handling of pipes with external coating and lining, slings of canvas, rubber belting or special fittings shaped to fit the pipe ends shall be used. Hooks shall not be used for lifting of pipes nor shall pipes be dropped or dragged.

Under no circumstances shall pipes be dropped, be allowed to strike on another, be rolled freely, or dragged along the ground.

Pipes being transported shall be supported by timbers, sand bags or padding arranged in such a way that the pipes do not rest on their sockets but on their barrels and that adjacent pipes do not touch.

The height of the load for the various pipe diameters shall not be more than prescribed by the manufacturer and approved by the Engineer.

Ropes or other lashing arrangement shall secure each load so that the pipes do not move or chafe and suitable padding shall be used to ensure that the pipe coating is not damaged by these lashings.

The Contractor shall check the pipes for any visible defects or damage and notify the Engineer if any are found. The Contractor shall be responsible for making good any damage or defect to the approval of the Engineer.

The pipes shall be strung consecutively along the working width on timbers or similar, with at least two per pipe, to avoid damaging or fouling the pipes. The pipes shall be strung in such a way that the normal use of the surrounding areas is disturbed as little as possible. Pipes shall be secured against rolling. When stringing pipes with diameter tolerance marks, only ends with the same mark shall abut.

E.2.6.2 Storage on Site

Handling and storage of material and equipment shall be in accordance with the manufacturer's recommendations and approved international Standards.

All materials provided by the Contractor shall be stored in a proper storage area subject to the approval of the Engineer. The Contractor shall construct a fenced and lockable compound in which all pipes, fittings, valves and other pipe appurtenances are to be kept, and also maintain shelters of sufficient size and capacity to store the materials and to protect them from the effects of weather always in accordance with the manufacturer's prescriptions. The Contractor shall be responsible for cleaning, levelling and enclosing the storage site and shall provide all necessary security.

Storage areas shall be carefully set out to facilitate unloading, loading and checking of materials with different consignments stacked or stored separately with identifications marks clearly visible. Storage stacks shall be arranged so that the belled sockets are at alternate ends of the stack and do not bear any load.

Pipes and fittings shall be stored raised from the ground and shall be carefully supported cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more quantity high than that of manufacturers recommendation. Thermoplastic pipes shall be protected from high temperatures and not be exposed to direct sunlight.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry and cool conditions, raised from the ground in sheds or covered areas and protected from direct sunlight and frost.

All pipes, fittings and appurtenances shall be protected from weather, including sunlight, and fouling during transport, storage and stringing. If any pipe gets fouled, it shall be cleaned before installation.

The Contractor shall at all reasonable times allow the Engineer free access to any place for inspection and testing.

The Contractor shall, at his own expense, carry out all tests he considers necessary to ensure that all pipes, fittings, valves and other appurtenances are in accordance with the Contract, on his own responsibility. The Engineer may witness such tests without incurring any responsibility for the materials.

In all cases the Contractor shall satisfy the Engineer that all material has been delivered in good and clean condition, identification markings shall be clear and stock piling shall be in approved manner.

The Contractor shall keep detailed records in a format approved by the Engineer of all pipes, fittings, valves and other pipe appurtenances, showing the quantities of each type and class which have been:

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- Received by the Contractor during the course of the Works;
- Declared on delivery to be faulty, damaged or deficient, broken, damaged or lost during the course of the works;
- Found to be surplus to the requirements and held by the Contractor.

Such records shall be updated and delivered by the Contractor to the Engineer on a monthly basis.

The Contractor shall comply with the Engineer's instructions as to the disposal, repair or replacement of any pipe, fitting or valve which has been notified as being faulty, damaged or missing.

E.2.6.3 Stacking of Pipes

The Contractor shall properly stack the pipes at the Site and the stacks shall be laid out in regular pattern as prescribed by the Manufacturer. The limits of each stack shall be marked so that the movement of cranes and vehicles shall be restricted to access tracks between the stacks and the control of delivery and removal of pipes is facilitated.

Where the pipes are to be delivered and stacked on designated sites along the pipeline route, the areas where the pipes are to be stacked shall, if directed by the Engineer, be graded flat by the Contractor at his own expense to provide a firm and even surface and be kept free from loose stones, rubbish or waste liable to damage pipe coating.

Material delivered will be accepted only if proper storage provisions have been made and if equipment which was damaged during shipment is either repaired or replaced.

E.2.6.4 Distribution at the Site

In distributing the material at the site of works, each piece shall be unloaded adjacent or near to the place where it is to be laid. Rubber rings for pipe joints shall be stored and protected in an appropriate manner to prevent deterioration and loss.

The Contractor shall keep the pipe and the appurtenances clean during the progress of the work. Dirt, debris or other foreign material shall be removed from the interior of the pipe and the joints before installation.

Pipes and appurtenances shall not be strung out along the trench for more than 1 day prior to installation in the trench.

E.2.7 Pipe Laying

E.2.7.1 Routing of Pipelines

Before setting out any section of a pipeline, the Contractor or his representative shall make an inspection on Site together with the Engineer. The Contract Drawings show the approximate lines and levels to which the pipeline is to be built however such alignments are subject to the amendments made by the Engineer on Site.

The Engineer reserves the right to vary or abandon any part or parts of the route of pipelines indicated on drawings and the Contractor shall lay the pipes in accordance with any such variation the Engineer may issue. The Contractor shall prepare the working drawings and shall lay the pipes in accordance with any such variation the Engineer may issue.

E.2.7.2 General Requirements for Pipe Laying

Approved works

The Contractor shall lay pipes and fittings in accordance with the manufacturer's installation recommendations as approved by the Engineer.

The construction of open channels and trenches for pipelines shall at any time be limited to lengths previously approved by the Engineer in writing. Except with the written approval of the Engineer, work on each approved length shall be completed to the satisfaction of the Engineer before work on any new length is commenced.

Water tightness

Pipes, fittings and valves shall be of the diameter and class of material as specified or shown on the Drawings and their joints shall be completely watertight. It also includes the duct pipes.

Alignment levels and slopes

All pipes and specials shall be laid in accordance with the alignment, levels and slopes shown on the working drawings approved by the Engineer, adjusted in the field by the Contractor as may be required from time to time and as finally authorised by the Engineer. Invert levels are to be set to a tolerance of plus or minus five (± 5) millimetres.

Completed pipelines shall run straight between chambers and between any bend or any curved alignment and a uniform slope shall be accurately maintained between changes of slope as shown on Drawings or otherwise instructed by the Engineer.

The direction of each section between two manholes is checked from the outside by the use of a tightened thread, which is parallel to the designed pipe route and supported at maximum 7,5 m distance, and from the inside by means of rays of light (or a laser, or electric torch reflected in a mirror).

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Pipe shall be laid with socket ends facing in direction of laying, unless directed otherwise by the Engineer. Where a pipe is laid on a grade of 10 % or greater, the laying shall start at the lower end and shall proceed upward with the bell ends of the pipe upgrade.

The pipes shall be laid in straight lines where possible. Curves of long radius shall be obtained by deflection at the joints. The deflection of the joints for this purpose shall not be more than 50% of the maximum deflection as specified by the pipe manufacturer for the relevant type of joint. Where a required change of direction cannot be obtained by deflection of the joints, prefabricated bends shall be used.

Pipe repairs

The Contractor at his own expense shall repair any damage of the protective coating of the pipes from any causes during the construction of the pipeline to the satisfaction of the Engineer.

Temporary protections

The contractor shall provide, install and maintain temporary protective caps or discs to prevent water, animals or extraneous material entering pipelines. Such caps or discs shall not be permanently removed until immediately prior to the relevant pipe or fitting being jointed.

At the end of each day's work a strong wooden plug or iron disk shall be firmly fixed in each open end in order to prevent any foreign material to enter the laid pipe.

E.2.7.3 Specific Requirements for Sewers

Protection against Corrosion and Abrasion

Where corrosion or abrasion may be expected from contact with wastewater, sediments or from any other cause, the Contractor shall supply suitably resistant materials. Any material showing signs of corrosion or distortion before the expiry of the maintenance period shall be replaced with material approved by the Engineer, at the Contractor's own expense.

Slopes of Gravity Sewers

The design criteria for the minimum slope of the sewer shall be as follows (diameters shall be as small as possible / minimum diameter is DN 100):

- for the minimum design flow, the minimum tractive traction shall be 1 N/mm²;
- for the maximum design flow, the maximum water depth shall be 80 % of the inner diameter.

Slope Tolerances of Gravity Sewers

The tolerance regarding the slopes of gravity sewers shall derive from the tolerances regarding the maximum hydraulic capacity. The maximum hydraulic capacity of the built sewers shall be

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± 5 % the same as the maximum hydraulic sewer capacity planned and approved by the Engineer.

Pipe Laying of Gravity Sewers

As a general principle, gravity sewers have to be built from downstream to upstream. Other methods shall not be implemented without prior approval by the Engineer.

Connection or Crossing of live Sewer Pipe

The Contractor has in many cases to either intercept existing wastewater sewers or to cross live wastewater sewers by the new main collectors during the construction works.

The Contractor shall assume full responsibility for the protection of such sewer pipes during construction, whether or not they are shown on the drawings. The Contractor shall carefully maintain, support and protect such sewers from injury of any kind. Any damage resulting from the Contractor's operations shall be repaired at his expense.

The Contractor shall not demolish or remove any existing sewers, whether indicated on the Drawings or not, unless on a specific instruction from the Engineer.

During the construction period such wastewater sewer lines being under operation have to be protected, suspended and kept at all times operative. Where such pipes have to be broken off, for instance when they cross a manhole to be newly constructed, a temporary steel or plastic connection pipe has to be laid to maintain the continuous waste water flow. Flooding of the construction pit or the new manhole shall be avoided. If the installation of such a temporary connection pipe is not feasible, the waste water flow shall be maintained by pumping over through a temporary hose pipeline.

All costs for the measures required to maintain the permanent wastewater flow in existing sewer pipes are deemed to be included.

At connection manholes e.g. where existing pipes connect to the new main collector, such existing pipes shall only be broken up and their sewage flow diverted into the new collector, once the new sewerage system has been fully completed, tested and passed all tests under dry conditions.

E.2.7.4 Replacement of Water Supply Pipe

In case of pipe replacement, unless otherwise instructed by the Engineer, the Contractor shall after obtaining the approval from the Engineer and after obtaining the excavation permit by the Employer / Engineer, follow the instructions as below:

- a) the pipe to be replaced shall be clearly located;

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- b) before isolation of the pipe the Contractor shall, if required, provide and install temporary pipes in HDPE materials to supply the consumers along the section of replacement with water during the works;
- c) the temporary pipe will be laid above ground and fixed to the front of the buildings at a regular distance. Unless otherwise instructed by the Engineer, the diameter of the temporary pipe shall not exceed 80 mm. Slabs will be laid on the temporary pipe to enable the exit of the vehicles;
- d) service connections shall be shifted from the existing connection pipe to the temporary pipe;
- e) the pipe to be replaced shall be isolated from the network. The Contractor shall check in advance the good operation of the valves required and shall install new valves or missing valves for isolation in case of deficiency;
- f) once the new service connections have been laid and the new main pipe tested, the new system will be put in service;
- g) all the temporary pipe shall be removed and hauled to the site approved by the Engineer.

Interruptions in potable water supply will be allowed for no more than 12 hours. In case of any interrupted water supply, the public affected due to the work needs to be informed minimum 3 days before commencement of the work about the works itself and the inconvenience which might occur during and after the work.

E.2.7.5 Pipe Cuttings and Matching Pipe Pieces

Cutting of Pipes

For closing lengths, it may be necessary to cut pipes of various materials. However field cutting of the pipe and field fabrication of fittings shall be kept to a minimum. When such cutting is required it shall be done by a suitable cutting machine, recommended by the manufacturer for the particular pipe material and approved by the Engineer. Cuts shall be made in conformance with the pipe manufacturer's recommendations.

Cuts shall be smooth and perpendicular to the axis of the pipe or in the plane of the bend or other fitting. Pipes shall be cut by a method which provides a clean square profile without splitting or fracturing the pipe wall and which causes minimum damage to any protective coating and lining. Damages to coatings or linings (if any) shall be repaired.

Cut ends shall then be chamfered, and the bevelled end shall be exactly the same as the spigot end of the pipe as manufactured at the factory. Spigot ends to be joined to sockets shall be chamfered. Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used.

The cut ends of glass-reinforced plastic pipes shall be sealed with resin, as supplied by the manufacturer, but using a pigment different from that of the pipe itself.

Where ductile pipes larger than 450 mm diameter are to be cut to form a non-standard lengths, the Contractor shall comply with the manufacturer's recommendations in respect of ovality correction to the cut spigot end.

Where cut concrete pipes are used, any exposed reinforcement shall be sealed with an approved epoxy resin.

Matching Pieces

Matching pieces required in any section of a main or to terminate the main in chambers or other parts of the works shall be cut only after all adjacent pipes have been installed and jointed.

E.2.7.6 Laying of Pipes in Trenches

E.2.7.6.1 General provision

Installation of pipelines includes the excavation of trenches, supply, laying and jointing of pipes and fittings, construction of beddings and foundations, manholes and other structures in the line, testing, backfilling of trenches, reinstatement and commissioning.

Pipelines and chambers shall be installed according to international standards and pipe manufacturer's guidelines. The contractor must ensure and document that the conditions and assumptions used in the structural calculations comply with the actual conditions of soil, excavations method, cross section of the trench, compaction, materials, earth cover etc.

E.2.7.6.2 Excavation and Backfilling

Excavation shall be carried out in accordance with Section D.4.2. Backfilling shall be carried out in accordance with Section D.4.4.

Unless otherwise specified, the minimum trench width shall follow requirements as stated in EN 1610. Trenches shall be secured against risks of collapse with adequate shoring systems in accordance to EN 1610 and local regulations.

The formation of excavation for pipelines shall be even and free from stones and other protrusions. The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of each pipe; bell holes shall be provided as required.

Pipes shall be laid in a dry excavation. If the formation of the excavation lies below the water table, the Contractor shall install a dewatering system, to the approval of the Engineer. Dewatering shall continue until all works below the water table are completed or as otherwise directed by the Engineer.

The Contractor shall inform the Engineer sufficiently in advance when a section of trench has been prepared ready for installation of pipes or concrete foundations and ready for inspection.

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The Contractor shall not continue with laying of pipes, concreting or other work until the trench bottom has been inspected and approved by the Engineer.

Before being positioned, each pipe shall be thoroughly examined to ensure that it is free from defects and shall have all dirt removed from the inside thereof. The Contractor shall lay the pipe in accordance with professional practice and install all fittings, specials and adaptors as may be required for the proper execution of the works.

E.2.7.6.3 Bedding to Pipelines

Unless otherwise specified and except where concrete protection is required, pipes shall generally be laid on a well-compacted bed of approved granular material after excavation. The granular material for pipe bedding shall consist of gravel and shall fulfil the requirements of EN 1610. The particle-size distribution curves shall be in accordance with addendum B, tables for Austria, Switzerland, Germany or Netherlands. The minimum thickness of the compacted bedding material shall be:

- 0,10 m (internal diameter of pipe $\leq$ 1,0 m or for cables);
- 0,2 m (internal diameter of pipe $>$ 1,0 m).

The bedding material for plastic pipes (GRP, HDPE, PVC, PP) shall be according to the manufacturers requirements.

The bedding material for concrete and steel pipes shall consist of sand-gravel, graded 0-25 mm.

The bedding material for thermoplastic and GRP pipes shall consist of fine grained sand in the fraction 0-8 mm.

The bedding material for cable conduits and cables shall consist of sand, graded 0-2 mm.

Where pipes are jointed, bell holes of ample dimensions shall be formed in the bedding, to ensure that each pipe is uniformly supported throughout the length of its barrel and to enable joints to be made.

The granular material shall be spread over the full width of the formation and lightly compacted to a level slightly higher than the level corresponding to the underside of the pipe barrel, to allow for settlement of the pipe to the correct level.

Further granular material shall be placed in the trench, special care being taken to fill under the sides of the pipe to ensure full contact with the barrel of the pipe, but leaving the joints exposed for a length of approximately 200 mm on each side of the joint collar, sleeve or socket. The granular material shall then be compacted evenly on both sides of the pipe.

Where applicable, concrete blinding layers shall be made of concrete C12/15 and shall be applied over the full width of the bottom of the trench in a minimum layer thickness of 10 cm.

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Any concrete bed shall be allowed to set and be thoroughly washed down before pipe laying commences.

E.2.7.6.4 Laying of Pipes

Pipes, fittings and sealing rubber gaskets shall be carefully cleaned and examined for soundness before they are lowered into the trenches or before they are installed. Spigot and socket ends of pipes shall be examined with particular care. The Contractor will label all damaged pipes and fittings and remove them from the site. Only pipes approved by Engineer can be installed. Any pipe which is damaged or has any perceptible objections will be rejected by the Engineer and replaced at the Contractor's expense.

Pipe lowering shall be carried out in a safe manner in accordance with applicable safety regulations and normal practices. The pipe shall be handled with approved equipment designed to prevent damage to the pipe and the external coating. Bare cables, chains, hooks or metal bars will not be allowed to come into contact neither with the external coating nor with the inner lining. Bitumen coated pipes shall be handled with suitable slings which do not damage neither pipe nor coating. A sufficient number of lifting machines (e.g. side booms) shall be used to ensure that the pipe is not subject to detrimental stresses.

The pipes must not be thrown into the trenches. Damaged pipes, fittings and sealing elements must not be used.

The Contractor shall, before lowering the pipe, ensure that the bottom of the trench is even and free from stones and other deleterious matter which may damage the coating.

The lowering-in procedure shall ensure that the pipe is not subjected to shocks or unnecessary stresses. If a section is damaged during lowering, it shall be taken up again, repaired and relowered. Any damage which may affect the structural integrity of the pipeline shall be treated as directed by the Engineer. The Contractor shall bear all costs associated herewith.

Where possible the ends of all lowered pipeline sections shall be closed with watertight caps. The Contractor is responsible for keeping the pipeline internally clean and free from foreign matter.

Any additional excavation required after the pipe has been lowered shall only be carried out with the permission and of the Engineer.

Each pipe shall be laid accurately to line and gradient so that the finished pipeline shall be in a straight line both in horizontal and vertical planes. The Contractor shall use suitable mechanical equipment, preferably hand operated, for pushing the pipes at the joints.

Where pipelines are to be constructed in trenches the Contractor shall provide, fix and maintain at intervals not exceeding 10 m, or at such points as may be directed by the Engineer, properly painted sight rails and boning rods of predetermined measurement for the boning in of individual pipes to correct alignment. The bobbing rod shall have a horizontal shoe to rest on

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the invert. The sight rails shall be situated vertically above the line of pipes or immediately adjacent thereto and there shall at no time be less than three sight rails in position on each length of pipeline under construction to any gradient. Consideration will be given by the Engineer to alternative methods for controlling alignment such as laser beam instruments.

The Contractor shall keep the interior of pipes clean and free from water, dirt, stones and other foreign matter as installation proceeds, and at the end of the day's work or at other times when installation work is not proceeding the open ends of the pipes shall be sealed off by a suitable stopper. The Contractor shall take such precautions as are necessary to prevent pipes from floating.

The pipes shall be positioned and bedded in the trenches on the compacted bedding layer and jointed in an approved manner. The jointing of all pipes shall be carried out in strict accordance with the manufacturer's instructions. All joint holes have to remain uncovered until passing the prescribed pressure test to the Engineer's satisfaction.

E.2.7.6.5 Back-filling of Excavations for Pipes or Cables

Initial Backfill

Initial backfill (embedding) of pipes and cables includes for the supply of bedding material, preparation of the bed, placing of embedding layers and compaction either by hand or with appropriate machines to the specified density below and around the pipes. The embedding works shall be carried out in compliance with EN 1610.

Sand shall be used for initial backfilling of trenches. Material shall be sound, clean, uncontaminated granular material, uniformly graded and of a maximum size of particles of 20 mm and particles smaller than 0,02 mm less than 10 %. In addition material shall be free from organic and deleterious matter and shall not contain more than 15 % by weight of clay or silt, individually or in combination.

The bedding zone below, lateral and above the pipe or cable shall be filled and carefully compacted by a method approved by the Engineer to avoid change in alignment and level of the pipes or cables. Unless otherwise specified, the same material as for the bedding shall be used.

Lateral bedding shall be formed by spreading and compacting bedding material over the full width of the trench. Sufficient bedding material shall be provided to allow the pipes or cables to be worked into the bedding material and firmly supported to true line and level. Special care must be taken to backfill on both sides of the pipe evenly to support the pipe properly and avoid distortion of the pipe. The difference in the level of backfill on each side of a pipe shall not exceed a maximum of 0,2 m.

Sufficient space shall be left to enable the pipe joints to be made, tested and inspected and the Contractor shall ensure that at least three quarters of each pipe length is fully supported. The joints of thermoplastic pipes which shall be kept exposed during the pressure test, shall be

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shaded with hessian or hemp cloth fixed at least 0,5 m above the top of the pipe until the final backfilling starts. Before any further filling the pipeline shall be tested and approved by the Engineer.

Unless specified otherwise for the specific pipe types, all pipes shall be covered by bedding material to a level of 0,3 m above the top of the pipes. Unless specified otherwise for the specific cable types, all cables shall be covered by bedding material to a level of 0,2 m above the top of the cables.

The pipe bedding material shall be compacted in layers not exceeding 100 mm thick after compacting by small manually manoeuvred compaction equipment on each side of the pipe only. Mechanical compaction of the main backfill directly above the pipe may not be commenced until a total depth of cover of at least 300 mm above the top of the pipe is reached. Each layer shall be separately compacted to a dry density not less than 95 % of maximum density obtained in Modified Proctor Test where the pipeline is under existing roads and to 90 % where the pipeline is not subject to vehicular traffic and under new roads. Site tests shall be made to prove the effectiveness of the method of compacting at intervals or as indicated in Section D.13.1.4 or as instructed by the Engineer.

General Backfill

The remainder of the backfilling up to ground level shall be placed and compacted in layers not exceeding 300 mm thick. Heavy tampers shall not be used within 300 mm above the top of pipes of diameter < 200 mm and within 500 mm above larger pipes. Under vehicular traffic areas backfilling shall be made in layers not exceeding 200 mm.

The remainder of the trench shall be back-filled with approved selected material and shall be compacted flush with ground level in accordance with the Employer's Requirements. Trench supports shall be gradually withdrawn in accordance with the progress of the fill subject at all times to the provision that it will not prejudice the safety of works.

Excavated or borrow material used for general back-filling, shall be free from cinders, ashes, organic matter and debris or other contamination and shall be granular and suitably graded to obtain the required compaction and shall not contain stones or crushed rock larger than 75 mm in the largest dimension. Additionally back-fill material for trenches shall conform to the following requirements:

- Uniformity Coefficient 6 minimum;
- Plasticity Index 15 maximum;
- Liquid limit 35 maximum.

E.2.7.6.6 Selected Fill Material

Selected fill for general refill of excavations for structures and pipelines, etc., shall comprise uniform readily compactable material free from tree roots, vegetable matter, building rubbish and or other particles greater than 25 mm in size, and shall be selected from either the

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excavated material from trench or the suitable excavated material from road works when cutting material quantity is more than filling quantity for roads. Dune sand arising from the works shall be accepted as selected fill but only for use in confined areas which are to be agreed with and approved by the Engineer. Dune sand must be flooded with water to be used in backfilling of trenches.

Where material has to be obtained from sources outside the site of the project such material will be classed as imported selected fill.

E.2.7.6.7 Stanks to Pipeline with Granular Bedding

Stanks (which are impermeable barriers designed to prevent groundwater flow along the trench) shall be provided across the full width of the trench and for the complete depth of the bedding when pipes are laid with granular bedding or backfill, at any points where pipe trenches pass through or into impermeable strata whose permeability is lower than that of the adjacent ground so as to form a restriction to the flow of groundwater. In these cases, the stanks shall be formed so as to restore the continuity of the impermeable, or low permeability, stratum where it has been intersected by the trench excavation.

Fill between stanks shall not exceed 50 m intervals and shall be generally midway between manholes or thrust blocks.

The stank shall consist of:

- a 300 mm long plug of clay, clayey soil or other approved impermeable soil, or of a mixture of sand and bitumen, consolidated in an approved manner;
- a layer of plastic sheeting, minimum thickness 1 mm, cut to fit around the pipe across the full width of the trench and laid of the granular bedding or fill material at the natural repose angle.

All methods must form an impermeable barrier.

Bitumen shall not be used for trenches containing thermoplastic pipes.

The cost of providing stanks shall be included in the Contractor's rates for pipe laying.

E.2.7.6.8 Branch Pipe to Pipe Connections

General Requirements

The connection angle between the secondary pipe and the main pipe shall be at least 30° above the horizontal. Exceptions shall have to be approved by the Engineer.

The combination of pipe reducers with the 45° branches or with the saddles is not allowed.

Connections between new Pipes

If the diameter of the main pipe is lower than DN 400 mm the connection shall be implemented with a 45° degree branch.

If the main pipe diameter is equal or larger than DN 400 mm, then the connection shall be made by drilling the main pipe and installing a compatible saddle. Drilling shall be made with a specific saddle manufacturer drilling tool.

In both cases, the connection angle between the secondary pipe and the main pipe shall be at least 30° above the horizontal. Exceptions shall have to be approved by the Engineer.

The combination of pipe reducers with the 45° branches or with the saddles is not allowed.

Connection to existing Pipes

If the diameter of the main pipe is lower than DN 400 mm the connection shall be implemented with a 45° degree branch. The connection angle between the secondary pipe and the main pipe shall be at least 30° above the horizontal. Exceptions shall have to be approved by the Engineer.

If the main pipe diameter is larger or equal to DN 400, then the connection shall be made by drilling the existing main pipe and installing a compatible saddle. Drilling shall be made with a specific saddle manufacturer drilling tool.

If the main pipe diameter is lower than DN 250 mm, then existing main pipe shall be cut for the installation of a 45° branch. The connection of the 45° branch shall be made with coupling adaptor(s) as required.

E.2.7.6.9 Connection to existing Pipe Works

Where the drawings indicate that a connection of any kind to be made into an existing pipeline, or whenever directed by the Engineer to make such a connection, the Contractor shall investigate and verify all such connections before start of the works to determine the material, exact diameter and level of any existing pipe to which a new pipe will be connected. When necessary the Contractor shall excavate trial holes, to ensure that the materials to be furnished under the Contract will be suitable for making the connections. Having excavated the test pit and exposed the existing pipe the Contractor is to measure the invert level of the existing pipe and its external diameter. The Contractor shall submit to the Engineer a proposal for the intended transition pieces for approval before ordering the respective accessories.

In case of pipe replacement, new pipes shall be laid on the same horizontal alignment as the old ones. Old pipes shall be removed and hauled to a site approved by the Engineer.

The Contractor shall note that the period of interruptions of the existing service pipeline shall be kept to the minimum and shall arrange to make such connections at periods agreed with the Engineer.

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Before attempting any connection to the existing network, the Contractor shall in-form the Engineer and the service provider responsible for operating the network and agree on a suitable procedure for the works. The Contractor shall give at least six working days notice to the Engineer and will be required to execute these works so as to cause minimal interference with the normal operation of the network, including night working where necessary. Extension of the Contract Period will not be granted for any delays arising out of the Contractor's failure to follow the agreed procedure. The Contractor shall submit additional shop drawings and a detailed method statement for approval by the Engineer. Cutting into the existing main pipe and effecting the interconnection shall only be made in the presence of the Engineer or Employer at the time specified by the Employer.

Cutting into the existing main pipe and installation of the connecting pipework shall be carried out efficiently and rapidly so as to reduce to a minimum the interruption of the regular operation of the network. Existing mains shall only be cut using special equipment approved by the Engineer. Under no circumstances shall oxyacetylene or electric arc cutters be used. The cut shall be perpendicular to ensure that the new pipework shown on the Drawings may be installed. The Contractor shall agree with the Engineer's Representative the length of existing pipework to be removed. The Contractor shall take every care to avoid any dirt or extraneous material entering existing pipes. The Contractor shall have available at the site of the connection an efficient de-watering pump before commencing any cut into the existing main in order that excavation remains dry at all times and to reduce the risk of dirty or contaminated water entering the existing distribution system. The work shall be carried out in a clean and efficient manner. Sufficient length of hoses shall be provided to dispose the water to safe places. The Employer will in general wish to re-commission the pipeline as soon as possible after its installation and will carry out an inspection to detect any evidence of leakage; any remedial work necessary to eliminate leakage shall be carried out by the Contractor. No pipework shall be covered or backfilled until the Engineer's Representative is satisfied that the interconnection is free from any leakage.

The new pipe and connection together with any adjacent portion of the existing pipeline, which may have been disturbed by the Contractor, shall be tested for leakage. Any existing pipe failing to pass the test due to damage occurring during the connection operation shall be removed and replaced by the Contractor. The test shall be repeated until a satisfactory test obtained. Any additional cleaning and disinfection procedures required in respect of the connection shall be performed by the Contractor at no additional cost.

E.2.7.6.10 Thrust Blocks

Except where welded steel pipelines or self-anchoring joints are used, concrete thrust blocks and anchorage shall be provided to pressure pipelines at the points where following thrusts are produced or where ordered by the Engineer or indicated on the Drawings:

- changes in direction (bends deflecting 11,25° or more)
- changes in nominal diameter (reducers);
- branching (tees);

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- pipeline ends (blank flanges) whether permanent or temporary as during testing of pipeline sections.

At all the above points the Contractor shall construct a thrust block. Thrust blocks shall be of reinforced concrete class C20/25 or mass concrete C12/15 to the dimensions appropriate for the purpose of the pipe, or as ordered by the Engineer. Any additional excavation required to accommodate thrust blocks shall be carried out after the bend or branch is in position and the thrust face shall be trimmed back to remove all loose or weathered material immediately prior to concreting. Thrust blocks shall extend from the fitting to solid undisturbed ground, shall be suitably reinforced, if necessary, and shall be installed so that all joints are accessible for repair. The concrete backfill to the excavation shall be placed the same day as any additional excavation for the thrust block or anchorage is carried out. All concrete thrust blocks and collars shall be allowed to cure for at least 7 days before backfilling or bringing thrust to the blocks.

Thrust forces and shaping and siting of the thrust blocks and collars shall conform to the field test pressure and shall be calculated by the Contractor considering the prevailing soil bearing capacity.

Where it is not possible to brace against undisturbed soil, suitable fenders shall be arranged as directed by the Engineer.

The dimensions, classes of concrete and steel reinforcement given in typical standard drawings are approximate only. For concrete chambers, the Contractor shall determine the structural requirements to safely transmit the thrust into the natural soil.

Thrust blocks shall be allowed to develop adequate strength before any internal pressure is applied to the pipeline.

Plastic pipes shall be wrapped with a layer of plastic sheeting before being surrounded by concrete.

E.2.7.6.11 Anchor and Support Blocks

Movement of non-flanged or not welded pipelines or without thrust resistant joints, must be prevented by concrete anchor blocks. The Contractor shall design, supply and construct all necessary anchor blocks.

Anchor blocks shall be provided for all horizontal or vertical bending of pipeline. The quality of concrete shall be of class C 25/30. The structural analyses for anchor blocks shall be prepared by the Contractor and approved by the Engineer. Thrust forces, calculation and sizing of anchor blocks shall be taken from the manufacturer's instructions for a particular pipe material, whereas the pipe pressure is identical with the actual field test pressure.

Anchor blocks will also be required in water soaked soils to prevent an up-drift of pipes when empty in accordance to Section E.2.7.6.12.

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The Contractor shall determine the size and weight of the concrete anchor block and its spacing and obtain approval from the Engineer.

Plastic pipes shall be wrapped with a layer of plastic sheeting before being surrounded by concrete.

Support blocks must be cast between the fitting, which is to be supported, and the undisturbed wall of the trench. The concrete must be placed around the fitting in such way that the couplings are not covered or fixed by it, to allow flexibility and to provide access to the collars for replacing when necessary. Anchor blocks against up-drift shall be cast under the pipeline and the pipe must be fixed with a clamp onto the block as directed by the Engineer. Support block shall be placed to support any piece of equipment, as well as tees, bends, or other fittings as directed by the Engineer. Support block shall be placed in such manner to allow easy access for removal of valves, fittings etc. Before casting concrete, bituminous felt must be wrapped around the fitting at the interface between concrete and the fitting. Where required, anchor clamps shall be provided by the Contractor and deemed to be included in the unit prices for anchor blocks.

E.2.7.6.12 Securing against Uplift

Pipelines shall be secured against uplift by hydraulic pressure. All static calculations shall be made for the empty pipe.

Securing against uplift may be accomplished by backfilling with material or concrete or by anchorage. The contractor has to submit his calculations for securing against uplift to the Engineer for approval.

E.2.7.6.13 Concrete Protection to Pipelines

Where required, pipelines, and notably plastic pipelines running under drain channels, culverts, streams or roads, shall be encased in reinforced concrete class C25/30 pipes in full length. The inner diameter of the concrete pipe shall be sufficient for the undisturbed installation of the plastic pipe.

Where a pipeline crosses over drains or other utilities, and where the soil cover is not sufficient and concrete encasement is not advisable, a reinforced concrete slab shall be placed 200 mm above the top of the pipe. The slab may not be cast before the backfilled ground has been compacted. The concrete protection to the pipelines shall be either bed or surround and shall be of concrete C20/25 along such lengths as are shown on the approved drawings or ordered by the Engineer.

After the pipeline has been tested by the Contractor and approved by the Engineer the pipe outer face shall be thoroughly cleaned. Concrete C20/25 shall be carefully placed and compacted thereon to avoid disturbing the pipes or joints until the appropriate profile for the type of protection required has been reached.

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The concrete protection shall be placed to the full width of the trench and never less than 150 mm wider on each side than the barrel of the pipe. When support of excavation is provided building paper shall be placed against that support before concreting to facilitate withdrawal of the support.

In the case of spigot and socket pipes with flexible joints the concrete protection at each joint shall be interrupted in a vertical plane at the edge of the socket by a strip of fibreboard or other material approved by the Engineer and of the following thickness:

Pipe nominal diameter [mm]	Fibreboard thickness [mm]
≤ 300	12
> 300 and ≤ 600	24
> 600 and ≤ 1100	36

Where two or more pipelines are laid in the same trench, the joints shall coincide at the points where the continuity of the concrete surround is broken at the joints in the pipeline with the longest pipes, and any intermediate joints in the other pipeline with shorter pipes shall be surrounded in concrete.

Pipework systems shall be complete and checked for correct position and alignment before and after being embedded in concrete.

Pipes in roads with heavy traffic have to be protected by appropriate drag plates.

Plastic pipes shall be wrapped with a layer of plastic sheeting before being surrounded by concrete.

E.2.7.6.14 Laying of Concrete Pipes

Laying of pipes shall generally be as specified in Section E.2.7.6, in accordance with the requirement as specified in EN 1610 and with the instruction of the manufacturer in the case of the factory made pipes, unless otherwise directed by the Engineer.

The pipe bedding material for concrete pipes shall be as follows:

- For pipes up to 1.200 mm internal diameter the material shall be graded 20 mm to 5 mm all passing 20 mm and not more than 20 % passing 5 mm sieves;
- For pipes above 1.200 mm internal diameters internal diameter the material shall be graded 37,5 mm to 5 mm all passing 37,5 mm not more than 45 % passing 20 mm and not more than 20 % passing 5 mm sieves.

The pipes shall be laid on the backfilled, graded and finished bedding of the trench and special joint holes shall be provided. Spigot and socket pipes shall normally be laid with the socket at the upper higher end.

The whole inside and outside area forming the joint of pipes and fittings shall be thoroughly cleaned before laying. Every precaution shall be made to prevent foreign material entering the

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pipes. During laying operation no debris, tools, cloth or other material shall be placed in the pipe.

Except where concrete protection is to be provided the Contractor shall not, at any stage in the laying of pipes support the pipes on anything else than granular material. Temporary packing of brickwork, stones etc., will not be permitted.

During the jointing, displacement of the rubber ring shall be prevented in the case of adopting the sliding method. The noose shall not be removed until the joint is made and the pipes sufficiently supported and after the approval of the Engineer.

E.2.7.6.15 Laying and Jointing of Ductile Iron Pipes

Laying of pipes shall generally be in accordance with the requirements of the applicable standard and with the instruction of the manufacturer.

The pipes shall be laid in straight lines both in horizontal and vertical planes. Changes of direction of less than 11,25° shall be obtained by deviating the pipes after jointing at one or more joints. The angle of deviation at each joint depends on the ND and has the following maximum values:

Nominal Diameter DN [mm]	Maximum Deviation
100 to 150	5°
200 to 300	4°
350 to 500	3°
600 to 700	2°
800 to 1100	1°30'

No deviation can be made at a locked joint.

The general jointing procedure may vary with the type of joint used, but the basic requirements are:

- Overall cleanliness;
- Correct positioning of the components;
- Correct centring of the spigot in the socket;
- Strict observance of the manufacturer's assembling instructions.

The Contractor shall be responsible for providing the necessary copies of these instructions.

The contractor has to make sure that the pipes and fittings will meet the requirements for the negative and positive pressure and a related calculation has to be provided. Where needed the pipe connections have to be fixed in longitudinal direction by using TYTON joints according to DIN 28603 or equivalent.

E.2.7.6.16 Laying of Steel Pipes

Transport, laying and measurement of steel pipes shall be in accordance with the rules outlined for DI pipes.

However the specific requirements for the jointing and handling of steel pipes are summarised as follows:

- Steel pipes shall be joined together by electric butt-welding. Welding shall be in accordance with approved standards. The electrodes used shall be suitable for overhead welding and shall be subject to the Engineer's approval. Pipes shall be joined beside the trench;
- The Contractor's welders shall have passed welding tests as prescribed by the Engineer and no welder shall work on the pipes before passing the test and being approved by the Engineer in writing;
- After passing the prescribed pressure test, external coating of all joints shall be completed in accordance with the Engineer's instructions and to his satisfaction;
- After inspection of the joints the pipes shall be lowered into the trench.

E.2.7.6.17 Laying of HDPE Pipes

The pipes shall be taken from the roll, straightened, cut to the required lengths, positioned and bedded in the trenches on the compacted and finished bedding and jointed with the appropriate fittings.

E.2.7.6.18 Laying of GRP Pipes

Pipes shall be laid in the trench straight and without tension. The maximum allowed change of direction on the joint coupling shall be in accordance to the manufacturer's instructions and not more than 3°.

E.2.7.6.19 Laying of Galvanised Iron Pipes

If ordered by the Engineer, the installation of GI pipes, diameters ranging from ½" to 1", from behind the water meter to the consumer's house piping system shall be executed by the Contractor.

Piping shall include all fittings, connecting materials, supports, earthwork chiselling, mending and pressure tests for the complete installation of GI pipes in every respect.

E.2.7.7 Pipe Joints

E.2.7.7.1 General

The Contractor shall use only the proper jointing parts as specified and obtained from the suppliers of pipes or fittings. All joints shall be assembled and tightened in accordance with the manufacturer's instructions.

Unless specified otherwise joints having exposed mild steel components shall be cleaned and all loose rust shall be removed. The internal lining in a gap, which has been left for the joint to be made, shall be completed in accordance with the recommendations of approved supplier, unless specified otherwise. The external protection shall comprise bitumen applied to a thickness of not less than one millimetre on to the external surface of the joint, followed where appropriate by a spiral wrap of heavy duty glass fibre tape bonded with hot bitumen.

Solvent cement type joints shall not be used for pipe jointing.

E.2.7.7.2 Push-in Joints

Joint rings and gaskets shall be stored until needed in a cool place protected from direct sunlight.

The pipes shall be positioned and bedded in the trenches on the compacted and finished bedding and jointed in an approved manner using the proper lubricant, rubber rings and methods in strict accordance with the manufacturer's instructions.

Special care shall be taken to see that the axis of the pipe to be laid forms one straight line with the axis of the previously laid pipe. Spigot and socked ends shall be central with regard to each other.

The inside of the socket and the outside of the spigot end shall be thoroughly cleaned to remove oil, grit, excess coating, and other foreign matter. The circular rubber gasket shall be flexed inward and inserted in the gasket recess of the bell socket.

The following measures shall be taken for joints made with the "sliding method". A thin film of gasket lubricant shall be applied to either the inside surface of the gasket or the spigot end of the pipe, or both. The gasket lubricant shall be as supplied by the pipe manufacturer and approved by the Engineer. In no case shall an un-approved lubricant be used. The substance to be used needs to be approved by the manufacturer of the rubber rings.

For joints executed by "rolling" of the rubber ring the Contractor shall ensure that spigot and socked ends and the rubber ring are completely dry and clean before insertion of the joint. The positioning of the rubber ring shall be such that twisting is prevented while the circumferential stress is applied before each joint is made.

The spigot end of the pipe shall be entered into the socket with care to keep the joint from contacting the ground. The joint shall then be completed by forcing the plain end to the bottom

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of the socket with a forked tool, jack-type tool, by leverage with an iron bar against the opposite end of the pipe being installed or other device approved by the Engineer.

A wooden block or other suitable device shall be used to prevent any damage to the socket against which the bar is being pressed. No blocking will be allowed under the pipe, and it shall bear evenly along its entire length on the bedding material. Particular care shall be applied to ensure that the spigot end of the pipe does not damage or displace the rubber ring joint. Pipes that are not furnished with a witness mark shall be marked before assembly to assure that the spigot end is inserted to the full depth of the joint. Field cut lengths shall be filed or ground to the same dimension as the manufactured spigot end.

A penetration gauge shall be used to check each joint after assembly, to ensure that the rubber ring is properly seated. When it is desired to deflect push-on joint pipe in order to form a long radius curve, the amount of deflection shall be directed by the Engineer and the instructions of the manufacturer shall be observed. It is important that in making the joint, the pipes are maintained in a straight line and the deflection introduced after the joint has been assembled.

After completing the joint any protective or other coating shall be made good and any lining and joint protection completed as specified without delay.

The pipe shall be secured in place with approved backfill material (preferable concrete B 5-10 on fine sand) tamped around it, except at the joints. Pipes shall be laid in such a manner that the whole body of the pipe is in contact with the bedding. Precautions shall be taken to prevent dirt from entering the joint space. All joints shall remain uncovered until successful completion of the pressure test.

The Contractor shall supply all the materials, equipment and tools required for the proper jointing of the pipes at his own cost.

The finished pipeline shall run straight between the bends and curves and a uniform gradient shall be accurately maintained between changes of gradient shown on Drawings or authorized by the Engineer. All pipelines must be inspected and approved by the Engineer before they are tested and finally covered.

E.2.7.7.3 Mechanical Joints

To assemble the joint, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before inserting the spigot into the socket of the joint. Bolts shall be tightened alternately on opposite sides of the joint diameter and in rotation around the pipe. When properly assembled, the gland shall be equidistant from the socket face at all points.

All mechanical joints shall have their coating made good before assembly.

E.2.7.7.4 Flanged Joints

Flanged joints shall be properly aligned before any bolts are tightened. Gaskets shall be used at all flanged joints. Gaskets for flanged joints shall be of the inside-bolt-circle type. Slip-on flanges

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shall be double welded to the pipe with a full strength fillet weld joining the flange hub to the pipe, and a seal fillet weld inside the flange at the pipe end. Jointing compounds shall not be used when making flanged joints, except that to facilitate the making of vertical joints, gaskets may be secured temporarily to one flange face by a minimum quantity of clear rubber solution.

Flanged joint pipe shall be firmly and fully bolted with machined bolts provided by the manufacturer. Bolt threads shall be treated with graphite paste and the nuts shall be tightened gradually and evenly in diametrically opposite positions using only standard spanners of type approved by the Engineer. Nuts shall be secured against loosening by vibration.

E.2.7.7.5 Welded Joints

Welding of joints shall be carried out in accordance to Section E.4.3.3.5 for HDPE pipes and Section E.4.7.6 for steel pipes.

E.2.7.7.6 Thrust resisting Joints

The Contractor shall use fittings with thrust resisting joints where appropriate to prevent the main from pulling apart at certain pipe sections and where those sections are not anchored otherwise.

E.2.7.8 Trenchless Pipe Laying

This paragraph concerns the installation of water supply or sewer lines by horizontal directional drilling. Works shall include all materials, equipment, labour and work as required.

Horizontal directional drilling equipment shall comprise the following:

- Directional drilling rig of sufficient capacity to perform bore and pull-back operations;
- Drilling fluid mixing, delivery, and recovery system of suitable capacity;
- Automated magnetic guidance system with sufficient accuracy;
- Automated detected and warning system to locate other infrastructure ahead of bore;
- Tanker truck or other suitable mobile storage for handling of drilling fluid;
- Steel casings of various diameter, fit for purpose;
- Any other equipment required for horizontal directional drilling.

Any equipment shall be in good and safe operating condition with sufficient spares and consumables to ensure continuous operation.

Horizontal directional drilling shall be undertaken in 2 steps:

1. A pilot bore shall be driven with no deviations from the bore path;
2. Upon completion of the pilot hole the bore shall be reamed to ≥ 10 to 25 % of the outside diameter of the pipe to be installed.

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Once reaming is completed, graded casing shall be pulled-in, giving sufficient support to avoid damage of the pipe.

Pull-back of the pipe shall be through wet insertion.

The Contractor shall maintain a thorough and neat boring log, subject to the Engineer's approval. Works shall be implemented in close coordination with the Employer and relevant authorities. Safety procedures have to be closely followed.

E.2.7.8.1 Construction Site Requirements

Excavation for entry, recovery pits, slurry sump pits, or any other excavation shall be carried out as specified in Section D.4.2. Sump areas are required to contain drilling fluids.

After completing installation of the product, the work site shall be restored. The work site shall be cleaned of all excess slurry left on the ground. Removal and final disposition of excess slurry or spoils as the product is introduced, shall be the responsibility of the boring contractor.

Excavated areas shall be restored. The cost of restoring damaged pavement, curb, sidewalk, driveways, lawns, storm drains, landscape, and other facilities is borne by the Contractor.

E.2.7.8.2 Quality Control

A representative of the Contractor must be in control of the operation at all times. The representative must have a thorough knowledge of the equipment and the procedures to be performed, and is present at the job site during the installation.

The Engineer must be notified 48 hours in advance of starting work. The installation shall not begin until the Engineer is present at the job site and agrees that proper preparations have been made.

E.2.7.8.3 Boring Path Report

The Contractor shall furnish a Bore Path Report to the Engineer within 14 days of the completion of each bore path. The completed As-Built-Plans shall be submitted to the Engineer within 30 calendar days. The report shall contain:

- a) Location of project;
- b) Name of person collecting data, including title, position, and company name;
- c) Investigation site location (contract plans station number or reference to a permanent structure within the project right of way);
- d) Identification of the detection method used;
- e) As-built placement drawings showing roadway plan and profile, cross section, boring location and subsurface conditions as defined in Bore Path Drawings below. Plan elevations shown shall be referenced to the given bench mark and to the used grid

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system and datum. These drawings shall be done to the same scale in black ink on white paper, of the same size and weight and as the contract Drawings.

E.2.7.8.4 Boring Path Drawings

Boring Path Drawings shall be dimensionally correct copies of the contract plans. Notes shall be included on each drawing stating the final bore path diameter, facility diameter, drilling fluid composition, composition of any other materials used to fill the annular void between the bore path and the pipe. The drawings shall be produced as follows:

- a) The contract plan view shall show the centre-line location of each pipe installed to an accuracy within 3 cm at the ends and other points physically observed. They show the remainder of the horizontal alignment of the centre line of each pipe and note the accuracy with which the installation was monitored.
- b) As directed by the Engineer, either a profile drawing for each bore path, or a cross section of the roadway at a station specified by the Engineer, or a roadway centreline profile, shall be provided. They shall show the ground or pavement surface and the crown elevation of each facility installed, or installed and placed out of service, to an accuracy within 3 cm at the ends and other points physically observed. It shall show the remainder of the vertical alignment of the crown of each pipe and notes the accuracy with which the installation was monitored. On profile drawings for bore paths crossing the roadway the contract plans stationing of the crossing shall be shown.
- c) On the profile drawings for bore paths paralleling the roadway the contract plans stationing are also shown.
- d) If the profile drawing for the bore path is not made on a copy of one of the contract profile or cross section sheets, a 10 to 1 vertical exaggeration shall be used.

E.2.7.8.5 Directional Boring

The work specified in this Section documents the approved construction methods, procedures, and materials for Directional Boring, also commonly called Horizontal Directional Drilling (HDD).

Drilling Fluids & Reamer Hole Diameter

The Contractor shall identify the source of fresh water for mixing the drilling mud. Approvals and permits are required for such sources as streams, rivers, ponds, or fire hydrants. Any water source other than potable water may require a pH test.

A mixture of bentonite clay or other approved slurry and potable water shall be used as the cutting and soil stabilisation fluid. The viscosity shall be varied to best fit the soil conditions encountered. Water shall be clean and fresh, with a minimum pH of 6.

No other chemicals or polymer surfactant is to be used in the drilling fluid without the written consent of the Engineer and after a determination is made that the chemicals to be added are not harmful or corrosive to the facility and are environmentally safe.

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Monitoring of the drilling fluids such as the pumping rate, pressures, viscosity, and density is required during the pilot bore, back reaming, and pipe installation stages, to ensure adequate removal of soil cuttings and the stability of the borehole. Relief holes can be used as necessary to relieve excess pressure down hole. To minimise heaving during pullback, the pull back rate is determined in order to maximise the removal of soil cuttings without building excess down hole pressure. Excess drilling fluids shall be contained at entry and exit points until they are recycled or removed from the site. Entry and exit pits shall be of sufficient size to contain the expected return of drilling fluids and soil cuttings.

The Contractor shall ensure that all drilling fluids are disposed of or recycled in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in suspected contaminated ground, the drilling fluid shall be tested for contamination and disposed of appropriately.

Any excess material shall be removed upon completion of the bore.

Restoration for damage to any transportation facility or non-transportation facility caused by heaving, settlement, escaping drilling fluid (fracout) or the directional drilling operation, is the responsibility of the Contractor. Any pavement heaving or settlement damage requires restoration / replacement of the pavement.

Testing

When there is any indication a pipe has sustained damage and may leak, the work is to be stopped and the damage investigated. The Engineer may require a pressure test. The testing may consist of one of the following methods but shall always meet or exceed the testing requirements stated in Section 0.

- a) Manufacturer's pressure testing recommendations for the type of pipe being installed shall be followed. The Engineer shall be notified and at his option be present during the test for review of the test results for compliance. The pressure test shall be performed within 24 hours. A copy of the test results shall be furnished to the Engineer. If the pipe is not in compliance with specifications, the Engineer may require it to be filled with flowable fill.
- b) Product carrier pipes installed without a casing must meet pressure requirements set by the Manufacturer. If the Manufacturer does not require pressure testing, the Engineer may require at least one test. A copy of the test results shall be furnished to the Engineer. If the pipe is not in compliance with specifications the Engineer may require it to be filled with flowable fill.
- c) The Engineer requires that conduit or pipe must meet or exceed soil tight joint requirements when leakage would not cause failure or adversely affect the integrity of the roadway pavement or shoulders.
 - d) Where leakage could adversely affect pavement or shoulder integrity, a water tight joint is required.

Locating and Tracking

The Contractor shall describe the method of locating and tracking the drill head during the pilot bore. The Engineer recognises walkover, wire line, and wire line with surface grid verification (i.e. True-Track), or any other system as approved by the Engineer, as the accepted methods of tracking directional bores. The locating and tracking system shall be capable of ensuring that the proposed installation is installed as intended. If an area of radio signal interference is expected to exceed 1,5 m, the Engineer may specify the use of a suitable tracking system.

The locating and tracking system shall provide information on:

- Clock and pitch information;
- Depth;
- Transmitter temperature;
- Battery status;
- Position (x, y);
- Azimuth, where direct overhead readings (walkover) are not possible (i.e. subaqueous or limited access;
- transportation facility.

Before commencement of a directional drilling operation, proper calibration of the equipment (if required) shall be undertaken.

Alignment readings or plot points shall be taken and recorded every 1,5 m.

All facilities shall be installed in such a way that their location can be readily determined by electronic designation after installation. For non-conductive installations, this shall be accomplished by attachment of a continuous conductive material either externally, internally, or integrally with the product. Either a copper wire line or a coated conductive tape for this material may be used. Any break in the conductor must be connected by electrical clamp of brass or solder and coated with a rubber or plastic insulator to maintain the integrity of the connection from corrosion.

Equipment Requirements

The Contractor shall ensure that appropriate equipment is provided to facilitate the installation. Equipment shall be matched to the size of pipe being installed. Installations must be approved by the Engineer. The Contractor ensures that the drill rod can meet the bend radius required for the proposed installation.

Multiple pipe or conduit installations shall not exceed the total outside pipe diameters stated above.

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Obstructions

If during installation an obstruction is encountered which prevents installation of the pipe in accordance with this specification, the pipe may be taken out of service and left in place at the discretion of the Engineer, and shall immediately be filled with flowable fill. A new installation procedure and revised plans must be submitted to and approved by the Engineer before work can resume. If a bore path is abandoned without installing a pipe, the drawings shall show the abandoned bore path along with the final bore path. The abandoned bore path shall be noted as "Abandoned Bore Path." They shall also show the location and length of the drill head and any drill stems not removed from the bore path. If conditions warrant removal of the materials installed in the abandoned bore path, as determined by the Engineer, during construction or in the future, the cost and responsibility shall be borne by the Contractor.

The type of material, horizontal and vertical location, top elevation and lowest elevation observed, diameter and material type of all utilities encountered and physically observed during the subsoil investigation shall be noted on the drawings.

E.2.7.8.6 Jack and Bore / Micro-Tunnelling

The work specified in this Section documents the approved construction methods, procedures, and materials for Jack and Bore (J&B), also known as auger boring. Micro tunnelling (MT) is considered to be a hybrid of Jack and Bore for purposes of specifications.

Materials

Materials approved for installation shall be selected based on their suitability for the construction method as defined in the following table. After determining product suitability, individual material standards as contained in the subsequent table shall apply. Requirements on steel and RC pipe casings are specified hereinafter.

Type Pipe / Casing Installation Mode	Suitable Pipe / Casing
J&B Jacking	Steel pipe
MT Jacking	Ductile iron pipe, prestressed or reinforced concrete pipe, Steel pipe

Steel Pipe Casing

The size of the steel casing shall be at least 15 cm larger than the largest outside diameter of the carrier pipe.

The casing pipe shall be straight seam pipe or seamless pipe. All steel pipes may be bare inside and out, with the manufacturers' recommended minimum nominal wall thicknesses to meet installation and loading requirements. Coatings to extend the service life may be permitted. All steel casing pipe shall be square cut and have dead-even lengths which are compatible with the J&B equipment.

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All steel pipe casings and welds shall meet or exceed the thickness requirements to achieve the service life requirements. Steel pipe casing of insufficient length shall achieve the required length through fully welded joints. Joints shall be air-tight and continuous over the entire circumference of the pipe with a bead equal to or exceeding that required to meet the thickness criteria of the pipe wall. All welding shall be performed by a qualified welder.

Reinforced Concrete Pipe Casing

In addition to the concrete pipe standards, the pipe shall comply with the following minimum requirements:

- a) 35 MPa concrete compressive strength;
- b) Strengthened wall as required by load calculations;
- c) Full circular inner and/or outer reinforcing cage;
- d) Multiple layers of steel reinforcing cages, wire splices, laps and spacers are permanently secured together by welding in place;
- e) Straight outside pipe wall with no bell modification;
- f) No elliptical reinforcing steel is allowed;
- g) Single cage reinforcement with a 3 cm minimum cover from the inside wall;
- h) Double cage reinforcement with a 3 cm minimum cover from each wall;
- i) Joints are gasket type;
- j) Additional joint reinforcement.

Upon installation, the Engineer may at his discretion require the contractor to perform concrete wiping or injection of the joints if it is believed the joints have not maintained their water tightness during the jacking operation. No additional payment will be made for this operation.

Ground Water Control

When ground water level must be controlled, the system shall be compatible with the properties, characteristics, and behaviour of the soils as indicated by the soil investigation report.

Ground water may be controlled from sumps constructed inside the excavated areas (pits). When sump pumps are not sufficient to control the ground water, de-watering is required as specified in Section D.4.2.4.

Specific Micro-Tunnelling Requirements

Continuous pressure shall be provided to the face of the excavation to balance groundwater and earth pressures. Shafts shall be of sufficient size to accommodate equipment, the pipe selected, and to allow for safe working practices. Entry and exit seals shall be provided at shaft walls to prevent inflows of groundwater, soil, slurry, and lubricants. Thrust blocks shall be

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designed to distribute loads in a uniform manner so that any deflection of the thrust block is uniform and does not impart excessive loads on the shaft itself, or cause the jacking frame to become misaligned.

The Micro-Tunnelling boring machine (MTBM) shall meet the following minimum performance requirements:

- a) Capable of providing positive face support regardless of the MTBM type;
- b) Articulated to enable controlled sheeting in both the vertical and horizontal directions to a tolerance of plus or minus 2 cm from design alignment;
- c) All functions are controlled remotely from a surface control unit;
- d) Capable of controlling rotation. This is accomplished by a bi-directional drive on the cutter head or by using anti-roll fins or grippers;
- e) Capable of injecting lubricant around the exterior of the pipe being jacked;
- f) Capable of controlling heave and settlement to acceptable tolerances as indicated in the contract documents.

The main control system of the MTBM shall provide the following information to the operator as the minimum required for successful operation of the MTBM:

- Deviation of the MTBM from the required line and grade of the pipeline (normally by reference to a laser beam);
- Grade and roll of the MTBM;
- Jacking load;
- Torque and RPM of the cutter head;
- Instantaneous jacking rate and total distance jacked;
- Indication of steering direction.

For slurry systems, the following shall be indicated:

- The volume of slurry flow in both the supply and return side of the slurry loop;
- The slurry bypass valve position.
- The pressure of the slurry in the slurry chamber.

The jacking system shall have the capability of pushing the MTBM and pipe through the ground in a controlled manner and compatible with the anticipated jacking loads and pipe capacity. The jacking force applied to the pipe shall be monitored and not exceed the pipe manufacturer's recommendations.

The pipe lubrication system shall be functional at all times and sufficient to reduce jacking loads. Pipe lubrication systems shall include a mixing tank, holding tank and pumps to convey lubricant from the holding tank to application points at the rear of the MTBM. Sufficient fluids shall be maintained on site so as not to allow loss of lubrication.

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Spoil removal capability and method shall be identified so as not to create a hindrance to other activities which may be necessary in the area.

Locating and Tracking

For all installations, the Contractor shall submit sufficient information to establish his proposed strategy for providing:

- a) A positive indication of where the leading edge of the casing is located with respect to line and grade. This indication is provided with a water gauge (Dutch level), electronic transmitting and receiving devices, or other approved methods. The Contractor shall indicate the intervals for checking line and grade, and a record is maintained at the job site.
- b) Equipment of adequate size and capability to install the project. This includes the equipment manufacturer's information for all power equipment used in the installation.
- c) A means for controlling line and grade.
- d) A means for controlling overcut to a minimum, with the maximum limited to a 2 cm space around the circumference of the casing pipe.
- e) A means for centring the cutting head inside the borehole.
- f) A positive means for preventing the rear of the cutting head from advancing in front of the leading edge of the casing by more than 1/3 times the casing diameter in stable cohesive conditions not to exceed 20 cm. In unstable conditions, such as granular soil, loose or flowable materials, the cutting head is retracted into the casing a distance that permits a balance between pushing pressure, pipe advancement and soil conditions to assure no voiding takes place.
- g) Adequate casing lubrication with a bentonite slurry or other approved techniques.
- h) An adequate band around the leading edge of the casing to provide extra strength, which in loose, unstable materials when the cutting head has been retracted into the casing reduces skin friction as well as provides a method for the slurry lubricant to coat the outside of the casing.
- i) At least 6 m of full diameter auger at the leading end of the casing. Subsequent auger size may be reduced, but the reduced auger diameter must be at least 75 % of the full auger diameter.
- j) Water to be injected inside the casing to facilitate spoil removal. The point of injection is be no closer than 60 cm from the leading edge of the casing.

All the above options are required for major installations unless the Engineer has agreed in writing that they are not necessary. For both major and minor installations, the Contractor is responsible for submitting to the Engineer information indicating his proposed strategy for providing compatible materials and equipment.

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All facilities shall be installed in such a way that their location can be readily determined by electronic designation after installation. For non-conductive installations this shall be accomplished by attachment of a continuous conductive material either externally, internally, or integrally with the product. Either a copper wire line or a coated conductive tape for this material may be used. Any break in the conductor must be connected by electrical clamp of brass or solder and coated with a rubber or plastic insulator to maintain the integrity of the connection from corrosion.

E.2.7.9 Pipes laid “Not in Trench”

Pipe laying items indicating that pipes are laid “not in trench”, include the pipe laying above ground (Section E.2.8). These items include following works with all materials, equipment, labour and work as required:

- All required pipe fixing systems;
- In case no near and/or adequate fixing point exists, the pipe laying items comprise all works required for the construction of the needed fixing points (e.g. reinforced concrete foundation block);
- All ancillaries including the required equipment for contact corrosion protection (between metal pipes and metal pipe fixing units);
- All “fittings” as required.

The pipe fixing systems shall be submitted to the Engineer for approval. Depending on the pipe types, the fixing system type shall be designed according to the pipeline type (e.g. pressure or gravity pipe, diameter, etc.). As requested by the Engineer, the contractor shall provide structural design calculations of the fixing systems.

Metal systems shall be made corrosion resistant metal (e.g. stainless steel, galvanized steel, aluminium or epoxy coated steel).

When installing piped services the following minimum clearances shall be provided:

- Walls: 300 mm
- Ceiling: 200 mm
- Floors: 200 mm
- cables and conduits: 150 mm

No joint of any description shall be made in the thickness of walls, solid floors etc. of any other position where access for maintenance is difficult.

E.2.7.10 Marker Posts

E.2.7.10.1 General

In order to leave permanent indication of the routes and depths of the pipelines and cables where they are below ground the Contractor shall provide and set up marker posts with indicator plate. Marker posts are not required for sanitary sewers with manholes.

The marker posts shall be set up as soon as practicable after trench excavations have been refilled but the Contractor shall provide any temporary marking required and shall be responsible for correct information being given on the indicator plates.

Marker posts shall be provided generally at 200 m spacing, at changes in direction of the main, adjacent to all valves and valve chambers, dead ends, and elsewhere as may be ordered by the Engineer. The depth to the top of the pipeline shall be indicated on all markers.

As directed by the Engineer the spacing of marker posts shall be varied where appropriate to avoid obstructing traffic or conflicting with other uses of the land.

Marker posts shall serve to mark DN and locations of valves, air venting and underground hydrants of mains. Locations shall be indicated by x, y offset originating from the location of the plate. Each unit shall consist of a plate and the letters and figures that shall be fixed to it. Letters and figures shall be 50 mm high and be of Latin character.

Plate, letters and figures shall be of weather-proof plastic or galvanised steel. The plate shall be fixed on a wall or at a galvanised steel or aluminium-alloy pipe of at least 40 mm. The pipe shall be fixed in the underground by concrete foundation.

The Contractor shall propose a proven system, according to the water supply company requirements and approved international Standards.

E.2.7.10.2 Marker posts for Water Networks

Markers for pipelines, valves and hydrants shall be prefabricated of concrete C 20/25 or aluminium with the following dimensions: 15 / 15 / 250 cm, with chamfered edges and placed in a concrete bed of 50 / 50 / 50 cm so that the marker protrudes 200 cm from ground level. The posts shall bear head of 25 x 35 cm having a recess of 10 mm and the size of 20 x 20 cm to receive the plate. At the edges of the recess, 4 dowel holes shall be provided.

Figures and letters on the plate shall show the following information on the valves: number of valve, DN and offsets; for hydrants: number of hydrant and offsets. Figures and letters shall be placed by the Contractor.

E.2.7.11 Marker Tapes

Marker tapes shall serve to mark location of pipes in the ground and to prevent unforeseen uncovering and damage to the pipe. Marker tapes shall be laid 300 mm above pipe crest to

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mark location of mains in the ground and allow detection by all standard and advanced detection methods using conductors. Tape shall satisfy the requirements of EN 12613 be of PE or equivalent and be fitted out with at least one stainless steel or copper conductor. Thickness shall be not less than 0,25 mm and width shall be at least 50 mm. The tape shall be supplied in coils of at least 100 m.

The marker tape shall have following colours and warning signs or equivalent along the top section of the pipe:

- Water supply: blue with warning signs "Caution Water Main below";
- Sewer pipe: brown or orange with warning signs "Caution Sewer Pipe below";
- Electrical cable or cable duct: red with warning signs "Caution Electric Cable below";
- Gas pipe: yellow with warning signs "Caution Gas Pipe below";
- Telecommunication cable or cable duct: green with warning signs "Caution Telecommunication Cable below".

Samples of the tape shall be submitted to the Engineer for his approval.

The provision and installation of these tapes are included in the duct pipe laying unit rates.

E.2.8 Erection of Pipework above Ground

Pipes shall be installed above ground where shown on the Drawings and/or as directed by the Engineer. Pipes for river crossings and bridge crossing and those exposed to sun radiation shall be of ductile cast iron as shown on the Drawings or as directed by the Engineer.

E.2.8.1 Preparation of Pipes

The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly cleaned before and during erection and before it is placed into commission.

Cleaning shall include the removal of all dirt, rust, scale and welding slag due to site welding. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment.

E.2.8.2 Installation of Pipes

Care shall be taken during the erection of pipework to ensure that no loads of any kind are transmitted through to the pump flanges or the flanges of any other equipment. Care shall also be taken that pipe flanges are accurately aligned to prevent distortion of flanges and/or pipework when bolting together. Bolts of flanged connections shall be tightened uniformly so that the gasket pressure is evenly distributed around the circumference.

E.2.8.3 Installation of Appurtenances

E.2.8.3.1 General Requirements

Valves, fitting, plugs, and caps shall be set and jointed to a pipe in the manner specified above for cleaning, laying and jointing of pipes. The Contractor shall furnish all components required for construction of valve chambers and access to buried valves, including cast iron covers, as shown on the Drawings. Each valve and equipment on pipeline shall be supported by a concrete base but not concreted into the base.

E.2.8.3.2 Valves

Isolation valves, if required, shall be installed according to the Drawings and/or directed by the Engineer. Special attention shall be drawn to clean and careful installation of valves. Any foreign matter resting in valve seats shall be removed in order not to obstruct the efficient operation of valves.

E.2.8.3.3 Bends and Fittings

Bends, tees and other fittings shall be installed according to the Drawings and/or as directed by the Engineer.

E.2.8.4 Support of Pipework and Valves

The Contractor shall furnish and install all pipe hangers, attachments, and supports, including structural steel work foundations, hangers, saddles, sliding, expansion pieces, fixing bolts, foundation bolts, fixing and anchor points as required according to needs. For this purposes Contractor shall provide adequate technical solutions approved by the Engineer. Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing pipes to prevent damage to the pipe coating or to adjacent structures or equipment. All supporting means shall be in place and installed before temporary supports and bracings are removed.

The Contractor shall install sleeves, puddle pipes or wall castings for all pipes passing through masonry walls and concrete floors or walls and concrete inserts for hangers and supports as soon as formwork is erected and before concrete is placed. Before setting these items, the Contractor shall check all plans and figures which have a direct bearing on the pipe location and he shall be responsible for the proper location of the pipes during the construction of the structures.

All pipes shall be rigidly supported by approved hangers, inserts, or supports with adequate provisions for expansion and contraction. Pipes shall not be supported from other pipes or from stairs, ladders, or walkways unless specifically directed by the Engineer. Where pipes are installed on structural steel supports, the pipe shall be fixed to them in order to avoid pipe movement. All vertical pipes shall be supported at appropriate length intervals approved by the Engineer, pipe collars, clamps, brackets, or wall rests, and at all points necessary to ensure

rigid construction. Valves, meters, strainers and other devices mounted in the pipework and its associated equipment shall be supported independently of the pipe to which they connect.

E.2.9 Passing through and Connection of Pipes to Concrete Walls

E.2.9.1 General Requirements

Where pipes pass through a concrete or brick wall or structure, a wall pipe sleeve or puddle pipe of appropriate dimensions shall be installed. Collars and/or short pipe pieces shall be used as directed by the Engineer to absorb any differential displacement that may occur at the interface between natural ground and the structure.

E.2.9.2 Sewer Pipes

Unless rare exceptions, passing through or connection of sewer pipes to walls of sanitation works shall be sustainably watertight. Therefore following standard shall apply to these works.

In case of pressure pipes and flanged pipes, connecting to walls or passing through walls:

- Method 1: Pipe insert sleeve with central puddle flange and flange connections, to be cast in concrete walls;
- Method 2: Core drilling of concrete wall and installation of a pipe sealing insert (press-seal).

In case of gravity pipes or flanged pipes

- Method 2: Passing through walls with: a wall core drilling and installation of a pipe sealing insert (press-seal);
- Method 3: Connecting to walls with: a pipe connection socket (including rubber gasket) that shall be cast in concrete walls.

Methods described for passing through of water supply pipes (Section E.2.9.4) are not allowed for wastewater and sludge pipes.

E.2.9.3 Duct Pipes

For duct pipes, passing through and connection to walls shall be made with insert sleeves, to be cast in the concrete walls.

E.2.9.4 Water Supply Pipes

Whenever pipework passes through walls, the Contractor shall provide block-outs and install the pipes only after the structure has been completed and grout the pipes in secondary concrete after the pipes have been accurately positioned. Peripheral expansion joint shall be installed before concreting the block-out. Where axial thrust is to be transmitted, puddle flanges

shall be grouted and reinforcement be placed in such manner that the thrusts will be safely transmitted into the structure.

In exceptional cases the Engineer may accept to incorporate the pipes into primary concrete provided that all pipe elements and appurtenances are completely wrapped into PE-sheets.

E.2.9.5 Preparation before Concreting

Before “concreting”, the pipe inserts or voids shall be adequately and firmly fixed in position in order to avoid movement or damage.

Individual pipes of complex pipe systems shall not be built into the concrete structures before accurate fitting of the whole system. Moreover, in such cases, the contractor shall foresee a minimum number of “pipe connection / passing through” to be built according to method 2 (core drilling and press-seal) as described in section E.2.9.2. Core drilling, which will per definition be implemented after wall construction, will allow for easy adjustment of their location basing on the location of the “pipe connection / passing through” existing in the freshly built wall.

E.2.9.6 Case of Brickwork Walls

For passing through and connection to existing or planned brickwork walls, no extra payment shall be made for the related works.

In case of existing walls, the Contractor shall drill a hole with an adequate drilling machine. The remaining spaces shall be grouted and the surfaces shall be reinstated.

In case of walls to be built, the contractor shall incorporate a short pipe length (maximum 50 cm) with pipe socket, during wall construction.

E.2.10 Contact Corrosion

Insulating flange sets shall be provided where shown and where necessary to prevent contact between dissimilar metals. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 40 mm or smaller and shall be made of acetal resin. For bolt diameters larger than 40 mm, insulating sleeves and washers shall be 2-piece and shall be made of polyethylene or phenolic insulating gaskets shall be full-face.

E.2.11 Manholes and Chambers

The manholes and valve chambers shall be either cast in-situ or pre-fabricated reinforced concrete or prefabricated thermoplastics.

E.2.11.1 Pre-cast and In-situ Concrete Manholes and Chambers

Dimensions of pre-cast concrete manholes and chamber shall be as required by local conditions. The access opening shall have a clear circular opening of 600 mm circular or rectangular of 550 x 750 mm.

Cast iron, GRP or plastic covers with frames shall be installed for all manholes and chambers as specified or shown on drawings. The bearing capacity of covers shall be in accordance to Section E.2.11.5. All chamber covers supplied under this Contract shall be embossed with the words as agreed with the Engineer in advance of the Contractor manufacturing the covers.

The Contractor shall submit to the Engineer for approval the structural design of the precast reinforced concrete chambers according EN 1917 (reinforcement bars, concrete exposure classes, resistance, etc.). Pre-cast concrete chambers shall be built with moulds.

E.2.11.2 Water Supply and pressurised Sewer Chambers

Reinforced concrete chambers for water supply and pressurised sewer shall be located as indicated on Drawings or directed by the Engineer. In-situ concrete chambers shall comply with the applicable specified requirements for Earth Works and Concrete Works.

All external pipework before entering and after exiting a reinforced concrete chamber shall be fitted with flexible joints at a minimum distance of 300 mm from the external face of the chamber.

The following types of chambers shall be applicable for water supply and/or pressurised sewer:

- Gate valve chamber;
- Service valve chamber;
- Air valve chamber;
- Washout chamber;
- Water meter chamber in main lines;
- Chambers for other valves.

The structures shall be built into the pipelines in accordance with Standard Drawings. Given dimensions on the drawings shall be verified by the Contractor so as to suit the pipe installation and the prevailing conditions on Site.

Blinding of not less than 10 cm thickness and an offset of not less than 5 cm shall be provided for all in-situ cast chambers. Pre-cast chamber bases shall be laid in lean concrete of not less than 10 cm thickness.

The floor of the chambers shall have a minimum slope of 3 % towards a drain sump with a minimum size of 400 x 400 x 200 mm.

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Two pairs of keys for use with each type of cover shall be handed over by the Contractor after completion of works at no extra cost.

All valve chambers shall be equipped with step irons as indicated in drawings or as directed by the Engineer. All valve chambers shall have pump sumps installed as shown on the Standard drawings or as instructed by the Engineer.

E.2.11.3 Sewer Inspection Manholes and Chambers

E.2.11.3.1 Location

Manholes and valve chambers shall be located as indicated on the Drawings or directed by the Engineer.

All manholes and inspection chambers shall be placed at all changes in direction, either horizontally and vertically, and connections to sewer lines. They shall be constructed with incoming and outgoing pipes neatly and truly concreted in, complete with benching, iron steps and manhole cover as specified herein and shown on Typical Drawings.

E.2.11.3.2 Material and Diameter

Sewer inspection manholes and chambers shall generally be precast chambers.

The typical standard manholes shall be constructed according to the detailed design drawings.

Unless otherwise specified, typical manholes and inspection chambers placed in the sewerage network shall be made of cast-in-situ bottom parts and pre-cast circular manhole rings, cones and levelling rings of appropriate size and diameters as shown on Typical Drawings and in accordance with the requirements of EN 1917. The contractor may propose alternatively the construction of the bottom part as pre-cast concrete structure subject to the Engineers approval.

In-situ concrete manholes and chambers shall comply with the applicable specified requirements of the present general specifications for Earth Works and Concrete Works.

Material

Precast chambers shall be made of:

- Reinforced concrete, or
- plastic (uPVC, PP or HDPE).

Except for small chambers near buildings, which shall be made of brickworks.

Inner Diameter

Unless otherwise specified or instructed by the Engineer, Sewer inspection manholes shall have a diameter of 1000 mm. Diameters of the precast sewer inspection chambers shall be either DN 600 or DN 300 mm.

E.2.11.3.3 Construction of Sewer Manholes

The Contractor shall construct manholes to the levels, dimensions and shapes shown on Drawings or as directed by the Engineer.

The construction of concrete manholes shall be as indicated on Standard Drawings and comprise:

- a) well compacted blinding layer, concrete C 12/15, thickness 10 cm;
- b) bottom of manholes, in cast-in place, as shown on the drawings. The Contractor may propose the construction of the bottom of the manholes in pre-cast concrete, being subject to the approval of the Engineer;
- c) tops of manhole frames (rings) and covers to the elevations as indicated on drawings, unless otherwise directed;
- d) building in and grouting of pipe ends (watertight construction), iron steps (at 300 mm centres) and drop fittings (encased in concrete C 20/25);
- e) benching to manholes (plain concrete C 30/37, compacted, well-formed and smooth trowelled);
- f) placing of cast iron, GRP or plastic manhole covers including frames.

The change between shaft ring and shaft cover shall be done with a shaft neck / shaft cone. A cover plate shall only be used in case of unsatisfying height of the shaft. The compensation of small level differences between shaft neck and shaft cover or shaft plate and shaft cover shall be made with level adjustment rings. Several rings may be used. The maximum height however is 125 mm.

E.2.11.3.4 Sewer Manholes Invert and Benching

Manhole inverts and benching in sewer pipes, drains and culverts shall be formed in concrete grade C 20/25 to the same gradient and diameter as the connected pipe works and with a smooth finish.

Inlet and outlet pipes shall be connected with channels at the bottom of the manhole. Channels shall be smooth with a size equal to the diameter of the inlet and outlet pipes. Changes in direction of flow shall be with smooth curves, as large as the size of the manhole permits. The bottom of the manholes shall have a minimum slope of 3 % towards the channels.

Inverts and junctions for pipes up to and including 400 mm diameter shall be formed of half-round, pre-formed channels, bends, tapers and specials. Inverts and junctions for pipes over

400 mm diameter shall be carefully formed in situ with 25 mm mortar shredding floated to the required shape.

The channel and the tread shall be protected against chemical attacks by the wastewater with appropriate coating.

E.2.11.3.5 Manholes and Chambers made of Polymer Material

Prefabricated polymer manholes made of HDPE, PP or GRP shall be in accordance with EN 13598, EN 13476 and EN 752 and placed on a prepared base made of concrete C 16/20, thickness 150 mm. The width of the concrete base must be wider than the manhole for 300 mm on each side. Connections of the pipes to the bottom of the manhole will be made on the same way as the standard sealing ring for the sewer equipment. On the overall height of the manhole there are gradually distributed steps of stainless steel or already spilled steps of polymers compliant with Section E.2.11.6.

E.2.11.4 Water Tightness

Concrete Quality

In case of reinforced concrete chambers, coatings to seal the chambers are not allowed. These chambers shall always be made of watertight concrete.

Between Chamber Elements

Assembly of all chamber elements (base and rings) shall be made with the insertion of elastomer gaskets between each element (gaskets according EN).

In case of reinforced concrete chambers, the profile geometry at assembly surfaces shall be as per standard drawing ("Z-profile").

Pipe Connections

Pipe connections to chambers or manholes shall be in accordance with Section E.2.9.

Hydro-insulation

Hydro-insulation of the manholes and chambers bottom and walls shall be applied in wet soils where the groundwater level exceeds the bottom of the manhole or chamber. The top of the hydro-insulation shall not be less than 0,5 m above highest ground level.

E.2.11.5 Covers

Cast iron, GRP or plastic covers and frames shall comply with EN 124. They shall be manufactured from cast iron and be coated with an approved heavy duty abrasion resistant pitch epoxide to a minimum of 375 microns. The load class shall be selected in according with

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the expected loadings. If not otherwise specified, heavy duty covers and frames shall be installed in all roads, streets and highways of width exceeding 3 m.

Unless otherwise directed, cast iron covers shall have the following bearing capacity.

Class (acc. to EN 124)	Minimum required load class	Bearing capacity [kN]	Location of installation
1	A 15	15	Green areas and areas where only pedestrians and cyclists have access
2	B 125	125	Car parks and pedestrian areas where only occasional vehicular access is likely
3	C 250	250	Car parks, forecourts, industrial sites and areas with slow moving traffic
4	D 400	400	Areas where cars and lorries have access, including carriageways, hard shoulders and pedestrian areas

The above indicated bearing capacities may be amended to suit the actual site conditions.

The provision and installation of covers shall always include the provision of a compatible frame. The related costs are to be included in the cover rate (or chamber rate if the cover rate is also included in the chamber rate). In all cases, chamber frames and covers shall be constructed so as to permit adjustment should the elevation of the road change. All removed chamber frames and covers need to be returned to the related local authority.

Covers of concrete manholes and chambers located in the asphalt-concrete paved road or pavement areas shall be placed on the same level as the surface of the road. Covers of manholes and chambers in green areas shall be at higher level than the ground level as follows:

- In built-up areas: 0,05 m;
- In non-built up areas: 0,20 m.

Covers shall be rain watertight and tightly fitting on frames to avoid vibration under passing traffic. This must be demonstrated to the Engineer before the concerned road is open to traffic.

All sewer manhole covers shall be equipped with dirt pans.

Unless otherwise specified, all covers shall be provided with approved corrosion resistant locking mechanism and provisions for lifting. Holes provided in covers for lifting shall be appropriately shaped pockets and there shall be no projections above cover level.

All chamber covers supplied under this Contract shall be embossed with the words as agreed with the Engineer in advance of the Contractor manufacturing the covers.

E.2.11.6 Steps and access Ladder

If not otherwise specified, steps in manholes and inspection chambers shall comply with the specifications of EN 1917 and be made of cast-iron with rubber coating, well covered against erosion and of 25 mm diameter, dimension 300 x 270 mm. The steps shall be installed in a staggered pattern at not more than 300 mm centres and well grouted.

Safety Access Ladders

According to standard EN 353-1, manholes with a depth greater than 5 m shall be provided with safety access ladders with guard rail, with design certification and CE marking, in accordance with EN 14396, made of 1.4307 (AISI 304 L) stainless steel, designed to attach an insertable entrance aid.

E.2.11.7 Lifting Keys

Lifting keys, tee keys and hooks for manholes and other chambers shall be black steel suitable for use with the covers supplied and shall be obtained from the cover Manufacturer. A set of lifting keys shall be supplied by the Contractor with each grade of covers.

E.2.11.8 Passing Through and Connections to Existing Chambers

For connections to existing reinforced concrete chambers shall the specification of section E.2.9 shall apply.

E.2.12 Pipe Thermal Insulation

All pipework conveying cooling or heating fluids shall be insulated.

A vapour barrier jacket is required for chilled water piping, equipment, refrigerant suction piping, domestic cold water piping, air handling ducts and equipment with air temperatures of 15°C or less.

Fittings, valves, and flanges shall have an insulation with a thickness no less than the adjacent piping but must be removable without damage for easy reapplication.

Pipe insulation in maintenance areas (mechanical rooms, accessible shafts, etc.) is subject to mechanical damage (crushing, abrasion and laceration) resulting from maintenance activities. Rigid insulation materials protected with appropriate casings and vapour barrier linings are required in these spaces.

Insulation shall have a durable finish suitable for painting for colour coding, or other identification marking.

E.2.12.1 Standards

Main applicable standards are, but shall not be limited by the following:

- ASTM C 533 Calcium Silicate Block and Pipe Thermal Insulation
- ASTM C 534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- ASTM C 547 Mineral Fibre Pipe Insulation
- ASTM C 552 Cellular Glass Thermal Insulation
- ASTM C 647 Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
- ASTM C 1136 Flexible, Low Permeance Vapour Retarders for Thermal Insulation
- EN 12237 Ventilation for buildings - Ductwork - Strength and leakage of circular sheet metal duct

E.2.12.2 Insulating Material

Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either the wet or dry state. Materials shall be asbestos free.

The Contractor shall submit to the Engineer's approval a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalogue cuts, and installation instructions. The product number, k-value, thickness and furnished accessories for each pipe system requiring insulation shall be included.

After approval of materials and prior to applying insulation, a booklet shall be prepared and submitted for approval. The booklet shall contain detail drawings showing the insulation material and insulating system for each pipe required to be insulated per this specification.

The insulation shall have a minimum thickness of 50 mm and a thermal conductivity coefficient of 0,02 W/(m x K) maximum at a mean temperature of 24°C.

E.2.12.3 Jackets

Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials which require factory applied jackets are mineral fibre and cellular glass. Jackets shall be easily removable and reusable.

Aluminium Jackets

Aluminium jackets shall be corrugated, embossed or smooth foil, 0,4 mm nominal thickness or with factory applied moisture retarder. Aluminium jacket securing bands shall be of stainless steel, 0,4 mm thick, 20 mm wide.

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Aluminium jacket circumferential seam bands shall be 50 x 0,4 mm aluminium matching jacket material. Bands for insulation below ground shall be 20 x 0,5 mm thick stainless steel, or fibreglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated longitudinal joints. The bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

PVC Jackets

PVC jacket and fitting covers shall have high impact strength, UV resistant rating or treatment and moderate chemical resistance with minimum thickness 0,8 mm and shall otherwise comply with Section E.4.3.2.

PEHD Jackets

PEHD jacket and fitting covers shall have high impact strength and moderate chemical resistance with minimum thickness 0,6 mm and shall otherwise comply with Section E.4.3.3.

Galvanised Folded Spiral Pipe Jackets

Galvanised folded spiral pipe jackets shall have outside fold and only be used for uncovered laying inside or outside of buildings and shall comply with EN 12237.

E.2.12.4 Vapour Retarder Coating

To ensure integrity of the vapour barrier, joints shall be coated with a vapour sealing compound compatible with the aluminium foil vapour barrier. The vapour retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Colour shall be white.

E.2.12.5 Installation General

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests specified in other sections of this specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the site. Joints shall be staggered on multi-layer insulation.

Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used.

E.2.12.6 Installation of Flexible Cellular Insulation

Flexible cellular insulation shall be installed with seams and joints sealed with a contact adhesive. Flexible cellular insulation shall not be used on surfaces with a temperature greater than 93° C. Seams shall be staggered when applying multiple layers of insulation. Insulation exposed to weather and not shown to have jacketing shall be protected with two coats of UV resistant finish as recommended by the manufacturer after the adhesive is dry.

Flexible cellular pipe insulation shall be tubular form for pipe sizes 150 mm and less. On pipes larger than 150 mm, insulation shall be adhered directly to the pipe. Seams shall be staggered when applying multiple layers of insulation. Bends shall be insulated with mitre-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from mitre-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation.

Pre-cut or preformed insulation shall be placed around all fittings and accessories.

Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapour retarder jackets or PVC fitting covers shall be protected with two coats of vapour retarder coating with a minimum total thickness of 2 mm, applied with glass tape embedded between coats. Tape seams shall overlap 25 mm. The coating shall extend out onto the adjoining pipe insulation 50 mm. Fabricated insulation with a factory vapour retarder jacket shall be protected with two coats of vapour retarder coating with a minimum thickness of 2 mm and with a 50 mm wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapour retarder coating and a 100 mm wide tape which matches the jacket of the pipe insulation.

Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 150 mm from the insulation surface.

E.2.12.7 Factory Pre-insulated Pipe Systems

Factory pre-insulated pipe systems shall be used for buried pipes. The joints shall be gasketed push-joints. The carrier pipe shall be steel, copper or GRP. Insulation shall consist of a layer of polyurethane foam, with a PVC or LDPE outer casing. The joints shall provide for expansion and contraction through the use of a pre-insulated grooved coupling with two EPDM sealing gaskets. The void between carrier pipe and casing at the pipe ends shall be sealed by an EPDM end seal ring. Fittings shall be insulated with one-piece, pre-moulded, high-impact PVC or LDPE fitting covers with fibre glass inserts and accessories. Casing joints shall be covered by self adhesive PVC tape or with heat shrinking LDPE sleeve.

E.2.12.8 Pipe Heating Cables

The heating cable shall consist of 2 nickel-coated-copper bus wires embedded in a radiation-crosslinked polymer capable of regulating its power output in response to temperature changes all along its length with a self-regulating index of no less than 90 % between 10° C and 60° C. The heating cable shall be covered with a radiation- cross-linked modified polyolefin dielectric jacket which in turn shall be covered with a tinned copper braid (10 Ω / 1.000 m maximum electrical resistance) and an outer modified polyolefin jacket.

The heating cable shall be installed under the pipe's thermal insulation without spiralling and with sufficient heat output to maintain the pipe temperature of no less than 5° C when outside ambient is – 10° C and the average wind speed is 25 km/h. When used on non-conductive pipe, the heater shall be attached to the pipe with a solid aluminium tape. After cable installation and before and after installation of the pipe insulation, the heating cable shall be tested using a 2.500 V insulation tester. Minimum electrical insulation resistance shall be 20 M Ω regardless of circuit length. Both bus wires and braid shall be tested to verify the connection of all splices and tees. A copy of the meggering report shall be supplied to the Engineer. All material shall be installed in accordance with the manufacturer's recommendations.

E.2.13 Cathodic Protection

E.2.13.1 Standards

Main applicable standards are, but shall not be limited by the following:

- EN 12068 Cathodic protection - External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials;
- EN 12954 General principles of cathodic protection of buried or immersed onshore metallic structures;
- EN ISO 8044 Corrosion of metals and alloys - Basic terms and definitions
- ISO 15257 Cathodic protection — Competence levels of cathodic protection persons — Basis for a certification scheme;
- ISO 12696 Cathodic protection of steel in concrete;
- ISO 12473 General principles of cathodic protection in seawater;
- ISO 22426 Assessment of the effectiveness of cathodic protection based on coupon measurements;
- ISO 15589 Petroleum and natural gas industries — Cathodic protection of pipeline transportation systems;
- ISO 19097 Accelerated life test method of mixed metal oxide anodes for cathodic protection;

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- ASTM B418 Standard Specification for Cast and Wrought Galvanic Zinc Anodes;
- ASTM A518 Standard Specification for Corrosion-Resistant High-Silicon Iron Castings;
- ASTM B843 Standard Specification for Magnesium Alloy Anodes for Cathodic Protection;
- DNVGL-RP-B401 Cathodic protection design;
- NACE SP 0169-2013 Control of External Corrosion on Underground or Submerged Metallic Piping Systems;
- NACE SP 0285-2011-SG Corrosion Control of Underground Storage Tank Systems by Cathodic Protection;
- NACE SP 0387-2019 Metallurgical and Inspection Requirements for Cast Galvanic Anodes for Offshore Applications;
- NACE SP 0492-2016-SG Metallurgical and Inspection Requirements for Offshore Pipeline Bracelet Anodes.

E.2.13.2 General

E.2.13.2.1 Scope of Works

The works for design and implementation of cathodic protection systems comprises measurements, analyses, design of project, supply and installation, control and tests of the installed system as well as submission of an operation and maintenance manual.

Minimum requirements of works to be carried out by the Contractor include:

- Measurements to determine the specific resistivity of the soil along the pipe routes;
- Measuring of the pH-value along the pipe routes to determine the variation of soil characteristics;
- Analyses of the chloride and sulphate content along the pipe line to determine the positions of isolating flanges;
- Investigation of electrical continuity along the pipe line to determine the positions of isolating flanges;
- Select suitable places for anode beds;
- Decide on suitable points on the pipe line for current connections;
- Preparation of project including calculations and criteria for approval of the Engineer;
- The project shall be shown on the pipe line plans and include divisions of the pipes with isolating flanges, sites for transformer/rectifier units, anode beds, measuring posts and cable routes;
- Detail drawings of cabinets for transformer/rectifier units and for measuring posts;
- Preparation and submission of electrical diagrams;

- The anodes shall be designed to have a life time of minimum 15 years.

E.2.13.2.2 Systems to be protected

The following metal structures shall be protected by a Cathodic Corrosion (CP) system:

- Pipelines in case of steel pipelines;
- Discharge pipe or sea outfall in case of steel or reinforced concrete pipeline;
- Steel tanks for water, wastewater, and sludge;
- Alike structures.

E.2.13.2.3 Services of Corrosion Engineer

Design, supervision, installation, and testing of the CP system shall be carried out by a qualified, experienced, recognised and certified firm. The Contractor shall furnish the Engineer with names and references and certificates of firms for approval. The Contractor shall make his own arrangements with one (or more) of the approved firms for providing this system of protection.

The Contractor shall name a qualified "CP Engineer" to supervise, inspect and test the CP installation. CP Engineer's name and qualifications shall be certified in writing to the Engineer for approval prior to the start of construction. The CP Engineer shall ensure that the cathodic protection system is installed, tested, and placed into service in accordance with the specified requirements.

E.3. REINSTATEMENT

E.3.1 General

Except where otherwise specified, the Contractor shall reinstate the surfaces over all trenches and all surfaces impacted by the works as hereinafter defined. The Contractor shall also be aware that the competent Authorities may require additional and/or substitute measures associated with reinstatement. The Contractor shall familiarise himself with same prior to bidding and his rates shall also be deemed to cover any variation in method, materials, etc. from the following requirements as may be instructed by the Authorities.

The surface shall be reinstated after backfilling of the pipe trench or other excavation has been completed. If final surfacing in paved areas will be done at a later stage, temporary measures e.g. gravel layer of 100 mm thickness, flush with the existing pavement, shall be carried out subject to approval by the Engineer.

Heavy and Medium Duty Carriageway shall be reinstated in two stages as described below. Heavy Duty Carriageway is normally defined as comprising two and three lane dual carriageway and main single carriageway roads. Medium Duty Carriageway comprises service roads and district roads. The Contractor shall commence all reinstatement with due expedition and diligence. This particularly applies to carriageway crossings where no more than 3 days shall elapse between the initial breaking of the road to lay the pipe and the completion of the first stage of the reinstatement unless otherwise directed.

If, in the opinion of the Engineer, and with due regard to the particular circumstances, the Contractor is not making every effort to complete the reinstatement within the set limits or any reasonable extension thereof allowed by the Engineer, then the Engineer may order additional steps or alternative methods to be adopted by the Contractor in order to hasten the completion. Such orders from the Engineer shall not relieve the Contractor from his obligations under the Contract.

In the event that the section of pipe beneath the carriageway has not been tested prior to the completion of the reinstatement works, it shall remain the responsibility of the Contractor to expedite repairs to the pipe and the renewal of the reinstatement in case this section of pipe fail the test, in the same way as if it had been tested prior to reinstatement and subsequently failed.

E.3.2 Asphalt cutting and re-asphalting

With any application to the Authorities for permission to cut roads, the Contractor must submit his method statement (including type of machinery for the crossings). The Authorities may instruct changes to the Contractor's proposals to comply with their requirements.

Cutting of asphalt on the routes of future sewer shall be done with an appropriate asphalt cutting machine. The width of the asphalt which is to be cut shall be 10 cm than the width of the trench on both sides of the trench.

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After laying, testing and backfilling of the pipe and compacting of the trench, re-asphalting of the excavated surface shall be done. Asphaltting shall be carried out in one or two layers depending on the road rank, respectively the layers that have been cut. The new asphalt surfaces shall be properly rolled.

Connections between new and old asphalt shall be additionally covered with bituminous emulsion. Kerbs that need to be excavated shall be returned after completion of works, and if they are damaged they shall be replaced with new kerbs of the same dimensions. Bituminous compounds for re-paving the route shall meet the requirements of EN 13108.

E.3.3 Maintenance of Reinstatement in Roads

The reinstatement in roads and public pathways shall be maintained in a proper condition to the satisfaction of the competent Authorities and the Engineer for six months.

E.3.4 Reinstatement of Concrete pavement

The concrete used shall be C-200 (200 kg/m³ of cement). Cement and aggregates shall be as approved by the Engineer. Additionally coarse aggregates of nominal size up to 32 mm may be used. Placing and compaction of the concrete shall be as described in Section D.7.7.

Reinforcement shall comply with Section D.7.4. It shall be firmly held in position during concreting and so fixed that it does not distort due to concreting operatives walking across the slab. Rates shall include for all stools, spacers, binding wire, cutting and waste.

The finish to the surface of the concrete shall be provided as directed by the Engineer.

Traffic will not be allowed on the concrete pavement before 7 days if rapid-hardening cement is used and after 10 days if ordinary Portland cement is used.

E.3.5 Reinstatement of Gravel roads

Gravel roads and unpaved roads shall be reinstated to their original condition. Unless the original road construction can clearly be identified the following construction shall be applied, i.e. 100 mm subgrade as specified before and 100 mm well graded gravel material compacted to 95%.

E.3.6 Reinstatement of Paved Pathways (asphalt)

For the reinstatement of asphalt pathways the Contractor shall cut back neatly on each side of the trench for a width of 150 mm and to a depth of 75 mm below the adjoining surface. The top of trench shall be made up with:

- 150 mm consolidated granular material, rolled in place with an approved 5 ton power roller;

- A spray sealing coat of bitumen emulsion followed by 40 mm thick coat of asphaltic concrete rolled with an approved 5 ton power roller.

E.3.7 Reinstatement of Paved Pathways (slabs or tiles)

For the reinstatement of paved pathways (with slabs or tiles) the Contractor shall take up and clean the existing stone or concrete slabs or tiles carefully and dress them suitably for relaying on a 150 mm bed of consolidated granular material. The slabs or tiles shall be bedded solid on a 50 mm bed of mortar and grouted with mortar (coloured if necessary) as specified. They shall be laid to match up to the existing paving.

Any stone or concrete slabs or tiles damaged in taking up or relaying shall be replaced. New slabs or tiles shall be of type approved by the Roads Department

Concrete Footpaths

For reinstatement of concrete pathways, the concrete layer thickness shall be minimum 60 mm. The concrete shall be of approved class by the Engineer.

E.3.8 Reinstatement of Kerbs, Channels and Edgings

Any lengths taken up shall be carefully cleaned and dressed to the satisfaction of the concerned Authorities be railed and jointed with mortar.

The Contractor shall supply new kerbs, channels or edgings to replace any damaged sections and these shall conform to the requirements of the Authorities. Make up pieces shall not be less than 450 mm long.

Bedding and backing shall be of concrete (grade 15/20). Kerbing to carriageway shall have a 150 mm thick bed and a backing to within 75 mm of the top. Edging or kerbing to verges, footways and footpaths shall have a 50 mm thick bed and a backing to within 25 mm of the top.

Where necessary in-situ kerbs shall be re-cast using concrete (Grade 15/20) and shall conform to the lines and levels of the existing adjoining kerbs.

Where no kerbs or similar road edgings are present the Contractor shall neatly trim the edge of the road reinstatement to follow the line of the existing road edge.

E.3.9 Reinstatement in Gardens, Verges and other surfaces

All surfaces shall be restored to a condition equal to the original surface to the satisfaction of the Engineer and the plot owners and, where applicable, the competent Authorities.

E.4. MATERIAL AND EQUIPMENT

E.4.1 General

All pipes, fittings and valves and all materials and other equipment shall conform to the relevant local or international norms and standards. The Contractor shall, if requested, forward to the Engineer certificates showing that the materials have been tested and comply with the requirements if this Specifications and the relevant standards.

Only materials approved and accepted by the Engineer shall be supplied and installed. Materials which are rejected shall immediately be removed from the Site at the cost of the Contractor.

E.4.2 Concrete Pipes

E.4.2.1 Standards

Main applicable standards are, but shall not be limited by the following:

- EN 1916 Concrete pipes and fittings, unreinforced, steel fibre and reinforced;
- EN 639 Common requirements for concrete pressure pipes including joints and fittings;
- EN 640 Reinforced concrete pressure pipes and distributed reinforcement concrete pressure pipes (non-cylinder type), including joints and fittings;
- EN 641 Reinforced concrete pressure pipes, cylinder type, including joints and fittings;
- EN 642 Prestressed concrete pressure pipes, cylinder and non-cylinder, including joints, fittings and specific requirements for prestressing steel for pipes;
- EN 1917 Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced;

E.4.2.2 General

Concrete pipes shall be used exclusively for buried gravity pipes within the fields of sewerage, rainwater drainage and waste water treatment works, but always above the groundwater level.

Concrete pipes should be made of sulphate resistant cement and show smooth inside and outside surfaces without honey-combed texture. The pipes, whether fresh or hardened, should not be treated, brushed or coated using water, cement grout, mortar or any other material. Pipes should not show cracks or penetrating holes. Pipes which do not comply with these requirements shall be rejected and removed from the site immediately.

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The type of concrete used in the manufacture of the pipes shall be in accordance with Section D.7.3. No admixtures shall be added to the concrete without the written approval of the Engineer. Steel reinforcement for concrete pipes shall be in accordance with Section D.7.4.

Concrete pipes and fittings shall not be dispatched from the factory before 28 days have elapsed after manufacturing.

For the cutting of pipes, mechanical sawing machines shall be used such that the piece meets the requirements of the whole pipe. No hammering or chiselling will be allowed.

E.4.2.3 Classification

Concrete pipes used in the Works shall be classified under the following categories.

- a) Pipes with internal diameter ≤ 300 mm and below may be without reinforcement provided they meet the requirements of extra strength pipe class. They shall in accordance to EN 1916 (concrete pipes unreinforced).
- b) Pipes with internal diameter > 300 mm and above shall comply with EN 1916 (reinforced concrete pipes).
- c) Prestressed concrete pipes, shall comply with EN 642 (prestressed concrete pipes).

The pipes mentioned under a) shall have the following principal features:

- a self centring socked joint with a performed gasket or rubber ring for insertion of the spigot.

The pipes mentioned under b) shall have the following principal features:

- a reinforcing cage (or cages) of steel bars, wire fabric or welded fabric.
- a wall of dense concrete covering the reinforcement cage or cages.
- a self-centring socked joint with a performed gasket or rubber ring for insertion of the spigot.

The pipes mentioned under c) shall have the following principal features:

- Lined cylinder pipe (LCP): a concrete core cast inside a steel cylinder that serves as a watertight membrane. The cured concrete core is subsequently wire-wrapped and externally coated with a cement-rich mortar
- Embedded cylinder pipe (ECP): a steel cylinder fully encased in a concrete core which is subsequently wire-wrapped and externally coated with a cement-rich mortar.
- a self-centring socked joint with a performed gasket or rubber ring for insertion of the spigot.

E.4.2.4 Quality and Testing of Materials

The quality of the concrete for the pipes shall conform to the requirements as specified in EN 1916 and where applicable Section D.7.3. Generally, no reinforcement shall be used in the making of the pipes until the materials have been tested as specified. Certified copies of the test certificates shall be submitted to the Engineer.

Concrete for concrete pipes shall be manufactured from sulphate resisting Portland cement (CEM I) class CE I 42.5 in accordance to EN 197.

E.4.2.4.1 Unreinforced Concrete Pipes

Dimensions of not reinforced concrete pipes (300 mm internal diameter and less) shall conform to EN 1916.

The plane of the pipe ends except for shapes, shall be perpendicular to the longitudinal axis of the pipe. The interior surface shall be smooth and well finished. The pipes shall have the type of joints specified in Section E.4.2.5.

The pipe shall be free from fractures, cracks, laminations, or surface roughness.

Each pipe shall be marked clearly and legibly to show the manufacturer's name or trade mark, year and week number of production and minimum test bearing capacity (FN in kN/m)

E.4.2.4.2 Reinforced Concrete Pipes

Dimensions of reinforced concrete pipes (internal diameter greater than 300 mm) shall conform to EN 1916.

The circumferential steel reinforcement cage(s) shall be made of continuous or welded steel bars or wires of minimum cross sectional area of 1 % of the cross sectional area of concrete per metre length of pipe wound in a helical form, and individual bars shaped and butt or lap welded into cages, as approved by the Engineer. The circumferential bars or wires in the cage(s) shall be accurately spaced and shall be rigidly held by means of longitudinal bars or wires securely fixed to them in an approved manner. The axial pitch of the spiral reinforcement shall be less than 150 mm. Each cage shall be fabricated and rigidly held in such a manner that the reinforcement will remain in proper position during the casting of the pipe. The minimum cover to the reinforcing steel shall be 40 mm unless directed otherwise by the Engineer.

Concrete pipes shall be manufactured by either the centrifugal spun process or be vertically cast in a steel mould and shall be mechanically vibrated during the manufacturing.

E.4.2.4.3 Prestressed Concrete Pipes

Dimensions of prestressed concrete pipes shall conform to EN 642. Prestressed concrete pipes shall be of Lined cylinder pipe (LCP) or Embedded cylinder pipe (ECP) type in accordance to following specifications:

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- LCP pipe shall have a concrete core cast inside a steel cylinder that serves as a watertight membrane. The cured concrete core shall be wire-wrapped and externally coated with a cement-rich mortar.
- ECP pipe shall have a steel cylinder fully encased in a concrete core that is subsequently wire-wrapped and externally coated with a cement-rich mortar.

The minimum cover to the steel cylinder inside shall be 40 mm, the minimum cover to the prestressing wires outside shall be 40 mm unless directed otherwise by the Engineer.

The spigot and bell joint rings shall be galvanised steel and in accordance to the following specifications.

Spigot and Bell Rings Outside Corrosion Protection

A grout band shall be strapped to the outside of the completed joint so that it encompasses the external joint recess. A grout consisting of one part Portland cement, three parts sand, and sufficient water shall be mixed to produce a grout free of lumps and with a consistency of heavy cream. The grout shall be poured into the opening at the top of the grout band so that it completely fills the external joint recess. The grout should be rodded or puddled to ensure complete filling of the joint recess. A stiffer mix can be used to trowel over the opening at the top of the grout band.

Spigot and Bell Rings Inside Corrosion Protection

The interior, exposed surfaces of the steel joint rings shall be protected in one of the following ways:

- a) The interior joint recess shall be grouted using a stiff 1:3 Portland cement/sand mortar.
- b) A butyl rubber mastic joint filler shall be applied to the spigot end or bell socket prior to joining the pipe such that the mastic squeezes out and fills the interior joint recess.

E.4.2.5 Joints

E.4.2.5.1 Type of Joints

Unless otherwise specified, the joints for concrete pipes shall be of the spigot and socket type, sealed with continuous rubber ring gaskets. Joints shall be carried out in accordance with the requirements as described in the relevant standard and instructions of the manufacturer in the case of factory made pipes.

At changes in direction (bends) or nominal diameter (reducers) and when branching (tees) is constructed or at pipeline ends (blank flanges) joints shall provide restraint if the pipe is not secured according to Section E.2.7.6.10.

E.4.2.5.2 Sealing of Joints

The joints between the pipes shall be sealed with sealing rings made of styrene butadiene rubber. The sealing rings shall be stored in well covered areas and different types and/or dimensions shall be kept separate. Lists of deliveries shall be supplied and shall be handed over to the Engineer. The material shall be applied according to the recommendations of the manufacturer and the pipe joints must be of such quality that a leak-proof connection is guaranteed.

Joint lubricants for sliding joints shall have no deleterious effects on either the joint rings or pipes and shall be unaffected by the liquid to be conveyed in the pipes.

E.4.2.6 Inspection and Testing of Concrete Pipes

Inspection of concrete pipes will be made at the pace of manufacture as may be deemed necessary by the Engineer or on delivery at the construction site. Pipes will be rejected as unsuitable for the Works for any of the following reasons:

- A piece of any size broken out of the pipe;
- Defects that indicate imperfect mixing or moulding of the concrete;
- Any crack extending through the wall of the pipe and having a longitudinal or transverse length greater than the wall thickness of the pipe;
- Any shattering or flaking of concrete;
- Any concrete deficiency on the inner surface of the pipe deeper than 10 mm of any area or on the outer surface of the pipe deeper than 10 mm of an area greater than 100 cm². The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasket jointed pipe. Dimensions and tolerances of such contact surfaces shall be submitted for approval;
- A variation of more than 1 % from the true circle of the specified pipe internal diameter;
- Rock pockets and water pockets in any pipe;
- Exposure of any reinforcement or insufficient cover to reinforcement;
- Surface defects indicating honey-comb or open texture;
- Separation or "blisters";
- Any continuous crack having surface width of 0,25 mm or more and extending for a length of 300 mm or more, regardless of depth or position in the wall of the pipe;
- The pipe fails the strength test.

E.4.2.7 Repair of Pipe Imperfections

For pipes that are not rejected according to Section E.4.2.6 the following repair methods for small imperfection shall be applied:

E.4.2.7.1 Preparation of Surfaces to be repaired

Unsound or imperfect concrete shall be removed by careful chipping. Edges where concrete has been chipped out shall be scraped and square with the surface, leaving no feather edges. The chipped area shall be washed with water to remove all loose material and concrete dust.

Surfaces within the trimmed areas shall be kept wet for several hours, preferably overnight before the repair is made. All surfaces in areas to be repaired shall be damp, but not wet, when the material is applied.

E.4.2.7.2 Placement of Repair Mortar

The mortar used for repair shall in generally comply with the specification set forth in Section D.7.5.10.2 and contain an expanding additive.

Workmanship of repair shall be according to Section D.7.5.11.2.

E.4.3 Thermoplastic Pipes

E.4.3.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following.

- EN 13476 Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE);
- ISO 13267 Thermoplastics piping systems for non-pressure underground drainage and sewerage — Thermoplastics inspection chamber and manhole bases — Test methods for buckling resistance;
- ISO 13266 Thermoplastics piping systems for non-pressure underground drainage and sewerage — Thermoplastics shafts or risers for inspection chambers and manholes — Determination of resistance against surface and traffic loading;
- ISO 13260 Thermoplastics piping systems for non-pressure underground drainage and sewerage — Test method for resistance to combined temperature cycling and external loading;
- ISO 9969 Thermoplastics pipes. Determination of ring stiffness.
- ISO 21138-1 Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Part 1: Material specification and performance criteria for pipes, fittings and systems;

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- ISO 21138-2 Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Part 2: Pipes and fittings with smooth external surface, Type A;
- ISO 21138-3 Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Part 3: Pipes and fittings with non-smooth external surface, Type B;
- ISO 13262 Thermoplastics piping systems for non-pressure underground drainage and sewerage — Thermoplastics spirally-formed structured-wall pipes — Determination of the tensile strength of a seam;
- ISO 23711 Elastomeric seals — Requirements for materials for pipe joint seals used in water and drainage applications — Thermoplastic elastomers;
- EN 13598 Plastics piping systems for non-pressure underground drainage and sewerage - Unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE);
- EN ISO 12162 Thermoplastics materials for pipes and fittings for pressure applications - Classification, designation and design coefficient;
- ISO 161 Thermoplastics pipes for the conveyance of fluids - Nominal outside diameters and nominal pressures

E.4.3.2 Unplasticised Polyvinylchloride (PVC-U) Pipes and Fittings

E.4.3.2.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following.

- ISO 16422 Pipes and joints made of oriented unplasticized polyvinyl chloride (PVC-U) for the conveyance of water under pressure — Specifications;
- ISO 4435 Plastics piping systems for non-pressure underground drainage and sewerage — Unplasticized poly(vinyl chloride) (PVC-U);
- EN 1401 Plastics piping systems for non-pressure underground drainage and sewerage - Unplasticized poly(vinyl chloride) (PVC-U);
- EN ISO 1452 Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure - Unplasticized poly(vinyl chloride) (PVC-U);
- EN 1453 Plastics piping systems with structured-wall pipes for soil and waste discharge (low and high temperature) inside buildings - Unplasticized poly(vinyl chloride) (PVC-U);

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- EN 1329 Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure - Unplasticized poly(vinyl chloride) (PVC-U);
- EN 12200 Plastics rainwater piping systems for above ground external use - Unplasticized poly(vinyl chloride) (PVC-U);
- EN 1453 Plastics piping systems with structured-wall pipes for soil and waste discharge (low and high temperature) inside buildings - Unplasticized poly(vinyl chloride) (PVC-U);
- EN 1566 Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure - Chlorinated poly(vinyl chloride) (PVC-C);
- EN ISO 15877 Plastics piping systems for hot and cold water installations - Chlorinated poly(vinyl chloride) (PVC-C);

E.4.3.2.2 Pipes, Fittings and Accessories - General

The Contractor shall advise the manufacturer of the climatic and transporting conditions at the site of the Works and shall seek his advice on the storage of PVC materials on site. Subject to the Engineer's approval this advice shall be followed at all times.

PVC granulate shall be virgin and comply with approved international health standards. PVC pipes shall be capable of withstanding ultraviolet degradation. A rodent inhibitor shall be incorporated in the material of the pipe. The Contractor shall provide such certificate for each 5000 m supplied from an institution appointed by the Engineer.

Except in the case of flanged joints and where otherwise specified or approved by the Engineer pipe joints shall be of the spigot and socket type, sealed with a flexible rubber ring or gasket to the approval of the Engineer and shall withstand the various tests specified in the applicable standards. Splicing joints are not allowed.

For pipes with a nominal bore of 600 mm or less, the joints shall be capable of withstanding a deflection of not less than 1,5 degrees in any direction and for pipes with a nominal bore of more than 600 mm 0,5 degrees in any direction.

All pipes shall be capable of withstanding a "draw" of 13 mm over and above the initial jointing allowance. The initial jointing allowance is the gap measured parallel to the centre line of the pipeline and shall not be less than 6 mm or more than 13 mm or as otherwise recommended by the pipe manufacturer and approved by the Engineer. Pipes and fittings shall be indelibly marked prior to laying to indicate the correct initial jointing allowance.

All PVC-U pipes shall have the following minimum required marking: Standard Number; Manufacturer's Name and/or Trade Mark; Material; Nominal Outside Diameter; Nominal Pressure PN; Manufacturer's Information (production period, year and name of the production site); Number of the extrusion line (if not included in manufacturer's information). Fittings shall

have the following required minimum marking: Standard Number; Manufacturer's Name and/or Trade Mark; Nominal Diameter; Material; Nominal Pressure PN; Manufacturer's Information (production period, year and name of the production site).

Flanges shall have the following minimum required marking; Standard Number; Manufacturer's Name and/or Trade Mark; Nominal Size DN of Flange; Material; Nominal Pressure PN of Flange; Manufacturer's Information (production period, year and name of the production site).

Pipes and fittings which conform to EN Standards, and also conform to other standard(s) may be marked additionally with the number(s) of the other standard(s), together with the minimum required marking in accordance with the other standard(s).

E.4.3.2.3 Pipes, Fittings and Accessories for Pressurised Systems

All pipes, fittings and accessories shall be fabricated and supplied according to EN ISO 1452-2 (pipes) and EN ISO 1452-3 (fittings).

The pipe material to be used shall conform to EN ISO 1452-1 and to the requirements given in chapter 4.2 and 4.3 of EN ISO 1452-2.

Any deviation from these standards shall be inadmissible and shall lead to rejection of the material.

Pipes shall be at least of PN 10 SDR 21; the pipes and fittings shall be jointed by flexible push-fit collar type with rubber gaskets. Use of glue shall not be permitted.

The fitting material to be used shall conform to EN ISO 1452-1 and to the requirements given in chapter 4.2 of EN ISO 1452-3.

Fittings with flanges shall be of ductile iron, PVC or epoxy-coated.

E.4.3.2.4 Gravity Pipes

If there are no other factors which can influence the selection of gravity pipe class, pipes with ring stiffness 4 kN/m^2 (SN 4) shall be used when the height of filling up layer is between 0,8 m and 6,0 m. If the height of filling up layer is up to 0,8 m and more than 6,0 m, pipes with ring stiffness 8 kN/m^2 (SN 8) shall be used.

E.4.3.3 Polyethylene Pipes and Polypropylene and Fittings

E.4.3.3.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following.

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- ISO 4427-1 Plastics piping systems for water supply and for drainage and sewerage under pressure — Polyethylene (PE) — Part 1: General;
- ISO 4427-2 Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 2: Pipes;
- ISO 4427-3 Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 3: Fittings
- ISO 8772 Plastics piping systems for non-pressure underground drainage and sewerage — Polyethylene (PE);
- EN 12201 Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE);
- EN 12666 Plastics piping systems for non-pressure underground drainage and sewerage - Polyethylene (PE);
- EN 1519 Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure - Polyethylene (PE);
- EN ISO 15875 Plastics piping systems for hot and cold water installations - Crosslinked polyethylene (PE-X);
- EN 1555 Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE);
- DIN 8074 Polyethylene (PE) - Pipes PE 80, PE 100 – Dimensions ;
- DIN 8075 Polyethylene (PE) pipes - PE 80, PE 100 - General quality requirements, testing;
- ISO 8773 Plastics piping systems for non-pressure underground drainage and sewerage — Polypropylene (PP);
- EN 1852 Plastics piping systems for non-pressure underground drainage and sewerage - Polypropylene (PP);
- EN 10284 Malleable cast iron fittings with compression ends for polyethylene (PE) piping systems.

E.4.3.3.2 Pressure Pipes

HDPE (high density polyethylene) pipes shall comply with ISO 4427 and/or EN 12201 or equivalent standard. Principal and local mains shall be at least of SDR 17 (standard dimension ratio), PN 10. Service pipes shall be of SDR 11, PN 16.

The pipes and fittings shall be jointed in accordance with the diameters as set forth hereinafter.

PE granulate shall be PE 100 quality, be virgin and comply with ISO 4427 and/or EN 12201. In accordance with ISO 12162 the PE 100 material shall have a Minimum Required Strength (MRS) value of 10 MPa. The Contractor shall provide such certificate for each 5000 m supplied from an institution appointed by the Engineer.

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Any deviation from these prescriptions shall be inadmissible and shall lead to rejection of the material. The pipe shall be coiled such that localised deformation, e.g. that buckling and kinking, is prevented. The minimum internal diameter of the coil shall not be less than 18 x nominal outside diameter. The ends of the pipe shall be plugged or covered.

If not otherwise specified, pipes outside diameter up to OD 125 shall be delivered in coils, the larger will be delivered in parts of 12 m.

The pipes must be stored in such a way that they are protected from exposure to direct sunlight. If covered with tarpaulins, the pipes and fittings shall be well ventilated to prevent any accumulation of heat and resultant deformation. Transparent sheeting or tarpaulins are not suitable for covering the pipes. The storage location should be flat and support the pipes over their entire length. The pipes must not be stored on stones or objects with sharp edges. Gaskets shall be always stored in a cool place protected from direct sunlight. Pipes should not be stacked to a height exceed 1 m. The pipes must be secured at the side to prevent them from rolling away. Contact with harmful media must be avoided. Coils should be stored in a horizontal and not on top each other. The pipes and pipeline parts shall be stored in such a way that they do not get dirty inside. Protection caps shall not be removed prior installation.

The minimum required marking for HDPE pipes shall conform to Standard Number; Manufacturer's Identification; Nominal diameter; SDR or k Series; Material and Designation; Pressure Rating in Bars; Production Period (date or code).

The metric system shall be used for flange connections. The following table shows the dimensions of HDPE pipes, SDR 17 and the corresponding nominal diameter (DN) of flanges:

Nominal Diameter DN ¹⁾ [mm]	HDPE Pipe Outer Diameter OD [mm]
50	63
80	90
100	110
150	160
150	(180)
200	225
250	280
300	355
400	450

¹⁾ Nominal diameter according to EN 805 and EN 1092 for flanges

E.4.3.3.3 Pressure Pipes Joints

Pipes of diameters equal or less than OD 180 shall be joined with electro-fusion (EF) couplers of PE-HD. If approved by the Engineer, small diameter pipes (OD < 63 mm), pipes within structures and pipes connecting to metal fittings shall be jointed using mechanical jointing

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techniques, such as compression, flanged joints or push-fit joints. Pipes of diameters equivalent or larger than OD 180 shall be joined by butt fusion.

Fittings for diameters equal or less than DN 180 including service tee set flats shall be either of electro fusion type or compression type, all made of HDPE. Fittings for larger diameters shall be of butt fusion type.

Following rules shall apply for jointing of HDPE pipes with pipes of other material or valves:

- for joints between two HDPE pipe sections (OD $\geq$ 63 mm) only electro-fusion couplings or butt fusion shall be used;
- for joints to ductile iron / steel pipes (spigot): very large coupling tolerance coupling shall be used;
- for joints between HDPE pipe and flanged valves: flanged spigot piece shall be used;
- for joints between HDPE pipe and other valves: valves EURO 20 Type 26 (or similar) shall be used.

The Contractor shall make his choice of either electro fusion or compression fittings and maintain the same type throughout the works. In case electro-fusion welded joints in high-density polyethylene pipes are foreseen, they shall be made only between pipes having the same physical characteristics. Joints between pipes from different manufacturers shall only be made with the specific approval of the Engineer and incorporate a flexible joint seal.

Flanges shall be made of hot-dip galvanised steel. The galvanisation shall be by hot-dip process according to ISO 20081 and/or EN 1179.

E.4.3.3.4 Pressure Pipes Fittings

All fittings shall be made according to ISO 4427 and/or EN 12201. Electro fusion adapter HDPE – galvanised steel pipes (thread female transition fitting) SDR 11 / S 5 shall be used for service pipes.

All fittings shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure. The minimum required marking for fittings shall conform to Standard Number; Manufacturer's Name or Trade Mark; Nominal Diameter and Pipe Series / SDR; Manufacturer's Information; SDR Fusion Range; Material and Designation.

E.4.3.3.5 Pressure Pipes Butt Welding

PE HD pipes and fittings of diameter equivalent or bigger than DN 180 shall be jointed by heating-element butt welding. Heat fusion welding, extrusion welding and socket welding shall not be accepted.

The Contractor shall provide all necessary personnel, equipment and materials.

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The Contractor shall supervise the site, the welders and their work during the entire working period. For this purpose the Contractor shall use a qualified and certified welding specialist. Welding certificates shall be submitted to the Engineer.

Only skilled welders and welding operators who can document qualifications relevant for pipeline welding will be accepted by the Engineer. Prior to the performance of any production welding operators shall qualify for the relevant welding procedures according to DVGW W 330 or equivalent.

Surfaces to be welded have to be sufficiently clean, to avoid deterioration of weld quality by any dirt, oil, grease or other contamination.

Each pipe or component shall be visually inspected to ensure that it has not sustained any visually determinable damage. Disposition of damaged items shall be resolved in consultation with the Engineer.

Welding shall be suspended by the Contractor when prevailing weather conditions will impair the quality of the work, e.g. rain or thunderstorms.

Vibration inducing operations carried out in the vicinity of welding machine are prohibited during welding operations.

Welding shall be carried out only by using welding butt machines capable to weld all pipes from PN 2,5 to PN 40 according to the pipe material and having following characteristics:

- electro-hydraulic control of the pressure;
- automatic pipe cut;
- self-aligning frame;
- computer control of all welding steps after the facing operation, until the end of the welding cycle, providing easy set-up of the relevant welding data, in particular welding temperature. At the end of the cycle, a printer shall give the results of the weld with all necessary data according to international standard specifications.

After welding, the joint shall be checked visually. In case of any of the following imperfections, the pipe ends shall be cut and welded again:

- different high welding beads on pipe end;
- welding beads too narrow and too tall;
- welding beads too small;
- crack on the centre of welding beads;
- offset too high (10 % of pipes wall thickness is tolerated).

E.4.3.3.6 Gravity Pipes

If there are no other factors which can influence the selection of gravity pipe class, pipes with ring stiffness 4 kN/m^2 shall be used when the height of filling up layer is between 0,8 m and

6,0 m. If the height of filling up layer is up to 0,8 m and more than 6,0 m, pipes with ring stiffness 8 kN/m² shall be used.

E.4.4 Glass Fibre Reinforced Plastic (GRP) Pipes and Fittings

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following.

- ISO 16611 Plastics piping systems for drainage and sewerage without pressure — Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) — Dimensions, requirements and tests;
- EN 14364 Plastics piping systems for drainage and sewerage with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) - Specifications for pipes, fittings and joints,
- EN 1796 Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP);
- EN 1115 Plastics piping systems for underground drainage and sewerage under pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP);
- EN 705 Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipes and fittings - Methods for regression analyses and their use;
- ISO 10467 Plastics piping systems for pressure and non-pressure drainage and sewerage - Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin;
- ISO 10639 Plastics piping systems for pressure and non-pressure water supply - Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin;
- CEN/TS 14578 Plastics piping systems for water supply or drainage and sewerage - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) - Recommended practice for installation;
- CEN/TS 14807 Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) - Guidance for the structural analysis of buried GRP-UP pipelines;
- ISO/TS 10465 Underground installation of flexible glass-reinforced pipes based on unsaturated polyester resin (GRP-UP);
- DIN 16868 Glass fibre reinforced unsaturated polyester resin (UP-GF) pipes;

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- DIN 16869 Centrifugally cast filled glass fibre reinforced unsaturated polyester resin (UP-GF) pipes;
- DIN 16870 Wound glass fibre reinforced epoxy resin pipes; dimensions;

Glass-reinforced plastic pipes and fittings shall be supplied from an approved manufacturer. They shall be filament wound or centrifugal cast on automated machinery, capable of producing a product of consistent quality, maintaining a close tolerance on the designed locations and proportions of resin, glass and sand filler within the pipe wall, and minimizing trapped air. All raw material constituents shall be metered during manufacture.

The resin used in the main body of the pipe wall shall be of the isophthalic polyester type. The pipes shall have an internal, resin rich primary barrier of not less than 1,0 mm thickness. The resin used in the inner barrier layer shall be of the isophthalic polyester type, or if required for high corrosion applications, of vinyl ester or bisphenol A.

The external surfaces of the pipes shall also have a resin rich layer, but of isophthalic polyester resin unless otherwise required for particularly aggressive ground conditions. The pipes shall be capable of being stored outside in direct sunlight for a minimum of 5 years without degradation; if necessary an ultra-violet inhibitor shall be added to the resin for this purpose.

GRP fittings shall be fabricated from cut and mitred straight pipe, which has already been tested, the mitre joint being over wrapped with woven roving and chopped strand fibre mat thoroughly impregnated with resin. The design and fabrication of fittings shall be such as to give equal strength and corrosion-resistant properties to that of straight pipe. Flanges shall be drilled to PN 10, unless otherwise stated.

The Contractor shall advise the manufacturer of the climatic and transporting conditions at the site of the Works and shall seek his advice on the storage of GRP materials on site. Subject to the Engineer's approval this advice shall be followed at all times.

Except where otherwise specified or approved by the Engineer pipes shall be jointed with push-fit couplings appropriate for the chosen design pressure. Couplings shall withstand the various tests specified in the applicable standards.

The pipes shall be supplied in standard length of 6,00 m with stiffness class SN 5000 (5 kPa), pressure class PN 1 for pipes laying in depth up to 4 m. Pipe sections to be installed deeper than 3 meter shall be of class SN 10.000 (10 kPa). Pipes may be cut to required length, chamfering the cut end to fit with the coupling. Non pressure field closures may be used with closure coupling.

Pipes and fittings shall be indelibly marked prior to laying to indicate the correct initial jointing allowance.

E.4.5 Ductile Iron (DI) Pipes and Fittings

E.4.5.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

Pipes and Fittings

- ISO 2531 Ductile iron pipes, fittings, accessories and their joints for water applications;
- EN 545 Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods;
- EN 598 Ductile iron pipes, fittings, accessories and their joints for sewerage applications - Requirements and test methods;
- ISO 16631 Ductile iron pipes, fittings, accessories and their joints compatible with plastic (PVC or PE) piping systems, for water applications and for plastic pipeline connections, repair and replacement;
- ISO 10803 Design method for ductile iron pipes;
- ISO 7186 Ductile iron products for sewerage applications;
- ISO 1804 Restrained joint systems for ductile iron pipelines - Design rules and type testing.

QC standards

- EN 10204 Metallic products - Types of inspection documents

E.4.5.1.1 Materials

All pipes and fittings and accessories shall be made from ductile cast iron, also called nodular or spheroid graphite cast iron, characterised by the presence of graphite in the spheroid state in sufficient quantities to impart the mechanical characteristics defined in the respective standards.

Pipes, fittings and accessories must not have any defects likely to be detrimental to their use.

Unless otherwise specified minimum pressure classes shall be as follows:

Nominal Diameter DN [mm]	Pressure class
60 to 300	C40
350 to 600	C30
700 to 2000	C25

Minimum wall thicknesses for pressure classes shall be in accordance with EN545 and ISO 2531. The tolerances on thickness and on masses shall not exceed the tolerances given in ISO 2531.

E.4.5.2 Joints

E.4.5.2.1 Socket and Spigot Pipes and Fittings

All buried pipes and fittings shall, unless otherwise indicated, be of the socket and spigot type with coatings as specified in Sub-Clause E.4.11.4. The joint to be used shall be the automatic push-in joint. The joint is made watertight by the compression of a rubber gasket.

Rubber gasket materials for drinking water pipelines shall be of EPDM (Ethylene Propylene Diene Monomer) in accordance with the requirements of EN 681-1, type WA.

Rubber gasket materials for waste water pipelines shall be of NBR (Acrylonitrile Butadiene Elastomer).

The storage conditions for the gaskets shall be as follows:

- the storage temperature should be between + 5 °C and + 25 °C. If they are stored at low temperature, care should be taken not to deform gaskets when handling them. They should be brought to about 30 °C for long enough to give them original flexibility before being used.

At changes in direction (bends) or nominal diameter (reducers) and when branching (tees) is constructed or at pipeline ends (blank flanges) joints shall provide restraint if the pipe is not secured according to Section E.2.7.6.10.

E.4.5.2.2 Flanged Pipes and Fittings

All non-buried pipes and fittings (in pumping stations, etc.) shall, unless otherwise specified, be flanged with internal and external coatings as specified in Section E.4.11.4.

Flanges shall comply with EN 1092-2. Bolts, nuts and washers shall be as specified in Section E.4.12.2.

For flanged joints of drinking water pipelines the gasket shall be made of EPDM (Ethylene Propylene Diene Monomer) in accordance with the requirements of EN 681-1, type WA. The gaskets for flanged joints shall be reinforced by means of a metallic ring.

Where flanged connections are covered by backfill, all flanged joints shall be wrapped in PE-sheets.

E.4.5.3 Transport and Storage

During transport pipes shall be solidly supported not only under the lower layer and between the layers, but also laterally and at the ends and the top in wooden crates to prevent accidental damage. Storage on site shall be on a raised floor with support frames so that the sockets do not touch the ground. Storage can be either head to tail storage or all pipes pointing in the same direction. The storage of all pipes shall be carried out in strict accordance with the manufacturer's instructions.

E.4.5.4 Re-Rounding and Cutting of Pipes

Pipes, which have been roughly handled, can have an ovalisation at the spigot end, which prevents a correct assembly of the pipeline. Such ovalisation may be corrected with special tensioning equipment to the approval of the Engineer. The application of correction methods has to ensure that no damage will be caused to the preventive coating of the pipes.

In general no cutting of ductile iron pipes, fittings and accessories on site is allowed. All delivered pipes shall provide a thoroughly proper preventive coating according to the defined requirements.

E.4.6 Cast Iron (CI) Pipes and Fittings

E.4.6.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

Pipes and Fittings

- ISO 6594 Cast iron drainage pipes and fittings — Spigot series;
- EN 10242 Threaded pipe fittings in malleable cast iron;
- ISO 6594 Cast iron drainage pipes and fittings — Spigot series;

QC standards

- EN 10204 Metallic products - Types of inspection documents

E.4.7 Steel Pipes and Fittings

E.4.7.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following.

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Steel pipes

- EN 10224 Non-alloy steel tubes and fittings for the conveyance of water and other aqueous liquids - Technical delivery conditions;
- EN 10255 Non-Alloy steel tubes suitable for welding, threading and other joining methods - Requirements and test methods;
- EN 10220 Seamless and welded steel tubes - Dimensions and masses per unit length;
- EN 10216 Seamless steel tubes for pressure purposes - Technical delivery conditions;
- EN 10217 Welded steel tubes for pressure purposes - Technical delivery conditions;
- EN 10226 Pipe threads where pressure tight joints are made on the threads;
- EN 10311 Joints for the connection of steel tubes and fittings for the conveyance of water and other aqueous liquids;
- DIN 2460 Steel water pipes and fittings;
- EN ISO 3183 Petroleum and natural gas industries - Steel pipe for pipeline transportation systems.

Fittings

- EN 10253 Butt-welding pipe fittings;
- EN 10241 Steel threaded pipe fittings;
- DIN 2460 Steel water pipes and fittings.

Steel Names and QC Standards

- EN 10027 Designation systems for steels;
- EN 10204 Metallic products - Types of inspection documents.

Material Tests

- EN 10204 Metallic products - Types of inspection documents;
- EN ISO 6892 Metallic materials - Tensile testing;
- EN ISO 6506 Metallic materials - Brinell hardness test;
- EN ISO 6508 Metallic materials - Rockwell hardness test;
- EN ISO 7438 Metallic materials - Bend test;
- EN ISO 5173 Destructive tests on welds in metallic materials - Bend tests;
- EN ISO 5178 Destructive tests on welds in metallic materials - Longitudinal tensile test on weld metal in fusion welded joints:

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Corrosion Protection & Coating

See Section E.4.11.

Welding

- EN ISO 9606 Qualification testing of welders - Fusion welding;
- EN ISO 15607 Specification and qualification of welding procedures for metallic materials,
- EN ISO 14731 Welding coordination - Tasks and responsibilities;
- EN ISO 3834 Quality requirements for fusion welding of metallic materials;
- EN ISO 9692 Welding and allied processes - Types of joint preparation;
- EN 287 Qualification test of welders;
- EN 288
- EN 1011 Welding - Recommendations for welding of metallic materials;
- EN 5817 Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections;
- DIN 1910 Welding.

Welding Consumables

- EN ISO 2560 Welding consumables - Covered electrodes for manual metal arc welding of non-alloy and fine grain steels – Classification;
- EN ISO 14341 Welding consumables - Wire electrodes and weld deposits for gas shielded metal arc welding of non-alloy and fine grain steels - Classification;
- EN ISO 14171 Welding consumables - Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non-alloy and fine grain steels – Classification;
- EN ISO 636 Welding consumables - Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels – Classification;
- EN ISO 20378 Welding consumables - Rods for gas welding of non-alloy and creep-resisting steels - Classification;
- EN ISO 20544 Welding consumables - Technical delivery conditions for filler materials and fluxes - Type of product, dimensions, tolerances and markings;
- EN 12074 Welding consumables - Quality requirements for manufacture, supply and distribution of consumables for welding and allied processes.

Welding Tests

- EN ISO 17637 Non-destructive testing of welds - Visual testing of fusion-welded joints;

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- EN ISO 4136 Destructive tests on welds in metallic materials - Transverse tensile test;
- EN ISO 5173 Destructive tests on welds in metallic materials - Bend tests;
- EN ISO 23277 Non-destructive testing of welds - Penetrant testing - Acceptance levels;
- EN ISO 17638 Non-destructive testing of welds - Magnetic particle testing;
- EN ISO 23278 Non-destructive testing of welds - Magnetic particle testing - Acceptance levels;
- EN ISO 17636 Non-destructive testing of welds - Radiographic testing;
- EN ISO 11666 Non-destructive testing of welds - Ultrasonic testing – Acceptance;
- EN ISO 23279 Non-destructive testing of welds - Ultrasonic testing - Characterization of discontinuities in welds;
- EN ISO 17640 Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment;
- EN ISO 10893 Non-destructive testing of steel tubes;
- EN ISO 17635 Non-destructive testing of welds - General rules for metallic materials;
- EN ISO 10675 Non-destructive testing of welds - Acceptance levels for radiographic testing;

E.4.7.2 General

Steel pipes and fittings shall be factory made. Factory welding of longitudinal and spiral seams shall be an automatic submerged arc welding process, except for smaller pipe diameters as detailed under Manufacture in this clause. The ends of pipes, fitting and specials shall be fully prepared for jointing by the specified method, prior to delivery to site.

Internal and external corrosion protection systems shall be applied at the factory only. On-site application shall only be admissible protection systems at welded joints, and such shall be supplied to the site in adequate quantities.

E.4.7.3 Materials and Dimensions

All pipes, and fittings and accessories shall be made from steel of quality and dimensions to impart the mechanical characteristics defined in applicable standards and shall meet the pressure class required for the specific application.

Dimensions of pipes shall be in accordance with EN 10220. Pipes and fittings must not have any defects likely to be detrimental to their use, and shall be supplied with an inspection certificate according to EN 10204.

Steel pipes shall be usually supplied in lengths of 6 m or 12 m, but with a maximum length of 14 m. Steel pipes for the conveyance of water shall be made of L 235 (1.0252) or L 355 (1.0419), according to EN 10027-1 and EN 10027-2 respectively.

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Materials for applications other than conveyance of drinking water are only admissible after approval of the Engineer. For coatings of pipes see section E.4.11.

E.4.7.4 Marking, Tolerance Class and Certification

Marking of the pipe shall be made in white reflective weather resistant paint at one end of the pipe and indicate the information as specified in Section E.2.3.3. and following information:

- Pipe number (individual and selected consecutively, no two pipes shall bear the same number). The pipe number shall ensure full traceability to test reports;
- Tolerance symbols for pipes ≥ 500 mm.

The pipe certification package shall comprise the Manufacturer's Certified Test Reports and inspection certificate (i.e. certified to EN 10204, or equivalent) including, upon request, Independent Inspectors Reports and third party certificates, all marked with the supply contract number and containing:

- Heat and product analysis results;
- Mechanical test results;
- Non-destructive examination reports with a statement of method used;
- Statement of compliance with visual and dimensional checks;
- Statement of manufacturing process and type of heat treatment;
- Statement of compliance with hydrostatic test requirements including test pressure;
- Inspection certificates and reports for surface treatments.

Pipes for laying as part of a trunk main shall be supplied with ends prepared for butt-welding of joints.

The individual sections of manifolds shall be prefabricated in required lengths. Whenever feasible, welding on site shall be avoided and shall only be admissible in particular cases, and after approval of the Engineer.

E.4.7.5 Laying of Pipes

Laying of pipes shall be in accordance with the requirement as specified in Section E.2.7 and with the instruction of the manufacturer.

E.4.7.6 Welding of Pipelines

The Contractor shall provide all necessary personnel, equipment and materials. The equipment shall include, but not be limited to:

- Welding machines and generators suitable for pipeline welding;
- Preheating equipment which ensures uniform preheating around the whole circumference of welding ends;

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- Post weld heat treatment equipment;
- Internal and external line-up clamps (the external clamp shall be hydraulically operated);
- Protective canopies (or umbrellas and wind shield collars) so that welding can be carried out even in relatively bad weather;
- Weather proof, insulating mats for the thermal insulation of girth welds (at least 1,5 x d wide).

The Contractor shall supervise the site, the welders and their work during the entire working period. For this purpose the Contractor shall use a qualified and certified welding specialist. All welding certificates and tests reports shall be submitted to the Engineer.

E.4.7.6.1 Materials

The weld filler metal selected shall give a weld metal matching the base metal properties as closely as possible. The yield strength of consumables shall neither overmatch the base material yield strength by more than one level stated in the respective standards, nor shall undermatching be allowed.

Attention shall be paid to obtaining a good working environment such as selection of low smoke developing consumables etc.

E.4.7.6.2 Welding Processes

Acceptable welding processes are:

- Shielded Metal Arc Welding (Stick) SMAW
- Gas Tungsten Arc Welding (TIG) GTAW
- Gas Metal Arc Welding (MIG/MAG) GMAW
- Flux Cored Arc Welding FCAW

The use of welding processes other than those listed above is permitted only with the prior approval of the Engineer. Processes may be used in combination if the same combination and sequence of processes have been qualified by the welding procedure qualification test.

The welding shall be inspected by an independent inspection company engaged by the Contractor. It is the sole responsibility of the Contractor to document that welding and welding inspection fulfil all specified requirements.

E.4.7.6.3 Welding Procedure Qualification

The Contractor shall submit detailed welding procedure requirements complying with the standards. All dimensions, all combinations of materials to be joined and all repair welding shall be covered by the procedure requirements. The procedure requirements are subject to the approval by the Engineer.

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The Engineer may, at his sole discretion, approve the use of already established, sufficiently tested and documented procedures not more than 2 years old. Transfer of welding procedure qualification records from one contractor to another is not permitted.

For each procedure requirements and prior to start of production welding, the Contractor shall carry out welding of test joints under site conditions following all of the details of the approved procedure specifications.

The qualifications test shall be carried out on steel with the highest specified minimum yield strength / maximum carbon equivalent which is expected to be covered by the Welding Procedure Specification. All the results from the procedure qualification records shall be submitted to the Engineer for approval of welding procedures.

E.4.7.6.4 Qualification of Welders and Welding Operations

Only skilled welders and welding operators who can document qualifications relevant for pipeline welding will be accepted by the Engineer. Prior to the performance of any production welding operators shall qualify for the relevant welding procedures according to EN ISO 9606-1.

The qualification tests are acceptable if they meet the requirements for visual examination, destructive testing and for radiographic examination as specified in the respective standards. The testing shall be carried out by an approved laboratory at the Contractor's expense. Welder and welding operator performance test certificates shall be issued and kept on site during the whole working period.

Welder and welding operator qualification tests may be performed together with welding procedure qualification tests.

These certificates are only valid for 6 months after the last welding

E.4.7.6.5 Welding Preparation

Items material grades, wall thickness and ratings shall conform to the requirements laid down in the applicable Drawings and Employer's Requirements.

Surfaces to be welded have to be completely clean to avoid deterioration of weld quality by any oxide, oil, grease or other contaminations or impurities. Raw edges after oxygen cutting shall be ground to remove any residual oxides, dross, or slag. Edges before welding shall be clamped in position with suitable mechanical devices.

Each pipe or component shall be visually inspected to ensure that it has not sustained any visually determinable damage. Disposition of damaged items shall be resolved in consultation with the Engineer.

All requirements for welding preparation contained in the qualified welding procedure Employer's Requirements shall be strictly adhered to.

E.4.7.6.6 Weld Pointing

Weld points shall be made by skilled welders as specified above and under conditions required for welding as specified below:

- electrodes shall be dried and conserved according to the recommendations of the producers;
- pre and post-heating shall be applied where necessary;
- length of weld points shall be greater than 30 mm.

The parent metal dilution shall be limited to avoid risk of weld metal deposited cracks. Backward welding shall be carried out at the end of each bead to properly fill the craters of welding pass end and, thus, avoid incipient cracks. Any cracked tack weld must be removed before the welding operation.

Fastening of welded edges shall ensure compliance with alignment tolerances during all the welding operations.

E.4.7.6.7 Welding Workmanship

All welding shall be performed by qualified welders and strictly in accordance with qualified welding procedures.

Welding shall be suspended by the Contractor when prevailing weather conditions will impair the quality of the work, e.g. airborne moisture, blowing sand, high winds or thunderstorms.

Vibration inducing operations carried out in the vicinity of welded plates are prohibited during welding operations.

Stray arching outside the weld groove is not permitted. Should stray arching outside this area occur, this shall be brought to the attention of the Engineer who may require any such damaged section to be repaired or cut out at the Contractor's expense.

Earth connections for the welding shall always be positioned in the centre of the joint during root and cap-bead laying. They shall be mechanically or magnetically connected to the pipe.

Each pass shall be completed around the whole circumference before the next pass is started.

The position of start / stop on subsequent passes shall not be identical. Upon completion of the cap bead, the weld and the pipe surface shall be cleaned of weld spatter and other deposits, and shall then be wrapped with a dry, waterproof insulating mat to ensure a slow cooling of the weld zone and to give protection against rain.

E.4.7.6.8 Cleaning after Welding

The surface shall be dry and free of oil, grease, soil and concrete residues. All loose rust and mill-scale shall be removed by wire brushing immediately before welding inspection. On straight

pipes, brushing shall be done mechanically using sharp brushes to avoid polishing of the steel surface. Therefore a stock of readily accessible new brushes is required.

Welds fabricated with basic filler metals shall be washed with fresh water.

Cleaning by sandblasting is allowed as an alternative.

E.4.7.6.9 Post Weld Heat Treatment (PWHT)

PWHT of weld seams shall only be carried out if specified in the approved welding procedure or where this is indicated in the project material. PWHT procedures shall be approved by the Engineer.

E.4.7.6.10 Identification of Weld Seams

Every girth weld shall be numbered by the Contractor in accordance with a system to be approved by the Engineer. This number shall be painted on the pipe coating on one side of the joint between 0,5 m and 1,0 m from the seam together with the pipe number and pipe length to facilitate completion of the pipe book.

For each pipeline and each pressure test section, the Contractor shall fill out pre-printed forms and enter these in a pipe log. As the work progresses, the Contractor shall present the pipe log forms to the Engineer. Before the start of a pressure test the completed pipe log for the section in question shall be handed over to the Engineer.

E.4.7.6.11 Closing of Pipe Ends

During welding on a pipeline segment all open ends of that segment shall be kept closed with a plug or a cap.

At interruption in the pipeline construction, the Contractor shall close the ends of the pipe strings. The closure shall be tight enough to prevent any entry of foreign matter into the pipe.

Plugs or caps must not be fixed by welding or by any other method which damages the pipe. They shall be securely attached to the pipe and shall remain in place until the string is laid.

E.4.7.6.12 Welding of Fittings

Fittings shall be for butt-welding. The wall thicknesses shall harmonise with the PN of the adjacent straight pipe. Flanges for butt-welding shall be according to ISO 7005 and/or EN 1092 or equivalent standard.

E.4.7.6.13 Welding, Testing and Inspection

Examination shall be performed according to applicable standards approved by the Engineer and the following inspection methods:

- Radiographic examination according to ISO 17636 and EN ISO 10675;

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- Ultrasonic examination according the standards EN ISO 10893;
- Magnetic particle examination according to EN ISO 10893;
- Liquid penetrant examination according to ISO 3452;
- Visual examination according to EN ISO 17637 ;
- Hardness measurement according the standards.

The Contractor shall engage a qualified independent inspection company which shall perform, evaluate and document all welding inspection. The inspection company shall be approved by the Engineer.

All non-destructive examination shall conform to the requirement of the adequate method standard and the Employer's Requirements. Procedures shall be submitted to the Engineer for approval.

Document Requirements

The following documents shall be submitted to the Engineer for approval:

Before examination:

- Certificates for welding personnel;
- Welding procedures;
- Report forms;
- Request for deviations, if any, from specified requirements.

During examination:

- Examination reports with enclosed field reports and films.

E.4.7.7 Other Jointing Methods

E.4.7.7.1 Threads

Steel pipes with nominal diameters up to and including 150 mm may be threaded (female or male) at both ends and provided with a detachable screwed coupling attached to one end. Threads shall comply with EN 10226, BSPT/P or ANSI B1.20.1, NPT/S. Couplings shall be made from similar material to that of the pipes.

E.4.7.7.2 Flanges

Where flanges are required they shall be forging or made from steel plate meeting the steel specification of the pipe material. Flanges shall be weld-on type and drilled to the application, PN 10 or PN 16.

Flanges shall comply with the standards stated in Section E.4.12.1.

E.4.8 Galvanised Iron (GI) Pipes and Fittings

E.4.8.1 Standards

Galvanised pipes and fittings (in accordance with the appropriate EN Standards or equivalent standards) shall only be used when approved by the Engineer. The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following.

- EN ISO 1461 Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
- EN 10240 Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants;
- EN 1179 Zinc and zinc alloys - Primary zinc

E.4.8.1.1 Pipes

Galvanised iron pipes shall be manufactured according to ISO 1461 and EN 10255. The galvanisation shall be by hot-dip process according to EN 10240 and EN 1179 and shall satisfy the copper sulphate test procedure according to EN ISO 1460.

All pieces shall be straight, cleanly finished, free from cracks, surface flaw lamination and other defects and shall have a reasonably smooth surface. The overall pipe length, with one socket fitted, is to be 6 m plus or minus 150 mm.

E.4.8.1.2 Joints

Galvanised steel pipes and fittings shall be supplied with either flanged ends or with threaded ends.

Where flanged joints are specified for use with galvanised steel pipe and fittings the flanges shall be in accordance with Section E.4.12.1.

Threaded sockets shall be in accordance with ISO 228-1, EN 10226, ISO 65 or equivalent. Screw threads shall be clean, well cut and square with the axis of the pipe and be free from excessive burrs. The end of each socket shall be chamfered internally.

E.4.9 Stainless Steel Pipes

E.4.9.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. Main applicable standards are, but shall not be limited by the following:

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- EN ISO 1127 Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length;
- EN 10296-2 Welded circular steel tubes for mechanical and general engineering purposes - Technical delivery conditions - Part 2: Stainless steel;
- EN 10297-2 Seamless steel tubes for mechanical and general engineering purposes - Technical delivery conditions - Part 2: Stainless steel;
- EN ISO 14343 Welding consumables - Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels;

E.4.9.2 Materials and Dimensions

All pipes, and fittings and accessories shall be made from stainless steel of quality to impart the mechanical characteristics defined in the respective standards.

The following stainless steel qualities shall be used according to EN 10027.

EN 10027 Material No.	Specification	ASTM / AISI	UNS-Number
1.4301	X5CrNi18-10	304	S30400
1.4571	X6CrNiMoTi17-12-2	316Ti	S31635
The following shall be used for minor quality requirements, only after prior approval by the Engineer.			
1.4401	X5CrNiMo17-12-2	316	S31600
1.4404	X2CrNiMo17-12-2	316L	S31603
1.4436	X3CrNiMo17-13-3	316	S31600

The tolerances on thickness and on masses shall not exceed the tolerances given in EN 1127.

E.4.9.3 Welding

For welding of stainless steel pipes and fittings in general, the requirements stated in Section E.4.7.6 shall apply.

Only the welding methods WIG (Wolfram-Inert-Gas) and MAG (Metal-Active-Gas) shall be applied. Only suitable equipment that guarantees a professional performance is to be used for this purpose.

The contractor has to ensure that the material combination in the area of the welding zone will not be negatively altered and that intercrystalline corrosion will not develop. For this reason, only certified welding additions according to EN ISO 14343 and a shielded arc atmosphere shall be used that is in accordance with the material.

As far as possible, welding, edging and drilling shall be performed in the workshop under controlled conditions. Permanent protection from corrosion is to be guaranteed through a pickling treatment in the pickling bath with the correct acid consistency and temperature and

through a follow-up passivation. Local pickling treatment and passivation at the construction site is only permitted in special cases. Pickling treatment and passivation have to be certified.

E.4.10 Clay Pipes

Vitrified clay pipes shall comply with following standards:

- EN 295 Vitrified clay pipe systems for drains and sewers.

E.4.11 Internal Lining and external Coating of Pipes and Fittings

E.4.11.1 Standards

The Contractor shall carry out the works described in accordance with the appropriate standards or equivalent local or international standards. The main standards are, but shall not be limited by the following:

- ISO 4179 Ductile iron pipes and fittings for pressure and non-pressure pipelines - Cement mortar lining;
- ISO 8179 Ductile iron pipes, fittings, accessories and their joints - External zinc-based coating;
- EN 545 Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods;
- ISO 2531 Ductile iron pipes, fittings, accessories and their joints for water applications;
- ISO 16631 Ductile iron pipes, fittings, accessories and their joints compatible with plastic (PVC or PE) piping systems, for water applications and for plastic pipeline connections, repair and replacement;
- EN 14628 Ductile iron pipes, fittings and accessories - External polyethylene coating for pipes - Requirements and test methods;
- EN 15542 Ductile iron pipes, fittings and accessories - External cement mortar coating for pipes - Requirements and test methods;
- EN 10287 Steel tubes and fittings for on and offshore pipelines - External fused polyethylene based coatings;
- EN 10288 Steel tubes and fittings for on and offshore pipelines - External two layer extruded polyethylene based coatings;
- EN 10289 Steel tubes and fittings for onshore and offshore pipelines - External liquid applied epoxy and epoxy-modified coatings;
- EN 10290 Steel tubes and fittings for onshore and offshore pipelines - External liquid applied polyurethane and polyurethane-modified coatings;

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- EN 10298 Steel tubes and fittings for onshore and offshore pipelines - Internal lining with cement mortar;
- EN 10300 Steel tubes and fittings for onshore and offshore pipelines - Bituminous hot applied materials for external coating
- EN 10310 Steel tubes and fittings for onshore and offshore pipelines - Internal and external polyamide powder based coatings;
- EN 12068 Cathodic protection - External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials;
- EN 14901 Ductile iron pipes, fittings and accessories - Requirements and test methods for organic coatings of ductile iron fittings and accessories;
- EN ISO 22063 Metallic and other inorganic coatings - Thermal spraying - Zinc, aluminium and their alloys;
- DIN 2880 Application of cement mortar lining for cast iron pipes, steel pipes and fitting;
- DIN 30670 Polyethylene coatings of steel pipes and fittings - Requirements and testing;
- DIN 30675-1 External corrosion protection of buried pipes - Part 1: Corrosion protection systems and application for steel pipes;
- DIN 30675-2 External corrosion protection of buried pipes - Part 2: Corrosion protection systems and application for ductile iron pipes;
- DIN 30674-3 Sheathing ductile cast iron pipes - Part 3: Zinc coating with protective sheathing;
- DIN 30674-5 Sheathing ductile cast iron pipes - Part 5: Polyethylene sleeving;
- BS 4164 Specification for coal-tar-based hot-applied coating materials for protecting iron and steel, including a suitable primer,
- AWWA C 203 Coal-Tar Protective Coatings and Linings for Steel Water Pipe;
- AWWA C 213 Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and fittings.

E.4.11.2 General

The Contractor shall provide detailed information and technical documentation of the internal and external protection of pipes, and shall specify the guarantee period of all coatings.

All pipes and fittings shall be factory coated only. Surface shall be free of any impurity, stain, dirt and corrosion prior to application of any coating to guarantee maximum adherence of the coating.

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Internal lining of pipes and fittings shall be certified for use for potable water when required. Internal lining shall guarantee that the hydraulic performance of the pipes and fittings shall be maintained long term even if the water was chemically aggressive.

In general, the quality of internal lining and external coatings shall be excellent upon delivery. The Engineer shall not accept pipes with damaged lining and coatings.

E.4.11.3 General Requirements for internal Lining and external Coating

a) Internal lining and external coating must:

- Be applied on a properly prepared surface;
- Have sufficient adhesion to the metal surface to effectively resist underfilm migration of moisture;
- Be sufficiently ductile to resist cracking;
- Have sufficient strength to resist damage due to handling and soil stress (external coating);
- Have high UV resistance (external coating);
- Have high resistance against water, wastewater and sludge and its contents as required (internal lining);
- Shall be suitable for potable water applications (where applicable) and shall not contain any toxic element or elements soluble in water, or elements susceptible to impart any smell or odour to the water (internal lining);
- Have properties compatible with any supplemental cathodic protection, in particular:
 - volume resistivity of at least 10¹³ Ωcm;
 - high resistance against cathodic alkali;
 - protected against blistering by hydrogen at a negative potential of – 1.100 mV (for aluminium or zinc anodes) or of – 1.600 mV (for magnesium anodes);
 - low moisture absorption and high electrical resistance (external coating);

b) Each external protective coating must be inspected just prior to lowering the pipe into the ditch and backfilling, and any damage detrimental to effective corrosion control must be repaired;

c) Each external protective coating must be protected from damage resulting from adverse ditch conditions or damage from supporting blocks;

d) If coated pipe is installed by boring, driving, or other similar method, precautions must be taken to prevent damage to the coating during installation.

The Contractor shall prove all the above requirements under (a) by test certificates to be submitted to the Engineer and by onsite tests on factory applied coatings and on field joint coatings as described below.

The Contractor shall submit to the Engineer a complete description of the lining and coating systems for approval prior to ordering.

For ductile iron pipes internal lining and external coating refer to Section E.4.11.4. For steel pipes internal lining and external coating refer to Section E.4.11.5.

E.4.11.3.1 Surface Preparation

Before blasting, all oil, grease, mill lacquer and other deleterious material on the surfaces of the metal to be coated shall be removed by suitable means.

In cold weather or any time when moisture tends to collect on the steel, the pipe shall be uniformly warmed for sufficient time to dry the pipe prior to cleaning. The pipe temperatures shall be maintained at least 3 °C above the dew point during the cleaning and coating operations. Pipe temperature shall not exceed 70 °C as a result of preheat.

Pipe surfaces shall be blast cleaned to a blast metal finish. The grade of derusting shall comply with ISO 8501-1 SA 2½. Certain coating systems require a greater degree of cleanliness; in such cases, the degree of cleaning shall be as required by the coating system.

Following cleaning and prior to coating the pipe, abrasive remaining on the outside and loose contamination on the inside of the pipe shall be removed by air blast, vacuum or other suitable methods. If air is used, the air should be dry and free of contaminants, and all particles removed from the surface shall be collected in such a manner as not to contaminate clean pipe.

Following cleaning and prior to coating, the pipe surface shall be inspected for adequate cleaning and surface condition. Pipe not properly cleaned shall be rejected and re-cleaned.

Blast cleaned pipe surfaces shall be protected from conditions that would allow the pipe to flash rust before coating. If flash rusting occurs, affected pipe shall be re-cleaned.

E.4.11.3.2 FBE / FBPE or FBPP Coating

FBE coatings shall be according to AWWA C 213 and comprise of 3 layers:

- a) FBE primer, thickness min. 0,15 mm;
- b) adhesive middle layer, thickness min. 0,15 mm;
- c) FBPE or FBPP top coat, compounded with an inert filler, thickness min. 1,2 mm.

The adhesive middle layer shall be designed to bond together the primer and top layer.

The FBPE/PP top coat shall be formulated to be ultra-violet (UV) resistant for a minimum of 10 years exposure.

E.4.11.3.3 Three-Layer PE / PP Coating

Polyethylene and polypropylene coating shall be according to DIN 30670 and comprise of 3 layers:

- a) electrostatically applied epoxy powder primer, thickness min. 0,2 mm;
- b) chemically modified adhesive applied by extrusion method, thickness min. 0,4 mm;
- c) polyethylene or polypropylene top coat applied by extrusion method, thickness min. 3,0 mm.

The PE/PP top coat shall be formulated to be ultra-violet (UV) resistant for a minimum of 10 years exposure.

E.4.11.3.4 CTE Coating

CTE coating shall be according to AWWA C 203 and comprise of 4 layers:

- a) Synthetic primer, thickness min 0,1 mm;
- b) Coal tar enamel, thickness min 3,0 mm;
- c) Resin-bonded glass fibre inner wrap, thickness min 3,0 mm;
- d) Coal tar saturated resin-bonded porous glass fibre outer wrap, thickness min 6,0 mm.

E.4.11.3.5 Zinc and Bituminous Coating

Zinc coating materials shall be either metallic zinc with a content of at least 99 %, or zinc-rich paint containing at least 85 % zinc in dry film. Zinc coating shall conform to DIN 30674-3. The minimum thickness shall be 40 μm . The minimum application rate shall be 600 g/m².

Metallic zinc-coatings shall be applied at the factory by projecting small droplets of zinc heated to the molten state by means of spray-guns.

Zinc-rich paint coatings shall be applied at the factory by spraying or brushing zinc-rich paint onto the pipe surface.

After zinc-coating, the pipe shall be given a finishing coat based on bituminous products according to DIN 30674-3 compatible with zinc, applied by any proven procedure such as gun-spraying or brush-coating. The mean thickness of the finishing layer shall be not less than 1 mm.

E.4.11.3.6 PU Spray Coat for Field Joints

The PU spray system shall conform to EN 10290 and shall provide a single high-build layer of robust, abrasion resistant polyurethane coating with a minimum thickness of 3 mm. The PU spray system shall guarantee an excellent adhesion to both the pipe substrate and PE/PP factory coating overlap areas.

E.4.11.3.7 Heat Shrinkable Sleeve for Field Joints

Heat shrinkable sleeves shall be designed to provide moisture penetration resistance and corrosion prevention for pipeline field joints and shall comply with DIN 30672.

Heat shrinkable material shall be fabricated from irradiated cross-linked polyolefin pre-coated with an epoxy primer and a hot-melt adhesive (mastic) and shall have a thickness of not less than 125 microns.

The sleeves shall shrink when heated and force the mastic (or adhesive) to flow into the irregularities of the weld.

The shrinking action shall provide a simple, reproducible delivery system for the mastic or adhesive.

When shrunk, the polyolefin sleeve shall provide penetration and abrasion resistance during handling, backfill, and operation of the pipe and shall provide resistance against soil stresses, alkalis, acids, microbes and fungi.

Heat shrinkable sleeves shall be self-priming in nature and shall be bondable substrates including heavy wall pipes, polyethylene, epoxy powder and bituminous coatings.

E.4.11.3.8 Mastic

Mastic shall consist in mineral aggregate and fillers in which the voids in the mineral matrix are overfilled with the adhesives. At ambient temperature, mastic shall be highly viscous under long-duration loading and shall have elastic behaviour when subjected to short-duration loading. Mastics shall be amorphous, pressure sensitive, and tacky, so they bond easily to substrates upon contact and pressure.

Adhesives for "cold mastic" shall be based on butyl rubber, polyisobutylene, synthetic rubbers, or asphalts and shall be self-priming. They shall have "cold flow" characteristics thus being self-healing in the event of a puncture.

Adhesives for "hot mastic" shall be based on bitumen and admixtures in portions and characteristics as needed. Typically hot mastic consists of petroleum hydrocarbons with additives to displace water, inhibit corrosion, enhance adhesion and control flow.

"Marine mastic" shall be a blend of petrolatum, inert fillers and expanded polystyrene beads, and special wetting additive to enable the product to be used in submerged marine applications. "Marine mastic" shall be non-setting and non-hardening, and shall give neutral buoyancy.

E.4.11.3.9 Reinforced Tape Wraps for Field Joints

Glass fibre reinforced coal tar enamel wrapping shall comply to DIN 30672 and shall comprise of:

- a) Mastic;

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- a) Inner tape wrap consisting of hot applied, mineral filled coal tar, reinforced with an inner layer of 50 g/m² glass tissue, spirally wound with overlap, separated from the pipe surface by at least 1 mm thickness of enamel giving a minimum finished thickness of 3,0 mm;
- b) Outer tape wrap consisting of coal tar impregnated, longitudinally reinforced with glass fabric spirally wound giving a minimum finished thickness of 6,0 mm.

Factory tape application shall only be applied using a winding machine.

E.4.11.3.10 Solids Rigid Polyurethane Internal Lining

PUR coatings shall be according to EN 10289 and AWWA C 210. Thickness of liner shall not be less than 0,5 mm. PUR shall consist of two components: one isocyanate-rich solution and one polyol-rich solution (ASTM D 16 Type V), bonded together rapidly by exothermic polymerisation and then forming an solid film after application.

E.4.11.3.11 Cement Mortar Internal Lining

Cement mortar for internally lining water supply pipes shall contain no toxic element or elements soluble in water, neither shall it contain elements susceptible to impart any smell or odour to the water. The characteristics of the mortar, its placing and control shall be in compliance with EN 10298 and DIN 2880. The mortar shall consist of at least one part of Portland cement by weight to 3,5 parts of sand by weight, i.e. a sand / cement ratio smaller than or equal to 3,5. The water cement ration shall not exceed 0,42.

Cement mortar for internally lining sewage pipes shall have a sulphate resistant cement according to EN 10298. The thickness of the liner shall not be less than 10 mm.

E.4.11.4 Ductile Iron Pipes and Fittings

Ductile iron pipes and fittings shall have coating and lining as follows:

Pipes, external coating:	rich metallic zinc spraying, plus additional bituminous paint coating
Pipes, internal lining:	cement mortar of blast furnace cement
Field joints	i) 100% solids rigid polyurethane (PU) solvent free spray or ii) Heat shrinkable sleeve or iii) Mastic plus two (2) reinforced tape wraps
Fittings, external coating	bituminous paint or epoxy
Fittings, internal lining	cement mortar of blast furnace cement or epoxy, min. 250 µm

Polyethylene sleeves shall be used only for field application and approved by the Engineer.

The thickness of the internal cement mortar lining shall be as indicated in the following table:

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Diameter	Nominal	Limit deviation
Up to DN 300	4,0 mm	-1,5 mm
DN 350 to DN 600	5,0 mm	-2,0 mm
DN 700 to DN 1200	6,0 mm	-2,5 mm
DN 1400 to DN 2000	9,0 mm	-3,0 mm

E.4.11.5 Steel Pipes

Following external pipe coating systems are allowed for steel pipes:

- i.) Fusion bonded epoxy (FBE) plus fusion bonded polyethylene (FBPE) or polypropylene (FBPP) top coat, or;
- ii.) Three-layer polyethylene or polypropylene (3-LPE / 3-LPP), or;
- iii.) Primer plus coal tar enamel (CTE) plus 2 reinforced tape wraps

Following internal pipe lining systems are allowed:

- i.) For potable water applications: Cement mortar of blast furnace cement, or otherwise
- ii.) 100% solids rigid PU solvent free spray, or
- iii.) rich metallic zinc spraying.

Steel pipes and fittings shall receive their coating and lining in the manufacturer's works prior to shipping. The thickness of the internal cement mortar lining shall be as indicated in the following table.

Diameter	Nominal	Limit deviation
Up to DN 250	4,5 mm	-1,5 mm
DN 300 to DN 600	6,0 mm	-2,0 mm
DN 700 to DN 900	8,0 mm	-2,0 mm
DN 900 to DN 1200	10,0 mm	-2,0 mm
DN 1400 to DN 2000	14,0 mm	-2,0 mm

E.4.11.6 Galvanised Steel Pipes

Standard references are EN 10240 and EN 10255 or equivalent. Pipes and fittings shall be hot dip galvanised. Minimum thickness shall be 50 µm. The coating shall be homogeneous.

E.4.11.7 Field Application

Coating and lining shall be realised at the Manufacturer's work only. Field coating is only admissible in exceptional cases and after approval of the Engineer.

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Pipe inspection shall be carried before any field coating. The pipe surface shall be inspected for surface contamination or surface imperfections. If any pipe cannot be coated, or is otherwise questionable, the segment shall be replaced.

E.4.11.7.1 Packing, Delivery, Storage

All coating materials, including repair or patch materials shall be packaged in suitable and approved containers. The containers shall be plainly marked with the name of the Manufacturer, type of material and batch or lot number where applicable. Bulk shipments shall be allowed provided the above information is included in the bill of lading.

The coating material shall be packaged in containers suitable to keep the contents clean and dry during handling, shipping and storage. Storage and handling conditions shall be in accordance with the Manufacturer's recommendations.

Precautions shall be taken during the handling, shipping and storage of all materials to prevent damage to the containers that would result in contamination of the coating materials. All contaminated, or otherwise damaged materials shall be discarded.

E.4.11.7.2 Priming

Immediately after cleaning, all blasted surfaces shall be free of dust, grit and other foreign material and shall be primed by brushing, spraying or other suitable means to produce an effective bond between the metal and subsequent coating. No primer shall be applied to a wet surface.

The use of primer that becomes contaminated with foreign substances or has thickened through evaporation of the solvents shall not be permitted.

The minimum and maximum allowable drying time of the primer between application of primer and application of the coating shall be in accordance with instructions issued by the Manufacturer of the primer. If the coating is not applied within the maximum allowable time after priming as required, the pipe shall be re-cleaned and re-primed.

After application, the primer coat shall be uniform and free from floods, runs, sags, drips or bare spots. Any bare spots shall be re-primed. All runs, sags, floods or drips shall be removed by brushing or scraping and the bare areas, if any, shall be retouched. Suitable measures shall be taken to protect wet primer from contact with moisture, dust or other foreign matter.

E.4.11.7.3 CTE Application

Coating materials may be delivered in hot bulk or solid forms. The coating shall be heated in approved heating kettles equipped with accurate and easily read thermometers, mechanically agitated, and covered with proper lids.

The coating shall be maintained moisture and dirt free at all times prior to and at the time of heating and application.

The coating shall be loaded into the kettles in pieces of suitable size for the melting equipment used. When the Contractor receives hot material in bulk, the holding kettles shall be operated in accordance with the Manufacturer's instructions.

In heating the coating material, the charge will be melted and brought to application temperature without injury to the coating material. The temperature of application shall not exceed that which is recommended by the Manufacturer.

The primed pipe surface shall be dry and clean at the time the coating is applied.

External coating shall be applied by spraying, flooding, or pouring in such a manner as to maintain the specified thickness. The coating shall overlap the preceding spiral, producing a continuous coat free from defects.

E.4.11.7.4 Application of Tape Inner Wrap

The inner wrap shall be applied directly onto the primed pipe surface with appropriate dispensing and tensioning equipment.

The inner wrap shall be spirally applied with overlap widths and application tensions required and/or recommended by the Manufacturer. The minimum overlap shall not be less than 1 cm. The minimum overlap at the end of a roll of tape shall be 15 cm or more.

The applied inner wrap shall conform tightly to the pipe surface, shall be free of voids and wrinkles and shall be smooth.

When a new roll of tape is started, the end lap of the splice shall overlap the previous roll. This splice shall be smooth and placed so as to maintain the continuity of the inner wrap coating

E.4.11.7.5 Application of Tape Outer Wrap

The outer wrap is applied directly over the inner wrap using the same type of mechanical tape tensioning equipment.

The overlap of the outer wrap shall not be applied directly over the lap of the inner wrap under any circumstances.

The outer layer may be applied at the same time as the inner layer

E.4.11.7.6 PU Spray Coat for Field Joints

PU spray coating shall be carried out by a hydraulic airless high pressure PU machine to guarantee an excellent material mix.

E.4.11.7.7 Heat Shrinkable Sleeve for Field Joints

To ensure mastic fluidity and full adhesive bonding the field joint area must first be pre-heated, to between 60 – 230 °C, depending on the mastic type, prior to sleeve installation. Heat

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induction shall guarantee rapid, uniform heating around the full 360 degree pipe circumference and over a controlled bandwidth by a "direct-to-metal" non-contaminating heat source, which ensures total mastic fluidity without over/under heating.

Sleeve shrinkage by manual gas torch heating methods shall only be applied for other than circumference weld seams. Sleeves shrinkage shall then be accomplished by using manual gas torch heating methods. Shrinking shall start at the top centre of the sleeve working toward one end. The torch shall be moved to avoid burning the sleeve. After this, shrinking shall continue circumferentially from the centre to the opposite end. The sleeve has conformed to the pipe when mastic flow is evident at the sleeve edges. Once fully shrunk the sleeve shall be 'rolled' to remove any residual air pockets at the mastic / substrate interface, typically found around the weld bead and factory coating edges.

E.4.11.7.8 Hot Mastic for Field Joints

Mastic mix materials shall be heated in a re-melt kettle to a temperature of approximately 175 to 190 °C or as specified by the manufacturer. Cooling shrinkage may be kept to a minimum if material temperatures are held to the suggested range.

In charging the re-melt kettle, the mastic level shall be maintained such that the paddle blades are visible at the top of their rotation. The unit may be used as a continuous mixer by charging the cold material from the back end while drawing hot material from the gate.

Accurate portable thermometers shall be readily available and used for checking mastic temperatures prior to moulding.

If it should become necessary to hold mastic mix material in the kettle for an unusual length of time, the lid should be closed, the fire decreased and a small amount of asphalt added to replace asphalt driven off by the continued application of heat.

The mastic mix form, or mould, shall consist of a pre-cut section of sheet metal wrapped over the field joint mould area and extending back over the plant applied concrete coating, if any. The form shall be securely strapped or banded at each end.

The pre-cut opening at the top shall be opened and mould shall be filled with mastic mix, being carefully agitated or vibrated and formed to assure complete filling and the elimination of voids or honeycomb within the joint. After filling the mould, the opening shall be strapped shut and at this time water cooling may be used. The number of straps or bands shall be chosen dependent upon the size or weight of the joint being installed.

E.4.11.7.9 Tape Coating Field Joints, Fittings, Connections

Primer respectively mastic shall be applied according to the above Sections.

Strips of wrapper shall be cut according to size of pipe (multiple strips may be required to cover the entire patch area). Length of wrapper should be 4 times the diameter of the pipe.

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The wrapper shall be slipped under pipe and ends shall be pulled above pipe on both sides, leaving about 2,5 cm distance from bottom of pipe to wrapper.

Molten mastic shall be poured on top 1/4 of pipe from one side of pipe to other. Mastic will flow down and around the pipe surface.

When mastic moves to the bottom of the pipe, the wrapper shall be seesaw loosely with an upward and downward motion to assure proper thickness.

The wrapper shall be pulled around the hot mastic tightly. A spot of mastic shall be poured on top to stick wrapper to overlap together.

E.4.11.8 Pipe Surface Contamination and Removal

Surface contamination shall mean any foreign material on the pipe surface that is detrimental to the finished coating:

- Organic contaminants such as oils, lubricants, or greases;
- Previously applied coatings;
- Stencil media;
- Soluble salts;
- Adhesive type material such as tape or stickers.

Removal of the contaminants shall be accomplished by cleaning with an acceptable solvent. Criteria of acceptance for a solvent include safety considerations and ability to remove contaminant without leaving a hydrocarbon residue.

If pipe is received containing soluble salts, the pipe shall be cleaned by rinsing of pipe surface with clean fresh water and use of a phosphoric acid wash pre-treatment prior to coating.

E.4.11.9 Inspection and Testing

The entire procedure of applying the protective coating material as herein specified shall be inspected either at manufacturer's premise or onsite. Improperly coated pipes shall be repaired. In case repair is not sufficient, the Engineer shall have the right reject the poorly coated pipe. Re-coating or coating repair that may be necessary shall be done at the Contractor's expense.

E.4.11.9.1 Coating Thickness Measurements

An appropriate and calibrated film thickness gauge shall be used to perform coating thickness measurement.

The coating thickness shall meet or exceed the agreed upon minimum coating thickness. All joints which fail to meet the minimum coating thickness test shall be re-coated or repaired.

E.4.11.10 Repair Procedures

All defects disclosed by the holiday detector and other obvious defects shall be repaired by the Contractor.

Areas of repair to the coating shall be holiday inspected by the Contractor on a 100 % basis. Repairs shall be inspected by holiday testing.

The damaged coating shall be removed from the steel surface. The edge of the cured coating adjacent to the damaged area shall be "feathered" and coated with an appropriate surface conditioning solvent recommended by the coating Manufacturer. This solvent shall be applied in accordance with the Manufacturer's recommendations.

The damaged area shall then be re-coated.

E.4.11.10.1 FBE Coating

Small holidays in FBE coatings may be patched by use of a two part, 100 % solids, liquid epoxy compound specified by the Manufacturer. The damaged area shall be abraded by hand filing or use of carborundum cloth. Application shall be made to a minimum thickness of 0,6 mm and shall overlap the undamaged area a minimum of 1,5 cm. The liquid patch compounds shall not be applied when the pipe temperature is below 10 °C unless provisions are made for heat curing the patch material using methods and temperatures in accordance with procedures recommended by the coating Manufacturer.

E.4.11.10.2 Tape Systems

All holidays detected such as damaged or flawed areas shall be repaired by peeling back and removal of the outer and inner layers from the damaged area.

The holiday area shall then be brushed with primer and a patching tape with a polyethylene backing and butyl adhesive should be applied directly to the defective area in the manner specified by the Manufacturer.

The minimum lap at the damaged area shall be 10 cm all around.

The repaired area shall be tested with a Holiday Detector after the repair is completed.

The repaired area may be covered in cigarette wrap fashion with the outer wrap to a minimum lap of 10 cm beyond the patching tape.

E.4.11.10.3 Cement Linings

Repairs shall be carried out as follows:

- a) The damaged lining shall be cut out to the metal. Edges shall be squared;
- b) The cut-out area and adjoining lining shall be wetted;

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- c) With the damaged area cleaned and the adjoining lining wet, mortar shall be spread evenly over the area to be patched in the lining thickness of the surrounding cement liner. After the lining has become firm and adheres well to the surface, it shall finish with a wet paint brush or similar soft bristle brush;
- d) The repaired lining shall be kept moist by tying canvas or wet burlap over the ends of the pipe or fitting for at least 24 hours. As an alternative the repaired lining may be seal coated with a cut back type of asphaltic seal coating. This must be sprayed or brushed on within 5 to 30 minutes after lining.

The repair cement shall comply with Section E.4.11.3.11 "Cement Mortar Internal Lining". Mortar for lining shall not be used after it has been mixed for more than 1 hour. Too rapid loss of moisture from fresh linings due to hot weather or high wind shall be prevented by appropriate curing measures.

E.4.11.10.4 Cold Caulking Compound

Cold caulking compound shall be asbestos free and special cement based material from an approved Manufacturer. The compound shall be suitable for use with water to set to form a hard solid capable of resisting hydraulic pressure immediately. It shall withstand thermal expansion and contraction, vibration and deflection normally associated with pipework applications. The compound shall be applied and cured in accordance with the Manufacturer's instructions.

E.4.11.11 Coated Pipe Handling, Storage and Loading Requirements

Pipe shall be stored, handled and transported in a manner to prevent damage to the pipe walls, bevelled ends and the coating.

Storage racks shall be so designed as to protect the coated pipe from standing water, direct soil contact, and sharp or hard objects that might damage the coating.

The coated pipe shall be shipped using sufficient and proper dunnage to adequately protect the pipe and coating.

E.4.12 Pipeline Appurtenances

E.4.12.1 Flange Connections

Wherever pipes and fittings are connected by flanges, the following standards apply:

- ISO 7005-1 Pipe flanges — Part 1: Steel flanges for industrial and general service piping systems
- EN 1092 Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated

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- EN 1514 Flanges and their joints - Dimensions of gaskets for PN-designated flanges

E.4.12.2 Fastenings

All bolts, nuts and washers necessary for assembly shall be supplied together with the equipment. The Contractor shall supply an extra 2 % of this assembly material as reserve. The cost of the assembly material + reserve shall be included in the unit price of pipes and fittings.

Bolts and nuts shall comply as a minimum with the requirements of EN ISO 4016 : 2000 and EN ISO 4034 : 2000, grade 4.6. Washers shall comply with EN ISO 7091.

The dimensions of bolts, nuts and washers used for flanged connections shall be in accordance with the flange dimensions. For flanged connections above ground or in chambers, bolts, nuts and washers shall be of stainless steel. All buried flange connections shall be made of hot-dip galvanised steel.

Bolts, nuts and washers and other demountable fastenings of all galvanised parts and also aluminium alloy parts shall be in stainless steel to the appropriate standard. P.T.F.E. washers shall be fitted beneath bolt-head and washer when fastening galvanised and aluminium alloy parts.

Fastenings, except high tensile, of all ferrous parts shall be steel prepared and galvanised to or sheradised to the relevant standards, primed and painted in accordance with location.

Unless specifically approved and required for superior protection, electro-galvanising, nickel, cadmium or any other plating process, except chromium plating, will not be acceptable, and shall not be offered.

E.4.12.3 Contact Corrosion

See section E.2.10.

E.4.12.4 Dismantling Joints

Dismantling joints shall be provided according to ISO 7005 and/or EN 1092-1 or equivalent standard or flange adapters as indicated on drawings or directed by the Engineer. Flanges shall comply with ISO 7005 and/or EN 1092-2, PN 10/16.

If not otherwise directed, body and glands of steel welded dismantling pieces shall be of pressure class PN 16 with bolts and nuts of stainless steel.

Surface protection shall be of one primer coat and two finish coats of solvent based two component epoxy resin. PE-sleeves for application by shrinkage and epoxy paint shall be provided for field-coating and wrapping after installation.

Rubber sealing rings made of perbunan (NBR) material; nitrile rubber or equivalent quality material shall be used.

E.4.12.5 Flexible Couplings and Flanged Adaptors

Flexible couplings and flanged adaptors shall be suitable for making a watertight flexible connection.

Surface protection shall be of one primer coat and two finish coats of solvent based two component epoxy resin. PE-sleeves for application by shrinkage and epoxy paint shall be provided for field-coating and wrapping after installation.

All mechanical couplings shall be of appropriate internal diameter, shall allow a joint deflection of up to 4° in any direction and longitudinal movements up to 9 mm. and shall be capable of withstanding the maximum working test pressure specified for the pipes they are to connect.

Flanged adaptors shall be capable of providing half of the flexibility of the couplings. Sliding action shall not provide the horizontal movement. It shall occur by deforming of the sealing rings.

All mechanical couplings and flanged adaptors shall be supplied complete with all necessary coupling rings, nuts, bolts, washers and rubber rings.

Wedge joint rings shall comply with ISO 228-1 and/or EN 681-1 or ISO 228-1 and/or EN 681-2 and shall be made of nitrile rubber, ethylene propylene rubber or other approved materials. The sealing shall be resistant against corrosive water and wastewater.

E.4.13 Tees and Wyes

Tees, crosses, couplings, Y-bends or other fittings that provide means of dividing or uniting flow in pipelines shall be factory made and shall comply with the respective standards. These fittings may be connected to pipes by welding. For connection of all kind of valves and return flow preventer, welding neck flanges shall be applied if the nominal diameter of the pipe is greater or equal 150 mm.

E.4.14 Valves, Air Valves, Hydrants and Control Equipment

E.4.14.1 General Requirements

All valves shall be flanged, if not specified otherwise, and supplied with bolts, gaskets, etc. All flanges of valves shall conform and satisfy the requirements of ISO 1452-4 and/or EN 736 1-3 and be in accordance with the required test pressure of ISO 1452-4 and/or EN 764.

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Surface boxes, covers and other accessories shall be supplied for all valves and fittings for which manholes with access opening are not foreseen. Access openings shall be positioned directly above the valves, fittings or accessories to allow dismantling with lifting facilities.

The face-to-face and centre-to-centre dimensions of flanged valves shall comply with EN 558-1 and EN 558-2, respectively.

Valves not in chambers and valves to be operated from outside the chamber shall be fitted with extension spindles and spindle support / guides. Valves installed in the ground shall be fitted with extension spindles and equipped with protection tubes. The material of the extension spindle shall be galvanised steel and the protection tube shall be PE. For valves not easily accessible, the Contractor shall furnish and install operation platforms, extended spindles, chain operated valves or such similar fittings or appliances as may be required to permit easy access for proper operation, lubrication etc.

Extended spindles and accessories (coupling, cap, extension tube, surface box) and headstocks, if required, shall be provided where necessary. Headstocks shall be provided in solid cast iron or stainless steel.

All shut-off devices shall close clockwise. This shall be indicated by 'O' (open) and 'C' (closed) with arrows either on the hand wheel or the head of a piece. Operation of shut-off devices must be easy both for opening and closing.

Manufacturer's marks, flow diameter and an arrow indicating flow direction must be visible on the device's outer surface.

Punched or forged special elements shall have this information stamped upon them.

Valves of all types shall be capable of withstanding corrosion in the ambient conditions and any parts manufactured from a material, which is not itself corrosion-resistant, must be protected.

One key and one extra hand wheel shall be provided for each type of valve delivered and installed in the system. The keys and hand wheels shall be included in the unit rates.

Profile sealing rings and O-rings shall be of EPDM or NBR suitable and approved for potable water.

All jointing material and rubber ring gasket or adaptors shall be provided by the contractor as necessary to connect the valves with the adjoining pipe material, without incurring any additional cost.

Before delivery to Site, all working surfaces shall be thoroughly cleaned and if metal, protected with grease. The initial charges of oil, grease and similar materials necessary for the correct setting to work and operation of valves and pen stocks shall be provided by the Contractor.

Packing must be sufficient to ensure complete protection of the fitting during transit and storage and all valves are to have their openings sealed until installation.

E.4.14.2 Gate Valves

Gate Valves shall comply with ISO 1452-4 and/or EN 1074-2.

Gate valves installed in chambers and buried shall be double flanged of series 14 and 15, respectively, of ISO 1452-4 and/or EN 558-1.

The body and obturator shall be of ductile iron grade EN-GJS-400-15 in accordance with ISO 148-1, ISO 6506-1 and/or EN 1563 of PN 10 / 16 / 25 with screw-less bonnet, pressure loaded and pressure sealed with easy assembly and dismantling of functional parts. Obturator shall be coated with Ethylene Propylene Diene Monomer (EPDM), thread of stem rolled, not cut.

Buried valves shall be supplied with stem nut coupling, sleeves and extension spindles of 0,5 m and 1,0 m length according to the requirements on Site. The extension spindles shall be made of hot dip galvanised iron, coupling sleeves of galvanised ductile iron, connection pins of Cr and Ni steel.

Where required, length of spindles shall be adjusted. The top of the extension spindle (key rod) shall be fitted with cast iron surface box with pre-cast concrete support of 380 mm diameter and 65 mm thickness. A suitable PE guard tube including cover shall protect the spindle itself.

Valves to be installed above ground or in valve chambers shall be provided with hand wheels of cast iron. Hand wheels shall have smooth rims and have a diameter to enable two men to operate the valve. The direction of opening and closing shall be marked on the hand wheel.

Areas of application: main pumping station, water reservoirs, transmission main, water treatment plant.

E.4.14.3 Butterfly Valves – Type Double Eccentric with Flanges

Butterfly valves of double eccentric type shall be according to ISO 1452-4 and/or EN 593, with face to face dimensions to ISO 1452-4 and/or EN 558-1 GR 14, flange dimensions and drilling to ISO 7005 and/or EN 1092-2 PN 10 / 16 / 25 and be soft sealing.

The body and disk shall be of ductile iron EN-GJS-400-15 according to with ISO 148-1, ISO 6506-1 and/or EN 1563.

Shaft, body seat, bolts and pins shall be made of stainless steel.

Drive mechanism of butterfly valves shall consist of a ductile cast iron casing with a crank or worm gear consisting of a bronze nut and a steel worm. Grease shall be provided for lifetime of the valve.

Butterfly valves installed below ground shall have the same underground equipment as the gate valves; those installed above ground or in chambers shall be hand wheel-operated.

Areas of application: main pumping station, water reservoirs, transmission main, water treatment plant.

E.4.14.4 Butterfly Valves – Type Centric to Pinch between Flanges

Butterfly valves of centric type shall be according to EN 593, to pinch between flanges with face to face dimensions to ISO 1452-4 and/or EN 558-1 GR 20, flange dimensions and drilling to ISO 7005 and/or EN 1092-2 PN 10 / 16 and be soft sealing.

The body and disk shall be of ductile iron EN-GJS-400-15 according to with ISO 148-1, ISO 6506-1 and/or EN 1563.

Shaft, body seat, bolts and pins shall be made of stainless steel 304 (minimum 1.4021) or 316 (minimum 1.4462).

Drive mechanism depends of function, dimension and operating pressure.

The following drive types are possible:

- with detent handhold
- with worm gear and hand wheel
- with electric drive including reduction gear

Areas of application: water treatment plant with limited space

E.4.14.5 Air Valves

Automatic air valves shall be able to perform the following functions:

- Aeration / vacuum breaking of large quantities of air to prevent excessive sub-atmospheric pressures;
- De-aeration of large quantities of air in a pipe at atmospheric pressure during initial filling of a pipe;
- De-aeration of small quantities of air under full internal system pressure for air that dissolves from the water at points of low pressure.

The air valves shall be suitable for reasonably clean and cold water. The basic operating principle shall comply with a kinetic air valve. It shall be suitable to operate with special gasket at internal pressures as low as 0,1 bar.

Automatic air valves shall have a single chamber and be directly operated by the flow medium. It shall have a large orifice for outlet and intake of large air volumes and a small orifice for discharge of pressurized air during service. The float shall be stabilised in a guide basket permitting high venting capacity.

The body and lid shall be of ductile iron EN-GJS-400-15 according to with ISO 148-1, ISO 6506-1 and/or EN 1563. The internal parts, bolts and nuts shall be stainless steel. The float shall be made of polypropylene.

Areas of application: transmission main

E.4.14.6 Non-return Valves – Type Nozzle Valve

Nozzle valves shall have a concentric, spring loaded obturator and be soft sealing. The length shall comply with ISO 1452-4 and/or EN 558-1 series 14-short (DIN 3202-F4), flange dimensions and drilling to ISO 7005 and/or EN 1092-2 PN 10 / 16 / 25. The advantage of this type of valve is the optimal hydraulic behaviour with a short closing path to minimize pressure surges.

The body shall be of ductile iron EN-GJS-400-15 in accordance with ISO 148-1, ISO 6506-1 and/or EN 1563. Valve plate shall be made of zinc-free bronze. The guide rod, valve ring, bolts and nuts shall be stainless steel.

Nozzle valves shall be suitable for operating in the horizontal or vertical position unless otherwise specified.

Areas of application: pressure pipe of main pumps PN 16 / PN25

E.4.14.7 Non-return Valves – Type slanted Seat Tilting Disk Check Valve

Slanted seat tilting disk check valve shall have a free swinging disc, with end position damping, with mechanical position indicator and be soft sealing. The length shall comply with ISO 1452-4 and/or EN 558-1 series 14, flange dimensions and drilling to ISO 7005 and/or EN 1092-2 PN 10 / 16 / 25.

The body and disk shall be of ductile iron EN-GJS-400-15 according to with ISO 148-1, ISO 6506-1 and/or EN 1563. Shaft bearing shall be made of zinc-free bronze. The shaft, bolts and nuts shall be stainless steel.

Slanted seat tilting disk check valves shall be suitable for operating in the horizontal or vertical position unless otherwise specified.

Areas of application: pressure pipe of raw water pumps PN10

E.4.14.8 Non-return Valves – Type Swing Check Valve

Swing check valves shall have an external shaft with lever and weight, flexible and damped double bearing of the disc and be soft sealing. The length shall comply with EN 558-1 series 48), flange dimensions and drilling to ISO 7005 and/or EN 1092-2 PN 10 / 16.

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The body shall be of ductile iron EN-GJS-400-15 according to with ISO 148-1, ISO 6506-1 and/or EN 1563. The shaft bearing shall be made of zinc-free bronze. The disk, shaft, bolts and nuts shall be stainless steel.

Areas of application: pressure pipe of service pumps

E.4.14.9 Non-return Valves – Type Check Valve with free Outflow

Check valves with free outflow shall have an external shaft with disc and be soft sealing. The flange dimensions and drilling shall be to ISO 7005 and/or EN 1092-2 PN10.

The body shall be of ductile iron EN-GJS-400-15 according to ISO 148-1, ISO 6506-1 and/or EN 1563 or polyethylene. The shaft, bolts and nuts shall be stainless steel.

Areas of application: Overflow pipes of water reservoirs

E.4.14.10 Pressure Reducing Valves

Pressure reducing valves used for pressure reduction shall be of double flanged and shall operate by use of an integral auxiliary pilot circuit suitable for the fluid and shall be actuated by the integral spring and the differential pressure on the diaphragm. For diameters less than DN 80 diameter a direct spring controlled valve may be used. Valves shall inherently close at backflow and have an indicator showing degree of aperture.

The body shall be of ductile iron EN-GJS-400-15 according to ISO 148-1, ISO 6506-1 and/or EN 1563. The housing seat and guide shall be made of aluminium-bronze. The spring, adjusting screw, guide rod, bolts and nuts shall be made of stainless steel. The length shall comply with ISO 1452-4 and/or EN 558-1 series 1, flange dimensions and drilling to ISO 7005 and/or EN 1092-2 PN 10 / 16.

The valves shall be adequately sized to control pressure differential required for the application with an accuracy of $\pm 2,5$ % of the set value. They shall be capable of operating at a sustained pressure 20 % in excess of the nominal declared working pressure.

The main pressure control valve operation shall be actuated by a hydraulic differential pressure system in balance with a spring loaded bellows type diaphragm, the reference pressure being bled from the inlet and outlet of the main valve. The diaphragm spring shall be adjustable by a screw to cover the range of pressure adjustment specified for the valve application.

Pressure gauges of appropriate range shall be provided upstream and downstream and shall be of class 1,6 100 mm diameter.

E.4.14.11 Fire Hydrants

E.4.14.11.1 Pillar Hydrants

Pillar hydrants, shall conform to ISO 1452-4 and/or EN 1074-1 and EN 1074-6.

The hydrant shall be connected to the water supply system including an isolating valve and be fitted with an inlet flange in accordance with ISO 7005 and/or EN 1092-2 and shall have two (2) outlets suitable for the connection of hose pipes, screw type.

The hydrant shall have a closed casing and cover, a valve with automatic discharge device, suspended connection piece flanged lateral or vertical to feeding pipe. The hydrant shall be installed according to drawing and as directed by the Engineer.

Hydrant bodies shall be of grey cast iron or ductile cast iron and shall be properly corrosion protected by painting according to approved international Standards.

Hydrant spindles shall be of stainless steel. Spindle nuts and body seating shall be of gunmetal or high tensile brass. Valve seats shall be of the resilient type.

Hydrants shall show no visible leakage when pressure tested in accordance with the approved Standards.

E.4.14.12 Corrosion Protection of Valves

All valves shall be internally and externally lined and coated by epoxy powder applied hot by electro-static method, complying with international Standards, coating thickness shall be minimum 250 µm. Coating shall be tested by high-voltage method for perfect cover.

E.4.15 House Connections

E.4.15.1 Water House Connections

For standard water house connections the following material shall be used:

- Tapping saddle with threaded joint to service pipe;
- Corporate stop cock for buried installation in the service pipe;
- Service pipe;
- Multiple jet water meter if applicable;
- Upstream stop cock;
- Meter box if applicable.

All material shall be tested when completely assembled.

E.4.15.1.1 Service Connections

Customer Connections shall be installed with materials as specified, according to EN Standards. The Contractor shall provide all materials of the same type from the same manufacturer to ensure uniformity of equipment for the operator. The Contractor shall supply and install all material. Connections may be required for any combination of new and existing lines with new and existing consumers.

Connections to the distribution system shall be made with pipe saddles corresponding with the main pipe's material and outside diameter. Drillings shall be made with special equipment, specially designed pipe drilling machines for under pressure drilling.

The cover of the connection pipe shall be 90 cm minimum, if required the connection has to be lowered to the required depth. The service connection pipe shall be in high density polyethylene (HDPE) material with a pressure rating of PN10. The HDPE piping shall meet the relevant ISO standards. All buried fittings including the ferrule should be manufactured from material suitable for underground use.

The Customer Water Meters shall be installed in accordance to the requirements of the local responsible water supply company. The water meters shall be sealed with a copper wire and lead seal.

Disinfection of the service connection shall be carried out at the same time as the main to which it is connected.

E.4.15.1.2 Pipe Saddles

Pipe saddles shall be of the Universal Type for DI, DCI, Steel, AC and PVC-U pipes PN 16, and, where required, shall be suitable and approved for the use with potable water.

The outlet of the saddle shall be female thread and specially protected to avoid corrosion and incrustation.

Clamping pieces (saddles) shall be of ductile cast iron, HDPE or PP. Ductile iron saddles shall be of EN GJS 400 acc. to ISO 148-1, ISO 6506-1 and/or EN 1563 or equivalent standard, inside and outside epoxy powder coated, coating thickness shall be minimum 250 µm, freedom from imperfections shall be tested by high-voltage method.

For tapping saddles for DCI pipes, the upper part of the clamping pieces (saddles) shall be of ductile cast iron EN-GJS-400 (GGG40) and the lower part shall be of stainless steel with EPDM gasket on contact side to the ductile pipe.

Saddle strap and bolts / nuts / washers shall be made of stainless steel 304 (minimum 1.4021) or 316 (minimum 1.4462). Each tapping saddle is to be supplied complete with the required nuts and bolts. Strap shall be rubber lined to avoid direct contact between the stainless steel strap and the pipe.

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If not otherwise specified or shown otherwise in the Drawings, the operating pressure is 10 bar, and the maximum allowable operating pressure is 16 bar.

Gaskets shall be of EPDM or NBR suitable and approved for potable water.

E.4.15.1.3 Service Valves (Stop Cocks)

Service Valves shall be suitable for a direct installation in the service pipe and shall allow a temporary shut-off of the house connection line in case of emergency.

Service valves shall be of the resilient seated gate valve type with integrated or adopted restraint push-on outlets for connection to PE pipes and female threads for GMS pipe connection, and shall be suitable and approved for underground installation and for the use with potable water.

Valve bodies shall be of GG 250, the bonnet of GGG 400, epoxy powder coated, and non-rising stainless steel spindle (1.4021). The sealing of the restraint socket for connection to PE pipes shall be done by an O-ring made from EPDM or NBR (suitable and approved for potable water), grip ring shall be of Poly-acetate.

The service valves shall be installed with an appropriate Extension Spindle made of steel with PE-protection tube to the street surface, additionally protected by a PVC pipe and a service valve surface box (cast iron).

E.4.15.1.4 Water Meters

Domestic water meters shall be in accordance to the requirements of the local responsible water company. Internal filter must be exchangeable without dismantling the meter.

Roller counter design for multi jet meters: 5 digits black, 4 pointers red and one low flow indicator. The roller counter shall be repairable. The roller counter shall be further prepared for afterward installation of Reed- or Radio modules.

All materials shall be anti-magnetic and not corroding. Both turbine and clock shall be fully and easily interchangeable without dismantling of body.

Meters shall be supplied with male threads according to EN ISO 228 and female sockets.

The meter shall be equipped with a non-return valve and a strainer. Both strainer and check-valve shall be detachable without breaking the seal.

E.4.15.1.5 Stop Cocks downstream of Meters

These stop cocks shall have spherical obturator with integrated passage at quarter turn opening. The material shall be as follows:

- Body: brass

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- Obturator: anti-lime deposit material or metal with anti-lime lining
- Seals: Teflon or Perbunan
- Stem: brass
- Handle: brass

E.4.15.1.6 Meter Box

The meter box shall be in accordance to the requirements of the local responsible water company. It shall be large enough to house the meter and a stop cock on either side. The test load shall be not less than 100 kN. The cover shall be made of durable glass fibre reinforced resin, the barrel and bottom of glass fibre reinforced thermoplastic material. The cover shall have an extra 50 mm thermal insulation of polystyrene, a second cover of same kind shall be placed above the meter. The cover shall close tight against surface water and dust. The mass shall not exceed 20 kg. Box shall include a bracket to hold the meter and the adjacent stop cock.

E.4.15.2 Sewer Pipeline House Connections

Connections between individual house connection boxes and the public sewer or the manholes shall be generally made of uPVC pipes DN 150. Connecting pipeline systems shall be constructed in accordance to the specification for uPVC pipes, but may include bends and other fittings.

House connection pipelines shall be measured by linear metres run along the centreline of the pipe from the centre of the house connection box to the centre of the sewer. The unit rates for the connecting pipelines for house connections shall include:

- trench excavation;
- pipe laying of uPVC pipes DN 150;
- embedding and backfill of trenches to surface;
- the building-in of uPVC pipes DN 150 to the manholes including all fittings.

E.5. INSPECTION AND TESTING OF PIPES AND FITTINGS

E.5.1 Testing at Place of Manufacture

Prior to shipment, all material, pipes, fittings and pipeline appurtenances, shall be tested at the place of manufacture in accordance with the approved supplier's / manufacturer's quality assurance system, applicable standards and recognised best business practice. The same applies for the Contractor for his part of supplies, as applicable.

The Contractor shall submit a certificate from the manufacturer certifying that all items have successfully passed the relevant tests prescribed by the respective Standard Specifications. Copies of current authenticated test results in accordance with the manufacturing standard shall be submitted.

Any or all materials and manufactured articles supplied by the Contractor shall, if so required by the Engineer, be tested in advance at the Contractor's expense in accordance with the tests specified in the applicable standards. The Contractor shall arrange for a co-operation with a certified testing lab for the needed testing (third party control).

Mill testing of sewerage pipes shall include one sample of 3 pipes for every 500 m.

E.5.2 Third Party Control

The Contractor shall at his own expense provide a recognized, independent third party control to ensure that the pipes, fittings and other appurtenances are all manufactured in accordance with their respective standards and who shall, among other duties and obligations, testify that they have witnessed all mill tests prescribed by the relative standards and that the material manufactured fulfil in every respect the requirements of the Contract and who shall check the materials in respect of proper packing and certify the Bill of Loading.

Before signing the Contract, the Contractor shall inform the Employer of the name of the control party he intends to engage, and obtain the Employers approval.

E.5.3 Testing of Sewers

The testing of sewers shall include:

- a) tests for straightness and obstructions;
- b) checks on infiltration, and
- c) tests for water tightness in accordance to Section E.5.4.

Repair and making good of defaults observed after testing includes, as directed by the Engineer, the correction of alignments and levels and the properly fixing of any two pipes.

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Brushing, grouting, cementing or concreting of pipes is not allowed, neither before nor after running the tests. All necessary repairs, re-testing and replacement ordered by the Engineer shall be at the Contractor's expense.

E.5.3.1 Tests for Straightness and Obstructions

Tests for straightness and obstructions will be carried out by means of visual inspection and/or CCTV survey in accordance to Section E.5.5.2.

Visual tests for linearity and freedom from obstructions shall be carried out after completion of the works and be performed by means of a lamp and mirror. Invert levels of the sewers and inspection chambers shall be tested and verified with levelling instruments.

Carrying out visual checks, the Contractor shall ensure that no unprotected lights are used in existing sewers and manholes or in any new sewers and pipelines in which risks of explosion may be given due to the presence of gases.

If the linearity of a sewer line between two manholes is not given, the Engineer may order to dismantle and relay the pipe or to arrange for an additional manhole at the bending ensuring the linearity between two neighbouring manholes.

E.5.3.2 Checks on Infiltrations

Infiltration checks shall be performed when backfilling is completed and all inlets to the length of sewers under testing have been effectively sealed. For sewers, not exceeding 500 mm nominal diameter, the infiltration rate shall be below 0,05 l/h per 100 linear meters and per mm of nominal bore.

Manholes and inspection chambers will be visually inspected for water tightness against infiltration after backfilling has been completed and groundwater table is at its highest level. Under these conditions no visible infiltration flow shall be admitted.

E.5.4 Water Tightness Testing of Pipelines

E.5.4.1 General

All pipes have to be tested. The tests have to be performed before backfilling of the trenches. Before pipe testing the trench must be filled on the pipe barrels, leaving the joints uncovered so as to prevent the pipeline from moving whilst leaving the joints accessible. Before testing any pipeline, the Contractor shall ensure that it is anchored adequately and that thrusts from bends, branch outlets or from the pipeline ends are transmitted to solid ground or to a suitable temporary anchorage. Thrust blocks must be constructed before testing. On roads with heavy traffic the backfilling at joints may take place before testing if the Engineer so allows in writing.

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The Contractor shall provide labour, install and work the test pump, pressure gauges and all other equipment required for the test and he shall fill the pipes with water and subsequently empty them after the test, all to the approval of the Engineer. Water drained from the pipes shall be discharged in a way that does not affect the stability of the Works or adjacent structures.

The Contractor shall be deemed to have allowed for all expenses in connection with pipe testing.

Before any water tightness test at pressure and non-pressure pipelines commences, the pipelines shall be cleaned by flushing, pigging or swabbing. All flushing, pigging and swabbing shall be included in the unit prices for pipe installation and repetitions of the procedure shall be entirely at the Contractor's expense. It is therefore in the Contractor's interest to maintain the cleanliness of the pipe during and after installation.

The ends of pipes under test shall be closed by means of plugs, caps or blank flanges with anchors all provided by the Contractor. Valves must not be used for this purpose. All scour valves and air valves shall be replaced by blank flanges before the commencement of the tests.

Potable water shall be used for the cleansing, testing and swabbing of water supply pipelines unless otherwise directed by the Engineer. Stand pipes for extracting water from the public supply system shall be in accordance with the requirements of the supply authority. As a minimum a check valve system shall be provided between the public supply and the item being filled to prevent the possibility of backflow.

After laying, jointing and anchoring the pipe shall be slowly and carefully charged with water so as to avoid water hammer and all air shall be released through the upper pipe end or in case of an intermediate high point by installing a service connection with a tap. Pipes internally lined with mortar shall be allowed to stand full for at least 24 hours before testing.

The test pressure shall be applied by means of a manually or motor operated test pump connected to the pipe and two parallel installed pressure gauges calibrated at an approved testing laboratory.

All joints, pipe foundations and the like shall be inspected during testing and pressure shall be maintained until such inspections are completed or as specified by EN 805 for the duration of testing, which ever lasts longer.

Should leakage of water occur at the joints, the joint shall be reassembled to eliminate such leakage or, should this not prove possible, the Contractor shall supply and assemble new joints at his own expense. Should any pipe or joint burst or should water leak through the body of a pipe or joint the Contractor shall forthwith remove the faulty pipe or joint and replace them with new at his own expense. No makeshift repairs or application of patching compounds shall be permitted. In all the above cases the length under test shall be re-tested as above described and the process repeated, if necessary, until the pipeline satisfactorily withstands the prescribed test.

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In the event that pressure loss encountered during test is higher than acceptable and/or any visible leak occurs or any foundation or puddle flange is found to have moved or cracked or appears damaged in any way, or if any pipe barrel or flange shows deformation, the test shall be declared as being unsuccessful.

With the approval of the Engineer pipelines with an internal diameter greater than 100 cm may alternatively be tested by a combination of visual inspection from the inside and the use of equipment designed to test the tightness of individual joints. This test, however, does not relieve the Contractor of his obligation to guarantee watertightness of pipelines. Furthermore, individual joints have to be testable (i.e. double gasket with spacing and devices to connect test equipment).

Should the losses in any line tested exceed the permissible leakage by more than 5 %, the Contractor shall determine the cause of the failure and shall locate, excavate and repair any damage or leakage sustained by the pipeline before or during the tests, and after repairing and making good any leaks, carry out further tests to prove evidence of the permissible leakage rate. The cost of such repair work, including (but not limited to) additional excavation and back-filling; repair or replacement of pipes; and the abortive test shall be borne by the Contractor.

No visible sign of leakage will be accepted. If a leak occurs in the pipeline it shall be located and shall be made good by the Contractor at his own expense before restarting the test.

If, during iterated testing the loss rate fails the permissible leakage by more than 5 %, the line shall be dismantled and reconstructed with new pipes at the Contractor's expense. The above procedure shall apply also for lines and house connections which are to be tested after backfilling, whereby a tolerance of 15 % from the permissible leakage rate infiltration shall be allowed.

If the calculated leakage rate is within the allowable leakage rate, the test water shall be transferred to the next section of the pipeline to be tested or disposed of as approved by the Engineer.

E.5.4.2 Test Report

A test report shall be prepared in respect of each and every test performed. The test report shall contain as a minimum the following data:

- Number and date of the test;
- Description of the stretch tested with unambiguous indication of the extremities of the stretch;
- Sketch showing in the order of laying, the number and the characteristics of the pipes, the fittings the specials and other apparatus incorporated in the stretch;
- Duration of the test, test pressure, results obtained;
- Decisions relative to possible repair works and conclusions.

The test report shall be signed by the Contractor and the Engineer.

A certificate shall be signed by the Engineer and the Contractor and the chart of the test attached. This certificate shall be produced when applying for Taking Over of any particular area. This documentation shall be prepared by Contractor and comprise all relevant information.

E.5.4.3 Pressure Testing of Mains

Pressure pipelines (together with all specials and valves incorporated) shall be tested with water in accordance with EN 805.

The Contractor shall provide all test rigs, temporary blind flanges, caps, plugs, pressure gauges, pipe connection cocks, Struts, Thrust blocks, pressure raising equipment, pressure recording instruments and all other necessary equipment to satisfactorily carry out the tests as specified in this Requirement. The Contractor shall further supply all labour and supervision needed for the performance of the tests and recording the results.

All gauges and equipment are to be submitted for approval to the Engineer. All test gauges shall be dead weight tested and proved at the commencement of use and at regular intervals thereafter as required by the Engineer. A pressure recorder shall be installed to provide a continuous record of the test and the chart submitted as part of the documentation for each pressure test performed.

The Contractor shall submit a systematic procedure for testing and a method of filling and draining all mains and pipework for approval to the Engineer. The pressure drop method shall be applicable as set forth by ISO 24516 and/or EN 805.

Prior to testing any pressure pipeline the Contractor shall submit for the Engineer's approval details of all temporary thrust blocks. These details shall be submitted with sufficient calculations to demonstrate that the thrust blocks will resist the specified test pressure. The

The Contractor shall supply all of the water required for the tests. Water may originate from the existing distribution system through direct connections or through hydrants, where permitted by the Employer in writing and approved by the Engineer or from Contractor's tanker trucks. Before start of test, air must be completely removed from the test section as its presence falsifies the test results.

Pipes shall be filled with potable water and tested in sections of convenient lengths, which must not exceed 500 meters. Where pipes are laid with steep gradients the length of pipes tested at any one time shall be as directed by the Engineer.

The Contractor shall perform the hydrostatic test, on all complete piping, prior to field coating of welds and fittings and prior to backfilling of the joints.

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Before testing, valves shall be checked and sealed, the sections of main filled with water and the air released. After having been filled, pipelines shall be left under operating pressure for the period specified in ISO 24516 and/or EN 805, so as to achieve conditions as stable as possible for testing.

The Contractor shall provide and fit any test heads required, and the Engineer shall be informed in time to make a final check of each section to be tested before test heads are connected. The Contractor shall ensure that any necessary bosses on the test heads or pipework are included as required for filling and venting during Site testing. Fill and vent points in the pipe shall be closed afterwards. Thrust blocks shall be provided and removed after testing. Tests shall not be performed against valves but against blank flanges and test heads exclusively. Pressure testing against closed valves or air valves will not be permitted.

Calibrated manometers of class 0,6 Ø 160 mm shall be used for testing and be placed at the lower end of the test section. Gauges used for testing pressure pipelines shall be capable of reading increments of 0,1 m head. The Contractor shall be responsible for the independent calibration of the gauge prior to commencement of testing.

System Test Pressure (STP), test duration and criteria for successful test shall be as indicated in the following table. The test pressure always applies to the lowest point of a test section.

Pipe material	Test Pressure (STP)	Test Duration	Successful test criteria
Ductile cast iron pipelines	PN 10: 1,5 MPa PN 16: 2,1 MPa	DN ≤ 200: 3 hours 200 < DN ≤ 400: 6 hours DN > 400: 12 hours	Max pressure drop for: PN 10: 10 kPa PN 16: 15 kPa
Steel pipelines	PN 10: 1,5 MPa PN 16: 2,1 MPa	DN ≤ 200: 3 hours 200 < DN ≤ 400: 6 hours 400 < DN ≤ 700: 12 hours DN > 700: 24 hours	Max pressure drop for: PN 10: 10 kPa PN 16: 15 kPa
Reinforced concrete pipes	PN < 0,25 MPa: 1,4 x PN PN > 0,25 MPa: PN + 0,1 MPa	DN ≤ 700: 12 hours DN > 700: 18 hours	Average replaced water losses during the first 6 hours: less than 0,15 l/m ² /hour (wetted inner surface)
Prestressed concrete pipes	PN < 1,00 MPa: 1,5 x PN PN > 1,00 MPa: PN + 0,5 MPa		Average replaced water losses during the first 6 hours: less than 0,02 l/m ² /hour (wetted inner surface)
PVC, HDPE pipes	Test according to EN 805		
GRP pipes	Test method of EN 805 shall be applied		

E.5.4.4 Pressure Testing of Plumbing Systems

The hydraulic test pressure of plumbing systems shall be 1,5 times the maximum working pressure for a period of 30 minutes. In addition to the above the equipment shall be inspected

and tested after erection. On completion all plumbing systems shall be flushed out with clean water and then subjected to a hydraulic test of 1,5 times the working pressure for a period of not less than 30 minutes. All welds shall be hammer tested and remain firm. A normal working test shall then be carried out with the plant operating temperature.

During this test all necessary adjustments and regulations of valves shall be effected. Installations or sections thereof which will be embedded in the structure or concealed in permanently sealed ducts, trenches etc. shall, in addition to the above specified tests be individually tested as they are laid before being embedded or concealed. All pressure tests specified above shall be carried out before the application of thermal insulation.

E.5.4.5 Water Tightness Testing of Gravity Pipes and Mains

E.5.4.5.1 General Requirements

Testing the water tightness of the gravity pipelines and chambers shall be in compliance with EN 1610. All costs related to these test are including in the sewer pipe laying unit rates.

Gravity pipelines shall preferably be tested with water. Air tests are subject to the approval of the Engineer.

Two types of water testing shall be implemented:

- Pipeline testing;
- Chamber testing.

Combined testing of pipelines and chamber(s) is not allowed.

The tests shall be implemented after laying the pipelines and chambers, before any concrete surround or backfill is placed, other than such as may be necessary for structural stability whilst under test.

The pipelines shall be tested in lengths applicable to the construction activities and in accordance with the programme.

A further test shall be carried out when any concrete surround has been completed and when backfill has been placed and compacted to a depth of 300 mm above the crown of the pipeline

The test schedule shall be approved by the Engineer.

E.5.4.5.2 Pipeline Testing

All lengths of sewers shall be tested for water tightness by means of hydrostatic testing. Hydrostatic testing shall be applied after partial backfilling leaving the joints exposed. Testing shall be carried out from manhole to manhole. Short branch laterals connected to the sewer may be tested as one system with the sewer. Long branches and manholes shall be separately tested.

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The tested element shall be sealed with adequate pipe plugs (LAMPE or equivalent). It includes pipes connections to the tested element.

The hydrostatic testing shall be carried out as follows:

- a) After completing the installation and covering of a sewer line or a section of the line, hydraulic testing of the line shall be performed, when directed by the Engineer. The test pressure shall be 1,0 m head of water at the highest point of the section under consideration. The length of each section to be tested shall not exceed 100 m and the pressure at the lowest point of the section shall not exceed 5,0 m head of water;
- b) At the upper end of the sewer a gauge glass shall be connected to the sealing plug to enable the observation of the water level during the test. The gauge glass should have an inner diameter of approx. 50 mm and shall be provided with a mark located 1,0 m above the top of the sewer. An air vent and a cock should be installed at the same end as to allow for the release of air during the filling of water for testing;
- c) The pipe shall be filled with water for a period of minimum 2 hours and maximum 24 hours before testing in order to allow for an adequate soaking period and the complete release of air. The water level shall be kept at the mark of the gauge glass during the entire soaking period. The hydrostatic test shall be carried out immediately after the soaking period;
- d) The leakage of the pipe is defined as the quantity of water which must be supplied to the pipe during 30 minutes to maintain the specified water level. The additional quantity of water filled into the pipe shall be measured with an accuracy of 0,1 litres. The losses shall be replaced steadily;
- e) The sewer will be accepted in respect of water tightness if the water loss after 30 minutes is not higher than 0,15 l/m² of pipe surface in contact with water (wetted inner surface) and if no other leakage is visible.

E.5.4.5.3 Chamber Testing

The pipe connections of the tested chamber shall be sealed with adequate pipe plugs. The chamber shall be filled with water up to 10 cm below cover level.

The volume of water loss and the related water pressure shall be measured and record during 30 minutes with interval of 0,1 l (i.e. accuracy).

The test shall be considered as successful if the water loss after 30 minutes is not higher than 0,40 l/m² of the chamber surface in contact with water.

E.5.4.5.4 Air Test for Non-Pressure Pipelines

Pipelines to be air tested shall have air pumped into the length under test until a pressure equivalent to 100 mm of water is indicated on a U tube gauge connected to the system. The pipeline shall be accepted if the air pressure does not fall below 75 mm water gauge after a period of five minutes without further pumping.

E.5.5 Inspection of Pipelines

The contractor shall furnish and maintain in good condition, all equipment necessary for the proper execution and inspection of the work.

E.5.5.1 Pipe Pigging

Pipes from thermoplastic or any other flexible material with a nominal diameter in excess of 150 mm shall be tested for ring deflection by pulling a mandrel through the pipe. This test shall be performed 3 months after backfill is completed. Mandrel shall be a minimum of one pipe diameter long and mandrel diameter shall be sized in accordance with pipe manufacturer's requirements for maximum ring deflection.

If mandrel cannot pass through pipe it will be assumed that ring deflection has been exceeded. In this case pipe shall be uncovered, removed and replaced. Special attention should be directed to pipe bedding. In no circumstances shall deflections exceeding 5 % of the nominal bore be acceptable

Where pipes are found to have deflected in excess of the approved limit the pipes shall be uncovered, removed and replaced.

The Contractor shall provide for the Engineer's use copies of all data relating to pipe deflections.

E.5.5.2 CCTV Inspection

E.5.5.2.1 General

Pipe systems with nominal diameter equivalent or in excess of 200 mm shall be inspected by close circuit television (CCTV) prior to acceptance of works. The CCTV survey should be executed after completion of construction of new pipelines and before and after the rehabilitation of the existing pipelines, if any. The inspection shall be conducted in the presence of the Engineer.

The CCTV inspection shall be carried out in accordance with EN 13508. Both the pipes and the manholes must be inspected and their condition assessment documented.

Necessary safety measures shall be observed when entering the manholes, which includes the use of gas detectors, forced ventilation, safety ropes and protective clothing. Generally all safety measures and traffic requirements shall be followed during the implementation of the CCTV survey.

Suitable measures are to be taken for the regulation, securing and stoppage of traffic, in agreement with the responsible road authorities.

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Before the start of the CCTV survey, the Contractor shall prepare and submit to the approval of the Supervisor a method statement providing at least following information:

- technical data of the equipment which is proposed to be used for the CCTV Survey;
- proposed procedure for the implementation of the survey including preliminary cleaning of the sewer section to be inspected;
- proposed health and safety and traffic regulation measures;
- recording method and data delivery: proposed coding of defects, template CCTV-survey data sheet, etc...

Should the results of this inspection reveal any defects, the contractor will be required to repair or replace these defects as ordered by the Engineer at the sole cost of the contractor.

E.5.5.2.2 Flushing and Cleaning

Prior to the inspection, the pipeline to be inspected shall be thoroughly cleaned to remove grit, loose solids, grease and any other debris that are present.

All sludge, dirt, sand, rocks, grease, and other solid or semi-solid material resulting from the cleaning operation shall be removed at the downstream manhole of the section being cleaned. All solids or semi-solids resulting from the cleaning operations shall be removed from the site and disposed of at a suitable landfill or disposal site.

Prior to camera inspection water shall be flushed through the pipe being inspected to make low points easier to detect. Additionally, during camera inspection the Engineer may require flowing water through the pipe.

E.5.5.2.3 CCTV Inspection Report and Deliverables

After completion of works, the Contractor has to prepare the CCTV documentation report in accordance to the EN 13508, including digital data recording and identification of deficiencies which allows classification of damage in accordance to the coding system of EN 13508.

The TV inspection shall be recorded in colour in full length on a digital support. Log sheets indicating date of inspection, location of services, any manholes, direction of view, pipeline length, and all found defects shall be kept during inspection. Digital files shall be numbered and marked with the location of the inspection.

The results of the inspection shall be recorded in digital form on an appropriate medium like DVD or similar. Notes shall be taken during the inspection and written on a standard survey data sheet. Photographs of particular sections of sewer shall be taken from the video recording in case of special occurrence regarding structural defects or conditions of the sewers and other particularities.

The results of the CCTV inspection shall be submitted to the Engineer and to the Employer in the form of:

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- a CCTV survey report including the method statement, duration and condition of survey, and CCTV survey data sheets for all surveyed sections in an appropriate format submitted in hard and soft copy with pictures of all relevant defects or particularities detected during the survey;
- colour videos of the whole network inspection on DVD or similar with a clearly defined content of each. The following minimum information shall be indicated on the videos:
- a scheme of pipeline inclination.

As a minimum, following parameters shall be recorded and qualitatively assessed:

- branches, connections, inlets and joints;
- obstacles;
- positional deviations;
- any bellies in a joint of pipe;
- mechanical wear, corrosion;
- deformations, alterations;
- cracks, fractures;
- leakages and infiltrations.

Photographs shall be clearly identified in relation to the location (minimum requirement manhole start and finish numbers or pipe length reference numbers) survey direction, chainage, photograph number, and date when the photograph was taken. The annotation shall be clearly visible and in contrast to its background, and be type printed. The annotation shall be so positioned as not to interfere with the subject of the photograph.

The photographs shall be presented in chronological order and each file shall contain a contents page providing clear cross-referencing to the report. The minimum requirements of the contents page shall be locations (town and street name), photograph numbers and dates when photographs were taken.

The detailed content and form of the report is to be agreed with the Engineer. All costs shall be borne by the Contractor.

The CCTV Survey Report and video of the inspection shall not be submitted later than 10 working days after the survey of the respective section was done. The complete CCTV survey report shall be submitted not later than 10 working days after finalising the complete CCTV survey.

E.5.5.2.4 Camera

The camera shall be remotely controlled and mounted on a self-propelled crawler with an accurate remote reading footage counter that displays on the monitor and on the record the camera distance from the centreline of the starting manhole. The footage counter shall be checked and calibrated, if required, before inspection begins. The camera runs should start

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from the upstream end of the pipe being inspected. The Camera shall be in focus and display a clear view of the pipe on the field monitor and meet following requirements as a minimum:

- The camera shall be detachable unit with compatible crawler;
- The camera, when fitted to the crawler, shall be capable of unrestricted use in a minimum pipe diameter of 200 mm;
- The camera shall be of the remotely operated pan and tilt type;
- The rotational range of the camera shall be 180 degrees in the vertical and horizontal planes. Scanning of view on screen shall always be oriented to the top;
- The camera's scanning movements shall be capable of being operated remotely from controller;
- The focus for the camera shall be operated remotely;
- The camera shall have a depth of range for inspecting the immediate pipe wall and up to a distance of at least five (5) metres away from the camera;
- The camera head shall be waterproof to a depth of 50 metres, explosion proof and gas tight;
- Lighting shall be integrated in the carriage and shall be capable of providing adequate illumination in the pipe up to one (1) metre ahead of the camera regardless of pipe material. The intensity of the lighting shall be constant so that true colour can be seen. The light input shall be controlled through an automatic iris in the camera head with remote control capability for manual override.

The photographic camera and illumination system shall be capable of providing an accurate and clear record of the sewers / pipeworks internal condition.

E.5.5.2.5 Camera Speed

The speed of the camera in the sewer shall be limited to 0,1 m/s for sewers of diameter less than 200 mm, 0,15 m/s for diameters exceeding 200 mm but not exceeding 310 mm and 0,20 m/s for diameters exceeding 310 mm, or such other speed as agreed by the Engineer to enable all details to be extracted from the video tape recording. The camera shall be "stopped" whenever a defect is encountered, until the defect has been noted on the coding sheet.

E.5.5.2.6 Control and Operating Unit

The CCTV system shall include a control and operating unit to the following requirements:

- a) It shall consist of a high quality colour monitor which shall be of a minimum 14" size diagonally and which can be adjusted for brightness and contrast;
- b) The control unit shall be capable of remotely operating the crawler and camera with respect to all functions described above. A joystick type control shall be used for camera scanning;
- c) The control unit shall have the capacity, including all connection points and circuitry, necessary for the connection of the following components:

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- Video recorder
 - PC and appropriate software
 - Additional monitors
- d) It shall have an integral text writer capable of displaying time, date, chainage, text, etc. It shall also have on-screen help text available to the operator. Other features such as pointers, display modes, special fields and text memory features shall be available.
- e) The control unit shall be capable of displaying a graphic representation of the position of the camera view on the screen. Tractor speed and internal high / low pressure also be displayed on screen;
- f) The control unit shall be able to display information on the monitor (and on any hard copies taken from that monitor) relating to the district in which the inspection is taking place, manhole numbers, sewer length, chainages etc., and any other relevant information.

E.5.5.2.7 Linear Measurement

The CCTV monitor display shall incorporate an automatically updated record in metres and tenths of a metre of the meterage of the camera position from the cable calibration point. The Contractor shall use a suitable metering device, which enables the cable length to be accurately measured; this shall be accurate to $\pm 1\%$ or 0,1 m whichever is the greater.

E.5.5.2.8 Data Display, Video Recording and Start of Survey

The Contractor's surveyor shall ensure that the meterage counter starts to register immediately the camera moves. At the start of each manhole length a data generator shall electronically generate and clearly display on the viewing monitor and video recording a record of data in alpha-numeric form containing the following minimum information:

- Automatic update of the camera's meterage position in the sewer line from adjusted zero;
- Sewer / pipe dimensions;
- Manhole / pipe length reference numbers;
- Upstream and downstream manhole number;
- Date and hour of survey;
- Road name/location;
- Direction of survey and direction of normal flow;
- Time of start of survey;
- Sewer Use.

The size and position of the data display shall be such as not to interfere with the main subject of the picture.

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Once the survey of the manhole length is underway, the following minimum information shall be continually displayed:

- Automatic update of the camera's meterage position in the sewer line from adjusted zero;
- Sewer dimensions;
- Manhole / pipe length reference number;
- Direction of Survey.

E.6. DISINFECTION

The disinfections shall be carried out in accordance with the following procedure. This procedure shall be carried out before being commissioned.

The entire disinfection procedure requires documentation in written form and confirmation by the Engineer.

The Contractor shall include all costs of labour, transport, materials, equipment, chemicals and water necessary for the satisfactory completion of the cleansing and sterilisation operations in his prices. The Contractor shall be responsible to maintain the quality of the works from disinfection to commissioning at his costs.

Disinfection of water supply facilities shall be carried out in accordance with EN 805.

EN 805 recommends several disinfectants. The disinfection agent can be Sodium hypochlorite NaOCl or Calcium chlorite $\text{Ca}(\text{ClO}_2)_2$. The disinfectant may be selected by the Contractor and submitted to the Engineer for approval together with the method of application. It is recommended to use a hypochlorite solution; the process for the hypochlorite solution is given hereinafter.

The concentration of the disinfection's agent per litre in the water must be between 35 and 50 mg/l. The duration of disinfection shall not remain under 12 hours. After that period the facilities shall be flushed with potable water.

Any effluent from the disinfectant shall be duly neutralised and disposed in compliance with local regulations.

The entire disinfection procedure requires documentation in written form and confirmation by the Engineer.

The Contractor shall be responsible to maintain the quality of the works from disinfection to commissioning at his costs.

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

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Section VII: Employer's Requirements

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b) Technical Specifications

General Technical Specifications

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- b) Technical Specifications
 - Particular Technical Specifications
 - General Technical Specifications
- c) Specifications for Project Area Environmental, Social, Health and Safety Management (ESHS)
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3. Supplementary Information

- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
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List of Acronyms

ASTM	American Society for Testing and Materials	PE	Polyethylene
BS	British Standard	PN	Nominal Pressure
BSt	British Standard	PP	Polypropylene
CEM	Cement	PU	Polyurethane
DIN	Deutsches Institut für Normung (German Standard)	PV	Prefabricated Vertical (drains)
DN	Nominal Diameter	PVC	Polyvinyl Chloride
EN	European Norm	SST	Stainless Steel
EPDM	Ethylene Propylene Diene Monomer	STP	Standard Test Pressure
GRP	Glas fibre Reinforced Polyester	SWG	Standard Wire Gauge
ISO	International Organisation for Standardisation	TR	Technical Report
KTL	Kathodische Tauchlackierverfahren (cathodic dip coating process)	TS	Technical Specifications
		UV	Ultraviolet
		WC	Water Closet

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

F.1. GENERAL

F.1.1 Scope

This sub-section covers the requirements for the construction of buildings and includes all building works, except earth and concrete works.

F.1.2 Standards and Rules

The Contractor shall carry out the works described in this Section in accordance with the appropriate ISO, EN, or equivalent international standards. The main standards include, but are not limited to, the following:

Cement	ISO 679, EN 197 ;
Mortar	ISO 13765, EN 459, EN 1008, EN 13139 ;
Concrete, reinforced concrete	ISO 22965, ISO 22966, ISO 15673, EN 206, EN 1008, EN 12620, EN 13055, EN 10080 ;
Bitumen	EN 12591, ASTM D4-86;
Brickwork and blockwork	ISO 5019, EN 413, ASTM C216;
Damp-proof course	ISO 13787, ISO 18566, EN 1094-1, ASTM C1696;
Plastering	EN 13914-1, EN 998, ASTM C932;
Floors	ISO 17959, ISO 9239-1, ISO 24342, ISO 24334;
Wall tiling	ISO/TR 17870, EN 12004;
Carpentry and joinery	ISO 13910, ISO 17754, ISO 8970, ISO 18100, EN 338, EN 912, EN 942, EN 1312 EN 1313;
Structural steel works	EN ISO 3452, EN ISO 1461, EN ISO 9934, EN 287, EN 10056;
Glazing	ISO 22897, ISO 16940, ISO 16934, ISO 16936, ISO 28278-2, EN 1096-4;
Painting	ISO 1514, ISO 8501, ISO 8502;
Slating and tiling	ISO 13007, ISO/TR 17870-1;
Stairs, ladders and walkways	ISO 3881, EN 1412;
Roofing	ISO 10904, EN 490, EN 491 EN 538, Plumbing ISO/TS 24522, EN 805, EN 1254-4.
Sanitary	EN 752, ISO/TS 7024, ISO/TR 4191;
Ventilation	ISO 13349, EN 12792, EN 13141 ;

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Fences	ISO 7900, BS 1722 ;
Safety of Machinery	EN ISO 14122, ISO 12100.

The designs shall be carried out in accordance with:

1. EN 1990 Eurocode 0: Basis of structural design;
2. EN 1991 Eurocode 1: Actions on structures ;
3. EN 1992 Eurocode 2: Design of concrete structures;
4. EN 1997 Eurocode 7: Geotechnical design;
5. EN 1998 Eurocode 8: Design of structures for earthquake resistance.

F.1.3 Approval of Materials and Workmanship

The supply of all materials and items shall be subject to the approval of the Engineer.

F.2. MASONRY WORKS

F.2.1 Materials

F.2.1.1 Bricks and Blocks

Bricks shall be clay facing bricks manufactured locally. Blocks shall be dense concrete blocks in accordance to ISO 5019 with a compressive strength of more than 7,5 N/mm². Bricks and blocks shall be hard, sound, square and clean with sharp, well defined arises.

The Contractor shall submit samples of each type of bricks and blocks used in the works and obtain the Engineer's approval before placing orders with suppliers. Strength test certificates performed on the basis of appropriate approved international Standards shall also be submitted on request of the Engineer.

External walls shall have interlocking junctions. The junctions of internal walls can be constructed using butted joints and high-grade steel stabilisers. The connecting joints shall be completely filled with mortar.

In the case of fairfaced brickwork, care shall be taken to maintain the surfaces clean during construction. The faces shall be covered with bags or reinforced paper for protection against falling mortar and splashes from scaffold edges.

F.2.1.2 Reinforcement for Brickwork

Reinforcement of brickwork shall be in accordance with ISO 22965, EN 206, EN 998-1 and EN 10800 or equivalent international standard. Reinforcement for blockwork shall be plain round bars BST 22/34 GU or ribbed bars BSt 22/34. Reinforcement shall be detailed, stored and tested as specified for Concrete Works.

F.2.1.3 Fixings for Brickwork

Fixings shall be, if not otherwise specified by the Engineer, of stainless steel for sheet, strip, plate and bars in accordance to EN 10088 and other relevant international Standards.

F.2.1.4 Sand

Sand shall be clean and sharp coarse grit, fresh water river or pit sand conforming in all respects to ISO 20290, ISO 19595, EN 12620 and EN 13139 and shall be re-washed on site if the silt, loam or clay content exceeds the limits prescribed in the relevant Standards. The sand shall be obtained from a source approved by the Engineer.

F.2.1.5 Cement

Cement shall be sulphate resisting Portland cement as specified in EN 206. The source of cement is subject to the approval of the Engineer and shall not be changed without his prior approval.

F.2.1.6 Water

For the mixing of mortar and plaster the Contractor shall provide tap water, if not otherwise instructed or approved by the Engineer.

F.2.2 Mortar Mix

Masonry mortar for setting blocks and bricks shall be of the quality group III set out in ISO 13765 and EN 998-1. The proportion shall be 1 part cement to 4 parts sand or as otherwise instructed or approved by the Engineer. Water shall be added to the mix in an amount compatible with workability. Mortar constituents shall be measured by volume using clean gauge boxes.

The ingredients for cement, lime and sand shall be measured in proper gauge boxes on a boarded platform, the ingredients being turned over twice dry and twice while water is added through a hose.

Mortar shall be mixed in a mechanically operated mortar mixer for at least three minutes after all ingredients are in the drum and the mixing time shall not be less than 5 minutes. The mixing by hand will only be permitted when the quality of hand mixing is comparable to mechanical mixing.

Mortar shall be used within 2 hours after discharge from the mixer at normal temperatures. No mortar shall be used after the initial set has taken place. Reconstitution of mortar will not be permitted.

The mortar is to be mixed only in quantities as required for immediate use. Cement mortar shall be used within one hour of mixing and lime mortar within two hours of mixing.

F.2.3 Workmanship

All masonry shall be laid plumb and true to lines and built to the thickness and bond required. Masonry shall be carried out in a uniform manner. No one portion shall be raised in height more than one metre above adjacent portions, except with the approval of the Engineer.

Sample panels of 1 m² size shall be prepared for each type of facing brickwork or blockwork, including jointing or pointing, and the Contractor shall not commence facework without the approval of the Engineer. Facework shall be kept clean during construction and until completion of the Works.

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Under hot and dry weather conditions, bricks and blocks shall be stacked on a hard standing level so as to prevent the absorption of water. Suitable shading shall be provided to prevent high temperatures within the brick and block stacks. Clay brickwork and blockwork shall be kept wet to the minimum extent required to prevent mortar drying out prematurely. Freshly laid brickwork / blockwork shall be protected during interruption through rain and at the completion of each day's work.

Facework shall be kept clean during construction and until practical completion. Scaffold boards shall be kept clear of the building at night and during heavy rain. Rubbing to remove stains will not be permitted.

All bricks shall be wetted before being laid.

Clay bricks shall not be used until completely cold from the kiln.

Facing bricks of varying colour shall be distributed evenly throughout the work so that no patches appear. Different deliveries, which vary in colour, shall be mixed to avoid horizontal stripes. Brickwork and blockwork abutting concrete columns, walls and beams shall be tied with stainless steel ties in accordance with the relevant references and as directed by the design. Additional ties shall be supplied at openings. Walls which are to be fair face shall have selected bricks and blocks with perfect arises and flat surface structures and with faces in line.

F.2.4 Exposed Concrete Blocks

Concrete blockwork shall be laid in stack bond and, unless otherwise directed, with joints not exceeding 1 m and uniform throughout. All blocks shall be laid in a full bed of mortar applied to shells only. Intersecting bearing walls shall be tied together with stainless steel ties at one metre vertical spacing.

Where directed, concrete blocks shall be reinforced and concrete blocks lintel type shall be built in above wall openings.

Hollow blocks must be uniform in size, colour and compressive strength and shall be thoroughly watered before use, so that they do not absorb any water from joint mortar. Hollow blocks with broken edges or otherwise damaged shall not be used.

Control joints shall be installed at the intersection with structural concrete and elsewhere where joints are useful. Joints not detailed otherwise shall be raked out to a depth of 2 m for the full height of the wall and be caulked. Joints are to be examined to locate cracks, holes or other defects and all such defects shall be remedied with mortar and pointed.

F.2.5 Concrete Blocks to receive Plaster

Concrete block walls to be plastered may be laid with bonds described above. Joints are to be left rough to assist in bonding of plaster. Control joints in plastered block shall be carried through the plaster. The joint shall not be plastered.

F.2.6 Brickwork

Solid brick walls shall be laid in common bond with all joints filled solidly with mortar and backs fully purged to form solid masonry structure. Joints of walls to receive plaster shall be lightly raked to provide a bond for plaster. Control joints in brick walls shall be carried through the plaster. The joint shall not be plastered.

F.2.7 Lintels, Miscellaneous

The Contractor shall build in or provide all miscellaneous items to be set in masonry including lintels, frames, reinforcing steel, electrical boxes, fixtures, sleeves, grilles, anchors and other miscellaneous items. All anchorage, attachments and bonding devices shall be completely covered with mortar.

F.2.8 Cleaning

Masonry work to be exposed shall be thoroughly cleaned. Mortar smears and droppings on concrete block walls shall be dry before removal with a trowel. Masonry work may be cleaned using a mild muriatic acid solution.

F.2.9 Damp-proof Courses

As a minimum requirement, damp-proof courses shall be in accordance with EN 12697, BS 6398 and BS 6515.

Bituminous sheet damp-proof courses shall be laid on a level bed of cement mortar with a minimum lap of 75 mm at angles and joints and neatly pointed in matching mortar on exposed edges. Horizontal and sloping damp-proof coursing over door openings shall be in single pieces of material of a length to extend 225 mm at both sides beyond the width of the frame.

F.3. INSULATION

All buildings shall be thermally insulated at base, walls and roof. The insulation must comply with the local legislation.

The insulation shall in general be placed on the cold side of electrical "outputs", ducts, pipes, such as ventilation and other service equipment. The widths of the insulations shall be exactly side-by-side. The insulation shall be cut to fit all inside and outside corners as well as irregular spaces. The insulation pieces shall follow one another without leaving gaps except for the case of expansion joints.

F.3.1 Blanket-type Insulations

Insulation blankets shall be placed in walls or in ceilings with a metal frame or external lining. The insulation shall fit between the frame and the lining pieces. The width of the insulation shall be as needed for an exact fit so that the insulation stays in place by friction alone. The intermediate spaces between frames or the voids between walls and lining shall be fully insulated.

Insulation placed above false ceiling shall be supported from the ceiling frame. The insulation pieces shall be cut with a width equal to the distance between the suspension wires and shall fit tightly together.

F.3.2 Board-type Insulation

The insulation to be placed between metal linings and brickwork or concrete walls shall be cut and placed so as to fit exactly between the lining members. The insulation shall be secured in place with flanges of the metal lining and with metal brackets or glue, according to the manufacturer's instructions. A gap of at least 20 mm shall be maintained between the insulation and the brickwork or the concrete wall.

In brick walls with a void between two sides, the insulation shall be placed in the void and against the inner side, with the large dimension of the boards in the horizontal direction and with alternately overlapping vertical edges. The insulation shall be anchored in place with mechanical clamps and shall fit tightly around objects that may be introduced in the void.

The insulation shall be placed at the same time as the outer side is being erected. The void should be temporarily covered to protect the insulation until the wall is completed.

For brickwork and concrete walls, the glue shall be applied according to the instructions of the manufacturer of the insulation and the placing of the board shall be further secured with mechanical clamps at distances recommended by the manufacturer of the insulation.

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Before the application of an asphalt coat, the wall surface shall first be primed. Following that, the nearside and the edges of the insulating material are immersed in hot asphalt and the board is placed against the primed surface.

Each insulation piece shall come into close contact with its adjacent piece, except for the cases of an expansion joint. The insulation shall also be placed around objects that may be introduced in the void.

F.4. PLASTERING

F.4.1 Materials

F.4.1.1 Sand

Sand shall be (clean and sharp coarse grit, fresh water river or pit sand) conforming in all respects to ISO 20290, ISO 19595, EN 12620 and EN 13139 and shall be re-washed on site if the silt, loam or clay content exceeds the limits prescribed in the relevant Standards. The sand shall be obtained from a source approved by the Engineer.

F.4.1.2 Cement

Cement shall be sulphate resisting Portland cement as specified in EN 206. The source of cement is subject to the approval of the Engineer and shall not be changed without his prior approval.

F.4.1.3 Water

For the mixing of mortar and plaster the Contractor shall provide tap water, if not otherwise instructed or approved by the Engineer.

F.4.2 Plaster Mixing

Plaster shall be mixed with proportions according to ISO 13765 and EN 998-1 and BS 4721. The constituents shall be measured by volume and water added in an amount compatible with workability.

Plaster shall be mixed in a mechanically operated plaster mixer for at least long enough to make a thorough, complete intimate mix of the materials. The mixing of plaster by hand shall not be permitted, unless otherwise directed. The mixer, bunker, gauge boxes and all tools shall be kept clean, and care shall be taken to ensure that fresh plaster is not contaminated with set plaster.

F.4.3 Workmanship

Plaster shall be of 2 or 3 coats. If plaster is to be applied to smooth surfaces, a dash coat shall be applied as a bonding surface. The dash coat shall be of mush consistency, composed of 1 part Portland cement and 1,5 parts of sand. The plaster coats shall be applied with the thicknesses given below, notwithstanding additional thickness being required in case of unevenness in the masonry surface.

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Location	Ceiling	Interior wall	Finish
Thickness of first coat	15 mm	10 mm	10 mm
Thickness of intermediate coat	--	6 mm	9 mm
Thickness of finish coat	10 mm	4 mm	6 mm
Total thickness	25 mm	20 mm	25 mm

F.4.4 Preparation of Surfaces

The Contractor shall carefully examine surfaces that are to receive plaster and any unsatisfactory surface shall be repaired as instructed by the Engineer. Where fixtures have to be installed prior to plastering they shall be adequately protected from damage during plastering. Concrete masonry and brick surfaces shall have sufficient roughness to provide proper bond and shall be dampened by brushing or spraying with water followed by plastering.

If surfaces are not rough, they shall be hacked or bushed-hammered, or a dash coat of Portland cement grout composed of one part cement to 1 ½ parts of fine sand mixed to a mushy consistency shall be applied to the concrete surface, using a stiff fiber brush with a whipping motion. This coat shall be kept damp for at least three days immediately following its application of plaster then allowed to dry. Before application of plaster, the surface shall be evenly dampened, if necessary, to provide proper suction.

F.4.5 Plastering

The dash coat shall be applied with a whisk broom or fibre brush and be kept moist for 48 hours before the first coat is applied to the dash coat.

Before the first coat hardens, the surface shall be scratched to provide bond for the intermediate coat. The first coat shall be kept moist for not less than 24 hours and be allowed to set for not less than 14 days before application of the intermediate coat.

The surface of the intermediate coat shall be brought to a true and even surface, and then roughened with a wood float before setting to provide a bond for the finish coat.

The finish coat shall be applied while the intermediate coat is moist and if the intermediate coat dries out it shall be wetted evenly. The finish coat shall be first floated to a true and even surface and then trowelled to a smooth and even finish.

F.4.6 Completion of Work

Completion of work includes curing (moisturising for at least 3 days) and removal of deficiencies (at the Contractor's expense). Upon completion of the work, all plaster surfaces shall be cleaned and all rubbish, debris and excess material and equipment shall be removed.

F.4.7 Waterproof Plaster

Waterproof plaster shall consist of waterproofing compound, cement and sand mixed in strict accordance with the manufacturer's specification. The water proofing compound shall be a mass product of a reputable manufacturer and shall be approved by the Engineer.

F.4.8 Tolerances

All surfaces shall be true to line, level, plumb and all junctions, angles and arises truly square. On two or three coat work, the plaster surface shall not show any deviation greater than specified in ISO 1803 or equivalent standard.

F.5. SCREEDS

F.5.1 General

Workmanship and construction shall generally conform to EN 13318, BS 8204 or equivalent international Standards.

Materials used for mortar shall be measured in gauge boxes. All concrete surfaces shall be adequately prepared and keyed to receive screeds. The screeds to be carried out have to be placed within buildings and shall be dense aggregate cement screeds.

F.5.2 Floor Screeds

Floor screeds in operation buildings shall be laid monolithically to a thickness of 2.5 cm if not otherwise specified and be laid separately.

The preparation of base concrete shall include the removal of laitance from the concrete surface to receive screed and the removal of all loose concrete, dust and dirt by thorough washing with water.

The screed mix shall be prepared in accordance to ISO 13765 and EN 998-1 or equivalent international standard and shall be thoroughly and efficiently mixed dry by mechanical means until a uniform distribution is obtained prior to adding the water. The water content shall be kept as low as is necessary to allow for sufficient workability for laying and compacting. Where only small quantities are required, mixing might be carried out by hand on a clean watertight surface with the approval of the Engineer.

The screed mix shall be placed between forms, rigidly fixed on a firm foundation and set true to level within ± 3 mm, and shall be fully compacted by means of a screed board providing laitance is not brought to the surface. The screed wearing course shall be tamped with a wood float and trowelled with a steel trowel to produce a smooth finish.

The screed mix shall be placed between the forms (and or other bays) worked around the penetrations, duct covers, chamber covers, gutters, balustrade standards, pipes, etc., and shall be fully compacted by means of a screed board, or other suitable compacting equipment, providing laitance is not brought to the surface.

Screed forming the final floor shall be applied onto the screed base course and shall be

- self-levelling;
- resistant to gasoline, oil and solvents;
- highly wear resistant qualified for any kind of mechanical stress;
- waterproof, qualified also in wet rooms;
- antislip even in cases of oil spills and in wet rooms;

- not electro-statically chargeable.

F.5.3 Joints

All edge joints of floor screeds shall be simple butt joints without filler. Screeds laid over construction joints in concrete shall be separated by 10 mm impregnated oakum strips or the like.

Joints in wearing courses shall be 10 mm poly-sulphide according to approved international Standards.

F.5.4 Tolerances

The finished surface of base course screeds shall comply with ISO 1803 or equivalent international Standard.

Floor screeds shall be free of all defects and any work which shows signs of bond failure, hollow patches, crazing, cracking or any other defects will not be accepted and shall be removed and replaced with acceptable work by the Contractor.

The extent of the work to be removed and the method to be used in the removal and replacement of this work shall be to the approval of the Engineer.

The Engineer shall approve all surfaces before continuation of works.

F.6. FLOORING

F.6.1 General

All materials and structural components not covered by ISO, EN or equivalent international Standards may be used subject to the Engineer's consent only. The floorings shall be such as to provide a cover surface that can well be walked on and must not give any rise to any unreasonable inconvenience.

F.6.2 Materials

Concrete paving slabs shall be 50 mm thick, hydraulically pressed pre-cast concrete slabs in accordance with EN 13318, BS 8204 or equivalent international Standards.

F.6.3 PVC Flooring

PVC flooring material shall comply with the requirements of ISO 11638, EN 649, EN 650, EN 651, EN 652 and EN 653 or equivalent international Standards and shall be temperature resistant, waterproof, abrasion resistant, flameproof, pigment or colour proof to light, evenly coloured throughout, resistant to chemicals, fats, acids and alkalines, odourless, easily laid and flexible, non-porous and slip proof.

All adhesives shall have suitable properties to ensure a firm and durable bond. They must not adversely affect either the flooring nor the underlays or the base and shall be odourless once applied.

All fillers and levelling compounds shall have a firm and durable bond to the base, provide a good bonding surface for the adhesive and be of suitable property so as to give an adequate support to the covering. They must have no adverse effect on base, adhesive, underlay, or covering.

F.6.4 Carpeting

Carpets shall comply with the classification and terminology laid down in the relevant Local Standards. Carpets shall be made from 100 % continuous filament nylon approved man-made fibre on man-made backing, and shall be broadloom with tufted tightly twist pile construction. Pile height shall not be more than 5 mm with not less than 3 rows per cm, 19 tufts per cm² and weight not less than 3.25 kg/m².

Carpet cushion shall comply with the following requirements:

- walking shock absorbing;
- moisture penetration resisting;
- noise reducing;

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- fire retardant;
- toxicity tested.

Samples of carpet and cushion shall be laid for approval of the Engineer.

Nosings at all steps and changes of level shall be protected with aluminium extrusions.

Skirtings to carpeted floors shall be in timber, counter sunk screwed to rough grounds set into walling and pelleted in grain.

F.6.5 Paving

Paving shall be either natural stone (marble, sandstone, granite, limestone) or ceramic tiles (for kitchens, toilets, showers, etc.).

Natural stone tiles shall be sound, durable, hard, and have such properties that they will not disintegrate from the action of handling and placing. The density of stones shall be not less than 2,2 t/m³.

Ceramic floor tiles shall be of best quality available on the local market.

Tiles in generally shall be even and regular in size, true to plane, free of warps, cracks, crazing, discoloration, stains or defects.

Paving shall be of approved co-ordinated dimensions. The kind, quality and colour shall be approved by the Engineer. Therefore, the Contractor shall submit samples to the Engineer before ordering the tiles.

A tile skirting, with the same kind of tiles, shall be provided for all areas where the floor is tiled.

Tile work on foundation blocks, supports, etc., for the mechanical and electrical equipment shall be carried out after installation of the equipment.

Tiling shall be free of any defects and any work that shows signs of bond failures, hollow patches, misalignment, cracking or any other defect.

In general, tiles shall meet the quality requirements of ISO 13006, EN 10545 or equivalent international Standard. Where tiles and flags are not standardized, the quality features shall satisfy the standard commercial requirements (top surface, parallelism of edges, colour, and water absorption) and shall be subject to the Engineer's approval. All floor and wall tiles shall be from the same batch. The tiles being vitrified throughout, they shall be very hard wearing and impervious to oils, alkalis and most commercial acids.

Ceramic tiles at laboratories and chemical storage rooms shall be oil and acid resistant, true to shape, flat, free from flaws, cracks and crazing, uniform in color.

Tiles shall be well-shaped with straight edges, perfectly flat and free from defects which affect appearance or serviceability. Colours shall be as selected from the manufacturer's standard colours and approved by the Engineer.

F.6.6 Terrazzo Floor Tiles

Terrazzo floor tiles shall be first class grade tiles of mechanically compresses type, samples shall be provided to the Engineer for approval. Unless otherwise indicated on the drawing, tiles shall be 20 x 20 x 2 cm, 20 x 10 x 2 cm, 30 x 30 x 3 cm in size.

The surface of the tiles shall be 6 mm for 20 mm thick tiles and 8 mm for 30 mm thick tiles. The surface shall be composed of one part white or coloured cement to 2½ - (two and half parts) by weight of dry marble chips.

Tiles shall be well-shaped with straight edges, perfectly flat and free from defects which affect appearance or serviceability. Tile with chips, cracks or defects will be rejected.

The tiles shall be thoroughly grouted with the same cement and colour composition as specified.

F.6.7 Cement Floor Tiles

Cement floor tiles shall be first grade tiles, mechanically compressed type, samples shall be provided to the Engineer for approval. Unless otherwise indicated on the drawings, cement tiles shall be 20 x 20 x 2 cm, size.

The surface of tiles shall be 6 mm thick and composed one part sand and two parts Portland cement or white or coloured cement. The back of tile shall be composed of one part Portland cement and three parts of fine sand.

Cement tiles shall be well-shaped, with straight edges, perfectly flat and free from defects which affect appearance or serviceability.

F.6.8 Concrete Floor Tiles

Concrete floor tiles shall be first grade tiles, mechanically compressed type, samples shall be provided to the Engineer for approval. Unless otherwise indicated on the drawings, concrete tiles shall be 30 x 30 x 4 cm, 40 x 40 x 4 cm, 70 x 30 x 5 cm in size.

Concrete tiles shall be composed of one part fine sand, two parts Portland cement, 2 ½ (two and half) parts chips of basalt or granite.

Concrete tiles shall be well-shaped with straight edges, perfectly flat and free from defects which affect appearance or serviceability.

F.6.9 Workmanship in General

All materials and structural components whose processing is subject to manufacturer's instructions shall be processed accordingly. The Contractor shall furnish the Engineer with the written instructions for the care and the maintenance of the flooring.

F.6.10 Preparation of Surfaces

The surfaces must be cleaned prior to flooring. The base for covering to be placed without underlay shall be smoothed with filler compound. In the case of major unevenness a suitable levelling compound shall be used.

Subject to the Engineer's approval, any filler or levelling compound may be applied so that it will bond firmly and durably to the base, and will not crack and will adequately withstand pressure. Any screeds such as magnesia and anhydride screed to which the filler or levelling compound will not sufficiently bond, shall receive a priming coat.

F.6.11 General Requirements for Application

Workmanship generally shall be in accordance with ISO 11683 or equivalent international Standards.

Floorings shall be placed without underlays unless otherwise specified.

The courses shall be laid towards the main window wall, in halls and corridors, however, in longitudinal direction, unless otherwise specified.

Deviations in colour which are not of minor importance and not due to the flooring pattern shall not be allowed if marring the overall appearance of the flooring. Courses with pattern shall be laid so as to suit these.

Where courses run towards doors, recesses and the like, they shall be laid so as to cover also the floor areas in such door openings, recesses etc. Strips or slabs may be used as coverings of such floor areas.

Plastic flooring shall not be welded unless otherwise specified or expressly required in the flooring material manufacturer's processing instructions.

Baseboards / skirtings of the same material as the flooring material with a minimum height of 6 cm have to be installed at all side walls.

F.6.12 Precast Concrete Slabs

All pre-cast concrete slabs shall be laid in bays not exceeding 10 m in length, the bays being separated by an expansion joint 10 mm wide.

F.6.13 Thin Floor Coverings

Flexible PVC sheeting or tiles shall be laid on a level and smooth background generally consisting of anhydride screed. Tiles shall be laid in strict accordance with manufacturer's instructions approved by the Engineer.

F.7. SURFACE AND WALL FINISH

F.7.1 General

The Contractor shall furnish all equipment, labour, materials and scaffolding necessary for the installation of decorative lining as shown on the drawings and as specified in this specification.

Prior installation, adequate samples of all materials, in the various dimensions and colours that are to be used in the work listed in this section, shall be submitted to the Engineer for approval.

Facing tiles indicated on the drawings for interior surface shall consist of: tiles, ceramic mosaic tiles, ceramic tiles, glazed ceramic wall tiles.

F.7.2 Materials

In general, tiles and flags shall be of best quality available on the local market, samples shall be provided to the Engineer for approval. Where tiles and flags are not standardised, the quality features shall satisfy the standard commercial requirements (top surface, parallelism of edges, colour, and water absorption). All floor and wall tiles shall be from the same batch.

Glazed ceramic wall tiles shall be in the colour selected by the Engineer, true to shape, flat, free from flaws, cracks and crazing, uniform in colour, keyed on the back. The tiles shall be of a suitable type, size, colour and acid resistance, where required (i.e. laboratory).

Cement based adhesives and other adhesives shall be subject to the approval of the Engineer and mixed and used strictly in accordance to the manufacturer's printed instruction. Mortar materials and adhesives shall not alter the top surface of the tiles.

F.7.3 Placing of Tiles

All cutting to tiles shall be fair cutting using a tile cutter.

In interior finishing works all tiles, flags or mosaic shall only be set and laid before the fixing of windows and door frames and trims, and after stop rails, plumbing installations and the application of plaster.

Wall faces shall be cleaned and primed according to the manufacturer's instructions and the adhesive shall be applied by the notched trowel technique and trowelled over the area to receive tiles in 4 mm thickness.

All tiles, flags and mosaic shall be set or laid plumb, in true alignment and horizontal or at the slope specified, without any projections, with regard to any specified reference or level lines. In wall coverings, projections shall be allowed only to the extent imposed by the particular type of tile or flag specified.

The external angles and side and top edges shall be formed with rounded edge tiles. At inter parts, returned rounded edge tiles shall be used.

F.7.4 Ceramic Mosaic Tiles, Ceramic Tiles

Ceramic mosaic tiles or ceramic tiles shall be the best selection possible, thoroughly and evenly matured and free from defects which affect appearance or serviceability.

Unless otherwise indicated in the drawings, mosaic tiles shall be laid in the required mosaic pattern, colours shall be as selected from the manufacturer's standard colours and approved by the Engineer.

Glazed ceramic wall tiles and trimmers for wall facing shall approximately 9-12 mm thick. Tiles shall be in the size indicated on the drawings or approved by the Engineer and trimmers shall have matt glazed finish or exposed-to-view surface. Stops, returns, caps and special shapes shall be provided as required for sills, jambs, recesses, offsets and other conditions so as to provide a complete and neatly finished installation.

Glazed ceramic wall tiles shall be free from dark spots, fractures of the glaze, heavy accumulation of glaze, spots insufficiently glazed, frosted or crystalline appearance, or rough spots.

F.7.5 Wall Painting

The surface of the plastered walls and ceilings shall be painted with a washable and, for outer walls, weatherproof wall paint. The paint to be used shall be the best quality plastic emulsion paint available in turkey. The colour will be selected by the Engineer.

Walls and ceiling shall be cleaned from plaster splashes etc. before painting.

All surface fittings, ironmongery, etc., except hinges shall be removed before painting and refixed on completion. They shall be entirely free of any droppings, paint smears and blemishes.

Ready floors and window frames shall be protected against splashing by covering with plastic sheets. Wall may be spread with spraygun. In any case the paint has to be spread in accordance to the manufacturer's instruction.

Inner walls shall be painted in 2 layers, outer walls shall be painted in 3 layers. Each layer shall be allowed to dry completely before the next layer is applied. The paint has to be spread evenly in an equal layer thickness.

F.8. DOORS AND WINDOWS

F.8.1 General

Doors and windows shall be of good quality and robust and shall be to the dimensions and details shown on the approved Contractor's Drawings.

The Contractor shall submit details of manufacture including parts of the frame members and no orders shall be placed until such details have been approved by the Engineer.

All doors or windows of the same material shall be from one manufacturer only.

Doors and windows shall be such that glazing or re-glazing on site is possible without the need to remove the outer frame from the structure of the building.

Flashings, weather bars, drips, storm moulds, caulking and pointing shall be installed so that water is prevented from penetrating the building between the frame of external doors or windows and the building structure under the prevailing service conditions, including normal structural movement of the building.

For external doors and windows, flashing and weather proofing shall be used which are corrosion resistant, compatible with the other materials in the installation, and coated with a non staining compound where necessary.

F.8.1.1 Construction

Joints shall be made accurately fitted tight so that neither fasteners nor fixing devices such as pins, screws, adhesives and pressure indentations are visible on exposed surfaces.

Moving parts shall operate freely and smoothly, without binding or sticking, at correct tensions or operating forces and that they are lubricated where appropriate.

Doors and windows shall be installed so that the frames are

- plumb, level, straight and true within acceptable building tolerances;
- are adequately fixed or anchored to the building structure;
- and will not carry any building loads, including loads caused by structural deflection or shortening.

Mouldings, architraves, reveal linings, and other internal trim shall be provided using materials and finishes matching the frames, to make neat and clean junctions between the frame and the adjoining building surface.

F.8.1.2 Frames

Door supporting frames shall be of U-form, window supporting frames shall be of □-form.

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In brick openings supporting frames shall be fixed and bedded in mortar, PVC frames shall be fixed with steel wedges and bedded in mortar.

In concrete openings, supporting frames shall be connected to the concrete walls using chemical anchors.

Steel supporting frames for steel or aluminium doors and windows shall not be used as centring for brickwork or to support a lintel.

Steel supporting frames shall be formed from 1,5 mm thick, hot-dip galvanised rectangular hollow parts of sufficient cross-partal-area, full welded at joints (flush joint). The frames shall be equipped with welded laps, each lap with one bolt hole. In case of connection aluminium blind frames to steel supporting frames, provision shall be made to avoid contact corrosion.

F.8.1.3 Jointing, Pointing, Sealants

Jointing and pointing materials, including sealants, mastic's, primers, gaskets and compressible fillers of types shall be compatible when used together, and non staining to finished surfaces. Bituminous materials on absorbent surfaces shall not be used.

Glass and perimeter seals for doors and windows shall be made of EPDM with a magnetic tape insert. The hinge side shall be constructed so as to avoid pinching or other distortion of the seal from opening and closing of the door or window.

F.8.2 Doors

All doors shall be flush doors. Clearance of external doors for persons shall be 90 cm x 200 cm. Clearance of internal doors for persons shall be 80 cm x 190 cm.

Exteriors doors and doors in air conditioned areas shall be weather-stripped.

External doors shall be in generally vacuum double glazed in 4 +4 mm thick bonze solar control thermal glass.

Internal doors shall be in generally single glazed in 6 mm thick Georgian wired plate glass, or approved equivalent.

F.8.2.1 Door Bottoms

Door bottoms for external doors shall be full mortised type with tubular neoprene and glass fibre core and shall close the entire gap between the door and the floor. Door bottoms shall ensure a continuous, positive, reliable seal at the floor with minimum friction, drag, and roll of the assembly on the floor.

F.8.2.2 Steel Door Frames

Frames shall be fabricated from at least 3 mm thick steel with the corners mitred, welded, and ground smooth. Strike, hinge, and other hardware reinforcement shall be of not less than 5 mm thick steel. The frame shall be provided with welded floor anchors at each jamb, and with a minimum of 3 wall anchors per jamb. Frames shall be set plumb and square in a true plane, and be securely anchored to the adjoining construction. Steel shims shall be provided and shall be set tight and rigidly attached between frame anchors and structure.

All parts shall be hot dip galvanised and shall receive thermoset powder coating.

F.8.2.3 Timber Door Leaves

Timber door leaves shall have a minimum thickness of 40 mm and shall be faced both sides with hardwood veneered faces. The core shall be constructed of longitudinal laminations of precision planed timber, butt jointed and glued with resin based adhesive under hydraulic pressure. All edges shall be bevelled and lipid with hardwood tongued into the edge of the door.

Hardwood doors shall be constructed out of teak or similar approved hardwood. Where required, the doors shall be glazed with 6 mm glass, fixed with hardwood glazing stops.

F.8.2.4 Steel Doors Leaves

Steel doors leaves shall be of full flush design with no visible seams. Steel door leaves shall consist in a corner frame formed from at least 1,0 mm thick, hot-dip galvanised rectangular hollow parts of sufficient cross-partial-area, full welded at joints (flush joint) and two 1,0 mm thick sheet metal leaf faces internally reinforced with □- or U-profiles welded in place to the inside of the leaf faces in sufficient number. The leaf cavity shall be filled with insulating material if necessary. Tops of exterior doors shall be provided with flush, water and weather tight, top enclosures.

Leaves shall be rigid and neat in appearance, and shall be free from warpage or buckle. Total thickness of leave shall be not less than 40 mm. Leave shall be rebated on 3 sides.

Glazing stops shall be formed from 1 mm thick steel sheet and shall be non removable on outside of exterior doors and shall be removable (screw-applied) on inside of exterior doors and internal doors.

All parts shall be hot dip galvanised and shall receive thermoset powder coating.

F.8.2.5 Aluminium Doors

The main elements of aluminium solid part outer frame shall be not less than 2,0 mm thick. The thickness of all other structural elements of the Parts shall be at minimum tolerance not less than 1,2 mm.

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Joints in frames shall be made neatly and accurately either by welding or by mechanical means (e.g. cleating and screwing) and may have flush stepped or lapped surfaces. Welded joints shall be cleaned off smooth on the surfaces which are exposed when the window or door is in closed position or where they come into contact with glazing.

Hinges shall be either of suitable corrosion resistant materials or if not compatible with aluminium shall be separated from the aluminium by the materials that are compatible with it. Materials or finishes which are not compatible with aluminium shall not be used unless they are satisfactorily separate from the aluminium by materials that are compatible with it. Screws, nuts, bolts, washers and other fastenings shall be of stainless steel or aluminium.

Door leaves shall consist in a corner frame formed from at least 1,0 mm thick, rectangular hollow parts of sufficient cross-partal-area and two 1,0 mm thick sheet metal leaf faces braced with internal □- or U-profiles welded to the inside of the leaf faces in sufficient number. Weather-stripping sheets and glazing stops shall have a thickness of at least 0,8 mm.

All aluminium parts shall be finished satin matt and anodised. Weather-stripping shall

- be made from materials known to be compatible with aluminium;
- not shrink or warp nor adhere to sliding surfaces or closing surfaces;
- not promote corrosion when in contact with the aluminium alloy used, and;
- be resistant to deterioration by weathering.

External doors and frames shall be thermal blistered and finished externally in anodised aluminium with a bronze tone that matches the windows.

F.8.3 Windows

All windows shall be pivot type window (tilt and turn). Both opening modes shall be controlled with the same lever handle.

All windows shall be provided by 3 cm thick marble sills.

All windows shall equal or exceed the following performance requirements: There shall be no water leakage when tested at 330 mm water gauge and air filtration shall be less than 12 m/h/m when tested at 40 mm water gauge.

F.8.3.1 Aluminium Windows

Windows shall be of the thermal blistered double insulated type and shall be glazed in brown tinned glass to the approval of the Engineer.

All aluminium surfaces in contact with block work, concrete render or other alkaline materials shall be coated with two coats of black bitumen solution or similar approved protective coating. All unit surfaces, which will be visible when the window is fixed in position, shall be protected

after manufacture by low tack tape or other suitable means capable of being removed after installation of the window to leave clean undamaged anodised surfaces.

F.8.3.2 PVC Windows

The main frame shall be of at least 80 mm extruded rigid PVC with integral nailing flange, mitred corners, fusion welded. The frame shall have structural cavities and shall be steel reinforced to avoid warp, twist, sag or bow.

Windows shall be made with a co-extruded double gasket seal forming an integral part of the entire unit and not subject to shrink, crack or pull away.

Windows shall be designed as highly heat-insulated plastic window system with central sealing system with 3 density levels as multi-chamber construction in plastic-aluminum composite construction. Glazing and abutting gaskets made of EPDM flush with the profile, UV-radiation and weather-resistant, color grey 20 mm, surface offset on the room side between the casement frame and the frame level

Wing overlap 4,5 mm outside or 8 mm inside, glazed stand 18 mm, all profile edges are rounded.

Concealed turn-and-tilt fitting with single-handed operation for cargo loads up to 100 kg, opening width tilt position 140 mm, overhanging corner and shear bearings coated with KTL (E-coating).

Integrated basic safety lock (at least two mushroom head locks on each side), metal safety elements, tilt bearing horizontally by safety tilt-on bracket with integrated release lever. Window handle in the centre, chamber gearbox with malfunction lock.

Wall connections are made to the monolithic masonry. The gap between the base and the building body must be filled with thermal insulation on all sides. On the inside, the basic construction is to be used to connect a window sill as specified elsewhere. The joint must be filled with thermal insulation and sealed with permanently elastic sealants. On the outside, the sealing film is clamped on the base construction. The film must be guided to the load-bearing structural body and bonded there.

Finish type shall be standard white. Weather stripping shall be of dual santoprene fin gaskets.

F.9. FINISH HARDWARE

F.9.1 General

The Contractor shall submit samples of all hardware to the Engineer for approval.

All hardware shall have the required screws, bolts and fastenings necessary for proper installation, wrapped in paper and packed in the same package as the hardware. Each package shall be legibly labelled, indicating that portion of the work for which it is intended.

All hardware shall be of the best grade, entirely free from imperfections in manufacture and finish.

Finish of all hardware shall be dull stainless steel unless otherwise noted.

F.9.2 Hardware Description

Locks

For kind of doors:	Entry, exit & office doors:	keyed on side, button opposite side
	Passage doors:	knobs both side, no lock
	Storage room:	single knob with key
	Lock quality:	Tabular cylinder locks: stainless finish
	Toilets:	stainless outside, chrome inside, pin opening outside for emergency with button inside

Door closers: heavy duty type with stainless cover; top installation for either right or left hand operation

Stops: floor or wall mounted type, stainless

Door pull: 10 x 30 cm stainless plate, with 15 cm shaped pull securely fastened to plate; mounted with oval head stainless screws.

Kick plates: 20 cm stainless plate, width of door less 5 cm

Coat hangers: stainless steel, standard

Door hinges: 10 x 10 cm stainless steel, three per door

Flush bolts: 15 cm stainless

Gravity hinges: set of upper and lower, chrome finish, adjustable to stay slightly ajar

Cabinet hinges: 6 x 10 mm stainless, three per door

Friction catch: heavy duty - two parts with rubber grips concealed installation

Cabinet, drawer pulls: stainless steel, 10 cm grip with concealed bolt fastenings

F.9.3 Window Hardware

Windows indicated to be pivot type shall be furnished with a pair of window fittings (friction stays), a window pull and one barrel bolt lock. Window fittings shall be galvanised or stainless steel. Window pull shall be 2,5 x 10 cm with 4 screws and barrel bolts 10 cm long, 6 mm bolt.

F.9.4 Installation of Doors and Hardware

Unless otherwise indicated, all hardware installation and hanging shall be done on site.

Exterior doors and doors in air conditioned areas shall be weather-stripped.

Provide one (1) painted wood key case in each structure, size 25 x 50 cm with door and lock. Supply plywood back inside with hooks for spare keys. All keys shall be clearly labelled with metal or hardboard tags size approximately 50 x 20 mm securely fixed to the keys and handed over to the Engineer.

Hardware shall not be fitted until the latest time in the Contract.

F.10. GLAZING

F.10.1 General

All supplied Glass shall be of quality in accordance to ISO 22897, ISO 16940, ISO 16934, ISO 16936, ISO 28278-2, EN 1096-4 or equivalent international Standards.

Sheets shall be selected quality glazing and have approved weight. Labels showing the glass manufacturer's name, type of glass thickness and quality will be required on each piece of glass and shall remain on the glass until it has been set and inspected.

F.10.2 Materials

Clear float glass shall be 6 mm thick. Obscured glass shall be rough cast to an approved pattern, untainted and of 6 mm nominal thickness. Wired glass shall be transparent with a polished surface, 6 mm thick, selected and cut parallel to the reinforcement.

Putty for glazing to timber frames shall be in accordance to, and to metal frames, it shall be of approved manufacture.

F.10.3 Size, Delivery and storage

Dimensions of glass and frame shall provide minimum clearance equal to glass thickness for single glass on all four sides. The sealed space between face of glass and applied glazing stops shall be not less than 3 mm minimum.

Glass shall be delivered to the site in suitable containers allowing protecting the glass from weather and breakage.

F.10.4 Installation

Clear glass shall be used except where ordered otherwise. The glass shall be cut and installed without any visible lines or waves running horizontally.

Glazing in wood shall have rebates and beads primed and painted. The glass shall be firmly seated into the previously bedded and back-bedded rebate with glazing compound and secured in place with wood beads, attached with not less than 25 mm finish nails or flat headed screws, countersunk and set approximately at 15 cm centres. Nails and screws used in beads shall be corrosion resistant.

F.10.5 Cleaning up

All glass shall be cleaned at the completion of construction and any broken glass replaced. The glazing shall be maintained in a clean condition until the date of handing over the works.

F.11. CORROSION PROTECTION AND PAINTING

For technical specifications for corrosion protection and painting, refer to General Technical Specifications Part E.2.

F.12. ROOFING

F.12.1 General

Roofing systems shall be in general the “inverted roof” or “protected membrane roof system” where the waterproof membrane is laid directly onto the structural slab and the insulating layer is then laid on the membrane and protected by a layer of second layer of waterproof membrane.

In case flat roofs are proposed, they shall be executed with extensive greening. Typically such a roof consists of the following layers (from top to bottom):

- Substrate (gravel, sand with little organic matter at least 20 cm);
- Water impermeable layer (membrane, bituminous polymer);
- Insulation (10-15 cm depending whether the room below is heated or not);
- Membrane as moisture barrier;
- Concrete slab.

Any special working details prepared by the Contractor shall be submitted to the Engineer for approval.

Upon completion, all roofs shall be left sound and watertight and in neat and clean condition. All roof finishes shall be carefully worked or fitted around pipes and openings.

F.12.2 Waterproofing and Insulation

The structural slab or surface screed on it shall be primed before application of the membrane in accordance to the manufacturer's instructions. The insulation layer shall have a minimum density of 35 kg/m².

The waterproofing system shall be of approved type and manufacture.

The waterproofing system shall be suitable for prevailing climatic conditions and shall be capable to withstand local weather conditions especially as regards to high temperature difference between day and night, high humidity and heavy rains. The waterproof membrane shall have a mineral fibre surface.

F.12.3 Filter Geotextile

The material shall have resistance to ultraviolet light, chemical attack and experience no significant change to its physical, chemical or engineering properties under the influence of sulphates, chlorides, acids and alkalis in the forms and concentrations in which they are present in soils and ground-water to be found in-place. The material shall have proven resistance against bacterial or other microbiological attack and shall perform according to its specifications

at working temperatures between 5 and 45 °C. Temporary exposure during construction to temperatures up to 60 °C shall not permanently impair the material.

Filter fabric shall be supplied in rolls of at least 2 m wide and shall unless specified otherwise be lapped in both directions at 0,3 m wide. Roll lengths of the fabric shall be such as to lay complete in one operation without jointing, each of the various sloping and horizontal lengths.

The water permeability of the fabric shall be greater than that of the soil it is protecting while the mesh size shall be smaller than the sieve size passed by less than 10 % of the soil particles. The weight of the fabric shall be at least 240 g/m².

F.12.4 Water Insulation Membrane

On inverted roofs, water insulation shall be made by two layer of water insulation membranes. The lower layer shall be 3 mm thick and the upper layer shall be 2 x 3 mm thick. The waterproofing material shall be approved by the Engineer.

The membrane shall be continuous and take up abutments and pipes to above the insulation layer. Exposed membrane shall be solar protected. The waterproof membrane shall be dressed and bonded into rainwater outlets and under flashings.

F.12.5 Heat Insulation Boards

The insulation board for buildings shall be not less than 50 mm thick closed cell extruded polystyrene loose laid in a single layer with tight staggered butt joints in accordance with the manufacturer's instructions. The board shall be trimmed to fit any and all fillets used under the waterproof membrane.

F.12.6 Lightweight Screed

Lightweight screeds shall be laid in accordance with the manufacturer's instructions and to falls not less than 2,5 % with a minimum thickness of 50 mm. The screed shall be laid in two courses and in bays not exceeding 15 m², laid alternatively and finished with a mortar topping of 1:4 cement / sand mortar. Immediately after laying, the screed shall be protected from wind and sunlight and cured for 7 days.

When required, joints shall be formed in the insulating screed. A vapour barrier and ventilation to the bituminous roof sheeting shall also be provided. The Contractor shall submit samples and references to the Engineer for his approval of the materials he intends to use before ordering these materials.

F.12.7 Flashings and Rainwater Outlets

Flashings shall be sheet aluminium neatly cut to the width and length required. The aluminium shall be carefully bent using a slightly rounded former so as to avoid surface cracking. Where

surface fixing is required, the sheet shall be pre-drilled and fixed with stainless steel screws to proprietary fixings or hardwood grounds let into the surface of the base concrete or brick work.

F.12.8 Steel Sheet

Unless otherwise specified in the particular specifications, the galvanized corrugated steel roof sheets shall be generally in accordance ISO 5000, ISO 16172, ISO 14788 or equivalent international Standard having a steel sheet not less than 0,559 mm (24 S.W.G.) thick with a coating of zinc on both sides with a total weight of not less than 610 and not more than 763 g/m² of steel surface area.

Sheets shall be laid with 150 mm end laps and side laps of one and half corrugations on the side away from the prevailing wind otherwise lapping shall be to the full extent indicated on the contract drawings or documents. Laps shall be not less than 150 mm long.

When timber purling are employed sheets shall be securely fixed to same on the crown of the corrugations at not less than 300 mm centres with 6 mm diameter galvanized drive screws each not less than 62 mm long with head and galvanized embossed curved washer under.

Sheets shall be fixed to steel purlins with 8 mm diameter galvanized mild steel hook bolts of 50 mm longer in the shank than the depth of the steel purling to which they are fixed each with nut and galvanized embossed curved washer. The sheets shall be fixed at not less than 300 mm centres on the crown of the corrugations.

Where sheets are required to be stitched together they shall be joined at not less than 300 mm centres with 6 mm diameter and finished clean without rags, burrs or damage to the surrounding zinc coating.

Ridges shall have a roll top and plain wings not less than 450 mm girth all in galvanized steel sheet not less than 0,559 mm (24 SWG) thick and fixed in similar manner to the sheeting.

At square abutments the last two corrugations of the corrugated iron sheets next to walls shall be flattened and turned up against the wall and covered with 24 SWG galvanised iron apron flashing.

Holes for bolts or screws shall be punched from the inside of the sheet and shall be in the ridges of the corrugations as fixed and not in the holes.

Bat proofing shall consist of "Perspex" or similar approved translucent plastic corrugated sheeting.

F.12.9 Aluminium Sheets

The aluminium corrugated roof sheets shall be in accordance with ISO 6361, or equivalent international Standards, having a minimum thickness of 0,559 mm (24 SWG).

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The aluminium troughed roof sheets shall be in accordance with BS 6100 - 1.3.2:1989 Type A or B as specified in the Contract Documents having a minimum thickness of 0,9 mm (20 SWG.) and 1,2 mm (19 SWG) respectively.

Sheets shall be lapped to the full extent indicated on the contract drawings and documents.

Corrugated roof sheets shall be fixed to timber purlins and corrugated roof sheets and troughed roofs sheets shall be fixed to steel purlins all as before described for galvanized corrugated steel roof sheets unless otherwise specified.

Troughed roof sheets shall be fixed to timber purlins on the crown of the trough at not less than 300 mm centres with 6 mm galvanized embossed washer under to give not less than 50 mm penetration of the purlins to which they are attached.

Sheets shall be stitched all as before described for galvanized corrugated steel roof sheets.

All holes in sheets shall be neatly drilled or punched, of the required diameter and finished clean without rages, burrs.

Ridges shall have a tool top and plain wings not less than 450 mm girth having a minimum thickness of 0,71 m (22 SWG) and fixed in a similar manner to the iron sheeting. Laps shall be not less than 150 mm.

F.12.10 Roof Tiling

Roofing tiles shall be first quality local clay tiles of the type as specified in the contract drawings and documents and are to be similar to those obtained from a firm approved by the Engineer.

All tiles shall be well and evenly burnt, uniform in shape, size and colour and free from cracks, twists and other defects.

Samples shall be provided to the Engineer for approval before the work commences and all tiles used shall be of equal quality to the approved sample.

Ridge and hip tiles shall be saddle back or half round tiles as indicated on the contract drawings of similar quality and manufacture as the roofing tiles.

Tiles shall be carefully graded for size shape and colour upon delivery and again before fixing.

All tiles shall be carefully stacked on edge in the site and rows of tiles shall be separated with a layer of straw or similar material between each to prevent damage.

Nails, when required, shall be stout zinc nails not less than 36 mm long.

Mortar for bedding shall be gauged mortar as before described and if required shall be tinted with an approved colouring compound to match the tiling.

When required, tile battens shall be of sawn pressure impregnated structural timber as described in chapter 0.

Tile battens shall be not less than 50 x 35 mm sectional area or as indicted on the drawings and shall be accurately spaced at the specified gauge and securely fixed at the intersection with each rafter with 75 mm stout round wire nails.

All tiling is to be laid with the specified lap and when laid on patterns the head of each tile shall be securely double nailed to the battens in every alternate course unless otherwise described.

An underlining of "Sisalkraft" orange label or other equivalent and approved reinforced waterproof paper shall be provided under all tiling battens. The paper shall be laid over the rafters with the length of the roll at right angles to same. Laps at heads of adjacent sheets shall be laid over the rafters with the length of the roll at right angles to same. Laps at heads of adjacent sheets shall be not less than 75 mm and at the ends 300 mm. End laps shall be made at a rafter. Sheets shall be lightly tacked in position to prevent movement whilst tiling battens are being fixed.

F.12.11 Proprietary Roofing Systems

When proprietary of specialist roofing systems are required to be used as specified in the Contract documents they shall be carried out strictly in accordance with the proprietors or specialist manufacturer's instructions.

F.13. CARPENTRY

F.13.1 Timber

All timber shall be free of live borer, rot and decay, brittleheart and compression failure and loose unsound or dead knots.

All timber shall be grade marked as specified in the Grading Rules and certificates of Grading shall be produced for verification by the Engineer.

Timber shall be purchased immediately after the contract is signed to enable it to be adequately seasoned before required for use.

F.13.2 Preventive Treatment for Timber

All timber for carpentry work shall be vacuum pressure treated with Celcure or Tamalith or other approved medium, toxic to termites, cryptoterms and other timber pests. All cut ends of timber so impregnated are to be treated with two coats of "B" crystals or other approved method.

A "charge sheet" giving details of treatment shall be supplied to the Engineer if he so directs.

Pressure treatment shall be carried out by a specialist firm with approved equipment.

F.13.3 Seasoning

Timber shall be seasoned after preservative treatment has been carried out to moisture contents as shown in the table below.

Position	Moisture Content of Timber in its Permanent Position [%]	Moisture Content of Timber at Time of Erection [%]
Rafters, battens, strusses	15	22
Floor joists	15	22
T and G flooring	12 - 14	15 - 22

After delivery to site timber shall be carefully stacked to ensure a free circulation of air throughout the stack and covered with a waterproof cover to prevent excessive drying by the sun or reabsorption of rainwater.

F.13.4 Samples and Testing

The Engineer may select any samples of timber he may require for the purpose of testing.

Samples for testing shall consist of cross sections not exceeding 50 mm thick cut at least 500 mm from the end of the piece. They shall be packed in polythene bags with the ends tightly tied, labelled and delivered to an approved laboratory as directed.

F.13.5 Sawn Timber

All timber, except as specified elsewhere, shall be die square clean sawn as left from the saw and shall hold the full dimensions specified.

F.13.6 Wrot Timber

The term "wrot" shall mean finished to a perfectly smooth finish to receive paint or other surface treatment. Pieces which have been machine planed shall be finely smoothed by hand plane and glass paper or sanding machines to remove all planning machine or other marks.

3 mm reduction of specified size will be allowed in respect of each wrot face except in members 25 mm thick or less or where described as finished size "finished" when the members shall hold the full size stated.

F.13.7 Workmanship

All Carpentry work shall be executed by skilled workmen, with workmanship of the best quality, accurately set out in strict accordance with the drawings and be framed together and securely fixed in the best possible manner with properly made joints; all brads, nails and screws etc., shall be provided as necessary, directed and approved, and the Contractor's prices shall allow for all the foregoing.

F.13.8 Jointing

All timber shall be as long as possible and practicable to avoid joints to the extent possible. Where joints are unavoidable surfaces are to be in good contact over the whole area of the joint before fastenings are applied.

Scarfed joint shall be of a length not less than twice the greatest dimension of the timber member and shall be bolted if required. Whenever practicable scarfed joints are to be placed at a point of support, in order to obtain maximum strength.

No nails, screws or bolts are to be placed in any split end. If splitting is likely, or is encountered in the course of the work, holes for nails are to be pre-bored at diameter not exceeding 4/5th of the diameter of the nails. Clenched nails must be bent at right angles to the grain.

Lead holes are to be bored for all screws. When the use of bolts is specified the holes are to be bored from both sides of the timber and are to be of the diameter $D + D/16$, where D is the diameter of the bolt. Nuts must be brought up tight but care is to be taken to avoid crushing of the timber under the washer.

A tolerance of 1 mm will be allowed in positioning of bolt holes.

F.13.9 Connectors

When trusses are required to be bolted together with timber connectors these shall be of the single or double sided toothed type in accordance with relevant standard or as instructed by the Engineer on Connectors for Timber.

F.13.10 Nails, Bolts, etc.

All nails, bolts and metal fastenings shall be of mild steel, free of all rust and defects and of approved manufacture.

F.13.11 Roofs

The roofs are to be constructed in accordance with the details and scantlings shown on drawings. All ironwork necessary at joints, etc., is to be fitted and bolts, nuts and washers provided and fixed as required. Trusses shall be hoisted into position at the spacing shown and such temporary strutting as may be required is to be provided. Purlins are to be of the size and intervals shown. Rafter feet are to be cut and splayed as shown on the drawings. Plates shall, so far as possible, be in one length between points of change of direction. Joints between continuous lengths or at changes of direction and intersections shall be halved.

F.13.12 Ends of timber

The ends of all cut timbers, whether exposed, built in or otherwise shall be painted with two coats of "Wykamol" or other equal and approved to prevent rot and entry of borers.

F.13.13 Fixing Slips, Plugs, etc.

The Contractor shall provide and fix all necessary hardwood plugs and fixing slips to walls and dovetailed blocks costs into concrete soffits, etc., for the purpose of providing fixings for joinery and other Trades.

All hardwood fixings shall be clean and dry and dipped in "Wykamol" or other equivalent and approved wood preservative before fixing.

Where work is described as "plugged" it shall be fixed with nails to treated hardwood plugs inserted into the brick or blockwork joints. Plugs shall be of dry hardwood with the end cut on the twist, dipped in "Wykamol" or other equivalent and approved wood preservation and tightly driven into the raked out joint in the wall.

Where work is described as "plugged and screwed" it shall be fixed with steel screws unless otherwise specified to cylindrical fibre or polyvinyl plastic plugs of approved manufacture let into

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holes of suitable size drilled in the walls. When the wall is of such a material that it is impossible to drill neat round holes they shall be packed with a suitable plastic plugging compound such as "Rawplastic" or "Philplug" or other equivalent and as instructed by the manufacturers.

Plugs shall be inserted in walls to provide fixings not more than 750 mm apart horizontally. The number of plugs at each fixing point will depend on the width, height and thickness of the material to be fixed but a minimum of two will be required with an additional one for each 150 mm width or height in excess of the first 150 mm.

F.13.14 Insect Damage

All timber brought on to the site shall be free of live borer beetle or other insect infestation and it will be the entire responsibility of the Contractor to see that it remains free of infestation until the end of the maintenance period.

F.13.15 Cleaning

The Contractor is to remove and destroy all cut ends, shavings and other wood waste from all parts of the building and the site generally both whilst the work is in progress and at its completion.

F.14. PAINTING

F.14.1 General

Painting includes emulsion, enamels, stains, varnishes, sealers and other coating organic or inorganic, whether used as prime, intermediate, or finish coats.

All paint used in the permanent work and its various ingredients shall be subject to such tests and analyses as may be deemed proper by the Engineer, and for this purpose the Contractor shall provide such unbroken samples in the original tins as may be required.

Paints shall be applied in a regular manner and in accordance with the directions of the manufacturers. A paint pattern with selected colours shall be approved by the Engineer before application of paint. Period for coats specified by the manufacturer shall be adhered to. Coats shall have different degrees of the specified colours to indicate full application of each coat.

F.14.2 Materials and Workmanship

All paints shall be obtained in the colours specified by the Engineer, readymade, and shall in all cases be obtained directly from the original makers in their trade cases. Where special thinners are required, they shall be obtained from the makers of the paint or as instructed by the Engineer.

All work shall be done in workmanlike manner, so that the finished surface will be free from runs, drips, ridges, waves, laps and unnecessary brush marks. All coats shall be applied in such manner as to produce an even film of uniform thickness. Welds and rivets shall receive special attention to ensure that they receive an adequate thickness of paint. Thoroughly experienced workmen shall do all painting.

The application of paint and similar coatings to all areas indicated and the painting of walls and ceilings shall include painting of reveals, pillars, beams, conduit, valve openings, alcoves and the like. Painting of doors includes door leaves and all edges.

If the floor is to be given a finishing coat and there is no skirting, the floor paint shall extend so as to cover approximately 100 mm of the wall bottom.

F.14.2.1 Trial Areas and Sample Pieces

Prior to the commencement of the site, painting work designated area(s) or section(s) of the works shall be completely painted as a sample of the work and workmanship to be carried out. The area(s) or section(s) shall include complete samples of all the major painting required in the works as determined by the Engineer.

The area(s) shall be offered for review by the Engineer and shall, upon approval, be then preserved as a reference standard for the work.

F.14.2.2 Plastic and acrylic paints

Plastic and acrylic paints shall be subject to the approval of the Engineer.

F.14.2.3 Bitumen coating

Bitumen coatings shall be applied to all concrete surfaces in contact with soil.

F.14.3 Preparation of Surfaces

Surfaces shall be cleaned from oil grease dirt, mill scale, rust, slag or flux, deposit, dirt and other materials by using special solvents conforming to International Specifications and blast cleaning. Special attention shall be taken to prevent rusting and/or contamination of cleaned surfaces.

F.14.3.1 Metal Surfaces

The metal surface shall be completely cleaned from oils, grease, paints, salts and pollutants in general, using a cleaning solvent. Loose rust and loose oxide+ scales shall be removed. The surfaces shall be primed with an organic zinc primer.

Galvanised surfaces shall be cleaned from solvents by using water. Water and detergents shall be used for dirt and chemicals, and a solvent for other dirt in general.

F.14.3.2 Concrete and Masonry

Concrete surfaces shall be cleaned from dirty materials, loose or superfluous mortar, as well as from residues of unsuitable oils used to remove the forms and from materials used for the preservation of concrete. If necessary the surface will have to be cleaned by sandblasting. Cracks and other types of defects, too big to be covered with paint must first be properly filled.

Masonry shall be cleaned from dirty materials, loose and superfluous mortar, and be perfectly dry. Cracks and any defects too large to be remedied with putty shall first be made good.

F.14.3.3 Plastering

Plastering has to be hard and dry. Plastered surfaces must be tested as to humidity with a hydrometer and no painting should take place if the humidity content does not agree with the recommendations of the relevant manufacturer.

Sand, mould and loose particles shall be removed and surface defects shall be repaired before proceeding with the painting.

Cracks and holes shall be repaired with putty which provides a good bond with the existing plaster, and then be smoothed with sandpaper.

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Plaster surfaces shall first be covered with a priming coat. If the primer does not dry in a manner to give a uniform lustre to the entire surface, the areas showing an increased absorbability shall be primed locally anew before proceeding with the application of other coats.

F.14.3.4 Wooden surfaces

Wooden surfaces shall be polished with sandpaper; any loose edges shall be removed, and be finally brushed to remove the dust.

Knots, circular cracks and visible resinous stains shall be cleaned and filled with putty. The surfaces shall receive a priming coat and subsequently any nail holes, seams and joints shall be filled with putty matching the final colour. The surfaces shall then be polished with fine-grade sandpaper and brushed to remove the dust.

F.14.4 Application of Materials

The mixing of ready-made paints or materials must be complete. Paints shall be applied with brushes, rollers or spray guns without the use of air and as recommended by the manufacturer.

The humidity of the surfaces to be painted shall be measured with an electronic hydrometer. No painting shall take place when the surface humidity exceeds the values given below:

- plaster, brickwork, concrete 12 %;
- wooden surfaces 15 %.

The Contractor shall study and carefully follow the directions given on each container regarding the minimum and maximum allowable temperatures of the surfaces to be painted. No painting work shall be undertaken when the temperature of the surface is below 10 °C or above 38 °C, and when the relative humidity is more than 90 %.

Adequate and continuous ventilation shall be ensured during the painting of interior areas. If needed, there should also be heating to maintain the interior ambient temperature above 10 °C 24 hours prior to, during and 48 hours after the painting.

The paint shall be carefully spread according to manufacturer's instructions. The thickness of the wet coat should be checked periodically with a special instrument. No drippings, unpainted areas, swellings or other defects should be present. The finished surfaces should have a uniform lustre, colour and texture.

Each coat of paint should be left to dry completely before the application of the next one. At least 24 hours should elapse between two successive coats on each surface, except if the manufacturer of the paint specifies otherwise.

Interior metal surfaces should be evenly polished with sandpaper between successive coats in order to create a smooth and polished surface for the final coat.

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Surfaces that will not be painted should be protected from paints.

Electrical wall plates, metal pieces of frames, handles, locks, etc., fixtures and fixings shall be removed before painting. These items shall be carefully stored, cleaned and replaced to their proper position at the end of the painting work. The cleaning of metal parts should not be attempted with solvents that may harm their permanent enamel. Items that cannot practically be removed shall be covered.

Grills, caps and inspection covers of electrical and mechanical equipment shall be removed and painted separately.

Bare pipes, conduits, junction boxes, special supports, collars and brackets shall be primed and painted.

All conduits and electrical equipment exposed within painted areas shall be painted if judged necessary. The colour and the texture shall match those of the adjacent surfaces.

The equipment, conduits, cables and in general any exposed network shall be painted according to colour codes required by the relevant technical specifications. This work also includes arrows indicating the direction of flow, inscriptions with names of identification, numbering, etc. The colour codes used shall be in agreement with the relevant specifications.

The Contractor is under the obligation to proceed with the quality control regarding the quality of the painting and to conform to the following special requirements:

F.14.4.1 Checking the surfaces cleaned by sandblasting

The Contractor shall regularly proceed with calamine detection tests using the "copper sulphate" method.

F.14.4.2 Checking the thickness of the wet coat

Each painter shall be provided with an approved type of measuring instrument so that he may check the progress of the painting.

F.14.4.3 Detection of unpainted points in steel or iron surfaces

The Contractor shall use a suitable and approved method for detecting unpainted pores created by the painting system through tests on test plates.

The sweep voltage in the High tension (dc) equipment shall not exceed half the voltage needed to create a spark within the entire specified painting system.

Painting areas of steel structures that have been damaged shall be mechanically rubbed with a wire brush to clean the bare metal, and the edges of the healthy paint shall be polished with sandpaper to create an even slant.

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Subsequently, the painting system shall be applied to restore the paint in the damaged areas to the original thickness and type. Each coat of the new painting shall overlap the existing coat by at least 50 mm.

Painted surfaces with drippings from arc welding or from concrete or with different pieces stuck on the surface shall be cleaned or washed to immediately remove the offending items. Any repairs or restorations of a damaged surface to its original state shall take place before the surface is repainted.

For the repair of damaged epoxy layers, a suitable material shall be used supplied by the manufacturer of the original layer and shall be applied according to the instructions of the supplier and as approved by the Engineer.

F.15. SANITARY SYSTEMS

This section covers the requirements for providing of all labour, materials, equipment, accessories, services and tests, necessary and requisite for a complete and adequate sanitary system, such as:

- Drainage and vent pipe system;
- Sewers and sewage disposal system, including connections;
- Rainwater system;
- Potable water pipework between buildings;
- Sanitary fixtures;
- Hot and cold water plumbing.

Also included are the following items:

- All work of a civil nature, such as placing of pipe sleeves through floors and roofs for the passage of pipes at the time the concrete is poured, hangers and supports, excavations and backfill, manhole with covers, inspection pits, etc.;
- Protection and cleaning;
- Testing;
- Miscellaneous.

F.15.1 General

The Contractor shall submit full details, together with Drawings, of his proposals for approval of the Engineer before commencing the work and shall carry out all tests and inspections of the finished work as may be considered necessary by the Engineer.

The word "complete" whenever used in the technical specifications shall mean, in addition to the major items of plant, all incidental sundry components necessary for the complete operation of the installation, whether or not these components are mentioned in detail. The word "piping" in the technical specification shall mean the inclusion of all pipes, fittings, nipples, valves, and all required accessories, supports, anchors, guides, etc., for a complete safe and operational network.

F.15.2 Pipes and Fittings

The materials to be used for soil, wastewater, rainwater and ventilating pipes, including fittings, within the building shall be of PVC, PP, PE, galvanised steel or GRP according to the relevant standards. Soil and waste piping for the drainage system outside the building shall be of concrete.

F.15.3 Joints and Connections

Joints and connections in the sanitary system shall be gastight and watertight for the pressure required by test. Leaky joints shall be remade by using new materials. Joints in galvanised steel pipes shall be made by threading. Welding and bending are strictly prohibited on galvanised pipes.

Joints in plastic pipes shall be made with factory pre-installed rubber seal gaskets and shall be carried out according to manufacturer's recommendations.

F.15.4 Unions

All pipes shall be provided with unions at adequate intervals to permit easy disassembly for alternations and repairs.

Unions shall be provided near valves and equipment, which need to be taken out for servicing or repairs.

The unions shall be of material corresponding to the pipes in which they are installed, and of the same weights and rating.

F.15.5 Hangers, Spacing and Supports

Piping shall be installed without undue strains and stresses and provisions shall be made for expansion, contraction and structural settlement. A sufficient number of horizontal and vertical supports shall be provided at proper intervals in accordance with the relevant standards and Engineer's instructions.

F.15.6 Manholes and Inspection Pits

Manholes shall be provided at suitable locations and additionally where instructed by the Engineer.

The dimensions of the manholes or inspection pits are subject to the Engineer's approval.

F.15.7 Sleeves

The Contractor shall co-ordinate placing of the necessary sleeves, of the appropriate sizes for his requirements, at the time the concrete is being poured. It is strictly prohibited to break or bore through reinforced concrete beams for the passage of pipe unless prior approval is obtained.

Pipe sleeves shall be of adequate size to allow free movement of pipes due to expansion and contraction, whether bare or insulated. Sleeves for sanitary pipes shall be PVC.

Pipe sleeves shall be finish flush with walls and shall project at least 3 cm above floors and approximately 15 cm above roofs or as otherwise agreed by the Engineer.

After the installation of pipes, the Contractor shall caulk the space between pipe and sleeve with an approved product to prevent the passage of air and vermin. The caulking shall be made in such a manner as to prevent it from coming off with pipe expansion or contraction.

F.15.8 Protection and Cleaning

The inside of all pipes, valves, etc. shall be clean and free from dirt or other objectionable matters when erected. All lines shall be blown before placing in service. If necessary, all openings in the piping shall be closed during construction in order to keep the lines free from dirt, etc.

F.15.9 Floor Drains

Floor drains shall have PVC/PP or SST traps and a minimum water seal of 7,5 cm and shall be provided with adjustable and removable PVC/SST strainers. The open area of strainer shall be at least two-thirds of the cross-partal area of the drain line to which it connects.

F.15.10 Installation of Pipes

Pipes passing through walls shall be protected from breakage. A soil or waste pipe passing through a foundation wall shall be fitted into a PVC sleeve pipe cast in the concrete and furnished with sockets at both ends. Where it is required to cut plastic pipes it shall be done by a suitable pipe cutter so as to leave a clean and square end to the axis of the pipe.

F.15.11 Inspection, Storage and Connections

All pipes shall be thoroughly inspected prior to laying and any suspected cracks or damaged material shall be rejected. The pipes shall be stacked horizontally during storage and the sockets must be prevented from resting on the ground. All connections shall be made watertight and gastight. Where vent pipes connect to a horizontal soil or waste pipe the vent shall be taken off above the centre-line of the pipe, and the vent pipe shall rise vertically.

No work of breaking into an existing public sewer and forming a connection shall be carried out without prior approval of the Engineer.

Connections to sewers shall be made at existing manholes.

F.15.12 Cold Water Pipes and Valves

The Contractor shall obtain the Engineer's approval to his proposal for the potable water distribution system on the site.

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Cold water main pipes inside buildings shall be PN 16 threaded PE, PP or galvanised steel. All precautions shall be taken to protect water supply and distribution pipes against contamination from the sanitary system.

Concealed pipes shall be installed in such a way as to permit easy access for maintenance. This applies particularly to valve locations.

All valves shall be fixed in neatly arranged vertical lines, and adequately pitched horizontal lines to allow the system to be properly vented and drained. Air pockets, traps and sags shall be carefully avoided. Pipes shall not be welded.

Gate valves shall be provided on all main and branch pipes for isolating parts of piping for maintenance. Each sanitary fixture shall be provided with a stop valve for washer replacement. The stop valve shall match the trim provided with the fixture.

F.15.13 Hot Water Boilers

F.15.14 Small Electric Boilers

Small electric boilers shall be installed where low hot water consumption is expected. Small electric boilers shall comply with the following specifications:

- pressureless internal tank with a volume of 10 l to 50 l;
- energy-saving PU foam insulation;
- white plastic case;
- variable temperature control up to 80 °C;
- performance monitoring lamp.

F.15.15 Large Electric Boilers

Large electric boilers shall be installed where high hot water consumption is expected. Large electric boilers shall comply with the following specifications:

- internal enamelled tank, working pressure 0,6 MPa, including protective anode, with a volume of at least 50 l or more;
- energy-saving PU insulation at least 50 mm thick;
- exchangeable electric heating system (discretionary heating-up time) consisting of an appropriate number of high-quality tubular radiators corrosion protected and mounted on a flange plate;
- separate probe protecting tube for the control of the central heating furnace;
- variable temperature control up to 85 °C;
- energy-saving button at 65 °C;
- performance monitoring lamp;

- integrated dial thermometer;
- suitable for 2, 4, 6, and 8 hours of heating-up time;
- connection voltage of ~230 V, 3~400 V, and 3N~400 V.

F.15.16 European Water Closet

The WC pan shall be manufactured of vitreous china and shall be of the flush down type and in white colour. The pan shall have flushing rim to wash to entire internal surface of the bowl without splashing and shall be of the floor mounted type. Floor fixing screws shall be of non-ferrous material. The seat and cover shall be manufactured of white coloured plastic, unless otherwise instructed by the Engineer. The seats shall be flat on the underside and provided with four rubber or plastic buffers to rest on the WC pan rim. The cover and seat shall be fixed directly to the WC pan with copper hinges and compressible protective washers on both sides of the ceramic lugs.

The flushing cistern shall be of low level type, connected to the WC pan by a PVC flushing pipe. The cistern shall be manufactured of vitreous china and shall be of the valveless siphon type of 9 l capacity. The cistern shall be provided with a suitable ball valve, operating handle direct mounted, water supply connection and overflow pipe discharging indirectly to a suitable conspicuous outlet. The flush pipe shall be of 32 mm bore. The fill fittings shall be of the quiet type and the flush pipe shall ensure the discharge of the total contents of the cistern.

All WC pans shall be provided with a toilet roll holder.

F.15.17 Squatting Water Closet

The squatting WC shall consist of the pan, high level flush cistern, flush pipe, flush chain and handle and all other necessary accessories. The WC pan shall be manufactured of vitreous china and consist of a floor level bowl with a squatting plate which is provided with raised foot treads. The plate forms and impervious surround and shall be formed in one piece with the bowl. The bowl shall be provided with a back flush inlet and may be supplied with or without an integral. The flushing cistern shall be provided with a ball valve, siphon flush fittings and an overflow pipe discharging indirectly to a conspicuous outlet. The flush pipe shall be of PVC or painted galvanised steel with a diameter of 32 mm. The cistern shall have a capacity of 9 l. All units shall be in white colour.

F.15.18 Bowl Urinals

The urinals shall be wall hung urinals provided with an extended lip and a spreader for flushing water to the whole internal surface of the bowl. The urinals shall be of vitreous china complete with outlet grids.

All urinals shall be provided with flushing. A single unit shall be provided with a manually operated flushing cistern. When the urinals are installed in ranges, they shall be provided with

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an automatic flushing cistern and dividing panels. The cistern shall discharge its contents automatically by siphonage, at intervals determined by the rate of water input to it. The capacity shall be 4,5 l of water per standing space while the water supply shall be provided with a regulating cock and stop valve.

F.15.19 Wash Basins

The wash-basins shall be of vitreous china, wall hung and in white colour. The wash-basins shall be provided with a waste connection, piped water supply, overflow outlet, plug and chain and water taps.

The wash-basin shall be designed to eliminate splashing and spillage. All exposed metalwork shall be chrome plated. The wash-basin shall be supported by wall brackets of painted steel firmly fixed to the wall. Each basin shall form a waterproof edge with the wall. A mirror of approximately 40 x 60 cm shall be provided and fixed above each washbasin.

F.15.20 Showers

Showers shall be fixed complete including shower bases made of enamelled steel, piped hot and cold water supply, wall mounted taps and floor drains. All shower rooms shall be provided with a built-in soap holder and a shower curtain rail. The floor in the shower rooms shall be provided with a sill.

F.15.21 Sinks

The sink-units shall be manufactured of stainless steel and each sink shall be formed in one piece.

The sinks shall be provided with a single drainer, including plugs and chains, wastes and traps, piped water supply and taps. The sinks shall be provided with suitable built-in pipework, taps and fittings shall be chromium plated.

F.15.22 Testing of Sanitary System

The sanitary system shall not be accepted until it has been tested as specified below. All tests shall be conducted in the presence of the Engineer. No part of the sanitary system shall be painted, covered or enclosed until it has been tested, inspected and accepted. All equipment, materials, instruments and labour necessary for testing and inspection shall be provided by the Contractor, to execute the work as instructed.

F.15.23 Pressure Tests of Drainage

The piping of the plumbing and drainage system shall be tested with water. After the plumbing fixtures have been set and their traps filled with water, the entire drainage system shall be

submitted to a final test. The water test shall be applied to the drainage system in its entirety or in parts. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to the point of overflow. If the system is tested in parts, each opening shall be tightly plugged except the highest opening of the part under test. Each part shall be filled with water but no part shall be tested with less than 3 m head of water.

The Contractor has to install temporarily a pipe of 3 m height in order to apply 3 m head at the uppermost parts of the system. The water shall be kept in the system, or in the portion under the test, for at least 4 hours before inspection starts. The system shall then be tight at all points.

F.15.24 Pressure Tests of Water Supply Pipes

Upon completion of the potable water distribution system, it shall be tested and proved tight under a water pressure of 1 MPa or 150 % of the working pressure, whichever is higher. Care shall be taken that no appliance or fitting shall be pressurised higher than its rating. If such an appliance is included in the testing circuit, it shall be blinded prior to applying the pressure. A hand pump shall be used for this purpose. All lines shall be properly plugged or capped, making sure that all air has been vented from the system before pressure is applied. The pressure shall remain constant without pumping for a period of 8 hours. Tests shall be run and/or repeated to the satisfaction of the Engineer.

F.15.25 Flow Test

A flow test shall be made of all the sanitary system components and in case any obstructions are encountered in the piping or equipment to the Engineer's satisfaction.

A watertight test for sleeves and the passage of pipes through floor and roof shall be made to the Engineer's satisfaction.

F.16. ELECTRICAL EQUIPMENT

For technical specifications for electrical equipment refer to General Conditions Part F.

F.17. SITE TESTING

Site testing includes for both tests during installation and tests at completion. The Contractor shall prepare and submit to the Engineer a comprehensive and detailed site testing program of all parts of the Works subject to Site testing. This program shall be submitted to the Engineer one month before start of erection / installation and be reviewed and updated as may be required from time to time.

F.18. TESTS ON COMPLETION

F.18.1 General

For complete transmission systems the Tests on Completion shall serve to determine the actual capacities of the various elements through the full ranges of possible operations.

In case that at the time of Tests on Completion connections to the public power supply have not been completed by the public electricity provider, the tests shall be carried out with power generated from the stand-by generating sets.

For mains the pressure test STP shall be deemed to constitute part one of the test at completion, subject to a successful test at normal operating pressures which shall constitute part two of the test at completion of mains. During this second part, the satisfactory function of valves, in particular air valves, washouts, hydrants, shall be tested.

The Contractor shall provide for the tests:

- All skilled and qualified operating and test staff for the testing of all equipment;
- Provisions and disposal of all services, lubricants, and fuels and electricity;
- All measuring and testing instruments to demonstrate that the equipment fulfils the requirements, in particular instruments to monitor transient processes such as surges, etc.

F.18.2 Building Services

The Contractor shall demonstrate that the building services installations conform to the Specification and applicable local regulations. The tests shall include but not be limited to:

- lighting installations;
- plumbing;
- ventilation and air conditioning.

The Contractor shall demonstrate that the illumination levels conform to the specified values.

Bidding Documents for the Construction of the Wastewater Treatment Plant, Sewage Sludge Treatment Plant and Sewage Sludge Incineration Plant for the City of Podgorica

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

1. Specifications

b) Technical Specifications

General Technical Specifications

Part G: Mechanical and Electromechanical Works

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- a) Scope of Supply of Plant and Installation Services by the Contractor
- b) Technical Specifications
 - Particular Technical Specifications
 - General Technical Specifications
- c) Specifications for Project Area Environmental, Social, Health and Safety Management (ESHS)
- d) Personnel Requirements
- e) Equipment Requirements

2. Drawings

3. Supplementary Information

- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
- f) KAP Well Water Analyses Data.

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List of Acronyms

AC	Alternating Current	IDM	Induktiv-Magnetisch Durchflussmesser(Electromagnetic flowmeter)
ANSI	American National Standards Institute	IE	International Efficiency
ASTM	American Society for Testing and Materials	IEC	International Electrotechnical Commission
BS	British Standard	IK	Impact Protection Rating
CEMEP	European Committee of Manufacturers of Electrical Machines and Power Electronics	IP	Indice of Protection
CEN	Comité Européen de Normalisation (European Committee for Standardization)	ISO	International Organisation for Standardisation
DC	Direct Current	NPSH	Net Positive Suction Head
DFT	Dry Film Thickness	PN	Nominal Pressure
DI	Ductile Iron	PRP	Rated for Prime Power
DIN	Deutsches Institut für Normung (German Standard)	PT	Platinum
DN	Nominal Diameter	PTC	Positive Temperature Coefficient
EN	European Norm	PTFE	Polytetrafluoroethylene
EPACT	Energy Policy Act	rpm	Rotation per Minute
EPDM	Ethylen-Propylen-Dien-Monomer	STP	System Test Pressure
ESP	Emergency Standby Power	TEFC	Totally Enclosed, Fan-Cooled

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

G.1 STEEL STRUCTURES AND ENGINEERING METAL WORKS

G.1.1 Scope

This section sets out the general technical requirements for the structural steel works and Engineering metal works covering the supply of materials, site clearance, erecting of any steel structures and ancillary tasks required for the completion of Works.

G.1.2 General

Unless otherwise specified, all steelwork (except roof structures and steel reservoirs) wherever installed shall be galvanised (hot dip or zinc spraying).

Metal support structures shall be designed in accordance with following standards or other applicable standards as instructed / approved by the Engineer:

- Eurocode 0 (EN 1990): Basis of structural design;
- Eurocode 1 (EN 1991): Actions on structures;
- Eurocode 3 (EN 1993): Design of steel structures;
- Eurocode 4 (EN 1994): Design of composite steel and concrete structures;
- Eurocode 9 (EN 1999): Design of aluminium structures;
- EN 1090 Execution of steel structures and aluminium structures.

Where the use of prefabricated proprietary designs is proposed, the standards to which they are manufactured shall not be less rigorous than specified herein.

Hot rolled structural steel shall conform to EN 10025 or EN 10056, hot finished hollow steel shall conform to EN 10210, or equivalent Standards.

For structural steel work assemblies, steel bolts, nuts and washers shall be high strength friction grip bolts conforming to EN 14399, black bolts including nuts and washers conforming to EN 15048 and ISO 4014, rivets as per ISO 1051, or equivalent standards.

All welding consumables (electrodes, wire, filler rods, flux, shielding gas and the like) shall comply with the requirements of the applicable EN standards and with the requirements of the appropriate welding procedure as instructed / approved by the Engineer.

The Contractor shall provide samples and supporting documents of all materials and works to the Engineer for approval upon the Engineer's request

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G.1.3 Steel Quality

The steel to be used for steel structures is grade S235JR and shall be weldable. All railings, caged ladder and footbridges are steel grade S235JR and the standard protective finish to all components is hot dip galvanizing.

Structural steel shall conform with the requirements as specified in the Standards and the design shall be based on the minimum properties for the steel to be normally used in the works are the following:

- Tensile yield point $\geq 235 \text{ N/mm}^2$;
- Tensile strength $\geq 360 \text{ N/mm}^2$;
- Module of elasticity 210.000 N/mm^2 ;
- Thermal coefficient of expansion $12 \times 10^{-6} \text{ mm/m/}^\circ\text{C}$.

All steel furnished for structures shall be properly identified for conformity to the ordered grade through mill tests reports and certification shall be furnished that the yield point of the material supplied equals or exceeds that considered in the design.

Steel which is not readily identifiable as to grade from marking and tests records shall be tested to determine the conformity with the Standards.

G.1.4 Design and Detailing

Structures and components, such as those required for the laddering, hoppers, etc., shall be shop fabricated so as to form sub-assemblies of the largest practical size suitable for transportation, handling and erection.

Structural design of any and all steel structures shall be submitted to the Engineer for approval.

G.1.5 Erection

Upon commencement of the Contract, and before beginning to erect any steel structure, the Contractor shall submit for approval of the Engineer the erection plan and the procedure describing the methods the Contractor intends to use on Site.

The erection plan and procedure shall provide all complete details of the erection process. The erection plan shall include drawings, notes, catalogue cuts, and calculations clearly showing all necessary details, assumptions and dimensions. Material properties, specifications, structural analysis and other data used shall be included.

After receiving the approval by the Engineer the Contractor can start the erection process.

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G.1.6 Test Certificates

The Contractor shall furnish copies of all mill orders and shipping statements to the Engineer's satisfaction.

G.1.7 Handling and Storing of Materials

All structural steel parts shall be transported safely and shall arrive sound without damage.

All storage facilities shall be subject to the approval by the Engineer and shall be such as to permit easy access for inspection and identification. All material shall be stored in such a way to prevent rust and loss of small parts. Piled material shall not rest on the ground or in water but on skids or platforms.

The loading, transporting, unloading, and piling of steel material shall be conducted in such a way that the steel will be kept free from injuries due to inappropriate handling.

In assembly of structural parts, the Contractor shall use methods and equipment not likely to twist, bend, deform or otherwise injure the material.

All items slightly bent or twisted shall be corrected before placing and all items damaged will be replaced at the Engineer's discretion.

G.1.8 Welding and Heat Treatment

G.1.8.1 General

All welding carried out during fabrication in the factory and erection on the site shall be carried out in accordance with the requirements of EN 10025 or equivalent standard and as shown on the approved detail drawings.

Before welding is commenced either in the fabrication shop or on site, weld procedures shall be submitted for approval of the Engineer and weld procedure tests shall be carried out where directed by the Engineer. The procedures shall specify the type of equipment to be used, electrode selection, preheat requirements, base material and joint details.

In the case that the procedures are not covered by Standards evidence of qualification tests shall be submitted.

G.1.8.2 Preparation for Welding

No welding on galvanised steelwork and over zinc primers or paint shall be allowed. Galvanised steelwork shall be exclusively assembled by bolts and nuts.

G.1.9 Anchor Bolts

G.1.9.1 Placing Anchor Bolts

Anchor bolts are set by the Contractor in accordance with the approved drawing and the bolts shall be set perpendicular to the horizontal surface of the foundation slab.

The Contractor shall comply with the following requirements in setting anchor bolts in the reinforced concrete foundation slab:

- If set in wet concrete, the bolts shall be accurately placed before pouring the concrete ;
- If the bolts are set in drilled holes, the clear diameter of the holes shall exceed the bolt diameter by at least 25 mm in order to place the grout. Before placing grout, the concrete shall be thoroughly cleaned and wetted with water ensuring a proper bonding. Grout shall be pre-packaged and mixed, placed and cured as recommended by the manufacturer. After 7 days the grout must have attained a minimum strength of 28 MPa. The Contractor shall submit all information to the Engineer for approval before using the grout.

G.1.9.2 Alternative Fixing of Bolts

Alternatively, fixing of anchor bolts may be realized with a threaded rod encapsulated in a quick-setting styrene-free vinyl ester resin and hardener. The resin must properly adhere to the surface of the threaded rod and bond it to the surface of the drilled hole.

G.1.10 Flooring

G.1.10.1 General

Flooring shall be prefabricated from chequer plate or open grid panels.

Flooring and supports thereto shall be designed and manufactured to resist a uniform applied live loading of 7,5 kN/m² unless otherwise specified or stipulated in applicable standards.

Flooring panels shall generally be removable by one person and the maximum weight of each panel shall not exceed 25 kg. Removable sections of flooring shall be provided with adequate holes for lifting keys, keys to suit for each location, and be arranged to permit removal without disturbance to support brackets, spindles, pipework, etc. Intermediate support members shall be provided as required and attached to the supporting structure.

Flooring shall be detailed and fabricated so that no cutting is required on Site. Flooring shall be secured to the frame or supports by stainless steel flush screws. Supporting steelwork shall comply with the requirements of clauses for structural steelwork.

Bolt holes in brackets and mountings shall be slotted to allow for adjustment of line and level.

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Cut-outs shall be trimmed with curved or straight edge trimming as appropriate. Internal access covers shall generally be designed and fabricated as specified for flooring. In situations which warrant special measures to prevent pollution the covers shall be air-tight.

G.1.10.2 Floor Plating

Plating and frames shall be heavily galvanised or made from aluminium alloys. Floor plating shall have a raised pattern to be skid-proof.

G.1.10.3 Open Grid Flooring

Open grid flooring panels shall be prefabricated from load bearing bars of flat section backed with round, square, or twisted bars perpendicular to and welded to each load bearing bar. Open grid flooring shall be heavily galvanised or made from aluminium alloys.

Panels shall be fixed to each other by a purpose-made fixing system with detachable connections.

G.1.10.4 Permissible Tolerances

For metalwork at floor level joints differences between flooring sections and between steel flooring and adjacent concrete shall be:

- difference in level at joints: 2 mm ;
- joint gap: 2 mm.

G.1.11 Handrails

Handrails shall be provided along every edge of all metalwork and concrete walkways, stairs or accessible open areas where the drop beyond the edge exceeds 1,0 m.

Handrails shall consist of standards at regular intervals not exceeding 1,5 m, and two rails. The upper rail shall be 1,0 m above the adjacent finished floor level, and 900 mm above the nosing line on stairways. The lowest rail shall be midway between floor and upper rail.

The handrail fixing and anchorages shall be designed to withstand a continuous horizontal load at the top rail of 750 N/m.

Unless otherwise required in the particular specifications, all for handrails inside buildings shall be fabricated from 33,7 mm bore galvanised medium weight steel tube, or tubular polished aluminium alloy.

Handrails shall be flush jointed. Handrails terminating against a wall shall either have a suitable wall fixing flange, or shall terminate at a standard with a gap between the standard and the wall not exceeding 100 mm.

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Where the shape of the concrete structure does not incorporate an upstand at the edge of walkways, toe plates 5 mm thick and 100 mm high shall be fixed to handrail standards. The bottom edge of such toe plates shall be 10 mm above the surface of the concrete walkway.

The handrail posts for stairways and for landings and walkways of width less than 1,2 m shall have palm fittings for bolting to the side of the structure.

Elsewhere the standards shall be designed for fixing 100 mm inside the edge of concrete structures, or at the supporting edge girder of steel flooring, or have palm fittings.

Horizontal mounting palms shall be drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the handrails. Vertical mounting palms shall be drilled for not less than two bolts the line through the bolts being vertical.

Where required, ladders, stairways or other openings shall be guarded on three sides by handrails conforming to the requirements stated above. Access to the ladders or openings shall be guarded by two removable galvanised hanging chains secured to eyes at top and middle levels.

Handrails shall be of uniform appearance and manufacture.

G.1.12 Ladders and Stairways

G.1.12.1 General

Stairs shall have an inclination of approximately 30° and ladders of 75° where practicable. Stairs shall be complete with handrails, minimum 100 cm vertical height.

Vertical ladders shall be installed alternating left hand / right hand side to horizontal platforms placed approximately every 6 m of vertical height. Vertical ladders of more than 3 m height shall be provided with safety hoops at intervals not exceeding 900 mm, with the lowest hoop 2,5 m above the ladder foot. Unless otherwise stipulated in particular specifications, live load assumptions for ordinary platforms shall be:

- for platforms used by personnel only with light equipment
with single weights of less than 50 kg: 2,5 kN /m²;
- for all other platforms 7,5 kN /m².

G.1.12.2 Ladders

Ladders shall be in accordance with EN 14396. Ladders shall be of heavily galvanized steel, aluminium alloy or stainless steel.

The stringers shall be sized to suit the height of the ladder and the interval of the stringer supports. Stringers shall be bent over the top and drilled to receive the rungs, which shall be welded to the stringers on each side of each stringer. The bottom ends of the stringers shall not

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be designed for floor fixing but shall terminate at wall fixing supports at least 150 mm above the floor. All edges of stringers shall be ground smooth to remove burrs and sharp edges.

Where the installation of hoops is not possible or inappropriate, as agreed with the Engineer, fall protection rails or anchorage points shall be provided for attaching safety harnesses.

G.1.12.3 Metal Stairways

If not otherwise specified in the particular specifications, metal stairways shall be designed for a loading of 7,5 kN/m² of plan area of the stairway. Stairways shall be made of heavily galvanized steel or aluminium alloy.

Stairways shall be provided with tubular handrails, stringers of cross section suitable for the span and loading, and treads of open grid flooring.

The stair rises and treads shall be perfectly uniform. Following criteria for the design of stair's tread and rise shall apply:

- Rise shall be between 14,0 and 19,0 cm ;
- Tread shall be between 26,0 and 32,0 cm;
- Relationship between rise height and tread length: $59,0 \text{ cm} < 2 \times \text{rise} + \text{tread} < 65,0 \text{ cm}$;
- Pitch shall be between 30° and 38°.

The tolerances regarding rise, treads shall be maximum 5 mm. The width of the stairways shall not be less than 800 mm.

The stringer may be mounted by means of angle brackets with slotted holes for adjustment of line and level.

G.1.12.4 Step Irons

Step irons for concrete walls of in-situ concrete chambers shall be in accordance with EN 13101. All step irons shall be of steel. The step width shall be 250 mm.

G.1.13 Miscellaneous

G.1.13.1 Dissimilar Metals

The use of dissimilar metals in contact shall be avoided where possible to prevent contact corrosion. Galvanised mild steel surfaces in contact with aluminium or aluminium alloy shall be deemed to satisfy this requirement. Components of aluminium or aluminium alloy shall be fixed to steel structures exclusively by means of bolts, nuts, washers and screws which are cadmium plated.

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Contact corrosion prevention measures shall be implemented as deemed required by the Engineer. These measures shall be submitted to the Engineer for approval.

G.1.13.2 Keys

Lifting keys and devices for unfastening screws shall be galvanised mild steel and supplied at the rate of one set for each five similar covers, with a minimum of two sets of each particular type.

G.1.13.3 Corrosion protection

The structural metal work shall be protected in accordance with the general specifications set forth in Section 0.

G.1.13.4 Installation

Where metalwork is to be founded on and fastened to concrete, the Contractor shall use one of the following methods as subsequently detailed:

Method	Description
1.	Bolting or screwing the metalwork to plates or angle sections with anchors set into the concrete structure or set into pockets left in the concrete structure.
2.	Setting the metalwork into pockets or recesses formed in the concrete structure.
3.	Bolting the metalwork to bolts set into the concrete structure or set in pockets or holes in the concrete structure.
4.	Bolting the metalwork to self-anchoring epoxy resin fixed bolts placed in drilled holes.
5.	Bedding the metalwork on cement-mortar placed on the concrete surface.

Cement-mortar of 1 part of cement to 3 parts of sand shall be used for bedding access covers and the like and for filling around metalwork or bolts set into pockets or holes smaller than 100 mm².

For larger holes, concrete of the same grade as the structure shall be used instead of mortar.

The installation methods permitted for each type of metalwork are specified in the table below. These shall apply unless instructed by the Engineer otherwise or specified in the particular specifications:

Metalwork item	Permissible methods of installation
Stairs and ladders	4
Flooring	1 or 4
Step irons	2
Hand rails	4
Access covers, surface boxes and gully grating	2 or 4

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During installation, each item of metalwork shall be temporarily braced as necessary to resist all forces which are likely to be applied to it during installation, fixing and building in.

Any bolted connections required as part of the installation operation shall be fitted and tightened before fixing bolts are tightened or pockets are grouted.

The nuts of grouted or resin fixed bolts shall not be tightened until the grout has fully cured. Small or lightly loaded items may be fixed using screws and approved plugs set in drilled holes.

G.2 CORROSION PROTECTION AND PAINTING

G.2.1 General

These Specifications cover the general requirements and standards of workmanship and the painting and protective coatings required to be carried out by the Contractor of the works, except where particularly defined in individual specification clauses or as necessary due to a particularly corrosive local environment, the possible reaction of escaping chlorine on the works or on the structures or the reaction of chlorine residuals on phenolic paints (e.g. inside pipelines) , harmful or toxic paint in contact with process liquids, or other special requirements, in which case the Contractor shall submit his own special specification along with his tender.

No alternative or substitute painting standard or specification will be accepted unless it is specifically required for the above stated reason. No painting or protective coating will be accepted by the Engineer unless it is at least to the standard and of the quality specified herein.

G.2.2 Contractor's Responsibility

The Contractor shall be responsible for the complete cleaning, preparation, priming, painting and protection of the works carried out by him.

G.2.3 Applicable Standards

Where no explicit instruction is given in standards in the Specification or by the manufacturer concerning any particular aspect of the workmanship, materials or procedures in connection with anti-corrosion protective systems in the works for iron and steel structures, the relevant recommendations of the following standards or codes of practice shall apply:

- EN ISO 8044 Corrosion of metals and alloys - Basic terms and definitions;
- EN ISO 12944 Paints and varnishes - Corrosion protection of steel structures by protective paint systems;
- EN ISO 1461 Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods;
- EN ISO 2063 Thermal spraying - Zinc, aluminium and their alloys;
- EN 13507 Thermal spraying - Pre-treatment of surfaces of metallic parts and components for thermal spraying.

All coatings shall be suitable for the long-term protection of the plant under operational conditions at the site of installation.

The Contractor's attention is specifically drawn to the extremes of temperature and humidity recorded in the region and he shall take into account possible abrasions, restricted ventilation, and the various potentially corrosive environments within the works buildings and structures.

G.2.4 Decorative Finish and Final Appearance

The Contractor is advised that internal civil works finishes, furnishings and decorative colour schemes in the main operational areas shall be of a pleasing appearance, co-ordinated and designed to produce a comfortable working environment. Accordingly, the Contractor shall obtain the Engineer's approval regarding the final colour scheme and decoration of the works.

G.2.5 Trial Areas and Sample Pieces

Prior to the commencement of the site painting work, designated area(s) or section(s) of the works shall be completely painted as a sample of the work and workmanship to be carried out. The area(s) or section(s) shall include complete samples of all the major painting required in the works.

The area(s) shall be offered for review by the Engineer and shall, upon approval, be then preserved as a reference standard for the work.

G.2.6 Precautions

All surface fittings, ironmongery, etc., except hinges shall be removed before painting and reattached on completion. They shall be entirely free of any droppings, paint smears and blemishes. Labels, pump and other machinery name plates, data plates, markings, etc., shall not be covered by paint but carefully preserved by removal and replacement or by masking.

The Contractor shall pay particular attention to the toxicity, flammability and the explosive dangers related to the storage and application of the systems and shall take all precautions necessary to the satisfaction of the Engineer to protect his operatives, the public and other site personnel.

No one site coat may proceed in any section of the works until the entire section is complete and the Engineer has received notice of completion in order that he may inspect the work and authorise the application of subsequent coats. Each successive coat shall preferably be of different colour or shade to facilitate inspection. The Engineer may apply his own identification markings on undercoats to ensure full compliance with the Specification.

Brushes, tools and equipment shall be kept in a neat and clean condition. Painting shall not be carried out in the vicinity of other operations, which might cause dust. The final coat shall be uniform in colour and free from brush marks, runs or other defects.

All paint shall be "new" and "fresh" and obtained from approved manufacturer(s).

If so directed by the Engineer, the Contractor shall ask the paint manufacturer(s) to spot-check the preparation and painting and submit to the Engineer and the Contractor a written report on his observations.

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All paint shall be supplied in sealed containers bearing the following information in addition to any statutory requirements:

- Manufacturer's name, initials or trade mark;
- Whether priming, undercoat or finishing coat;
- Whether for interior or external use;
- The colour reference number;
- The method of application (e.g. brush);
- The batch number and date of manufacture or re-test ;
- The shelf life of the contents.

Containers for materials other than paints shall bear as much of the above information as appropriate.

Paint shall be supplied from the Contractor's paint store to the painters ready for application. Any addition of thinners shall be made in the store under supervision and up to the limit detailed on the appropriate manufacturer's paint data sheet for the particular method and conditions of application concerned.

Paint, thinners, etc., shall be stored in sealed containers in a lock-up store at a temperature of not less than 4°C and not more than 27°C. Any special storage conditions for the paint recommended by the manufacturer shall be respected.

G.2.7 Application of Protective Coating and Paint System

Unless specifically specified elsewhere, the protective systems shall be applied in accordance with the manufacturer's instructions to the full thickness range specified, particular note being taken of the requirements for the time interval between successive coats of the system.

The coating thickness for painting on concrete or plaster surfaces shall be in accordance with the manufacturer's instructions or proposals.

G.2.8 Paint Thickness and Continuity

The Contractor shall provide and maintain, during manufacture and on site, gauges and measuring equipment of an approved type to ensure that the required film thicknesses are achieved, paint holidays are avoided, and that adhesion is to the satisfaction of the Engineer.

Wet film thickness gauges shall be provided to and used by each painter to check the rate of paint application.

The thickness of the built-up dry film after each paint coat applied to steel or other magnetic surfaces shall be measured systematically with a dry film thickness gauge.

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The Contractor shall adopt holiday detection on concrete, steel and iron surfaces and shall use a suitable method of detecting pinholes in the coating system after trials on test plates, which shall be notified in advance to the Engineer.

The sweep voltage on high voltage DC equipment shall not exceed half the voltage required to spark through the complete paint system specified.

Gauges, instruments and meters shall be maintained in an accurate working condition and shall be made available to the Engineer for checking when requested.

The following instruments, with the manufacturer's operating instructions, shall be provided, maintained and used by the Contractor's inspector. In addition, under the Contract a separate set shall be provided and maintained for the Engineer's sole use for the duration of the Contract:

- 1 adhesion tester, cover 0 to 280 kg/cm²;
- 1 DC high voltage holiday detector, 20 kV, with rechargeable batteries;
- 1 paint inspection gauge, 0 to 500 microns;
- "wet-check" moisture meters with suitable concrete and timber scales;
- 1 dry film thickness gauge, 0 to 500 microns;
- wet film gauges, up to 500 microns;
- 1 steel temperature gauge, up to 50°C;
- 1 air humidity gauge;
- 1 air thermometer (maximum and minimum);
- surface profile gauge, up to 150 microns.

Daily checks shall be carried out and recorded on site in accordance with the provisions of EN ISO 12944 and the approved quality management system.

G.2.9 Dry Film Thickness

References in the Specification to dry film thickness (DFT) shall mean the minimum dry film thickness measured with a suitable instrument, either of individual coats, or the total system, as specified in microns (µm). The maximum permissible coat tolerance shall be + 15 %, - 0 % over the DFT.

G.2.10 Colour Coding

Pipework, tanks and ducting shall be colour coded by totally painting with the appropriate code colour as specified.

The principal code colours shall be as follows:

Potable water Blue

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Hot water.....	Crimson
Raw water	Light green
Irrigation water	Medium green
Wastewater	Dark green
Fire fighting water (including sprinkler systems and hydrants).....	Signal red
Oil and fuel oil	Brown
Gas for fuel	Yellow ochre
Chlorine liquid and gas.....	Yellow
Compressed air	Light blue
Air (ventilation and air conditioning ducts)	Silver

The definition of RAL-notation of the colours mentioned above shall be subject to Engineer's approval after the commencement of the works.

The colour coding for other minor pipelines, etc., shall be agreed with the Engineer prior to the commencement of erection.

All pipes and tanks shall also bear painted labels to indicate the contents. Lettering shall be in English and/or Buyer's official language. Labels on pipework shall incorporate arrows showing the direction of flow within the pipework.

Black lettering shall be used on orange, yellow and green and white lettering shall be used on red and blue. Sufficient labels shall be used to ensure adequate identification throughout the length of the pipe runs. These shall be located at least adjacent to each flange or disconnecting joint, where pipework passes through walls, floors, crosses doorways and other access ways and at intervals in long runs of pipework.

G.2.11 Knotting and Stopping

Knotting shall comply with the approved international Standards.

Stopping for concrete or sand / cement plastering shall be of similar material to the background and shall have a similar surface finish.

Stopping for woodwork, hardboard and plywood shall be proprietary spirit-based wood filler, tinted to match the woodwork.

Parts to be subject to manufacturer's shop testing shall not be stopped or surface treated prior to satisfactory completion of the testing. Thereafter the specified treatment shall be applied.

G.2.12 Systems to be compatible and complete

All coatings, stoppings, primers, undercoats and finishing paints of any one complete protective system shall be compatible with each other and the completed system shall provide continuous,

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pore-free coatings resistant to physical and chemical disintegration in the environment in which they are to be used.

As far as is practicable, materials, forming any one protective and/or decorative system used in the permanent works, shall be obtained from one approved manufacturer.

G.2.13 Bitumen Coating

Bitumen coatings shall be to BS 3416 or equivalent standards. Suitable grades shall be selected where the coating will be in contact with potable water.

G.2.14 Waste

The Contractor shall provide on-site suitable moveable receptacles into which are to be placed all the liquid, slops, washings, etc. All solid refuse or flammable residues shall be removed from site. No refuse shall be deposited on any soil or disposed down any permanent sanitary fittings, sinks or drains. The Contractor shall immediately clean up any unauthorised deposition and remove from the site any employee found to be responsible. Handling and management of all such waste shall be in accordance with the approved standards and applicable local regulations.

G.2.15 Application

G.2.15.1 Spray application

The equipment to be used for spray application shall be in strict accordance with the paint approved manufacturer's instructions for each coating material. Any runs shall be immediately brushed out.

G.2.15.2 Brush application

The shape and quality of the brushes shall be suitable for the work to be carried out. Extension handles to brushes shall not be permitted.

G.2.16 Primers

Except if otherwise specified, primers for steelwork shall comply with the relevant EN Standards or equivalent and contain corrosion-inhibiting pigments, adhere firmly to the substrate and form suitable bases for the subsequent coats.

G.2.17 Surface Preparation by Sand Blasting

All surfaces to be coated shall be free of scale, rust, grease, oil, dust and other deleterious materials.

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In case sand blasting is required for surface preparation, the surface finish of sand blasted steel shall be in accordance with the relevant EN Standard or equivalent and to a visual standard in accordance international approved Standards at the time of painting. The blast profile shall be within the limits 50 – 75 microns.

Abrasives shall be restricted to reusable iron or steel (grit and shot) or copper slag. The type and grades of abrasive shall be selected in accordance with the appropriate EN standards or equivalent standards.

Within four hours of completion of surface preparation, and before surface re-rusting occurs, a coating of primer shall be applied to avoid deterioration of the prepared base metal. No contamination shall be permitted to occur between blast cleaning and primer coating.

G.2.18 Metal Coatings

Metal coatings required for protective purposes on any item of metalwork shall be applied as shop coats after fabrication of the items is completed, including all punching, welding, drilling, grinding, screw tapping and cutting, and after the removal of surface defects. Tapped holes shall be blanked off before the metal coating is applied.

Except if specified otherwise, all steelwork shall be galvanised either by hot dip or by zinc spray both not less than 100 g/m².

G.2.19 Coatings of Steel Structures

Coatings of general steel structures shall be multi-layered and as follows:

- Sand blasting to SA 2 ½ acc. to EN ISO 12944 part 4 and free of dirt, oil, grease ;
- 1 shop coat of 1-component high-pigmented rich zinc polyurethane primer, of low solvent content, 80 micron as primer, (Friazinc PUR or equivalent);
- field coat of 1-component high-pigmented mica-filled polyurethane paint, of low solvent content, 80 micron, (Icosit PUR or equivalent) ;
- 1 finish coat of 2-component epoxy resin, low solvent content, 80 micron (Icosit EG 4 of micaceous iron colour or equivalent).

G.2.20 Coatings of Steel Pipes and Tanks for Water

Coatings inside and outside on steel tanks and their pipework shall be multi-layered and as follows:

- Sand blasting to SA 2 ½ acc. to EN ISO 12944 part 4 and free of dirt, oil, grease ;
- 1 shop coat of 2-component high-pigmented rich zinc epoxy primer of low solvent content, 20 micron as primer, weldable (Friazinc R or equivalent) ;
- 1 site coat of the same primer, 60 micron, spray application (Friazinc R or equivalent) ;

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- 2 finish coats of solvent-free 2-component epoxy resin, 225 micron each (Icosit TW1 or equivalent).

G.2.21 Dehumidification Required for Special Purposes

The Contractor shall supply and operate such dehumidification equipment as may be necessary to preserve blast cleaned surfaces in a pristine condition until they can be coated and/or to provide the curing conditions necessary for such coats.

G.2.22 Classification of Painting

Lettered classification of surfaces shall be used for the purpose of identifying the protective coating specified herein:

- "A": Surfaces above process liquid level and not liable to splashing thereby, in non-aggressive atmosphere.
- "B": Surfaces in contact with untreated or treated water for potable use.
- "C": Surfaces below process liquid level or liable to splashing thereby in non-aggressive solutions and/or atmospheres.

For convenience the painting requirements are summarised in the table at the end of this section.

G.2.23 Embedded Steel

Steel which is to be totally embedded in concrete shall be cleaned to according to approved international Standards and shall not be primed.

G.2.24 Uncoated Surfaces

The only surfaces of iron or steelwork or non-corrosion resistant materials which are to be left unprotected by paint or metal coating are:

- The internal surfaces of boxes or hollow sections which are of dimensions too small to permit access for painting either at the fabrication stage or for maintenance during the operation life of the steelwork and which are to be hermetically sealed by welding;
- Those surfaces of built-in iron or steel members which are to have concrete cast against them;
- Machine bright parts and bearing surfaces which shall be thoroughly cleaned, polished and protected from corrosion by painting with one coat of a mixture of white lead and tallow or other similar approved material before dispatch. The Contractor shall provide solvent for removing the treatment;
- Parts which are specified to include corrosion allowances instead of protective coatings.

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Surfaces of iron or steel members which are to have concrete cast against them shall be clean and free of deleterious matter and loose rust at the time of concreting.

The paint protection system to be applied to the permanently exposed faces of these members before the members are built in shall be continued for 50 mm as marginal strip along the contact surface.

No paint containing aluminium in metallic form shall have direct contact with concrete.

G.2.25 Repair of defective Work

Unless specified elsewhere, areas of paint on steelwork, which have been damaged, shall be cleaned to sound material and the edges of the undamaged paint smoothed with sand-paper to a gentle bevel. Thereafter, the specified paint system shall be applied in accordance with manufacturer's instructions and to the satisfaction of the Engineer to bring the damaged area up to the same state of protection as the surrounding paintwork, with each coat of new paint overlapping the corresponding existing coat of paint by at least 50 mm.

Where epoxy coatings are damaged, suitable repair supplied by the manufacturer of the original coating shall be applied in accordance with the manufacturer's instructions.

G.2.26 Fastenings

Bolts, nuts and washers and other demountable fastenings of all galvanised parts and also aluminium alloy parts shall be in stainless steel to the appropriate EN standard and shall remain unpainted. PTFE washers shall be fitted beneath bolt-head and washer when fastening galvanised and aluminium alloy parts.

Fastenings, except high tensile, of all ferrous parts shall be steel prepared and galvanised to or sherardised to the relevant EN standards, primed and painted in accordance with the conditions at the location of works.

Unless specifically approved and required for superior protection, electro-galvanising, nickel, cadmium or any other plating process, except chromium plating, will not be acceptable, and shall not be offered.

G.2.27 Painting and Protection of bolted Connections

Joint areas of bolted connections shall be masked to maintain the surfaces free from any paint applied prior to making the connections. Masking shall be removed before erection.

After installation and after all bolts have been tightened, the area of the connection shall be cleaned to remove all dirt, dust, oil or other contaminant. Particular care shall be taken to ensure that all traces of oil and grease are removed from bolts, nuts and washers.

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Bolts, nuts and washers and any exposed at bolted connections shall also be primed as specified, particular care being taken to ensure that any crevices are fully sealed.

The remaining coats of the paint system shall then be applied.

Following painting and where the bolted connections are in an area to be backfilled (pipe trench flanges, etc.) the bolts, nuts and washers and the entire joint assembly shall be carefully packed with an approved purpose made water proof protective paste (non-solvent) and finally wrapped with an approved protective paste impregnated tape to completely encase the assembly. Pipe joint protection shall continue along the length of the barrel for a distance of 200 mm.

G.2.28 Copper and Brass

Copper pipes and brass fittings shall be painted where they are located in aggressive locations, or to colour code the function.

G.2.29 Plaster and Concrete Protection

Where specified or required for the protection of the work or the containment or storage of chemical solutions, concrete or rendered surfaces shall be protected with paint systems accordingly to the table at the end of this section.

G.2.30 Preparation of Concrete and rendered Surfaces

Concrete and rendered surfaces shall be thoroughly cured in accordance with the manufacturer's instructions before the application of any painting system is begun.

G.2.31 Minimum Thickness and Adhesion Tests for Painting Systems on Concrete and Plaster

The total dry film thickness of any used paint system shall have a minimum value of 0,75 mm. In order to restore the coating integrity and plaster thickness whenever the paint inspection gauge is used or wherever the coating has been otherwise damaged, the surface shall be abraded for 50 mm around such damage and the area touched up with not less than two thick applications.

G.2.32 Preparation of Plaster, Brickwork and Concrete Surfaces

Efflorescence present on the surface of internal plaster, brickwork and concrete shall be removed by scraping and brushing before any surface paint is applied. When efflorescence has been removed surfaces shall be left for at least three days before priming. Painting shall be deferred where further salt deposits form on the surface during this period.

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Plaster surfaces to be painted shall be cleaned down, smoothed as necessary and all cracks shall be filled with stopping for plaster. All fittings shall be carried out before paint is applied to the surface.

Brickwork, blockwork and concrete surfaces shall be cleaned of all contaminating matter before being primed. Subject to the approval of the Engineer large holes which would cause a break in the paint film shall be filled with mortar, the surface being rubbed down to match the surrounding areas.

G.2.33 Preparation of Wood Surfaces

Wood surfaces shall not be painted when the moisture content of the timber measured with an electric moisture meter exceeds 12 % for interior surfaces and 18 % for exterior surfaces.

Hardwoods and soft woods for which a clear finish is specified shall be rubbed down with abrasive paper to give a smooth surface which shall be free from contaminating substances, scratches and other imperfections.

Prior to coating all nail and screw holes, etc., shall first be stopped.

Surfaces which are to be painted shall be rubbed down to remove all contaminating substances and imperfections which would be visible in the finished paint film. The surfaces of knots and resinous streaks shall then be painted with two coats of knotting, the first being allowed to dry before the second is applied.

The surfaces of timber treated with a water-borne preservative by an impregnation process shall be rubbed down and dry brushed to remove all traces of efflorescence before the primer is applied.

Where surfaces are suspected of being infected with mould, they shall be thoroughly treated with a fungicide.

G.2.34 Final Treatment of Wood, Plaster, etc.

The final painting system required in the works is given in the following table and is presented to tenderers for guidance to include such work under this Contract.

G.2.35 Paint Schedule for Plaster and Concrete Protection

The following schedule for Plaster and Concrete painting shall apply:

Surface	Environment	Primer	Final treatment
Concrete and cement plaster	High humidity	1 coat of a highly weather resistant resin, thinned to manufacturer's instructions	2 coat of a highly weather resistant synthetic resin based paint

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Surface	Environment	Primer	Final treatment
Concrete	Exposed to oil	1 coat with a plastic modified hydraulic mortar	3 coats with an oil resistant synthetic resin based paint
Concrete	Exposed to mechanical and chemical attack	1 coat of colourless 2-pack epoxy-based paint, thinned to manufacturer's instructions	2 coats of a 2-pack epoxy-based paint
Concrete flooring	Exposed to mechanical wear and oil	1 coat of colourless rubber-based paint, thinned to manufacturer's instructions	2 coats of a 2-pack epoxy-based paint
Internal concrete and plastered walls	Exposed to minor abrasion		3 coats of an oil-free synthetic resin-based dust-binding paint
Concrete flooring	Exposed to minor mechanical wear		2 coats of an oil-free synthetic resin-based dust-binding paint
Internal plastered	Exposed to normal conditions	1 coat of polyvinyl-acetate dispersion type, non-chalking, thinned to manufacturer's instructions	2 coats of polyvinyl-acetate dispersion type, non-chalking

G.3 ELECTRO-MECHANICAL WORKS

G.3.1 Electric Motors

All motors shall comply with European Regulation (EC) No 640/2009 and requirements set forth therein regarding ecodesign and energy saving, and bear the corresponding values on the rating plate, be squirrel cage induction motors, having an efficiency class of at least IE3 "premium efficiency" as per IEC 60034-30-1.

Protection class shall at least be IP 55 (TEFC) and IK 08 for mechanical protection, continuous duty Class S1, basic design, normal rated output for ambient temperature up to 40 °C at altitudes up to 1,000 m above sea level, de-rating at higher altitudes.

Thermal class shall be according to International IEC and EN standard, fabricated to ISO 9001 quality standard, electrical standards IEC 60034, IEC 60038 and IEC 60085, and mechanical standards IEC 60072 and IEC 60034.

Safety factors shall be as per ISO 5199. However, the effect of ambient temperature on the motor's power rating shall be taken into consideration when sizing the motor. Insulation class of motors shall be class F in accordance to IEC 60034-1 and IEC 60085 but selection of motors shall be in accordance to class B only, allowing an additional safety factor.

Rated voltage shall be 400 Volts $\pm 5\%$, exceeding IEC 60038, winding 400 V D / 690 Volt Y, frequency 50 Hertz.

Number of starts shall be not less than 5 per hour, 3 minutes between restart.

G.3.2 Pumps

G.3.2.1 General Regulations and Requirements

These rules and regulations define the requirements for single and multi-stage centrifugal pumps or units with axial, semi-axial and radial flow, and for submersible pumps with electric motors.

Pumps shall fully satisfy the performance and efficiency requirements as specified in Directive 2009/125/EC and Regulation (EU) No 547/2012, and ISO 9906; be quiet in operation and free from vibration.

Dry installed pumps shall be mounted on base plates or suction stools manufactured of cast iron or steel plate. The pumps shall be accurately aligned and fixed by dowels or machined spigots. Holes shall be provided in the base plates or stools for foundation bolts.

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Production of pumps shall conform to current standards such as ISO 9905, ISO 5199 and ISO 9908, and IEC Standards (International Electrical Commission). Pumps shall be driven by electric motors.

A label made of non-deteriorating material shall be attached to each pump and motor in a place where it can be easily read and shall show at least the following information:

- Serial number of the pump / motor and type ;
- Nominal flow in m³/h ;
- Nominal delivery head in m ;
- Net positive suction head (NPSH) in m, where applicable ;
- Motor rating, voltage, frequency, power factor and start-up mode ;
- Number of rotations per minute.

Pumps shall withstand continuous operation at full load (8.760 hours/year).

Pump and motor material shall be suitable for the fluid they transport (aggressiveness, abrasion, impellers) and comply with detailed regulations. Ambient temperature and pumped water temperature will not exceed the condition as indicated in the Particular Specifications.

Calculations on required hydraulic heads and pumps selected shall be presented to the Engineer for approval. Pumps selected shall allow for high hydraulic efficiencies near the duty point and must be operated within allowable ranges of flow at all expected points of operation.

G.3.2.2 Centrifugal Pumps

Pump and impeller shall be designed in such a way that duty point(s) at possible operating range can be set as near as possible to the maximum efficiency point rate. Furthermore, besides operation of pumps during average demand periods the design shall as well consider operation during peak demand scenarios.

If one or several pumps are operated in parallel, the characteristics of the manometric lift depending on flow shall be perfectly identical. The maximum output of the pump shall be related to the maximum nominal performance of the motor, considering applicable reserve factors.

G.3.2.3 Construction Elements

Centrifugal pumps shall comply with EN 733 or EN 2858 standard.

G.3.2.3.1 General

The pump shall be standardised single stage volute casing pump, for horizontal installation, rotating part statically and dynamically balanced, with bearing bracket in back pull-out design. Bearings shall be grease-lubricated, maintenance-free, deep groove ball bearings, sealed for

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life, shaft seal shall be uncooled soft-packed stuffing box packing, suitable for potable water, asbestos-free, flanges drilled to ISO 7005-2.

G.3.2.3.2 Materials of Pump and Motor

Materials of pumps and motors shall be as follows:

- Volute casing: Grey cast iron JL 1040 (GG-25) ;
- Bearing bracket: Grey cast iron JL 1040 (GG-25) ;
- Discharge cover: Grey cast iron JL 1040 (GG-25) ;
- Impeller: Bronze CC 480 K-GS (G-CuSn10) ;
- Pump shaft: Steel C 45 or chromium steel 1.4021 ;
- Wear rings: Bronze CC 495 K-GS (G-CuPb10Sn) or equivalent ;
- Shaft protecting sleeves: Stainless steel 1.4122 or equivalent ;
- Outside coating: after surface treatment, 2-pack zinc-rich primer and top coat of epoxy resin with a layer thickness of not less than 100 micron in ultramarine blue ;
- Inside coating: after surface treatment, 2-pack zinc-rich primer and top coat of epoxy resin with a layer thickness of not less than 125 micron in black ;

Unless expressively specified a standard pump unit includes at minimum:

- Pump and motor completely mounted, painted, c/w soft-packed stuffing box, with strong type plate of corrosion-resistant material properly secured to the casing ;
- Common base plate / base frame for pump and electric motor in torsion-resistant design, including foundation bolts and nuts.

G.3.2.3.3 Accessories

Pump accessories shall include as a minimum:

- Flexible coupling with spacer sleeve allowing dismantling of impeller without loosening of pipework or motor ;
- Coupling guards per EN ISO 13857 ;
- Flushing / sealing water pipe ;
- Pressure gauges of CrNi-steel, 0 to 10 / 16 bar at discharge, - 1 to 1,5 bar at suction side, muting, cocks, vents ;
- Drain, horizontal ;
- Spare parts as per manufacturer's recommendations for 2 years service for the pump and the electric motor.

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G.3.2.3.4 Packing and Shipment

Unless stated otherwise in the particular specifications, the pump unit shall be supplied completely assembled and mounted on the common base plate / base frame in a strong and suitable case / crate / wooden box suitable for shipment to the place of ultimate installation.

G.3.2.4 Submersible Well Pumps

G.3.2.4.1 General

Submersible well pumps shall be designed as closed-coupled. Installation shall be vertically possible and up to at least 80° from the vertical with threaded connection to pressure port in accordance with EN ISO 228-1. Pumps are to be equipped with non-return valves. The motor enclosure must be IP 68 and equipped with a temperature sensor (PT 100). Cable extensions must be factory mounted.

G.3.2.4.2 Materials of Pump and Motor

Materials of pumps and motor shall be as follows:

- Impeller: stainless steel, 1.4301, 1.4404, or equivalent;
- Suction casing stainless steel, 1.4408, or equivalent ;
- Screws, bolts and nuts stainless steel, 1.4571, 1.4404, or equivalent ;
- Stage casing stainless steel, 1.4301, 1.4404, or equivalent ;
- Shaft stainless steel, 1.4305, 1.4401, or equivalent.

Materials other than indicated above are subject to the Engineer's approval.

G.3.2.4.3 Accessories

Pump accessories shall include as a minimum:

- Non-return valve ;
- Suction strainer ;
- Cable extension as per on-site requirements (factory mounted) ;
- Installation clamps for wall-fixing, where applicable ;
- Temperature monitor / measuring device for PT100.

G.3.2.4.4 Packing and Shipment

Unless stated otherwise in the particular specifications, the pump unit shall be supplied completely assembled in a strong and suitable case / crate / wooden box suitable for shipment to the place of ultimate installation.

G.3.3 Valves, Air Valves, Hydrants and Control Equipment

G.3.3.1 General Requirements

All valves and sluice gates shall be best water works quality and suitable for use with water or water works sludge at all fluid temperatures up to 40 °C. Valve parts to be in contact with potable water shall meet the relevant provisions of EN standards. Small valves and gates shall conform to DIN 3230-4. System pressure and allowed short duration overload for system pressure test shall be acc. to EN 1074. The design, construction and choice of materials shall take into account all operational deviations including pressure surge and thermal shock.

Generally, valves shall be leak-proof in either flow direction except for check (non-return) valves, when the nominal pressure is applied. All valves with design pressures larger than PN 10 and larger than DN 100 shall be workshop-tested to DIN 3230 for tightness and soundness of materials. All pressure reduction valves, safety valves and similar components shall be workshop-tested and provided with a works certificate.

If required by the design solution the contractor shall provide all needed accessories for the valve e.g. but not limited to the following:

- Stem cap ;
- Hand wheel ;
- Extensions spindle ;
- Street cover ;
- Flange adaptor ;
- Combi-flange.

Valve bodies shall bear the following information:

- Manufacturer's name ;
- DN ;
- PN ;
- Flow-direction arrow.

The operating gear of valves and sluice gates shall be such that one man can open and close the valve against an unbalanced head 15% in excess of the maximum to be encountered in service. Where necessary, arrangements shall be provided with gearing to achieve this requirement. The maximum couple which can be exerted by one man shall be taken as 130 N, and the maximum force as 250 N. Where specified, valves 300 mm nominal bore and over shall be fitted with bypasses with isolating valves. Valves above 250 DN shall be complete with a spur gear unit.

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Gate valves shall be provided with renewable seats and it shall be possible to remove the gates without removing the valve body from the pipe work. The operation of all valves shall be such that turning the hand wheel or tee-key in a clockwise direction closes the valves.

All materials shall comply with the appropriate EN or DIN standards and shall be subject to the Engineer's approval. All castings shall be free of blowholes and other defects. Valves of all types shall be capable of withstanding corrosion in the ambient conditions and any parts manufactured from a material which is not itself corrosion-resistant must be protected.

All valves shall be internally and externally lined and coated by epoxy powder applied hot by electro-static method, complying in general with DIN 30677 Part 2, coating thickness shall be minimum 250 µm. Coating shall be tested by high-voltage method for perfect cover.

One key and one extra hand wheel shall be provided for each type of valve delivered and installed in the system.

Gate valves and butterfly valves shall be suitable for flow in either direction.

All standard valves shall be suitable for frequent operation and for infrequent operation after long periods in the open or closed condition. Packed glands shall be arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipe. Precautions shall be taken to prevent corrosion of the valve spindles in contact with the gland packing.

Each valve or sluice gate or its operating equipment shall bear an approved brass or stainless steel nameplate stating it's function and the following data in English.

- Stem material ;
- Additional information for product standard ;
- Product number ;
- Max. application temperature.

Following information shall be cast into the body of the valve:

- Manufacturer
- DN-class
- PN-class
- Cast material

Valves, cocks and operating spindles which are for submerged operation, shall be independent of external lubrication.

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Table: Test pressure for equipment

Nominal Pressure	Test Pressure	
	Body	Tightness
6 bar	10 bar	6 bar
10 bar	16 bar	10 bar
16 bar	20 bar	16 bar
25 bar	33 bar	25 bar
40 bar	52 bar	40 bar

G.3.3.1.1 Spindle Operation

Unless otherwise specified, all valves shall be located and orientated in readily accessible positions with hand wheels conveniently arranged for ease of operation. Where this requirement is impracticable or would lead to undue complication in the works, operating spindles shall be taken vertically to penstocks for manual operation.

Chain operated wheels shall not be incorporated in the arrangements. Knuckling of spindle extensions and remote operation through mitre geared linkages shall be avoided wherever possible.

Tee-key operation of valves and sluice gates shall only apply where specified elsewhere in the documents. In such case, spindles shall be fitted with a cast iron detachable cap included in the Manufacturer's supplies an sized acc. to DIN 4056.

Sluice gates and valves of and exceeding DN 50 shall be fitted with mechanical position indicators.

G.3.3.1.2 Hand Wheels

Hand wheels for valves and penstocks shall be cast iron. All hand wheels on valves over 50 mm diameter shall be fitted with a circular inscribed brass disc with an arrow indicating the clockwise direction of opening and closing and the words "OPEN" and "CLOSE", respectively in English.

External hand wheels shall be fitted with a purpose made integral locking device to prevent operation by unauthorised persons. A padlock and chain will not be acceptable.

Unless otherwise specified, all valves shall be anti - clockwise opening and operated by hand wheel for up to 300 mm, above 300 mm geared actuators shall be used if not otherwise specified. The maximum effort required to be applied at the circumference of the hand wheel to operate the valves against the maximum unbalanced head shall not exceed 200 Nm.

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G.3.3.1.3 Gate Valves (with resilient rubber main seal)

General

The valve shall be a clear way, flanged gate type, cast in ductile iron, with a resilient rubber main seal, designed for installation in water supply systems. The design and testing shall be according to following:

- EN 1074-1 and -2 (water supply, isolating valves)
- EN 1171 (industrial cast iron gate valves)
- EN 558 (face-to-face)
- EN 1092-2 (flange dimensions)

Dimensions

Dimensions shall range from DN 40 to DN 500 with face-to-face distance acc. to EN 558. All dimensions shall be full bore. Pressure class shall be PN 10 or PN 16. End connections shall be flanges designed acc. to EN 1092-2.

Coating

Valve body and bonnet shall be both internally and externally corrosion protected with 250 micron fusion bonded epoxy coating, approved for drinking water(if applicable) and complying with DIN 30677-2. The colour shall be blue RAL 5017. No uncoated parts of the iron surfaces may be in contact with the fluid or the environment.

Material and Design features

Body / Bonnet

The valve body and bonnet shall be ductile cast iron acc. to EN 1563 grade GJS-500-7.

The bonnet bolts shall be internal hex drive stainless steel A2 countersunk into the bonnet casting, sealed with hot melt glue and with no contact to environment or fluid. The bonnet-body gasket shall be EPDM. The body shall have internal rails or grooves for wedge open/close travel guidance.

The internal body seats shall have plane surfaces in symmetric angles to position and support the wedge into closed position. The body waterway shall be smooth and unobstructed with no internal pockets in the dome above the seating area.

Stem

The stem shall be stainless steel, 1.4104. The stem seal shall consist of three systems:

- Innermost a lip seal in EPDM shall act as main seal against the internal fluid pressure.
- In the middle the radial bearing O-rings shall back up the inner main seal

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- Outermost an NBR wiper ring shall seal against dust and dirt from outside.

The innermost and outermost seals shall compress against an epoxy surface coating.

Wedge

The wedge shall provide the soft seal to the valve body and consists of an inner ductile iron core, GJS-500-7, fully encapsulated in vulcanized rubber. The surface shall be smooth with no grooves, splits or pockets. Except for the point of closure the only contact between wedge and body shall be via polyamide travel guides vulcanized into the wedge.

The wedge nut shall be an integral part of the design, firmly fixated in the wedge core in a cold press forging operation before thread cutting and rubber vulcanization. It must not be able to move within the wedge and the joint between nut and wedge shall be tightly sealed in the rubber encapsulation process.

Wedge Rubber Coat

The wedge rubber coat shall be EPDM applied in a vulcanization process. Layer thickness shall be min. 4 mm on seating areas and min. 1,5 mm on other surfaces.

Data for rubber shall be:

- Hardness 70 Shore A
- Tensile strength min. 14 MPa
- Elongation at break min. 315 %
- Compression set, EPDM max. 15 % (70 °C / 24 hrs / 25 %)

The rubber/wedge bonding shall be generated in a 2-step process that enables it to pass the ASTM D429 rip-off test after a 3 week/90°C exposure. The test shall verify that separation occurs in the rubber and not in the boundary between rubber and wedge core iron.

The rubber coat shall be taste-, smell- and colour neutral, resistant to chlorine, weather and ozone and approved for drinking water.

G.3.3.1.4 Gate Valves (with metal to metal seating)

General

The valve shall be a clear way, flanged gate type, cast in ductile iron, designed for installation in water supply systems. The design and testing shall be according to following:

- BS EN 1074-2, BS 5163
- EN 558 (face-to-face)
- EN 1092-2 (flange dimensions)

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Dimensions

Dimensions shall range from DN 50 to DN 600 with face-to-face distance acc. to EN 558. All dimensions shall be full bore. Pressure class shall be PN 16, PN 25 or PN 40. End connections shall be flanges designed acc. to EN 1092-2.

Coating

Valve body and bonnet shall be both internally and externally corrosion protected with 250 micron fusion bonded epoxy coating, approved for drinking water(if applicable) and complying with DIN 30677-2. The colour shall be blue RAL 5017. No uncoated parts of the iron surfaces may be in contact with the fluid or the environment.

Material and Design features

Body/Bonnet

The valve body and bonnet shall be ductile cast iron acc. to EN 1563 grade GJS-500-7.

The bonnet bolts shall be internal hex drive stainless steel A2 countersunk into the bonnet casting, sealed with hot melt glue and with no contact to environment or fluid. The bonnet-body gasket shall be EPDM. The body shall have internal rails or grooves for wedge open/close travel guidance.

The internal body seats shall have plane surfaces in symmetric angles to position and support the wedge into closed position. The body waterway shall be smooth and unobstructed with no internal pockets in the dome above the seating area.

Stem

The stem shall be stainless steel, 1.4104. The stem seal shall consist of three systems:

- Innermost a lip seal in EPDM shall act as main seal against the internal fluid pressure.
- In the middle the radial bearing O-rings shall back up the inner main seal
- Outermost an NBR wiper ring shall seal against dust and dirt from outside.

The innermost and outermost seals shall compress against an epoxy surface coating.

Wedge

The wedge shall be made from ductile iron with bronze face rings, which are machined to a fine surface finish to ensure optimum contact seal with body seat rings. The wedge face rings shall be accurately machined and firmly secured to the wedge. The guides in the wedge must ensure uniform closure regardless of high pressures. The wedge shall have a large through bore housing the stem that ensures no stagnant water or impurities can collect. The wedge nut shall be made of bronze with lubricating abilities providing optimum compatibility with the stainless steel stem.

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G.3.3.1.5 Nozzle Type Check Valves

Nozzle-type check valves shall have a concentric, spring loaded obturator, length shall comply with EN 558-1 series 14-short (DIN 3202-F4), flange dimensions and drilling to EN 1092-2 PN 16 (DIN 28605 / DIN 2501). Head loss factor zeta shall not exceed 0,7 when fully open and closure time not 0,15 sec. For DN > 250 and 0,1 sec. for DN < 300.

Check valves shall be double flanged conforming to EN 12334. Check valves shall be suitable for operating in the horizontal or vertical position unless otherwise specified.

G.3.3.1.6 Swing Check Valves

Swing check valves shall have an excentric, lever-and weight loaded obturator, length shall comply with EN 558-1 series 48 (DIN 3202-F6), flange dimensions and drilling to EN 1092-2 PN 16 (DIN 28605 / DIN 2501).

Check valves shall be double flanged conforming to EN 12334. Check valves shall be suitable for operating in the horizontal or vertical position unless otherwise specified.

- body ductile iron EN-JS-1030 acc. to EN 1563 (GGG 40.3 - DIN 1693)
- obturator (swing check valve) ductile iron EN-JS-1030 acc. to EN 1563 (GGG 40.3 - DIN 1693)
- obturator (nozzle-type valve) stainless steel 1.4404
- shaft stainless steel AISI 410
- seats stainless steel 1.4404
- all other elements stainless steel or zinc-free bronze.

Float Valves:

- Body Cast iron with guide brass
- Valve seal Soft seal on metal
- Piston seal Guide ring brass / O-ring seal
- Float lever Welded steel
- Float ball Copper sheet, tinned or stainless steel

G.3.3.1.7 Flap Valves

Flap valves shall be round or rectangular, single door bitumen coated, double hung tidal type flap valves, with the clear opening dimensions designed to pass the required discharge. Flap valves shall be fitted with phosphate or bronze or stainless steel or similar approved corrosion-resistant metal faces and hinge pins and shall have a galvanised mild steel lifting eye.

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Flap valves shall be designed to withstand a working pressure equivalent to 8,0 m of water and shall be tested after installation with a feeler gauge to a non-acceptance of 0,05 mm between sealing faces when closed.

Materials used in the manufacture of the flap valves shall be as specified above.

G.3.3.1.8 Butterfly Valves

Butterfly valves shall be in according to DIN and EN 593, double eccentric type with face to face dimensions to ISO 5752 series 14, flange dimensions and drilling to EN 1092-2 PN 16.

Body and disk shall be of ductile iron ISO 1083 / JS / 400-15 or 500-7 in accordance with ISO 1083 or grade EN-GJS-400-15 or 500-7 in accordance with EN 1563. Shaft shall be made of stainless steel ANSI 420-B. Body seat, bolts and pins shall be made of stainless steel 316. Endless profile sealing ring and O-rings shall be of EPDM suitable and approved for potable water. Drive mechanism of butterfly valves shall be a gear box with consists of a cast iron casing GG25 according to DIN 1693 with a worm gear from a reputed manufacturer such as Auma of Germany or Rotork of the United Kingdom. Grease shall be provided for lifetime of the valve.

Butterfly valves installed below ground shall have the same underground equipment as the gate valves; those installed above ground or in manholes shall be hand wheel-operated. Any butterfly valve shall have a gear box watertight and suitable for buried installation.

G.3.3.1.9 Pressure Control or Flow Control Valves

Pressure or flow control valves used for pressure reduction, pressure sustaining or pressure relief or flow control shall be of the double flanged type and shall operate by use of an integral auxiliary pilot circuit suitable for the fluid and shall be actuated by the integral spring and the differential pressure on the diaphragm. For DN less than DN 80 diameter a direct spring controlled valve may be used. Flow control valve shall have a downstream orifice installed and incorporated into the pilot circuit. Valves shall inherently close at backflow. All valves shall have an indicator showing degree of aperture.

Length shall comply with EN 558-1 series 1, flange dimensions and drilling to EN 1092-2 PN 16 (DIN 28605 / DIN 2501).

The valves shall be adequately sized to control the flow and pressure differential required for the application with an accuracy of $\pm 2,5$ % of the set value. They shall be capable of operating at a sustained pressure 20 % in excess of the nominal declared working pressure.

Globe-type control valves shall have a vertical spring and pressure loaded obturator, a pilot circuit with pilot valve, strainer, stop cocks, throttle needle valve as may be required for the particular purpose. Identical valves except for the elements making up for the pilot circuit shall be used for pressure reducing, pressure sustaining and flow limiting valves.

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The main pressure control valve operation shall be actuated by a hydraulic differential pressure system in balance with a spring loaded bellows type diaphragm, the reference pressure being bled from the inlet and outlet of the main valve. The diaphragm spring shall be adjustable by a screw to cover the range of pressure adjustment specified for the valve application.

Pressure gauges of appropriate range shall be provided upstream and downstream and shall be of class 1,6 100 mm diameter.

G.3.3.1.10 Drains and Vents

The Contractor shall be responsible for providing all the necessary facilities for the safe disposal of all matters arising from all drains and vents to the approval of the Engineer. All vents and drains shall be arranged to have a continuous rise or fall as appropriate, to the point of disposal of the matter being discharged. Where practicable, vents shall terminate 2.000 mm above roof level or as otherwise approved by the Engineer

The minimum size of the drain piping will be 50mm. Drain funnels may be manifolded into a common drain. Drains will be routed to the nearest drainage channel or floor sump.

The contractor shall provide all traps, drains and vents which are called for in the particular specification, drawings and where necessary for equipment operation, line or equipment filling, hydrostatic, and testing.

Air-lines shall be provided at all high points in pipe work to vent air during pipeline filling and for release of gases, which may collect during normal operation. Single small orifice, large orifice, or double air valves shall be provided as appropriate. Pressure ratings shall be appropriate to the maximum test pressure on the main.

G.3.3.1.11 Air Valves

Automatic air valves shall be manufactured in accordance with EN 1074-4 and able to perform the following functions:

- Aeration / vacuum breaking of large quantities of air to prevent excessive sub-atmospheric pressures
- De-aeration of large quantities of air in a pipe at atmospheric pressure during initial filling of a pipe
- De-aeration of small quantities of air under full internal system pressure for air that dissolves from the water at points of low pressure

The air valves shall be suitable for reasonably clean and cold water. The basic operating principle shall comply to a kinetic air valve. It shall be suitable to operate with special gasket at internal pressures as low as 0,1 bar. In operation the discharge differential pressure shall be limited to 0,05 - 0,07 bar or a maximum velocity of 30 - 40 m/s to prevent pressure surges.

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Automatic air valves shall have a single chamber and be directly operated by the flow medium. It shall have a large orifice for outlet and intake of large air volumes and a small orifice for discharge of pressurized air during service. The float shall be stabilised in a guide basket permitting high venting capacity. Standard double chamber air valve with ball-type floats are not allowed.

The body and lid shall be of ductile cast iron ISO 1083 / JS / 400-15 or 500-7 in accordance with ISO 1083 or grade EN-GJS-400-15 or 500-7 in accordance with EN 1563. The float, the shell, bolts and nuts shall be stainless steel.

G.3.3.1.12 Wash Water Hydrant Valves

Wash water hydrant valves shall be of the screw down, bottom entry top to accord with DIN standards. Bottom flanges shall be 80 mm diameter, faced and drilled PN 16. Each valve shall be provided with a spindle cap and outlet cap.

G.3.3.1.13 Fire Hydrants

The aboveground fire hydrant shall be of the breakable pillar type. The pillar type fire hydrant shall be manufactured in accordance with EN 14384 and shall be equipped with:

- Nozzle body holder fitted with 2 No. nozzles of 2 ½ " and 1 No. nozzle of 4" incl. Caps;
- 1 No. 4" pumper nozzle NST-Thread;
- Bronze valve seat ring and nozzles;
- Stainless steel 316 spindle;
- A frangible section which breaks on impact, at the same time as the clamping washers ;
- A "one piece" made valve box-duckfoot bend assembly (including main valve with EPDM rubber disk, fitted anti-water hammer guide, D.I. duckfoot bend with inlet flange of size DN 100 mm, PN 16 rating to EN 1092 standard;
- A screw and nut device fitted on the stem holder so that the valve remains closed in case of impact;
- Automatic drain valve.

The pillar type fire hydrant shall be supplied with hoods made of aluminium alloy (protection box), to be closed and opened through a key. Every pillar hydrant shall be supplied with one key. Each two pillar hydrants supplied shall be provided with one extra repair kit for the breakable section.

Each pillar hydrant shall be tested in factory:

- Body test at 24 bar, hydrant in open position;
- Valve seat test at 17,6 bar, hydrant in closed position.

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The pillar type hydrant shall be coated internally and externally with fusion bonded epoxy coating system to achieve a minimum dry film thickness (DFT) of 250 microns at any point. The maximum dry film thickness shall be as per paint manufacturer recommendations. The hood shall also be epoxy coated, to achieve an average dry film thickness (DFT) of not less than 60 microns but no value shall be less than 50 microns. Internal coating shall be non-toxic. All materials required for the Completion of the Works shall be supplied in time and at the cost and under the responsibility of the Contractor

G.3.3.1.14 Standpipe

Each hydrant valve shall be provided with one "screw-on" type standpipe with two outlets, one 65 mm and one 19 mm diameter. At the outlets shall be valves with instantaneous bayonet type connections.

G.3.3.1.15 Hose Box

Adjacent to each valve point shall be a hose box containing one of each above specified standpipe and hoses (carried on hose reels) in addition to one valve key and tome bar. The hose box shall be of a stainless steel lockable type and shall be mounted above ground level on an angle bar frame or fixed on the wall on a base plate.

G.3.3.1.16 Pressure and Vacuum Gauges

Pressure and compound gauges shall be of metrological class 2,5 (= accuracy of $\pm 2,5 \%$) shall be provided and fixed directly to and at the same levels on both delivery and suction sides of each dry well pump. The gauges shall be fitted with diaphragm type isolating valves and with siphon pipes and an additional branch allowing to connect precision gauges when required.

Gauges shall have concentric dials of not less than 100 mm in diameter, pressure gauges being graduated in metres head, and compound gauges in cm of mercury and metres head. Capacity shall be selected approx. 1,5 times the OP. The face of the dial shall bear the following label: "IMPORTANT: CLOSE WHEN NOT IN USE".

The gauge shall be of the Bourdon tube type, of stainless steel and copper spring and shall comply with EN 837-1. It shall be sealed from the fluid being measured by means of a diaphragm or capsule and be filled with silicone oil. All gauges shall be fitted with a pressure snubber to dampen pressure pulsations.

Before delivery to Site, each gauge shall be calibrated in accordance EN 837-1 and a calibration certificate for each gauge shall be provided. Further copies of the test certificates shall be incorporated in the operating and maintenance manuals.

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G.3.3.1.17 Bulk Water Meter – Woltman Type

Bulk water meters of Woltman type shall be of best water works quality and suitable for use with potable water, in compliance with relevant provisions of EN standards and allow for fluid temperatures of at least 30°C, PN16, IP class 68, Metrological Class B. Bulk water meters shall incur minimal head loss.

Meters shall be equipped with dry dials, covered by metal protective covers. The dial shall allow readings in the range from 1 to 99.999.999 m³ (eight digits!) and one low flow indicator.

The body shall be produced of grey cast iron, coated inside and outside with epoxy coating approved for application in potable water.

Both, turbine and dial shall be fully and easily interchangeable without dismantling of the body.

Flange dimensions and drilling shall conform to EN 1092-2 PN 16 (DIN 28605 / DIN 2501).

The meters shall be prepared for retroactive installation of pulsers or other equipment for data transfer.

Bulk water meters shall be tested and calibrated at the factory in accordance with relevant regulations. Test certificates shall be issued and submitted to the Engineer for approval. The meters shall bear the seal of the calibration bank. The certificate shall include precise information on the test and calibration processes applied.

G.3.3.1.18 Bulk Water Meter – IDM type

Bulk water meters of IDM type (measurement through electro-magnetic flow sensors) shall be of best water works quality and suitable for use with potable water, in compliance with relevant provisions of EN standards and allow for fluid temperatures of at least 30 °C, PN 10, IP class 68. The accuracy shall be at least 0,5 % of the measured value

IDM type water meters shall be of modular construction, consisting of a flow sensor and a signal converter installed in one unit (compact).

Whereas the measuring tube shall be of stainless steel, the inside lined with hard rubber, flanges of carbon steel (Flange dimensions and drilling shall conform to EN 1092-2 PN 16 (DIN 28605 / DIN 2501), all polyurethane coated.

The signal converter shall be equipped with a graphic LC display, be suitable for ambient temperatures from – 10 °C up to + 40 °C, IP class 66, and have equal accuracy as stated above.

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G.3.3.1.19 Electric Actuators

Unless otherwise specified actuators for modulating valves and dampers shall be electrically operated. Self contained sealed hydraulic units may be considered where high thrusts or high speeds of operation are required but each application shall be approved by the Engineer.

In order to prevent the risk of fire or explosion pneumatic actuators shall be used in hazardous areas and associated equipment (e.g. positioners) must be intrinsically safe in accordance with EN 50020.

Electrical driven actuators shall have an enclosure protection according to EN 60 5292 shall be IP 67 or if required IP 68. Motor shall be a 3-ph AC asynchronous motor, type IM B9 according to IEC 34, insulation class shall be at least F. Motor protection shall include thermo switches or alternative PTC thermistors (according to DIN 44082).

Operation control

1. Limit switching shall be provided by counter gear mechanism for end positions CLOSED and OPEN for e.g. 1 to 500 turns per stroke (optional e.g. for 1 to 5.000 turns per stroke). Tandem or single switch for each end position; switches galvanically isolated. An analogue position feedback signal shall be provided by analogue potentiometer or 4 – 20 mA.
2. Torque switching shall be provided by adjustable torque switches for direction OPEN and CLOSE by tandem or single switch for each direction. An analogue torque feedback signal shall be provided by analogue potentiometer or 4 – 20 mA.
3. Mechanical position indicator by continuous indication, adjustable indicator disc with symbols OPEN and CLOSED.

With either action the failure mode shall be suitably monitored and the plant operator informed by some form of alarm. The failure response of all actuators in the event of the loss of the prime mover (air pressure, oil pressure, electrical power) shall be indicated on the Piping and Instrumentation (P&I) diagrams, valve schedules, etc.

For all actuators of control valves and dampers of main systems local indicating pointer and position transmitters for remote indication and closed loop feedback shall be provided.

All actuators shall have a lockable handwheel for direct manual operation. A lockable mechanical clutch mechanism shall be provided to inhibit power control of the actuators when the handwheel is operated.

G.3.4 Power Generating Sets

For technical specifications for power generating sets, refer to Section H.2.4.

G.3.5 Spares, Lubricants, Tools and Ancillary Equipment

G.3.5.1 Spare Parts, lubricating Oils and Greases

The spare parts shall comply with the specifications and the applicable standards and shall be new, unused and readily interchangeable with the parts for which they are replacements. Each spare part shall be clearly marked with its identification reference and a detailed list shall be enclosed in each package containing spares.

All spares ordered for the plant shall be adequately protected for long periods of storage and shall be suitably labelled in English to simplify identification. All spare parts shall be handed over to the Employer / Beneficiary at the time the plant is commissioned and after the Engineer has certified that the parts are correct and complete.

G.3.5.2 Lifting Devices

The Contractor shall provide adequate lifting devices required for inspection, maintenance and repair of equipment installed in the plant. All lifting devices shall be new and handed over to the Employer / Beneficiary at the time the plant is commissioned.

G.3.5.3 Ancillary Equipment

The manufacture, delivery to site and erection of any and all ancillary equipment, such as holding down bolts, raw bolts, pipe clips, small bore piping, greasing piping, etc. to complete the machinery contract are all considered part of the mechanical equipment.

G.3.6 Erection of Mechanical and Electro-Mechanical Works

G.3.6.1 Delivery and Storage of Equipment

The Contractor shall submit to the Engineer a detailed schedule for manufacturing, delivery, transport and installation for each of the various subcontractors or suppliers. The schedule shall consider the following:

- a) All plant ready for erection arriving ahead of the deadlines, or plant ready for erection but for any reason delayed, shall be stored in a closed compound;
- b) All electro-mechanical equipment and measuring instruments shall be stored in a closed warehouse under conditions similar to the final ambience; where required in air conditioned rooms;
- c) The Contractor shall remedy any damage of the equipment prior to the delivery to the store in accordance with Contract provisions;
- d) The Contractor shall provide insurance and shall be entirely and solely responsible for the security of all equipment stored at the site before erection in accordance with Contract provisions.

G.3.6.2 Building-in of Equipment

After the equipment has been finally levelled and aligned, a final inspection shall be undertaken for each item of plant by both the Engineer and the Contractor, prior to the permission being obtained to commence "building-in".

The Contractor shall carry out all temporary packing, accessories, supports, etc., to facilitate the erection and alignment of the equipment and to ensure the retention of any such level and alignment during all installation works (e.g. backfilling, grouting, casting of thrust blocks, support blocks and the like), in accordance with the applicable standards and the approved method statements and manufactures' instructions. The Contractor shall also undertake to have an Engineer representative present for the respective installation.

G.4 INSPECTION AND TESTING

G.4.1 General

The Contractor shall request inspection and testing of all items of plant, mechanical and electrical works and shall give the Engineer four (4) weeks' notice that the equipment is ready for testing and of his intention to carry out tests in accordance with Contract provisions.

If any of the tests are beyond the resources of the Contractor or the Manufacturer, the Contractor shall make arrangements for these to be carried out elsewhere on suitable testing facilities.

The Contractor shall carry out tests as stated in the applicable National or International Standards (EN, ISO or IEC), for performance tests and such other tests that are stated and as may be deemed necessary by the Engineer, to proof that the Works comply with the Specifications set forth by the Contract Document as a whole. Each test certificate shall be in accordance with the Contract provisions, and shall contain concise information of the test; e.g. (Contract number and details, pay item number, prevailing specifications, manufacturer, type, model, serial number etc.) for unambiguous identification of the material or equipment tested and the extent of the certificate's validity.

The Contractor shall be responsible to fully document all tests carried out and readings taken and to keep a neat record of all tests.

However, no inspection, release or approval of any part of the Works by the Engineer, shall release the Contractor from any of his obligations under the Contract.

Whenever tests and inspections have been completed to the Engineer's satisfaction and when the test certificates, (including reports, notes, tables, graphical representations of results etc. as technical annexes) have been checked and deemed complete, the Engineer shall confirm acceptance in writing.

Where witnessed tests are not required by the Contract or waived by the Engineer, the complete test certificates including technical annexes shall be forwarded to the Engineer:

- either within two (02) weeks after shipment of the respective goods together with any other commercial document issued at the time of shipment;
- or within two (02) weeks after receipt of such waiver.

The Engineer may require the Contractor to remedy a failed test or inspection may require through supply of new parts from the manufacturer or return to manufacturer's plant of damaged parts for repairs if such repairs are still technically deemed feasible by the Engineer.

Any equipment used in testing shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

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The Contractor shall make sure that all sub-contractors are given copies of the relevant parts of the Specifications. Full details of the testing method proposed for each item shall be submitted to the Engineer.

G.4.2 Cost for Testing

The Contractor shall bear all costs of Third Party as may be required from time to time and of the Engineer if required to carry out inspections at places other than on the site or in the Contractor's storage facilities close to the site. Such costs of the Engineer shall comprise the per-day-fee, travel and accommodation cost and all other incidental costs occurring during the performance of test and inspection.

G.4.3 Test Instruments and Equipment

The Contractor shall satisfy the Engineer as to the accuracy of all instruments required for the tests.

kW-meters and kVAR-meters shall be checked for correct rotation and creep tests shall be carried out to ensure that the meter is inoperative with voltage alone if the secondary of the current transformers is left connected with the primary current interrupted.

G.4.4 Factory Tests

These are inspections and tests, at the place of manufacturing and apply for mechanical (e.g. pumps) and electrical items of equipment (e.g. instruments). Factory tests shall be carried out by the manufacturer according to the relevant standards and the manufacturer shall issue the relevant certificates.

The Engineer or his representative reserves the right to carry out pre-shipment inspections and witnessed testing at the manufacturer's facilities. All items of the plant shall be liable to works inspection at reasonable times by duly authorised representatives of the Engineer.

Each consignment of material and equipment delivered to the Site shall have been tested at the manufacturer's facilities or other approved place in accordance with the appropriate standard. The Contractor shall provide the Engineer with the manufacturer's test report for each such consignment before delivery to Site.

Whilst the Engineer shall be provided with facilities to witness testing and/or inspection of all items of equipment at the manufacturer's works, he may at his discretion advise that part of the tests shall proceed in his absence, the tests shall be made as if in his presence.

The Contractor shall submit to the Engineer a duly countersigned copy of the readings of any witnessed test and, within two weeks after completion of any witnessed or unwitnessed tests, a complete test certificate.

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The Contractor shall submit to the Engineer un-witnessed factory test certificates where applicable giving a detailed record of all tests performed.

If after inspecting, examining, or testing of any material or equipment, the Engineer shall decide that such items or any part thereof is defective, or not in accordance with the Specification or performance requirements, he may reject the said items or part thereof, giving to the manufacturer within a reasonable time, notice in writing of such rejection, stating therein the ground upon which the said decision is based..

As and when the Engineer is satisfied that the equipment shall have passed the required tests he shall notify the Contractor in writing to that effect.

Copies of test certificates shall be included in the As-Built Documentation as detailed elsewhere.

G.4.4.1 Pumps

G.4.4.1.1 Inspection

The inspection carried out prior to the test runs serves to verify the compliance of pump and motor type and size with the Contract, the correctness of pump materials, motor protection, anti-condensation heating, the scope of supply, pressure, etc. as laid down in the specification and the design standards for the pump types. The supplier shall make sure that all parts and materials can be inspected. If necessary, the pumps have to be dismantled to ensure inspection of the correct materials.

The inspection shall also include packing and correct marking of the parts, crates, boxes, etc. as described in the Contract respectively the instructions of the Engineer.

Product inspection witnessed 3.1B to EN 10204 (with the necessary certificates), including:

- a) Hydrostatic pressure test of complete pump with 20°C water, test duration 15 minutes, test pressure 16 bar;
- b) Dimensions check and visual inspection;
- c) Coating inspection;
- d) Balancing check of the impeller;
- e) Vibration test;
- f) Measurement of bearing temperature;
- g) Strip test, optional;
- h) Guarantee of submersible motor according to IEC 60034;
- i) Final inspection.

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G.4.4.1.2 Vibration Test

Vibration values of the pump shall be according to ISO 1949, in the operating range from 0,5 up to $1,2 \times Q_{opt\ veff} < 4,5$ mm/s.

G.4.4.1.3 Hydraulic Performance Test Standard

The Contractor shall submit a material and product inspection and certificate 2.2 in accordance with EN 10204. All pumps shall be manufactured and tested under a certified quality assurance system according to ISO 9001 / EN 29001.

The centrifugal pumps installed with their proper drives on the common base plate shall be inspected and tested in the presence of the Engineer at the pump manufacturer's test stand. The pump power input may be calculated either from the power input in the motor and its previously tested efficiency or by measuring torque and speed. The performance test shall generally follow the procedures laid down in ISO 9906, with the particulars as set forth hereinafter:

- each individual pump shall be tested with cold and clean water;
- each individual pump shall be tested according to ISO 9906 and the agreed acceptance grades;
- each individual pump shall be tested together with the pertaining electric motor;
- at the main duty point(s) flow, head, power demand, pump efficiency and NPSHr shall be measured, respectively calculated;
- the pumps shall be tested at the manufacturers test stand;
- details of place, date, testing personal, test procedure, measuring methods, NPSH-test, etc. have to be agreed upon by all parties prior to the testing in writing;
- the pumping units shall be tested at their actual speed and frequency;
- the tolerances for the main duty point(s) and the other measuring points shall comply to the below specification;
- submersible motor pumps shall be tested as one unit together with the non-return valve.

G.4.4.1.4 Pump Performance Curves, Tolerances

The pump test shall provide at least five (5) or more data points, of which one is the main duty point, other points shall be distributed over the pump curve and include regimes at or near the shut-off head at Q_0 and a further point shall be at or near the maximum flow Q_{max} of the Q-H curve. The remaining data points shall be suitably selected to allow the establishment of pump performance curves for Q-H (head against flow), Q- η (pump efficiency against flow) and Q-P (power consumption at pump shaft against flow). Unless otherwise specified, the required NPSH value of the pump shall be verified at the main duty point.

Accuracy of measurement of the various parameters shall be in accordance with ISO 9906 and agreed grades herein.

G.4.4.2 Blowers and Compressors

Each blower or compressor shall be witness tested as an integral unit for a complete sequence of operation for capacities of 80 %, 100 % and just below the action of the relief valve. The witness test shall obtain the guarantees of performance for each item of equipment.

Impellers of centrifugal air blowers shall be overspeed tested to 15 % above the maximum continuous service speed. The assembled blower units shall be proved mechanically by testing at contract service speed.

Tests shall be completed and witnessed at the manufacturer's works using a pipework system as required by the agreed code for aerodynamic testing. Blower testing shall be undertaken using the driver motor which will be coupled to the blower on Site.

The manufacturer's test drive motor may be used subject to the Engineer's written approval. Adequate reason for this option shall be supplied to the Engineer with the request to use other than the final drive motors to be used on Site. Where variable volumetric output is required, the blower and motor shall be tested in combination with the control system which will be ultimately used for this purpose on Site.

G.4.4.3 Vessels, Pipes, Valves

All valves shall be factory inspected and tested acc. to ISO 5208 and EN 3230. Where special hydraulic performance is specified elsewhere (e.g. head loss), such parameter shall be explicitly tested and certified.

All hydraulic equipment subject to hydraulic tests such as but not limited to: pressure vessels, pipes, fittings and valves, shall be hydraulically tested 1,5 times the maximum working pressure but not less than the test pressure applicable to the PN rating.

Such tests shall not be witnesses except if specified elsewhere in the Contract Documents.

G.4.5 Site Testing

Site testing includes for both tests during installation and tests at completion. The Contractor shall prepare and submit to the Engineer a comprehensive and detailed site testing program of all parts of the Works subject to Site testing. This program shall be submitted to the Engineer one month before start of erection / installation and be reviewed and updated as may be required from time to time.

G.4.6 Tests on Completion

For complete systems the Tests on Completion shall serve to determine the actual capacities of the various elements through the full ranges of possible operating conditions.

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In case that at the time of Tests on Completion connections to the public power supply have not been completed, the tests shall be carried out with suitable power generators.

The Contractor shall provide for the tests:

- All skilled and qualified operating and test staff for the testing of all equipment;
- Provisions and disposal of all services, lubricants, and fuels and electricity;
- All measuring and testing instruments to demonstrate that the equipment fulfils the requirements.

G.4.6.1 Pipe Works

The pressure test STP shall be deemed to constitute part one of the test at completion, subject to a successful test at normal operating pressures which shall constitute part two of the test at completion. During this second part, as well the satisfactory function of valves and other hydraulic accessories shall be tested.

G.4.6.2 Pumps

Each set tested for flow, head, power consumption, current and mechanical reliability. Thereafter, where applicable, parallel operation shall be tested.

G.4.6.3 Surge control

Satisfactory operation of surge control equipment shall be tested with instantaneous shut-downs of an increasing number of parallel running main pumps. Pressure and flow in the surge vessels shall be recorded.

G.4.6.4 Dosing Equipment

Each set shall be tested for dosing the specified volumes. Efficiency of mixing shall be determined by taking samples and analysing for dissolved agent after 15 minutes, 30 minutes and one hour after start of mixing.

G.4.6.5 Lifting Equipment

Each installation inclusive of rails and beams shall be tested with test loads, provided by the Contractor, to prove that the equipment is capable of satisfactorily lifting 125 % above its rated load (lift in centre of gantry and between cantilevers of track support) and total deflection shall be measured and compared to the tolerable maximum.

G.4.6.6 Diesel Generator Sets

Tests shall be carried out in accordance with ISO 3046 by of the Contractor's staff and supervision of the Engineer. The purpose of the tests on completion shall be to confirm the

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factory tests and each engine and generator shall be tested to verify the performance for a period of up to 4 hours or as the Engineer may determine.

G.4.6.7 Bulk Fuel Storage Tanks

Prior to being put into service, each tank and associated equipment shall be subject to a sustained pressure of 0,7 N/mm² to ensure that the installation is sound and shows no leaks or distortions.

G.4.6.8 Completion Certificate

The Contractor, upon completion of testing and commissioning of the installation/system shall submit to the Engineer all test results accompanied with all applicable certificates.

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

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Section VII: Employer's Requirements

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b) Technical Specifications

General Technical Specifications

Part H: Electrical and I&C Works

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- a) Scope of Supply of Plant and Installation Services by the Contractor
- b) Technical Specifications
 - Particular Technical Specifications
 - General Technical Specifications
- c) Specifications for Project Area Environmental, Social, Health and Safety Management (ESHS)
- d) Personnel Requirements
- e) Equipment Requirements

2. Drawings

3. Supplementary Information

- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
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List of Acronyms

AC	Air Conditionning	DP	Decentralised Peripheal
AC	Alternating Current	DQ	Design Qualification
ACC	Alarm Control Centre	DSL	Digital Subscriber Line
AI	Analog Input	DVD	Digital Versatile Disc
AN	Air Natural	DVD-RW	Digital Versatile Disc – Read Write
AO	Analog Output	EMC	Electromagnetic Compatibility
ATEX	ATmosphere EXplosible	EMF	Electromagnetic Flow Meter
AWG	American Wire Gauge	EN	European Norm
CATx	Category x network cable	ERP	Enterprise Resource Planning
CB	Circuit Breaker	ESP	Emergency standby power (generator)
CCTV	Closed-Circuit Television	FAT	Factory Acceptance Test
CD	Compact Disc	FB	Function Block
CE	Communauté Européenne (European Community)	FBD	Function Block Diagram
CEE	Certification of Electrotechnical Equipment	FIP	Factory Instrumentation Protocol
CEN	Comité Européen de Normalisation (European Committee for Standardization)	FNU	Formazin Nephelometric Unit
CENELEC	European Committee for Electrotechnical Standardization	FOC	Fibre Optical Cable
CFC	Continuous Function Chart	GPI	Graphical Plant Image
CHP	Combined Heat and Power (unit)	GPRS	General Packet Radio Service
CP	Communication Processor	GPS	Global Positionning System
CPU	Central Processing Unit	HART	Highway Addressable Remote Transducer
CT	Current Transformer	HD	High Definition
DB	Distribution Board	HMI	Human Machine Interface
DC	Direct Current	HRC	High Rupture Capacity
DCS	Distributed Control System	HV	High Voltage
DF	Disposability Factor	HW	Hardware
DGBT	Detection of Gas, Pressure and Temperature	I&C	Instrumentation and Control
DI	Digital Input	ID	Identification
DIN	Deutsches Institut für Normung (German Standard)	IEC	International Electrotechnical Commission
DMT	Definite-time overcurrent protection	IM	Interface Module
DO	Digital Output	I/O	Input / Output
DO	Dissolved Oxygen	IP	Index of Protection
		IP	Internet Protocol
		IQ	Installation Qualification
		I/Q/F	Installation / Qualification / Function

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ISDN	Integrated Services Digital Network	PE	Protective Earthing
ISO	International Organisation for Standardisation	p.f.	Power Factor
IT	Information Technology	PID	Proportional Integral Derivative
KVM	Kernel-based Virtual Machine	PLC	Programmable Logic Controller
LAD	Ladder Diagram	PROFIBUS	Process Field Bus
LAN	Local Area Network	PROFINET	Process Field Net
LCD	Liquid Crystal Display	PRP	Prime Power (Generator)
LED	Light Emitting Diode	PTC	Positive Temperature Coefficient
L-L	Line to Line	PTZ	Pan Tilt Zoom
LLDPE	Linear Low Density Polyethylene	PV	Photovoltaic
L-N	Line to Neutral	PVC	Polyninyl Chloride
LTE	Long Term Evolution	PWM	Pulse Width Modulation
LV	Low Voltage	QC	Quality Control
MCB	Main Circuit Breaker	RAM	Random Access Memory
MCC	Motor Control Centre	RCCB	Residual Current Circuit Breaker
MCCB	Moulded Case Circuit Breaker	RCD	Residual Current Device
MCT	Multiple Cable Transit	RFID	Radio Frequency Identification
MES	Manufacturing Execution System	rms	Root Mean Square
MLDB	Main Low Distribution Board	rpm	Rotation per Minute
MTBF	Mean Time Between Failure	RTU	Remote Terminal Unit
MTTR	Mean Time To Repair	SCADA	Supervisory Control And Data Acquisition
MV	Medium Voltage	SD	Secure Digital
MVDB	Medium Voltage Distribution Board	SF6	Sulphur Hexafluoride
NC	Normally Closed	SFC	Sequential Function Chart
NFC	Near Field Communication	SMS	Short Message Service
NO	Normally Open	SPDT	Single Pole, Double Throw
NPT	National Pipe Tapered	SQL	Structured Query Language
O&M	Operation and Maintenance	STL	Statement List
OD	Outer Diameter	TCP/IP	Tape Carrier Package Internet Protocol
ODBC	Open Data Base Connectivity	THD	Total Harmonic Distortion
OIP	Operator Interface Panel	TLC	Three Level Cache
OPC	Open Platform Communications	TN	Terre Neutre
OQ	Operation Qualification	TN-C-S	Terre Neutre – Combiné - Séparé
OS	Operating System	TR	Technical Report
P&I	Process and Instrumentation	TRAP	Threshold Regulated Algorithm with Power Management
PC	Personal Computer	TS	Technical Specification
PCS	Process Control System	UPS	Uninterruptable Power Supply
PE	Polyethylene		

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USB	Universal Serial Bus	VLAN	Virtual Local Area Network
VAC	Volt Alternating Current	VPN	Virtual Private Network
VDC	Volt Direct Current	VoIP	Voice over Internet Protocol
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik (German technical association for electrotechnics, electronics and information technology)	VSD	Variable Speed Drive
		VSD/P	Variable Speed Drive/Pump
		VT	Voltage Transformer
VdS	Verband der Sachversicherer (German association of property insurers)	XLPE	Cross-linked Polyethylene
		WAN	Wide Area Network
		WLAN	Wireless Local Area Network
VFD	Variable Frequency Drive		

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

H.1. GENERAL REQUIREMENTS

H.1.1 Regulations and Standards

All electric equipment shall conform to the latest version of:

- The IEC rules and regulations;
- Special standards and regulations set by the local authorities;
- Standards which apply within this particular project.

Local technical regulations take precedence over those of the country of origin of manufactured goods and over the regulations mentioned further down.

All other equivalent regulations and standards shall be applicable provided they do not violate the regulations and standards quoted above and provided they are approved by the Engineer.

Any discrepancies and irregularities between the regulations, standards and codes of practice shall be subject to consultation between the Contractor and the Engineer. The Engineer will take the final decision.

The following main standards apply:

- Local standards and regulation
- EN 60204 Safety of machinery - Electrical equipment of machines;
- EN 61439 Low-voltage switchgear and control gear assemblies;
- EN IEC 60076 Power transformers;
- EN IEC 60079 Explosive atmospheres;
- EN IEC 60282 High voltage fuses;
- EN IEC 60269 Low-voltage fuses;
- EN IEC 60364 Electrical Installation of buildings ;
- EN IEC 60376 Specification of technical grade sulfur hexafluoride (SF₆) and complementary gases to be used in its mixtures for use in electrical equipment;
- EN IEC 60617 Graphical symbols for diagrams;
- EN 60529 Degrees of protection provided by enclosures (IP Code);
- EN 62305 Protection against lightning;
- EN 50172 Emergency escape lighting systems;
- EN IEC 62271 High-voltage switchgear and control gear;
- pr EN 12464 Light and lighting - Lighting of work places;
- EN 1838 Lighting applications - Emergency lighting;

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- EN 60034 Rotating Electrical machines;
- EN 61082 Preparation of documents used in electrotechnology;
- EN 61800 Adjustable speed electrical power drive systems;
- EN 61131 Programmable controllers ;
- EN 88528 Reciprocating internal combustion engine driven alternating current generating sets;
- DIN VDE 0100 Erection of low voltage installations;
- DIN VDE 0105 Operation of power installation;
- DIN VDE 0276 Distribution cables of rated voltage 0,6/1 kV;
- DIN VDE 0800 Information technology;
- DIN VDE 0833 Alarm systems for fire, intrusion and hold-up;
- ISO 50001 Energy management systems - Requirements with guidance for use.

H.1.2 Scope of Works

The scope of this work includes, but is not limited to, the provision of all electrical equipment for the following main items:

- The electricity in-feed lines to the facilities (if required);
- The work in the local supply points (Transformer station);
- The medium voltage installation, step down transformers and metering;
- The internal low voltage distribution network in the facilities;
- The low voltage power and control cable installation;
- GSM or equal data transmission interface / connection;
- Control boards;
- Uninterrupted power supply (UPS) (as required for each facility);
- Co-generation and emergency power supply;
- Small power and lighting, area lighting;
- Process Control System for plant operation and control including all field devices, gauges, communication lines and devices;
- Motor Control Centres;
- Fire alarm and security alarm systems for each facility;

H.1.3 General Specifications for Electrical Works

All equipment shall be guaranteed to be suitable for operation under the prevailing environmental and other local conditions and shall be designed and built to the highest available standards of manufacture, reliability, accuracy and repeatability and:

- such that routine and occasional maintenance throughout its life shall be a practical minimum, compatible with the preservation of maximum reliability;
- to withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.

The degree of protection for equipment enclosures shall be in accordance with EN 60529 and as follows:

- IP 54 for indoor applications;
- IP 65 for outdoor applications;
- IP 68 for transducers and other equipment mounted within valve or meter chambers or similar locations.

For installation in hazardous areas all instruments including cable connections shall be ATEX certified according to the requirements defined in the hazardous area plan.

Submersible installations or installations susceptible of being flooded shall be installed in such a way to withstand the expected external water pressure.

External equipment shall be protected from direct sunlight by a well-ventilated cabinet, canopy or other approved type of sunshade. Equipment in air-conditioned locations shall be rated for continuous operation in ambient temperatures up to 45 °C. External equipment and internal equipment not in air-conditioned locations shall be rated for continuous operation over the ambient temperature range 0 °C to 50 °C. The above temperatures make no allowance for local temperature rises due to operation of the equipment itself or by adjacent equipment.

Where more than one component or item of equipment is supplied to perform a particular function, all such items shall be identical and interchangeable.

All electric equipment, switchboards and their equipment shall be designed and installed in order to provide for easy access, servicing and maintenance at all times without disturbing ordinary operations.

Prior to the order of the equipment and the start of installation work, all relevant drawings, calculations, documents etc. must be approved by the Engineer.

H.1.4 Manufacturer and Supplier Requirements

Equipment of similar design shall be from the same manufacturer. The tenderer shall verify local representative for chosen equipment with full name, contact person, address and telephone. Also

the representative's experience, service and spare parts organisation, etc, shall be provided. All supplied equipment must be certified (CE). All components shall be marked visibly and understandably with indication of relevant standard numbers.

H.1.5 Coordination with Power and Communication Companies

Proposed connections to the grid of the public Power Corporation, or for telephone / wireless shall be submitted to the respective companies for approval.

H.1.6 Climatic Conditions

All materials and apparatus must be designed for the local climate and conditions at the site of erection and use. They must be capable of operating and functioning permanently at ambient temperatures as indicated in the Particular Specifications. All conducting elements which are not geared to these temperatures shall be downgraded. Insulating materials must be non-hygroscopic and capable of resisting external currents. Insulation materials of machinery for rotating machinery must have classification F. All moving contacts must be self-cleaning and corrosion resistant. Control boards, stands and similar elements must be protected against penetration of insects.

H.1.7 Power Monitoring

A state of the art power monitoring according ISO 50001 shall be provided for the entire plant electrical system. All distribution panels and all consumers > 50 kW shall be equipped with energy monitoring device. All main incomer panels shall provide advanced quality monitoring including harmonics analyser.

The energy management system shall be a centralized system for acquiring, processing, archiving and reporting data of energy consumption, located on the Process Control System station. The system shall provide following characteristics:

- visualization of all measuring values;
- reports regarding consumption, definition and tracking of freely configurable parameters related to consumption;
- prediction of energy consumption in future period based on production plan;
- monitoring and control of energy efficiency measures according to ISO 50001 standard.
- costs distribution according to cost centres.

A Microsoft SQL database shall be included for archiving measured values. It shall support graphical web interface using advanced Dashboards and geographic view for dislocated units. Alarm tracking related to defined up/down limits of measured values. Comparing consumption data in freely defined time periods: day / week / month / year / optional. Calculation of plant efficiency (compressors, pumps ...), by comparing and tracking of consumed energy and production (Nm³/h, m³/h, ...). Integrated statistical functions - linear regression data analysis for prediction of

consumption in the future period, based on production and plans for facility working hours. It shall be possible to track energy efficiency improvements after they are implemented.

H.1.8 Documentation

The following documentation structure applies for electrical and I&C works including SCADA:

1. Table of contents with index;
2. Conformity certificate;
3. Protocols for insulation and loop resistance measurement;
4. Grounding log with photo documentation of the underground parts and measurement protocols;
5. Hazardous area certificates (if applicable);
6. Function description of the plant / control system;
7. Circuit diagrams (pdf + closed Software file);
8. Part lists with the number, reference IDs, manufacturer and general description of the device; I/Q/F reference lists, cable lists / diagrams and terminal diagrams;
9. Parameter lists, measuring ranges, setting values, commissioning log;
10. Automation Technology: Hardware (HW) structure (production schedule) and programme documentation with comments, including programme CD, DVD, or hard disk, which is used for the restart test. The PLC programmes shall be documented in such a manner that even external third parties can retrace the programme structure. The source code of user-created FBs shall be disclosed in order to ensure that adaptation work will still be possible even after the cooperation with the Contractor has ended. The PLC is programmed according to EN 61131-3 with FBD, LAD, STL and CFC;
11. Control Centre System: Device manuals, programme descriptions and operating manuals, configurators, a description of the user-specific software and hard copies of the process displays and input screens; including printouts of the implemented logs and reports.
12. Function descriptions of the built-in units / meters / plant technology used (divided into all of the individual components);
13. Operating and servicing instructions;
14. The closing documentation shall be supplied on a suitable data carrier (USB memory stick, DVD or CD). Preferably, the files will be delivered in *.pdf format;
15. Commissioning protocols for all consumers and instruments;
16. As built drawings (pdf + dwg/dxf) for small power and lighting, lightning protection, cable pipe and duct system, earthing system, cable tray system, cable system, switchgear layout, Automation scheme, fire alarm, CCTV.

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After the contract has been awarded, the Contractor shall submit the following drawings and documents:

- Dimensional drawings of the parts to be supplied, such as switch and control cabinets, consoles, on-site control centres, etc., incl. installation dimensions;
- Single-line diagram for all of the electrical switchboards and control systems;
- Cables list with cable types, cross-sections, and number of cores;
- Layout drawings, scale 1:50;
- Wiring diagrams;
- Power network calculations (short circuit, voltage drop, load balance, selectivity, pdf and programme file);
- Installation diagrams (building technology).

After the installation work is completed, the drawings, which are corrected according to the final version, shall be handed over marked with "as-built".

With respect to the data format and the documentation system to be used for the electrical planning, the following overview applies:

Document	Digital format / programme
Operating System	Microsoft® Windows® 2008R2/2012
Hardware Documentation	WSCAD ® Suite, EPLAN ® Electric P8, AutoCAD ® 2020

Deviating specifications are subject to the Engineer's approval.

The Contractor shall prepare and hand over all of the operating and maintenance instructions according to DIN 18382, the overview of circuit diagrams according to EN 61082, circuit documents, glossaries and divisions required for the safe operation of the system.

H.1.9 Programme Licenses and Passwords

All programme licenses, passwords and source codes which are required to operate the plant or to change the programming of a specific system are part of the project and shall be handed over to the Employer with the final documentation. This also applies for package units and third party vendors. All licenses shall include 20 % spare variables for future expansions.

H.1.10 Tagging and Labels

A common identification system for all components of the plant shall be implemented by the Contractor. All documents, lists and drawings shall be based on the identification system.

Each I&C equipment and cubicle is to be clearly labeled. Each measuring point, transducer, binary transmitter, control valve, control damper and local boxes is to be provided with a firmly attached weather and temperature proof plate.

All modules within the cubicles are also to be clearly labeled. These modules and also the labels and designations on the desk/panel instruments shall be inscribed in the agreed language.

Labels shall be made of stainless steel or plastic. All labels shall be fixed with screws or rivets, sticking is not allowed.

H.1.11 Training

During the object construction and hand-over, the Contractor shall train Employer's personnel to work with the installed equipment. Personnel training to operate and maintain the equipment shall be provided during the installation, mounting and start of equipment. Training shall be theoretical and practical. Training programs, revised drawings and O&M descriptions shall be submitted for the Employer's approval before starting the training.

H.1.12 Spare Parts and Equipment

The Contractor shall supply the necessary tools and equipment for maintenance of the Electrical and automation system and spare parts for at least two years.

In order to minimize the number of spare parts, cover as much equipment as possible, enable easier maintenance and servicing and increase availability, it is necessary to consider following requirements when selecting equipment that will be installed in the plant:

1. Wherever possible, components should be unified so that one spare part can be used in several locations;
2. For essential devices in the field (electrical components, control components and instrumentation), preference should be given to modular devices wherever it makes sense and replacing of single module or component is preferred. This should reduce the total number of spare parts and chances that failure of one element will require that the entire device needs to be serviced or replaced.

The equipment list shall at least include but not be limited to the following:

- Testing equipment for electrical protection systems;
- Analyser of electrical network parameters;
- Equipment for repairs and diagnostics of electric motors;
- Sets of tools and devices for control of electrical equipment:
 - Set of dielectric tools intended for electricians 2 No.;
 - Vacuum Cleaner for Industrial Use 1 No.;
 - Set of Protection means related to electrical safety 2 No.;

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- Maintenance Laptop with complete set of 1 No.;
- Documentation and settings of electrical items;
- All required Software for parameterization (VFD, instruments, etc), remote SCADA Access.

H.2. ELECTRICAL EQUIPMENT

H.2.1 Design requirements – Future expansions

The design of the electrical system shall cover the scheduled full load of the plant, even when the project is divided into several phases.

The plant power distributions shall provide spare feeders or shall be expandable for future extensions without interruption of supply. Switchgear rooms shall provide spare installation areas if required by the design.

The expansion of the plant shall be included within the initial electrical design.

H.2.2 Switchboards and Distribution Boards – General Requirements

Before ordering and assembly of electrical panels, the design, layout and component placement drawings, circuit diagrams, inspection drawings and mimic diagrams must be submitted to the Engineer for inspection and approval before the control cabinets are built.

If the size of the cabinets deviates from the size specified within the tender documents, this deviation has to be reported to the Engineer in a timely manner.

Before the final ordering of the switchboards and distribution boards, the component placement shall be discussed with the Engineer and adapted if necessary.

The following design criteria shall be observed:

- Control circuits: always grounded at one end, otherwise 2-pin disconnecter with ground fault monitoring;
- Emergency stop circuit: according to the requirements of category 0/1/2;
- Permitted areas for the arrangement of actuators, this includes fuses and circuit-breakers;
- Degree of protection: according to the installation location (closed areas: IP 21, outside areas IP 54, wet areas: IP 67).

The switchboards and distribution boards shall be delivered factory made up to the output terminal and wired according to a colour scheme subject to Engineer's approval. Damage to the paint after the cabinets have been installed must be remedied at no cost. The cabinets must therefore be protected against damage.

The control cabinets shall be uniformly aligned and levelled, even on lumpy surface. Corresponding constructions like steel frames must be calculated into the unit price, if applicable.

The wiring is performed inside the control panel by use of flexible cables. The connection to the devices is made by means of crimping cable lugs or wire end sleeves using a special crimping tool.

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Wiring inside cubicles shall not be less than 1,5 mm² for consumers and not be less than 0,6 mm² for automation system. For connecting the peripheral modules, use space-saving, pre-assembled and factory-tested basic wiring with front connectors and terminal strips from the manufacturer of the automation technology. All installed inputs / outputs of the automation system shall be terminated by clamp. For analog I/Os, isolating terminals shall be used.

The cross-section layout is done according to VDE. Upon the Engineer's request, a corresponding calculation of the selected cables must be submitted with regard to load rating, voltage drop and attenuation.

Measuring lines are shielded, if required. The wiring of the control circuits, signal circuits, measuring circuits and electronic inputs/outputs follows a colour scheme. The following colour code applies:

- Power cable 230 VAC / 400 VAC black;
- PLC 230 VAC red;
- PLC 24 VDC dark blue;
- PE conductor green / yellow;
- N conductor light blue;
- External voltage orange;
- Measuring line white;
- Screened cables grey.

Other colour codes (local standard or use of existing systems) are subject to the Engineer's approval. In this case, the installation guidelines of the manufacturer for the automation system must be considered – especially setup and connection of the measuring system where overvoltage, lightning protection and grounding measures are concerned.

Current transformer lines are wired with a cross section of 2,5 mm². Current transformer insulating terminals are used.

All built-in devices must be clearly arranged in the control cabinets. At least 20 % spare space must be available for future expansions. This also applies to PLCs.

Fuse elements and circuit-breakers must be covered to prevent accidental contact. The same applies to busbars, current transducers, etc. and installations in the front doors of the cabinets.

Control and monitoring elements such as pushbuttons, switches, indicator lamps, text and touch panels must be installed in the front door (front side) of the cabinets and provided with engraved identification plates (screwed or riveted, not glued) with a detailed description of their function.

The identification of the components in the cabinet must be permanently marked on the device itself and as a place designator on the base or guide frame. All circuits must be permanently marked according to the single-line diagram inside the cabinets. The cables must be provided with cable marker on both ends. The inscription must be made according to the specifications on the cable list.

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All the loads in a measuring circuit must be looped in via corresponding insulating amplifiers in such a manner that the measuring circuit is not interrupted when they are removed. This also applies to local displays.

In all cabinets and distribution boards, the space requirement must be taken into consideration for the cable inlet, the arranging and securing of the signal and power cables taking into account the permitted bending radius. Corresponding cable fixing bars must be provided. Cables may only be fixed using clamps that have a plastic counter-pressure tray. For single-core cables, clamps made of non-ferromagnetic material must be used. The use of cable stripes for cable fixing is not permitted.

If there is a terminal box on the cable path between the control cabinet and the field device, the terminals in the terminal box must be designated to correspond to the numbers of the terminals in the control cabinet.

When setting up the switchboards, the latest edition of the EMC regulations must be taken into consideration, if applicable.

For surge protection, the following wiring information applies:

- The process signals are laid out on terminal strips or isolating terminal strips and, if applicable, led through the overvoltage protection devices and separate from the unprotected lines in the cabinet;
- The overvoltage protection devices should be arranged appropriately in the immediate vicinity of the point where the cable enters the building. Corresponding intermediate terminal boxes are provided for this. They must be arranged in the field and in the control cabinet;
- If required, binary signals from and to the process are sent through coupling relays. Analog signals are sent through isolating amplifiers, if applicable;
- All the wires in a cable, even the unused ones, are connected to the terminal strip;
- When setting up the connector panel or distributor box, ensure that the areas in which signals without overvoltage protection are processed, are physically separated from the protected area 'behind' the overvoltage systems;
- The special requirements for a certain measuring system result from the descriptions in the specifications and the manufacturer's specifications;
- All from field incoming and outgoing to field cables for power, signals and telecommunications shall be protected by surge arrestors in order to prevent the installations from overvoltage;
- The Contractor has to provide a surge protection concept;
- Every surge protection device shall provide an alarm signal to the SCADA.

H.2.3 Medium Voltage Switchgear Panel

H.2.3.1 Clarification with local Authorities

The Contractor has to conduct comprehensive clarifications with local authorities for the design and installation of the power supply system. A clarification report shall be provided to the client with the design and prior to installation works. The report shall include, but shall not be limited to, the following main items:

- Grid parameters (voltage level, harmonics, power capacity at connection point);
- Technical requirements according to local power provider;
- Requirements according to civil defence;
- Type of supply (overhead line or cable feeder);
- Details on power metering;
- Requirements for operation of power producing equipment on site (CHP, generator sets, PV) – grid parallel operation, power recovery to public grid.

H.2.3.2 Supply Limits

The switchgear must be complete and ready for operation and shall include the following:

- base plate for fixing to the floor and expansion anchoring bolts (excluding any base irons to be embedded in the floor);
- side closure and cable passage sheets;
- terminals for connection of power cables (cables and terminals excluded);
- terminal box for connection of auxiliary cables where foreseen (cables and cable terminal excluded).

Any civil works needed for setting up and installing the switchgear panels are excluded from the scope of supply of the switchgear panels.

H.2.3.3 Reference Standards

The supply switchgear and apparatus must be designed, constructed and tested in conformity with the applicable EU and IEC Standards in force and in particular, but not limited to the following:

- Switchgear EN IEC 62271-200;
- Circuit-breakers EN IEC 62271-100;
- Isolators EN IEC 60694, EN IEC 62271-102;
- I.M.S. EN IEC 60694, EN IEC 62271-103/105;
- Fuses EN IEC 60282-1.

H.2.3.4 Design Characteristics

Environmental data (referring to the room where the switchgear is installed) to be considered in the design and installation are:

- ambient temperature: Max + 40 °C Min – 5 °C
- relative humidity: Max 95 % in absence of condensation
- presence of atmosphere: Normal
- maximum altitude: 1000 m^(*)

(*) In the case of installations at more than 1000 m above sea level, the correction coefficient must be taken into consideration, to be applied to the test voltages and taken from the EN IEC 62271-1 Standards.

Internal arc (only for arc-proof switchgear)

In order to guarantee top levels of safety, the medium voltage switchgear must be made so as to endure the thermo-mechanical stresses due to a fault inside the switchgear (internal arc). In particular, the structure must be able to endure the mechanical stresses due to the maximum pressure value of the gases produced by an electric arc inside the switchgear.

Under fault conditions the personnel in charge of operating the installation should not be surprised by incandescent materials.

The duration of the foreseen fault current shall be 0,5 or 1 sec.

The prescriptions of EN IEC 60271-200 Standards, Appendix AA internal faults, test criteria from 1 to 6, access in class A, must therefore be followed.

To guarantee the higher levels of safety, the switchgears have to be classified as IAC in agreed to IEC 60271-200 Appendix A, accessibility A, tested with indicators on the front F / lateral L / rear R.

H.2.3.5 Construction Characteristics

The structure of the switchgear must be made up of standardized type units side by side, each consisting of modular standardized and built-up elements tested on the plant.

The factory assembled switchgear must be made in the version suitable for indoor installation. It must therefore be possible to carry out all the control and maintenance operations from the front of the switchgear (possibility of wall- mounted).

The structure of each unit must be of the self-supporting type, made with 2 mm pre-galvanised and press-bent sheet metal. The panels and doors must be made with 2 mm and 1,5 mm thick press-bent sheet metal.

The degree of mechanical protection of the units which will be installed inside must be at least IP3X (IP2X inside the switchgear).

The units must be made so as to allow any future enlargements on the sides of the switchgear, by the addition of other units.

In this regard, the switchgear must be closed at the sides by sheet metal panels which can easily be removed to allow any above-mentioned enlargement.

Each unit must be constructed and consist of compartments containing the various electrical and mechanical components as described below and be separated from each other by segregation sheets or pieces of apparatus.

The following typical compartments must be found among the various units:

- Busbar compartment;
- Feeder compartment;
- Instrument compartment.

The medium-voltage part must be maintenance-free and independent from environmental influences.

All switching devices are to be operated from the switch panel front. It shall be possible to control the switchgear from remote by PLC or SCADA. All medium-voltage components of the switchgear shall be sealed and enclosed safe-to-touch.

Capacitive voltage taps (capacitive voltage dividers) in the bushing to the cable feeder shall enable checking the safe isolation from supply without danger at the switch panel front. The degree of protection of the switch panel shall not be reduced thereby.

In detail, the typical compartments must have the following construction characteristics:

H.2.3.5.1 Busbar Compartment

The busbar compartment must be located in the top part of the unit. It must contain the main busbar system supported by the top pole insulators of the branching component (isolator or switch-disconnector) to which the busbar terminals must be bolted.

The busbars must pass from one unit to the other without interposing intermediate partitions, so as to make up a continuous duct.

The top and side closure of the compartment must be made with removable sheets or panels to allow extraordinary interventions which require the possibility of inspecting the busbars.

H.2.3.5.2 Feeder Compartment (for units fitted with circuit-breaker)

The feeder compartment must be fitted with a hinged closure door fitted with a handle for opening and to allow access to the apparatus inside it.

It must be possible to mount the following components in the feeder compartment:

- vacuum circuit-breaker;
- isolator in SF6 with 3 positions;
- current transformers (if requested);
- capacitor dividers;
- cable terminals;
- anti-condensation heater (if requested).

The door of the compartment must be fitted with an inspection window to allow visual checking of the mechanical position of the spaced type earthing switch. These inspection windows must be made of material with high mechanical resistance.

An opening for passage of auxiliary cables coming from the floor must be available.

H.2.3.5.3 Feeder Compartment (for units fitted with switch-disconnector or only no-load isolator)

The feeder compartment must be fitted with a hinged closure door fitted with a handle for opening and to allow access to the apparatus inside it.

The following components can be mounted in the feeder compartment:

- SF6 switch-disconnector with 3 positions or SF6 no-load isolator;
- MV fuses and relative fuse holder frame (for units with fuses);
- capacitor dividers;
- current transformers (if required);
- voltage transformers (if required);
- cable terminals;
- anti-condensation heater (if requested).

The door of the feeder compartment must be fitted with an inspection window for visually checking the mechanical position of the spaced type earthing switch where provided. These inspection windows must be made of material with high mechanical resistance.

An opening for passage of auxiliary cables coming from the floor must be available.

H.2.3.5.4 Instrument Compartment

The instrument compartment (if provided), located in the front top part of the switchgear, must be fitted with a hinged door fitted with knurled knobs for opening, to allow access to the apparatus inside it.

It must be possible to mount the LV apparatus in the instrument compartment, and in particular:

- control and signalling devices;
- microprocessor protection, measurement, control and communication units (optional);
- relays, instruments;
- fuses, circuit-breakers auxiliary;
- terminal boxes.

A fixed sheet metal must provide segregation of the busbar compartment from the instrument compartment.

A support terminal box to carry the remote signals if required (open / closed circuit-breaker position, open / closed isolator position, signals from transducer, protection release tripped, etc.) must be provided in the instrument compartment of the unit.

H.2.3.5.5 Busbars and Connections

The omnibus busbars and the branch busbars must be made of flat electrolytic copper.

The busbar system must be sized to withstand the short-circuit currents according to parameters of the supply network. The Contractor has to clarify this details with the local power supplier and a comprehensive electrical network calculation has to be provided for approval of the engineer prior to ordering and installation of the system.

The main busbars must pass from one unit to the adjacent one without interposing partitions, so as to make a continuous duct.

H.2.3.6 Earthing Systems in the Switchgear

A copper electrical earthing busbar, solidly bolted to the metal structure and with a minimum cross-section of 75 mm², must run longitudinally on the front of switchgear under the door.

The whole structure and the metalwork elements must be openly connected together by means of screws or rivets, to guarantee good electrical contact between the parts.

The doors must be connected to the metal structure by means of flexible copper braids, with a cross-section of 16 mm².

Earthing of the frame of the isolators and switch-disconnectors must be ensured by connection to the earthing circuit.

All the main components must be connected to earth.

On the end of the switchgear, the earthing busbar must have a connection to the cable of the earthing installation of the substation.

H.2.3.7 Interlocks

The switchgear must be fitted with all the interlocks needed to prevent incorrect operations which, apart from the efficiency and reliability of the apparatus, may also jeopardize the safety of the personnel in charge of operating the installation.

H.2.3.8 Painting

The galvanised metal structure of the units must be suitably treated and painted (front or front and side panels) so as to offer excellent resistance to wear, according to the following cycle:

- hot (60/70 °C) surface-active alkaline pre-degreasing and degreasing;
- double washing;
- activation;
- phosphating;
- washing;
- 180 °C electrostatic powder painting of epoxy-polyester type with a thickness of 60 micron (- 0 + 20) dry film, embossed top coat.

The appearance of the surfaces must be embossed. The shade of colour must be RAL 7035 (internal / external).

The minimum thickness of the finish must be 50 micron.

The degree of protection must be equivalent to about 8, corresponding to the Re2 degree of the European scale of the degree of rusting (SVENK STANDARD SIS 185111), over a period of 5 years.

Alternatively, at the time of the offer, the manufacturer must indicate his own standard painting cycle. A painting cycle with epoxy powders will, in any case, be a reason for preference.

H.2.3.9 Apparatus

The main apparatus, mounted in the switchgear, must be suitable for the design characteristics indicated above and must conform with the relative product Standards.

The circuit-breakers and the operating and isolation apparatus must be made by the same manufacturer in order to guarantee perfect coupling and maximum reliability of the relative mechanical interlocks.

The apparatus installed in the switchgear must, furthermore, comply with the special prescriptions described below.

H.2.3.10 Vacuum Circuit-breakers

The circuit-breaker must use vacuum as the electric arc extinction medium. The circuit-breaker must have separate poles.

The operating mechanism of the circuit-breakers must be of the stored energy type by means of precharged closing springs. The closing and opening operations must be independent of the operator.

Each circuit-breaker must be fitted with auxiliary contacts for signalling the state of open / closed (in particular, at least five auxiliary contacts must be provided). The standard fittings must also include the following devices:

- manual operating mechanism;
- mechanical signalling device for closing and opening springs charged / discharged;
- mechanical signalling device for circuit-breaker open / closed;
- shunt opening release;
- spring charging crank handle.

Furthermore, each circuit-breaker can, on request, be fitted with the following devices suitably combined:

- shunt closing release;
- spring charging geared motor;
- thermomagnetic protection circuit-breaker of the geared motor;
- signalling contact of the protection circuit-breaker of the geared motor;
- undervoltage release;
- signalling contact for undervoltage release energised / de-energised;
- mechanical override of the undervoltage release;
- electronic time-delay device for undervoltage release;

H.2.3.11 No-load Isolators, Switch Disconnectors and Fuses

The isolators and switch-disconnectors must be made up of a stainless steel cylindrical housing, a set of three top insulators and a set of three bottom insulators in epoxy resin.

The stainless steel housing makes a metal earthing segregation between the busbar compartment and the feeder compartment, guaranteeing maximum personnel safety in the case of intervention in the feeder unit, even with the main busbars energised.

Furthermore, the metal segregation made by the housing, considerably reduces the possibility of short-circuit between the phases and between the top and bottom contacts of the same phase due to leakage currents.

It must be possible for the isolators to take up the three positions of closed, open and earthed.

H.2.3.11.1 No-load Isolators

The no-load isolators must be three-pole, with insulation in SF6 and with a capacity suitable for the load requirements of the units they are destined for.

It must be possible to fit the no-load isolators with the following devices and accessories:

- manual operating mechanism on the front of the switchgear;
- mechanical signalling of open and closed inserted in the mimic diagram given on the front of the switchgear;
- mechanical key lock;
- any other applications as described below (see description of single units).

H.2.3.11.2 Switch-disconnectors and Fuses

Three-pole switch-disconnectors with insulation in SF6 must be installed in the units for which they are requested, with a suitable capacity for the load requirements of the units they are provided for.

The closing and opening operations must be carried out by means of a spring (for simple IMS) or two springs (for IMS with fuse), to make them independent of the operator's action.

It must be possible to fit the switch-disconnectors with the following devices and accessories:

- manual operating mechanism on the front of the switchgear
- mechanical signalling of open and closed inserted in the mimic diagram given on the front of the switchgear
- any other applications as described below (see description of units)

The fuses must be of the current-limiting type in accordance with the recommendations of the IEC 60282-1 standard in force, and have dimensions conforming to DIN 43625.

Each fuse associated with a switch-disconnector must be fitted with a striker device and, only for the switch-disconnectors, blowing must be signalled by a dedicated auxiliary contact and a mechanical signalisation.

The rated current and the rupture characteristic of the fuses must be carefully selected on the basis of the load to be protected.

It must be possible to mount DIN type fuses with different capacities on the basis of the installation requirements but these must, in any case, have of a length less than 442 mm.

H.2.3.12 Earthing Switches

The earthing switches, provided for earthing cables and the MV apparatus accessible by the operator, must be three-pole, of particularly compact and sturdy construction, and suitable for withstanding a short-circuit current with limits as defined in the network calculation.

In any case, operation of the earthing switches must always take place, both for closing and for opening, from the front of the switchgear. It shall be possible to equip the earthing switches with the following accessories:

- manual operating mechanism on the front of the switchgear;
- mechanical signalling of open and closed indicated on the mimic diagram on the front of the switchgear;
- any other applications as described below (see description of units).

It shall be possible to fit a motor operating mechanism subsequently, the design must be approved by the utility.

In the circuit-breaker panel, it shall optionally be possible to fit an additional interlock between earthing switch and the vacuum circuit-breaker.

H.2.3.13 Current and Voltage Transformers (on-board switchgear)

The current and voltage transformers must have the performances and precision class indicated below. In particular, the CT must be sized to withstand a fault current of: from 12,5 kA / 31,5 kAp to 25 kA / 63 kAp. The current and voltage transformers must have insulation in resin, be suitable for fixed installation inside the units and be free of any partial discharges.

The CT and VT dimensions must be in accordance with international standards.

H.2.3.14 Current and Voltage Sensors

The traditional resin CTs and VTs can be replaced by measurement sensors in the case where protection, measurement, control and communication microprocessor units are used.

The current sensors shall consist of a Rogowski coil without the ferromagnetic core and must conform to the IEC 60044-8. Use of the current sensors must guarantee that no saturation phenomena occur.

The voltage sensors shall consist of a resistive capacitor and must conform to the IEC 60044-7. The use of the voltage sensors must guarantee that no ferroresonance phenomena occurs.

It must be possible to integrate the voltage and current sensors at the same time in the same resin body.

H.2.3.15 Cable Connections

The cable connection height shall be at least 550 mm above floor level. Cable plugs with surge arrestors shall be used. The cable connections of the 3 phases shall be in one level horizontally arranged side-by-side and easily accessible from the front. The cable connection compartment shall only be accessible if the feeder is disconnected and earthed. The incoming and outgoing cables have to be fitted by dustproof cable glands with integrated cable clamping mechanism.

H.2.3.16 Installation and Operation

Subsequent installation of extension panels must be possible on both sides.

The local operation of the vacuum circuit-breaker and the switch-disconnectors shall be made mechanically directly on the operating front of the switchgear. A PLC and SCADA based operation shall be implemented. The positions shall be indicated by mechanical switch position indicators. The following signals shall be provided to the SCADA system:

- Position of switches (breakers, earthing switches, disconnectors);
- Power and currents for all input and output circuits;
- Failures and general fault conditions;
- Voltage.

The ready-for-service indicator of the switchgear shall be independent from ambient temperature and site altitude. The indication shall be unambiguous, an indication " SWITCH / DO NOT SWITCH" or green / red shall be preferred.

The connected medium-voltage cables shall be earthed with the make-proof earthing switch of the switching device (earthing switch with rated short-circuit making capacity). Cable testing has to be possible without dismantling the cables.

One set of operating handles not integral with the switchgear shall be supplied for each substation. Each handle shall be labelled with details of the substation to which it belongs and an instruction notice prohibiting its removal shall also be provided.

H.2.3.17 Protection System

The following protection systems shall be provided as a minimum:

- Phase failure protection;
- Over current protection (DMT, Differential protection if required);
- Restricted earth fault protection;
- Standby earth fault protection;
- Busbar protection.

Protective relays for circuit breakers shall, unless otherwise specified, be the electronic type installed in draw-out cases mounted in an instrument cabinet above the circuit breaker on the front of the panel. Over-current and Earth Fault Protection shall be provided on all circuits. The protection shall be inverse, extremely inverse, definite time, instantaneous, directional or non-directional as appropriate to the circuit or circuits being protected. Discrimination must be provided with the reconnection protection, for all types of fault. The discrimination shall extend to all points on the system down to the final sub-circuit. Prior to installation the settings have to be reported and clarified with the client and local power authorities. All settings shall be based on a comprehensive network calculation.

H.2.4 Transformer

H.2.4.1 Dry Type Transformer

H.2.4.1.1 Codes and Standards

The equipment will be designed, manufactured and tested in compliance with the relevant IEC, CENELEC and ISO codes and standards and in particular the following:

- IEC 60076 Power transformers;
- CENELEC HD 538 Three-Phase Dry-Type Distribution Transformers;
- EN ISO 9001 Quality management.

H.2.4.1.2 System Characteristics

The characteristics of the system are as follows:

- Rated service voltage: HV: according to voltage level at place of installation;
LV: 0,4 kV;
- Number of phases: 3;
- Frequency: 50 Hz.

H.2.4.1.3 Documentation

The Contractor shall submit following documents with his offer:

- Technical datasheet;
- Preliminary Outline Drawing;
- Product Catalogue;
- Type test reports from similar transformers for:
 - Lightning Impulse Test;
 - Temperature Rise Test;
- Measurement of sound level.

The Contractor shall also submit following manufacturer's test reports:

- Short Circuit Test;
- Fire Behaviour Test;
- Climatic Behaviour Test;
- Environmental Behaviour Test.

The Contractor shall submit following information to the Engineer's approval before delivery of the equipment:

- Final drawings;
- Operation and maintenance manual for transformers;
- Operation and maintenance manual for temperature control device;
- Rating plate drawing;
- Connection diagram;
- Routine test reports.

H.2.4.1.4 Design and Construction

Rated power

The transformer shall be designed so that they can deliver continuously its rated current under steady loading conditions without exceeding the temperature rise, assuming that the applied voltage is equal to the rated voltage and that the supply is at rated frequency.

Overloads

Dry type AN cooled transformers, can be overloaded according to related standards

Core assembly

The core assembly shall comply with following requirements:

- The core shall be constructed of the best quality, low loss, cold rolled, grain oriented steel laminations insulated on both sides;
- Laminations shall be "step lap" overlapped to minimize core losses and noise;
- The assembled core shall be braced in suitable steel frames that make up the base-frame and lifting facilities for complete transformer;
- The core assembly shall enable the removal of the coils in the field, if this should become necessary;
- The entire core assembly shall be covered with a resin-based lacquer for corrosion protection before the coils are mounted.

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Windings

All the windings shall be of high conductivity conductors of best quality. The transformer shall have separate high voltage and low voltage windings. The insulation system of the windings shall consist of approved materials for assigned temperature class. The insulation level of the windings shall comply with the following table.

Highest voltage for equipment U_m [kV] (rms)	Rated short duration power frequency withstand voltage [kV] (rms)	Rated lightning impulse withstand voltage [kV] (peak)
< 1,1	3	-
3,6	10	40
7,2	20	60
12	28	75
17,5	38	95
24	50	125
36	70	170

The Fire, Environmental, and Climatic classes should be as stated below:

- Environmental Class: shall be E2 in order to be able to withstand condensation or pollution or combination of both;
- Climatic Class: should be C1 or C2.
 - C1: Indoor installation. The transformer is suitable for operation at ambient temperatures not below + 1 °C, but may be exposed during transport and storage to ambient temperatures down to – 10 °C;
 - C2: Outdoor installation. The transformer is suitable for operation, transport and storage at ambient temperatures down to 1 °C.
- Fire Class: shall be F1.

For transformers subjected to fire hazard, restricted flammability is required. The self-extinction of the fire (poor burning is permitted with negligible energy consumption) shall take place within a specified time period to be agreed between the purchaser and the manufacturer, unless specified by National Specification. The emission of toxic substances and opaque smokes shall be minimized.

High Voltage Windings

- The HV windings shall be vacuum cast with aluminium disk foil as conductor material and 155 °C (class F) insulation system temperature (copper can also be accepted);
- The winding design shall be adequate to allow for full encapsulation with filled resin under vacuum. The resin system shall be two components epoxy filled with a mixture of inorganic fillers improving its thermal, mechanical and fire behaviour properties. The single resin components and filler will be carefully stirred and degassed under vacuum in order to eliminate all air bubbles and then mixed together throughout a static mixer just before pouring them, under vacuum, into the mould that contains the coil (winding). The surface of

the encapsulated winding shall be smooth and completely closed and impervious to moisture and common industrial contaminants.

High Voltage Connections

- The HV cable terminals shall be made in retined copper material, located above the top of the connection bars. Each terminal will be drilled with a 13 mm hole ready for connection of cables;
- The HV delta connection will be made through copper bars protected by heat shrinkable tubing.

Low Voltage Windings

The LV windings will be of non-encapsulated design with aluminium foil wound (copper can also be accepted) together with an insulating pre-impregnated B-stage epoxy resin and thermally cured in an oven to achieve thermal, mechanical and moisture penetration properties that are comparable, for LV coils, with those of cast windings.

Low Voltage Connections

The LV connections will be made from above onto bars located at the top of the coils on the opposite side to the HV connections.

Short – Circuit Withstanding

The transformer shall be capable of withstanding, on any tapping, for two seconds (IEC value = 2 s), without damage, under service conditions, the thermal and mechanical effects of a short-circuit at the terminals of any winding.

Thermal Insulation Class

The insulation system temperature for HV and LV winding will be 155 °C (class F) .The average winding temperature rise for both HV (at rated tapping position) and LV windings at full load shall not exceed 100 °C (maximum temperature rise equal to 40 °C).

Off Circuit Tappings

The transformer shall be provided with tapping links on the HV windings. Their position can be selected whilst the transformer is off circuit. Tapping selection shall be by means of bolted links. The tapping range shall be:

- Plus 2,5 % and 5 %;
- Minus 2,5 % and 5 %. Tappings with connection cables are not accepted.

HV and LV windings assembly

- The high and low voltage coils of each phase shall be supported and clamped by lower and upper supporting blocks, each having rubber expansion blocks for thermal expansion.

- The position of the LV terminals shall be either at the opposite side of the HV terminals at the top or at the bottom of the transformer. The neutral bar terminal, if any, shall be at the same side as the LV phase terminal.

H.2.4.1.5 Location

Cast resin transformers with either primary or secondary MV windings shall be housed in Transformer Rooms. Transformer Rooms, shall be designed and constructed to withstand fire, and shall have doors designed to burst open in the event of an explosion. Doors into the transformer room may open into other rooms, but must be at least ½ hour fire rated and open outwards. The Transformer Room shall be vented to outdoors, it must not vent into another room or building.

The transformer shall sit on a concrete pad.

H.2.4.2 Liquid-Filled Ground Mount Transformer

H.2.4.2.1 Description

Free breathing transformers (with conservator tank)

In this type of transformer, a conservator (an additional dedicated tank mounted on the transformer cover) compensates for any volume changes in the transformer oil, relieving radiator fins from this task. The conservator is connected with the transformer tank. This connection enables flow of oil between both vessels when its volume changes. Transformer oil does not come into direct contact with the atmosphere, thanks to silica-gel dehydrating breather that absorbs all moisture from air and prevents it from entering the transformer tank. The conservator is equipped with a magnetic oil level indicator located on the bottom of the conservator tank.

Mechanical Strength of Tank

Oil-immersed transformer tanks shall be guaranteed to withstand without any permanent deformation internal pressure of about ± 300 hPa.

Loading of Transformers

Transformers should be loaded in accordance with standards they have been designed to meet. In particular, it is recommended to observe regulations included in IEC 60354: Loading guide for oil-immersed transformers.

Short-circuit withstand capacity

Transformers shall be designed and guaranteed to withstand without any damage all mechanical and thermal effects of short-circuit according to EN IEC 60076.

Withstand Voltage

Transformers are designed and guaranteed to withstand without any damage all test voltages within the range specified in EN IEC 60076.

H.2.4.2.2 Design and Construction

Core

The transformer's core shall be of column-type made of grain oriented, low loss magnetic cold-rolled silicon steel. Both sides of steel sheets shall be laminated with ceramic insulation. The core construction is optimised for cold-rolled steel properties so that best parameters for magnetic circuit are obtained, i.e. minimum no-load losses and small magnetising power.

Windings

The transformer's windings shall be made of electrolytic copper. High voltage windings shall be of the multi-layer type. The interlayer insulation shall be made from cable insulating paper, presspan and transformer oil. The low voltage windings shall be wound with profile wire or copper foil insulated with diamond dotted paper and presspan. The windings shall be wound directly onto the core columns and pressed by means of top and bottom yoke clamps.

Tap Changer

The Transformer shall be equipped with a three-phase off-load tap changer enabling voltage regulation when the transformer is de-energised. The tap changer's drive shall operate synchronously on all three phases and its handle / dial shall be located on the transformer's top cover. The voltage regulation shall be realised by means of turning the tap changer's dial to a required position. The tap changer may NOT be used when the transformer is energised.

The tap changer's dial shall incorporate perforated ring and locking pins that ensure correct positioning (setting) of the dial after voltage regulation.

In commutable transformers there shall be two tap changer dials on the cover. One of them is used for selecting one or two possible high voltage (HV) settings while the other allows small-step voltage regulation.

Tank

The tank shall comply with following requirements:

- The hermetically sealed transformers shall incorporate a tank with corrugated walls designed to act as radiator fins;
- Free breathing transformers (conservator type) may have either corrugated or radiator tank;
- In radiator tanks, the radiators shall be mounted on the tank walls. All radiators shall have valves located on a connecting pipe between the radiator and the tank wall. These valves

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must be open during normal transformer operation, as this will allow for natural circulation and cooling of transformer oil. Closed valves make possible to replace a radiator without the need to drain transformer oil from the tank;

- The transformer tank shall have a sturdy design that allows for normal transportation of an oil-filled transformer without any damage resulting from vibration;
- The tank's undercarriage shall have facilities for securing the transformer firmly in place during transportation by means of synthetic belts or ropes of high mechanical strength;
- The following facilities shall be found in the lower part of the tank:
 - drain / sampling valve;
 - sampling valve (optionally, in addition to drain valve);
 - undercarriage frame with bi-directional (90°) wheels and earthing terminals. The undercarriage frame has holes designed for pulling transformer for short distances on a smooth surface.

Cover

The following facilities shall be found on the transformer cover:

- 2 lifting lugs for lifting the transformer or its active part;
- An oil level indicator pocket (in hermetically sealed transformers);
- A filling orifice for filling the tank with oil (in hermetically sealed transformers);
- A thermometer pocket (optional);
- A DGPT-2 pocket (optional);
- A connecting socket for conservator (in conservator-type transformers);
- High and low voltage bushings;
- Earthing terminal(s) (optional).

Conservator

The conservator shall fulfil following requirements:

- The cylindrical vessel called conservator shall be located horizontally over the cover. In some versions, the pipe connecting conservator and the cover may be equipped with a gas-flow relay;
- A magnetic oil level indicator showing current oil level in the transformer shall be located at the bottom of the conservator vessel;
- An oil filling inlet can be found at the top of conservator vessel;
- The conservator may be either tightly sealed with a cap or have a short pipe leading to a silica gel breather providing means of balancing internal and external pressure;
- Conservator versions with a sealing cap only have the silica gel breather built-in and the breather's air inlet is located underneath the conservator vessel;

- Optionally, the conservator vessel may be equipped with a drain valve for removal of sediment or excess water.

Transformer Oil

Transformers shall be filled with mineral oil. Prior to filling, oil is treated in order to obtain the required electrical characteristics and insulating properties. The value of breakdown voltage in a sample of treated new transformer oil should not lower than 45 kV / 2,5 mm in a system defined by applicable norms. If the measured value of breakdown voltage is lower, oil needs to be regenerated by filtering or equivalent method.

On request, the transformer may be filled with biodegradable synthetic oil.

H.2.4.2.3 Transformer Accessories and Equipment

Reference is made to the transformer's technical specification and dimension drawing for a complete list of installed accessories and additional equipment.

Double contact thermometer

The thermometer shall be equipped with two switch-over electrical contacts that may be connected to trip and alarm circuits. The switch-over contacts shall be designed for 250 VDC or AC. The respective alarm or trip circuit shall be closed when the pointer (hand) crosses the pre-set (user adjustable) value on the thermometer's face.

The thermometer's range shall be: 0 °C – 120 °C. The thermometer probe shall have a length of 140 mm and shall be immersed in oil. The thermometer may be mounted in pockets with R ¾" or R 1" thread. The maximum cross-section of the connecting cables shall be 1 - 2,5 mm².

The thermometer alarm & trip settings shall be as follows:

- alarm 95 °C
- trip 105 °C

Safety Valve

The transformer tank filled with cooling liquid is a container subject to internal pressure. It needs to be provided with one or more safety valves suitably calibrated for the maximum allowed pressure, so that overpressure caused by internal faults can be instantaneously relieved. This will prevent any greater damage such as the deformation or even explosion of the tank that may result in fire risks.

The safety valve's rated overpressure is 0,030 – 0,035 MPa (0,3 – 0,35 at).

Buchholz Relay (in free breathing, conservator-type transformers)

The gas and oil actuated (Buchholz) relay shall be designed to detect faults as well as minimise propagation of any damage, which may occur within oil-filled transformers.

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The Buchholz relay shall incorporate two floats and two contacts for alarm and trip. It shall be mounted in on the pipe connecting transformer and the conservator.

An arrow on the relay cover must point at the conservator.

The signalling shall be as follows:

- gas accumulation - alarm
- missing oil - trip

The connector shall have following characteristics:

- voltage rating 24 – 240 VAC or DC;
- rated current 0,5 A

H.2.4.2.4 Location

Transformers shall be housed in Transformer Rooms or Transformer Pens. Transformer Rooms, shall be designed and constructed to withstand fire, and shall have doors designed to burst open in the event of an explosion. All doors into the transformer room shall be external doors, and shall open outwards, no doors or windows shall link into another building, or room, other than one used for housing transformers. The Transformer Room shall be vented to outdoors, it must not vent into another room or building. The transformer shall sit on a concrete pad. A catch basin as a oil soakaway shall be provided. This shall be designed to rapidly absorb any oil spillage and to prevent a fire being sustained in the event of the tank exploding.

Steel rollers shall be provided for positioning the transformer and left in-situ for future use.

H.2.5 Diesel Generator Set

H.2.5.1 General

All generators shall be a diesel-driven brushless synchronous three-phase, 50 Hertz, 1500 rpm, with a revolving field and a solid-state exciter. Generators shall have a CE certification and their design and dimensioning shall be in compliance with ISO 8528, ISO 3046, IEC EN 60204, and EN 61439.

Power ratings shall be in accordance with the site-specific conditions and requirements to supply either prime power or to maintain basic functions of plants during failure of public grid:

- PRP: Prime Power shall be available for an unlimited number of annual operating hours in variable load applications, in accordance with ISO 8528-1. A 10 % overload capability must be available for a period of 1 hour within 12-hours period of operation ;
- ESP: The emergency standby power rating shall be applicable for supplying emergency power in variable load applications in accordance with ISO 8528-1.

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The generator shall be of drip-proof type and shall be ventilated. The generator completes with voltage regulator with compounding system. The generator shall meet the following characteristics:

- Frequency 50 Hz ;
- Voltage 0,4 / 10 / 20 / 33 kV as per design requirement ;
- Revolution speed 1.500 rpm ;
- Stator winding connection: star ;
- Number of phases 3 ;
- Number of wires 4 (three plus zero / earth) ;
- Terminal voltage adjustment range ± 10 %.

The generator shall be designed for a runaway speed of 1,2 times the rated speed, and shall be suitable for unbalanced operation. The generator shall be provided with a superior class of insulation. A temperature-sensing element shall be fitted to each set of stator windings.

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The momentary short-circuit current shall not exceed the value of 3 times the peak value of the rated current. The end windings shall be properly braced and anchored in order to prevent injurious deformation in case of short circuits.

The diesel generator set shall comply with following requirements:

- The set should be deliver with all necessary equipment for manual / remote and automatic operation mode;
- The set has to be well balanced;
- The set shall be suitable for local climate;
- The set shall provide power to the medium or low voltage power supply system
- The generator shall supply the minimum required drives and functions of the plant, for the required period of 24 h with max load;.
- The diesel engine should be flange-coupled to the generator, with the torque transmitted through a flexible expansion coupling;
- The set should be equipped with the necessary devices for control and protection of the diesel engine and the generator, alarm signalisation and distribution of electric power;
- The generator should have a brushless excitation and voltage regulation system;
- The power unit should be equipped with an automatic control device which provides an automatic start-up and shut-down, alarm, signalisation of the condition of the diesel engine and the generator. A synchronization panel for parallel operation to network or parallel operation of more than one generator shall be implemented;
- The set should be equipped with an integrated ground fault indication;

- The diesel engine should be equipped with heavy duty air cleaners and bypass-type oil filters.

The starting system shall consist of:

- 24 VDC electric starter, and
- 24 VDC battery charger.

H.2.5.2 Engine

Standard features of the diesel engine shall be as follows:

- Operation method: four-stroke cycle, turbocharged if specified elsewhere;
- Combustion method: direct fuel injection;
- Valves per cylinder: two valves per cylinder;
- Engine mounting: resilient to base skid;
- Starter system: Electric starter, incl. batteries and charger;
- Governor: Electronic;
- Fuel System: Complete, pump, filter, line from tank;
- Oil System: Complete, pump, filter;
- Air intake: Heavy duty filter;
- Coolant System: Water cooled;
- Safety features: Low fuel level / high oil or water temperature shutdown;
- Mounting: Steel base frame on anti-vibration mounts;
- Protection class: IP 23;
- Noise level : < 75 dB(A) at 1 m;
- Further features:
 - Exhaust silencer;
 - Warranty – 5 years extended standby.

Radiation heat shall not be higher than 3 – 4 % of the engine rated power. All components of the engine shall be free of asbestos. The engine must be suitable for running with fuel of high sulphur content. The engine has to be painted with two coats of alkyd-resin paints, colour as instructed by the Engineer. Data and instruction plates shall be written in English. The engine shall be protected against radio interference.

H.2.5.3 Alternator

The alternator shall be a 3-phase, synchronous, brushless single bearing, self-exciting, self-ventilating alternator with damping equipment for unbalanced load up to 30 %.

The alternator shall be operated star connected. Both ends of each winding have to be brought out to terminals in the alternator's terminal box. Each terminal shall be equipped with a suitable current transformer for differential protection and over current / short circuit protection. At the outgoing terminal of the current transformer, auxiliary busbars to connect the power cables have to be installed. The size of the alternator's terminal boxes shall be sufficient to allow maintenance work and refastening of all bolt connections without hindrance or requirement for special tools. The alternator shall be delivered with the correct star-point reactor, which shall be installed in the alternator's switchgear cabinet.

The Contractor shall note that the generator must be suitable to be switched to the unloaded transformer in case of power failure. In this situation, initially high currents may be required to demagnetise the transformer. The windings and the mechanical components of the generator have to be manufactured to these criteria.

The characteristics of the alternator shall be as follows:

- Voltage: 0,4 / 10 / 20 / 33 kV as per design requirement ;
- Frequency: 50 Hz;
- Speed: 1500 rpm;
- Site rating: according basic operation needs;
- Degree of protection: IP 65;
- Insulation class: F, tropicalized with anti-humidity insulation;
- Set-point adjustment: ± 5 %;
- Cooling air temperature: ≤ 45 °C;
- Fully interconnected damper winding;
- AC exciter and rotating rectifying unit;
- Epoxy coated stator winding;
- Rotor and exciter impregnated with tropical grade insulating oil and acid resisting polyester resin.

H.2.5.4 Cooling System

If required, due to high ambient temperatures a proper ventilating or cooling system has to be proposed in the Contractor's offer to guarantee continuous and uninterrupted operation of the generator set. The cooling system shall comply with following requirements and be equipped with following features:

- Optimised for maximum efficiency and minimum noise;
- Propylene glycol coolant for greater environmental protection designed for ambient temperature of -25 °C up to $+55$ °C;
- Intake air filtration system (sand filter);
- Air discharge ductwork as required.

The cooling system shall preferably be supplied by the diesel-engine supplier and the sizing shall be done by the manufacturer according to the requirements at the site of use of the diesel generator. If the cooling system is obtained from a supplier other than the engine supplier the Contractor shall submit a heat rejection calculation.

H.2.5.5 Exhaust

The exhaust system shall be routed at high level to the exterior of the Engine Room, and shall blend with the fabric of the building. A section of flexible pipe must be fitted in the first section of pipe after the engine and the rigid pipework adequately supported directly after this and throughout its length. On long pipe runs adequate precaution must be taken to prevent damage due to pipework expansion.

Where more than one engine is installed, each must have its own independent exhaust system. Care should be taken to prevent the exhaust gasses from staining the walls of buildings. A mesh shall be provided to prevent birds entering the exhaust pipework. The exhaust shall be cut at an angle on the exterior of buildings to form an overlap to prevent water entering.

Silencers shall be selected to suit the site requirements (industrial or residential). Protection against contact by persons shall be provided, where the exhaust system is less than 2 metres above floor level.

H.2.5.6 Noise Attenuation

Noise level site surveys shall be undertaken. Noise attenuation shall be provided to limit the noise output to a maximum of 75 dB(A) at 1 metre from the external wall of the Engine Room or enclosure, and not more than 5 dB(A) above the ambient noise at the site boundary.

Where it is evident that a noise level of 5 dB(A) above background noise level would be impracticable, the noise limit set at the control point should be consistent with that achievable by applying the best practicable means and approved by the Engineer.

H.2.5.7 Earthing and Earth Fault Protection

The generator star connections and the frame shall be connected to the safety earthing protection system.

Current transformers shall be fitted to the generator windings, in order to feed the earth fault protection system in case of an earth fault. The protection system to be supplied and installed shall be of the 'fault current - circuit'-system.

H.2.5.8 Speed Control

The engine shall be equipped with an electronic, load-sharing governor that controls the actuator for speed control.

H.2.5.9 Mounting

The diesel-engine and the generator shall be mounted on a structural steel base. The base shall be firmly fixed on the concrete foundation by means of anchor bolts. Between base and foundation vibration dampers shall be fitted to prevent transmission of vibration to the inoperative diesel-generator sets.

The vibration isolators shall be rubber or spring type. The isolators shall be capable to isolate at least 80 % of the vibratory forces. A vibration calculation shall be carried out by the Contractor and submitted to the Engineer's approval.

H.2.5.10 Installation inside Buildings

In case of installation inside buildings, generators shall be cooled by an engine-driven blower-type fan. The Contractor shall provide steel ductwork for air cooling to the outside, equipped with flexible connecting section between radiator and duct. A grid shall be supplied to transit through outside walls. The dimensions of the grid shall be such that the maximum air speed through the bars not exceeds 6 m/s, and the maximum pressure loss as stated by the manufacturer is not exceeded.

The radiator is preferably to be purchased by the diesel-engine supplier (selection of the radiator sizing to be done by the engine manufacturer). If the radiator is obtained from a supplier other than the engine supplier, the Contractor shall submit a heat rejection calculation.

Furthermore, all generators inside buildings shall be equipped with a suitable exhaust system for the engine, including internally mounted box type exhaust silencer and duct to the outside of the building.

H.2.5.11 Instrumentation Panel

An instrumentation panel shall be mounted on each engine comprising the following instruments and features:

- Voltage measurement and indication;
- Current measurement and indication;
- Frequency measurement and indication;
- Motor speed measurement and indication;
- Battery voltage measurement and indication;
- Operation hours measurement and indication;
- Lubricating oil pressure measurement and indication;
- Oil temperature measurement and indication;
- Water temperature measurement and indication;
- Key-lockable emergency stop button;
- 'Idle - run' switch;

- Switches for local manual start.

H.2.5.12 Custom Switchgear

The custom switchgear shall comply with following requirements and be equipped with following features:

- Designed and built to meet hard operating conditions;
- Equipped for total remote automatic monitoring and control for stand alone, paralleling or emergency standby applications;
- Motor-operated circuit breaker;
- Convenient Shore Power connection providing power to interior lighting, jacket water heaters, battery charger and alternator anti-condensation space heaters.

H.2.5.13 Operator Panel Features

The operator panel shall be equipped with following features:

- Emergency stop switch;
- Indicating lamps for remote start, Not In Auto, common shutdown and common warning;
- Fault reset switch;
- Panel lamp / lamp test switch;
- Exercise switch and indicating lamp;
- Manual run / stop switch;
- Off / Manual / Auto mode select switch;
- Graphical display panel with pushbutton switches capable of displaying up to 9 lines of data approximately 26 characters wide, as well as graphical characters;
- Analog AC metering panel for simultaneous monitoring of 3-phase AC voltage and current, kW, power factor, and frequency. Voltage, current and kW are scaled in % of nominal values. All values shall be colour-coded to indicate normal, warning and abnormal operating conditions.

H.2.5.14 Standard Features

The diesel generator set shall be equipped with following standard features:

- Isochronous governing;
- 3-phase sensing voltage regulation with single and three phase fault current regulation;
- AC output protection including over / under voltage, over / under frequency, overcurrent, short circuit, and overload (kW);
- Engine control and monitoring system with displays for oil pressure, oil temperature, engine coolant temperature, engine speed, battery voltage and other values;

- Generator set protection system including AC output protection alarms, engine pressure, temperature warning, shutdown functions, low coolant temperature, low coolant level, low fuel level, failure to crank, failure to start and overspeed;
- Operator adjustments for time delay, start / stop, engine speed, and overspeed;
- Technician setup menu;
- Status and data display functions including engine operating hours, kW hour productions, AC metering functions and fault history.

H.2.5.15 Additional Features

The diesel generator set shall be equipped with following additional features:

- Alternative temperature alarms;
- Analog signal 4-20 mA for generator power (kW);
- Set of potential-free contacts for remote signalisation (gen. running, fault, etc.);
- Surge protection device;
- Set of measurement to monitor the runtime / remaining fuel storage etc. (warning / prewarning);
- Synchronization unit for network parallel operation;
- Control unit for parallel operation of more than one gen set.

H.2.5.16 Batteries and Battery Chargers

Nickel-cadmium batteries shall be provided for starting, the diesel engine. The batteries shall be mounted on a plate on the frame of the engine, nearby the starter motor. For re-charging the batteries, with the diesel-engine in operation, the batteries shall be connected to the alternator of the diesel engine by means of as short as possible, slack cables. The alternator has to be equipped with a voltage regulator.

To keep the batteries alive if the diesel-generator sets are not used for long periods, a battery charger shall be delivered for every diesel-generator set. The battery charger shall be placed in the corresponding section of the switchboard as indicated above.

H.2.5.17 Fuel Tank and Fuel Supply

The total fuel stored at site shall suffice to allow for the operation of the generator for the duration specified in the Particular Specifications at applicable load conditions. All tanks shall be equipped with level gauge, vent and fill point. All tanks shall be equipped with level gauge, vent and fill point. The fuel tank shall comply with following requirements, depending on the size of the generator.

For larger systems (fuel demand approximately > 200 l/d):

If not otherwise specified, the total fuel stored at site shall suffice to allow for the operation of the generator for a minimum duration of 24 h at applicable load conditions. A separate cylindrical and horizontally placed tank shall be provided. The tank shall be installed on steel supports. All inlets of the suction connections inside the tank shall be situated at least 80 mm above the tank bottom.

The tank shall be placed in a concrete reservoir, having a net volume at least equal to the maximum volume tanks. Alternatively, the tank can be a pre-fabricated double skin tank, made of steel, explicitly designed and approved for the aboveground storage of flammable water polluting liquids.

All required accessories for fuel supply of the adjacent diesel generator shall be included in the installation, such as but not limited to: fuel pumping system (including AC powered fuel transfer pump, pump controls compatible within generator's control system, additional fuel day tank and refilling pumps if required), all fuel lines (including feed and return lines between engine and tank), fuel cooler if required, ducts, connections and all safety equipment required.

Fuel transfer pumps shall be suitable for the duty taking into consideration the location of the bulk tank(s). The pumps shall be located so as to permit repair or replacement without removing other plant. Motors shall be 3 phase induction motors. If the system is not a flooded suction type (i.e. where the bulk tank is below ground) then facilities shall be provided to prime the pumps.

All fuel pipework shall be manufactured from mild steel or copper and shall be a pipe within a pipe. The inner pipe carrying the fuel. The outer pipe being provided to carry the fuel back to the Bulk Tank in the event of the inner pipe fracturing. A detector shall be provided in the outer pipe of the return pipework, nearest the bulk tank, to initiate an alarm in the event of the inner pipe leaking. The pipework shall have a continual fall from the day tank back to the bulk tank.

All joints, in both the inner and outer pipework, shall be welded. All pipework shall be treated, externally, to resist corrosion. Pipework above ground and external to buildings shall be trace heated and lagged, to prevent waxing. Pipework laid in the ground shall be half lap covered in a non woven synthetic fibre fabric impregnated and coated with a neutral compound based on saturated petroleum hydrocarbons and inert siliceous fillers.

The following pipework shall be provided:

- Filler pipework from the Outdoor Filler Cabinet to the Bulk Tank;
- Suction pipework from the Bulk tank to the pump;
- Delivery pipework from the pump to the Day Tank;
- Overflow pipework from the Day Tank to the Bulk Tank;
- Overflow pipework from the Day Tank Bund to the Bulk Tank;
- Engine feed and return pipes;
- Bulk tank and Day tank breather pipes.

For smaller systems (fuel demand approximately ≤ 200 l/d):

If not otherwise specified, the tank shall be integrated to the generator and it shall be large enough to last 10 hours at full load.

H.2.5.18 Packing and Shipment

Unless stated otherwise, the generating set shall be delivered with all required fuel, cooling, air and exhaust systems, the required instrumentation for operation control, all generator set accessories required for appropriate maintenance and testing (tool and test kits) and spare parts for two years of operation.

H.2.6 Low Voltage Switchgear Panel

H.2.6.1 General Requirements

The low voltage panels shall fully comply with EN IEC 61439 other relevant international standards. In case of internal fault of the panel, the protection must be guaranteed.

All electrical connections of the busbar and cabinet distributing busbar system shall be maintenance-free. The cable compartments shall be foreclose by metal partitions against the rail space. The cable entry into the switch panels shall be provided from below.

Low voltage switchgear panels shall comply with following technical specifications:

- Approvals: EN IEC 61439, VDE 0660 part 500 ;
- Personal Safety: IEC TR 61641, EN IEC 61439;
- Touch protection: EN 50274; VDE 0660-514 ;
- Type: Self standing, metal enclosed, vermin-proof;
- Structure: Minimum sheet steel thickness shall be 2,5 mm;
- Finish Color: RAL 7035;
- Isolation voltage: 1000 VAC;
- Degree of protection: IP 21 (indoor) / IP 54 (outdoor);
- Rated operational voltage: 400 VAC;
- Control voltage: 230 VAC / 24 VDC;
- busbar system: 3-ph + N / PE (TN-C-S system);
- Rated operational current: according to requirements (L1, L2, L3 and N conductor);
- Rated peak withstand current: as required and calculated;
- Rated short-time current: as required and calculated (min. 35 kA).

During equipment selection, preference should be given to devices that have a higher level of integration into the process control system through dedicated and pretested software libraries. This

functionality will be considered as an advantage, due to fact that when it is implemented it will increase the overall quality of the offered technical solution.

A block library must be made available for the measuring devices, circuit breakers and VFD used in a project that enables the integration of these devices into a process control system. The block library is to be made up of driver blocks, diagnostic blocks and faceplates for the various devices.

The faceplates are used in the operator stations of the process control system as the user interface for the supported measuring devices, circuit breakers and VFD so that the technologically relevant values and functions of these devices can be displayed and operated as objects of that PCS.

The block library is to be provided as engineering and runtime software.

H.2.6.2 Moulded Case Circuit Breaker (MCCB)

MCCB shall comply with following requirements:

- Type: 3-pole / 4-pole;
- Rated Voltage: 400 V;
- Circuit Breaking Current: Not less than 55 kA;
- Current Transformers: 1 set. Can be external;
- Transducers: 1 unit. Can be external;
- Fault indicators: 1 unit.

H.2.6.3 HRC Fuse Breakers

HRC Fuse breakers shall comply with IEC 60947-1, IEC 60947-3 and DIN VDE 0660 part 107..

The fuse links shall be tested according to the following short circuit ratings:

- Size: 00, 0, 1, 2, 3, 4;
- Max. current rating, AC 500 V: 16 – 630 A;
- time constant: < 20 ms 400 V;
- Breaking capacity, AC 500 V: 120 kA.

HRC fuse breakers should have arc extinguishing chambers and be able to break the circuit under load.

H.2.6.4 Surge Protection

Surge protection with fully encapsulated pluggable spark gap shall be used. In case of change of the lightning protection zone, all power and instrumentation cables shall be equipped with surge protection. The grounding, lightning and surge protection system shall be based on a comprehensive lightning risk and earthing concept prepared by the Contractor and submitted to the Engineer's approval.

H.2.6.5 Multifunction Measuring Instrument for Electrical Data

The power meter for panel mounting with graphic display and background illumination shall display: measured values, alarms and status information.

Power monitoring systems shall be permanently installed systems, which enable continuous logging of energy-related data and provide information on the operational characteristics of the electrical systems.

Measured values shall include but not be limited to:

- r.m.s values of voltages (phase-to-phase and/or phase-to ground);
- currents;
- active, reactive and apparent power and energy;
- power factor;
- phase angle;
- harmonics of currents and voltages;
- total harmonic distortion per phase;
- frequency and symmetry factor.

The meter shall provide minimum two adjustable digital outputs for e.g. counter signal and alarm. It shall have at minimum two adjustable analogue outputs and a bus connection via Profibus or Profinet.

The Power meter shall generate a list of minimum, average and maximum values for currents, voltages, power, energy, etc.

Independent settings for currents, voltages, active and reactive power, power factor, etc. shall be possible. If these limits are exceeded, the unit shall generate an alarm.

The device must also include the following:

- Real-time clock;
- Measured values and states will be recorded with time stamps;
- Recording and display of faults;
- Log entries.

Battery

The capacity of the battery shall be as to safely in the memory up to 3 months in case of a blackout all recordings such as limit value violations or energy counter values.

H.2.6.6 Miniature Circuit Breaker

Miniature circuit breaker shall have a rated insulation voltage of 400 / 230 VAC or 24 VDC and a switching capacity of 6 / 10 kA based on EN 60898-1.

H.2.6.7 Residual-current Circuit Breaker (RCCB)

Residual-current circuit breaker (RCCB) for AC and pulsating DC fault currents shall have a switching capacity of 6 / 10 kA.

H.2.6.8 Fuse

Fuse switch for installation in distribution boxes, shall be with fuse plug and fuse insert with a switching capacity of 50 kA.

H.2.7 Motor Control Centre (MCC)

H.2.7.1 Arrangement and Installation

Motor control centre and starter panels shall be as described below. Further details of the electrical system are subject to the single line diagrams, specification and general arrangement drawings. The MCC panels shall be installed according to EN IEC 61439 in form 4b.

Number of units, ratings and characteristics of equipment are subject to the Contractor's final design and may deviate from these documents. Any design changes by the Contractor shall be reported to and approved by the Engineer. Any additional costs caused by these design variations shall be covered under the scope of the contract.

H.2.7.2 General

Motor control centre (MCC) shall be provided to control and operate the consumer load of the plant. The MCC shall be composed of motor starters, hard relays, timers and other required devices. The panels shall be of modular construction.

Most of the consumers loads / motors shall be controlled from the MCC panel, and local control stations shall be provided near the drives / motors for manual operation. The control units shall consist of switchgear, contactors, measuring devices and motor control circuits.

Manual mode operation circuits shall be provided in the MCC panels to cope with failures of the programmable logic controllers (PLC) while automatic mode operation circuits shall be provided in the PLCs. It must be possible to run the plant in manual mode in case of PLC failures.

Motorstarters up to 5,5 kW shall be designed for direct motor starting. Motors above 5,5 kW up to 45 kW shall be softstarter type. Motors above 45 kW shall be designed and installed using VFDs. If required by process, VFDs shall be installed also for smaller motors.

Each electrical motor shall be provided with safety isolating switch mounted in vicinity of the motor. For motors with a nominal current above 250 A, the safety switch shall be connected to the motor circuit breaker or VSD. The switch shall be clearly labelled according to the number of the corresponding motor. The switch shall be connected to the PLC and SCADA system.

H.2.7.3 Low Voltage Control Cabinets

Low voltage control, cabinets shall comply with following requirements:

- Purpose: As specified above;
- Type: Indoor, self-standing, metal enclosed, vermin-proof;
- Structure: Minimum sheet steel thickness shall be 2,5 mm.
- Finish Colour: RAL 7035;
- Protective Level: IP 54;
- Rated Voltage: 400 VAC;
- Withstand AC Voltages: 1000 VAC;
- Circuit Breaking Current: 35 kA;
- Control Voltage: 230 VAC / 24 VDC;
- Accessories: Door Key 1 set;
- Inboard ventilator: 1 set;
- Lighting Door Switch: 1 set;
- Test Terminal: 1 set;
- Measuring Instruments:
 - Ampere meter with maximum demand indicator;
 - Voltmeter;
- Frequency: 50 Hz.

The MCC shall consist of following control units for starting of motor, operation of valves, power supplies and incoming supplies depending on the electrical consumer and location.

H.2.7.4 Incomer with Moulded Case Circuit Breaker (MCCB)

The MCCB Incoming shall consist of following components:

- Moulded case circuit breaker: 1 unit;
- Current transformer: 2 set;
- Grounding over-current relay: 1 unit;
- Ampere meter: 1 unit;
- Voltmeter with sector switch and fuse: 1 unit;
- Indicator lamp: 1 lot;

- Terminal box: 1 unit:
- Motorized actuation.

H.2.7.5 Variable Speed Drive (VSD)

Modular frequency converter for fluid flow engines as pumps, fans and compressors in water / wastewater, consisting of a power module, plug-in control module and plain text operator panel.

The replacement of the power component must be possible without reprogramming and switching off the control module whilst maintaining the field bus communication.

The frequency converter must be able to run 2 – 8 pole asynchronous motors of the efficiency classes IE2 to IE4 without overdimensioning. Further on it must be possible to operate synchronous reluctance motors.

For this, the following control methods must be available:

- v/f characteristic linear, parabolic, parametrizable, with flux current control, sensorless vector control.
- all control methods must have an energy saving mode for additional energy savings. Output frequency 0 – 550 Hz (0 – 100 Hz $\geq$ 160 kW) in v/f mode, 0 – 240 Hz (0 – 100 Hz $\geq$ 160 kW) in vector mode.

The drive system must be protected through thermal motor protection with PTC/KTY84/Pt1000/bimetal, thermal converter protection, monitoring for under voltage and overvoltage, overloading, grounding, short circuiting, stalling and blocking of the motor.

The frequency converter shall have the following functionality: set point via analog input, 16 freely parameterizable fixed speeds, integrated motorized potentiometer, and serial interface. Ramp generator with initial and final rounding, automatic adaption of ramp up and down times, slip compensation, dc braking, 4 switchable drive data sets, 4 switchable command data sets (manual/auto), real time clock with 3 parametrizable timer, runtime counter, error message memory with time stamp, function blocks for logical, arithmetical and technological operations, automatic restart after power failure or stoppage, synchronization to running motor, load torque monitoring with or without encoder for dry running/overload protection or belt monitoring, 4 parametrizable skip frequencies to avoid mechanical resonances, technology controller with PID behaviour, energy saving mode with internal or external PID technology controller, time-controlled start function to prevent the pump blocking, bypass control to switch the drive to the mains in case of failures or depending on speed, cascade controller for up to 3 pumps / fans with fixed speed, runtime-controlled drive change, multizone control for up to 3 zones with one set point or 2 zones with two set points, 3 additional PID controller for the control of dampers, heating and cooling sections, extended fire mode activated by a digital input to control the drive in case of fire.

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All digital and analogue inputs and outputs must be freely parameterizable and assigned to a specific function in the factory setting. The following has to be foreseen:

- 6 isolated digital inputs;
- 2 digital outputs as isolated contacts (230 VAC, 2 A);
- 1 digital output as isolated contact (30 VAC, 500 mA);
- 2 switchable analogue inputs for 0 – 10 V or 0/4 – 20 mA and parameterizable in addition as digital inputs;
- 1 switchable analogue input for 0/4 – 20 mA or PT1000 or NI1000 temperature sensors;
- 1 switchable analogue input for PT1000 or NI1000 temperature sensors;
- 2 analogue outputs for 0 – 10 V or 0/4 – 20 mA;
- 1 permanently assigned input for the thermal motor protection with PTC, KTY84, Pt1000 or bimetal, operating voltage 24 VDC external or via the power module.

To parameterize the drive, an integrated USB interface for PC connection is needed. Saving and loading parameter records and firmware updates must be possible by a MMC memory card. The terminals have to be identified by replaceable labelling strips for individual marking.

Compliance with low-voltage directive 73/23/EEG EN 60204 and EN 61800-5, certification in compliance with UL, CE, c-tick, protection class I (with protective conductor system), protection class III (PELV), shock-hazard protection, degree of contamination 2 in compliance with EN 61800-5-1, climatic environmental conditions in operation Class 3K5, environmental/chemical influences Class 3C2, organic/biological influences Class 3B1 in compliance with EN 60721-3-3, compliance with industrial standard SEMI F47 for immunity to voltage dips, manufacturing according to RoHS regulations, components according to WEEE, manufacturing location certified in compliance with ISO 14001.

- Rated voltage: 3 AC 380 – 480 V +/-10%;
- Rated frequency: 47 – 63 Hz;
- Overload capability: 135% x rated current for 3 seconds plus 110% x rated current for 57 seconds at a cycle time of 300 seconds;
- Degree of protection: IP20 / IP55;
- Operating temperature: -10 °C – + 40 °C, up to 50 °C with derating;
- Relative humidity: < 95%, condensation not permissible;
- Efficiency acc. EN 50598: class IE2, 98,1%;
- Electromagnetic compatibility;
- Limits for line harmonics acc. EN 61000-3-12.

An integrated PROFIBUS DP interface with PROFIdrive profile version 4.1 is required, the bus address has to be set via DIP switches or parameters.

Comfort Operator panel -High-contrast colour display - as input/output device for modular frequency converter, can be plugged in to the control module or via assembly kit for installation in the control cabinet door, operation and diagnostics via directly assigned keys and navigation wheel, graphics-compatible display with plain-text display and bar display. Extensive aid functions like application wizard for important applications, diagnostics support like simulation of digital and analogue inputs must be possible, display of diagnostics data, switchable operator hierarchy via key, upload/download of a parameter set, integrated USB interface for firmware updates and more languages or commissioning wizards, protection type IP 55 / UL Type 12 for door assembly.

Ready-to-operate mounting and electrical connection in control cabinet door.

During equipment selection, preference should be given to devices that have a higher level of integration into the process control system through dedicated and pretested software libraries. This functionality will be considered as an advantage, due to fact that when it is implemented it will increase the overall quality of the offered technical solution.

A block library for the integration of drives in a process control system must be made available for drives used in a project that enables the integration of these devices into a process control system. The block library is to be made up of driver blocks, diagnostic blocks and faceplates for the various devices.

The faceplates are used in the operator stations of the process control system as the user interface for the supported drives so that the technologically relevant values and functions of these devices can be displayed and operated as objects of that PCS.

The block library is to be provided as engineering and runtime software with a single license for one automation system (one installation).

Bidirectional communication links must be provided on the system side between faceplates and blocks, as well as between blocks and VFD.

H.2.7.5.1 Sine filter

General function

Sinusoidal filter to reduce voltage peaks and voltage rises (du/dt) at the motor terminals as well as to reduce bearing currents due to long motor cables. Operation of motors with standard insulation and without insulated bearings must be possible. Specifications according to brand manufacturer standards based on the selected VFD

- Degree of protection: IP 00 (for installation in electrical cabinet only and not for installation in the field).

Delivery complete with connection, terminal and fastening material, as well as ready-to-operate mounting and electrical connection in compliance with installation regulations.

H.2.7.5.2 du/dt Filter

Du/dt filter to reduce the voltage rise at the motor terminals to values $< 500 \text{ V}/\mu\text{s}$ as well as to reduce the overvoltage peaks to values in accordance with IEC 60034-17 2006. Specifications according to brand manufacturer standards based on the selected VFD.

- Voltage: 3 x 200 to 500 VAC;
- Power: 24 – 300 A;
- Motor frequency: 0 – 60 Hz;
- Ambient temperature: - 25 to 40 °C;
- Max. Switching frequency: 1,5 kHz – 4 kHz;
- Degree of protection: IP 00 (for installation in electrical cabinet only and not for installation in the field)
- Dimension: in accordance to the VSD specifications.

Delivery complete with connection, terminal and fastening material, as well as ready-to-operate mounting and electrical connection in compliance with installation regulations.

H.2.7.5.3 Harmonic Filter

Harmonic Filter shall have following characteristics:

- Compact housing;
- Reduces total harmonic distortion to 5 %;
- High efficiency;
- No ongoing maintenance required.

Passive harmonic line filter in compliance with limit values acc. IEC 61000-3-12, IEC 61000-2-2 and IEEE 519 independent of mains impedance. Specifications according to brand manufacturer standards based on the selected VFD.

- Degree of protection: IP 20
- Dimension: in accordance to the VSD specifications.

Delivery complete with connection, terminal and fastening material, as well as ready-to-operate mounting and electrical connection in compliance with installation regulations.

H.2.7.6 Soft starters (SA)

Soft starter shall consist of following components:

- Moulded case circuit breaker 1 unit;
- Electromagnetic contactor 2 sets;
- Soft starter unit 1 set;

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- Serial reactor 1 unit;
- Current transformer 1 unit;
- Grounding over-current relay 1 unit;
- Thermal relay 1 unit;
- Ampere meter with selector switch 1 unit;
- Running time meter 1 unit;
- Indicator lamp 1 lot;
- Fuse for control unit 1 unit;
- Terminal box 1 unit;
- Starting classes: 20 or 30;
- Local display Yes;
- Analog output 4-20 mA;
- Functions Auto parameterization, safe pump stop, automatic pump cleaning and possibility to work in both directions;
- Communication Profinet.

H.2.7.7 Push Buttons

Push buttons shall comply with the relevant standards. All push buttons shall be of the duty category AC 11.

The rated operational voltage and the rated insulation voltage shall not be less than 250 VAC. The rated operational current shall be not less than 6 A.

Where isolating transformers are not used, the rated fused short-circuit current shall not be less than the short-circuit strength assigned to the control gear.

All "start" and all "normal stop / reset" push buttons shall be of the raised type. "Emergency stop" push buttons shall be lockable.

The buttons shall be coloured in accordance with the relevant standards and requirements. The following colour scheme should be applied:

- Green Start, ON - with indicator lights;
- Red Stop;
- Yellow Acknowledge.

The Contractor shall submit to the Engineer's approval test certificates in accordance to the relevant standards.

H.2.7.8 Indicator Lights

Indicator lights shall comply with the relevant European standards. The rated insulation voltage shall be not less than 250 VAC.

Indicator lights shall be coloured in accordance with the relevant standards. The following colour scheme shall be applied:

- Green Motor ready and running;
- Red Motor default;
- Yellow Summary failure indication.

H.2.7.9 Terminal Blocks

Terminal blocks shall be of the feed-through type and moulded from high grade melamine material to provide protection of the terminals. The comparative tracking index as measured by the relevant standard shall be not less than the rated voltage of the terminal blocks and this rated voltage shall be not less than the rated insulation voltage of the equipment. The rated current shall be not less than the rated thermal current of the short-circuit protective device.

Clamping surfaces shall be serrated complete with clamping screws. Each terminal shall have a printed tag with a number which is not repeated in a compartment.

H.2.7.10 Indicating Instruments

Indicating instruments shall be of the industrial class and accuracy class 1,5.

They shall be of the continuously rated, heavy duty and flush-mounted type with black pointed indicator and anti-reflex dial glass according to the relevant standards.

Ranges shall be selected to show normal plant operation between 50 % and 75 % of full scale deflection. The instrument size shall be 72 by 72 mm or 96 by 96 mm.

H.2.7.11 Position Switches

Position switches shall comply with the relevant standards. All position switches shall be 2 or 3 pole and of the duty category AC 15.

The rated operational voltage and the rated insulation voltage shall be not less than 250 VAC. The rated operational current shall not be less than 4 A.

Where isolating transformers are not used, the rated fused short-circuit current shall be not less than the short-circuit strength assigned to the control gear.

The actuating mechanism shall be of robust construction with a nylon roller not less than 20 mm diameter. The contact elements shall be easy to replace.

All terminals shall be of the screw type suitable for 2,5 mm² conductors accessible from the front.

The Contractor shall submit to the Engineer's approval test certificates in accordance to the relevant standards.

H.2.7.12 Direct Starter

Direct starter shall consist of following components:

- Moulded case circuit breaker 1 unit;
- Electromagnetic contactor 1 unit;
- Zero phase current transformer 1 unit;
- Grounding over-current relay 1 unit;
- Thermal relay 1 unit;
- Amperemeter (if required) 1 unit;
- Running time meter (if required) 1 unit;
- Indicator lamp 1 lot;
- Fuse for control unit 1 unit;
- Terminal box 1 unit.

H.2.7.13 Reversible Starter

Reversible starter shall consist of following components:

- Moulded case circuit breaker 1 unit;
- Electromagnetic contactor 2 unit;
- Zero phase current transformer 1 unit;
- Grounding over-current relay 1 unit;
- Thermal relay 1 unit;
- Amperemeter (if required) 1 unit;
- Running time meter (if required) 1 unit;
- Indicator lamp 1 lot;
- Fuse for control unit 1 unit;
- Terminal box 1 unit.

H.2.7.14 Star Delta Starter

Star delta starter shall consist of following components:

- Moulded case circuit breaker 1 unit;
- Electromagnetic contactor 3 unit;

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- Zero phase current transformer 1 unit;
- Grounding over-current relay 1 unit;
- Thermal relay 1 unit;
- Amperemeter (if required) 1 unit;
- Running time meter (if required) 1 unit;
- Indicator lamp 1 lot;
- Fuse for control unit 1 unit;
- Terminal box 1 unit.

H.2.7.15 Emergency Stop

In general emergency stop for emergency shutdown is mandatory for any machine which can expose personnel to risk of injury during normal operation. Emergency push buttons are required adjacent to every pump (except drain pumps) and motor valves.

Emergency stop shall be housed in tough high visibility yellow enclosures with red mushroom button. The button shall stay in off position when activated and can only be brought back to normal position when reset.

Emergency stop circuits shall be hardwired into motor control circuits. After trip of emergency stop, the motor shall not continue operation automatically when reset. For restart of the motor, a reset button on the motor starter shall be available.

The status of the emergency stop system shall provide status signals to the PLC and SCADA system.

Emergency stop relay shall be according to EN IEC 60204 and VDE 0113 for installation in switchgear and distribution and shall have following characteristics:

- Operating voltage: 24 VDC;
- Operating voltage at the emergency stop button;
- Feedback loop for monitoring external contactors.

H.2.7.16 Emergency Stop Control Box

Emergency stop control box shall consist of following components and have following characteristics:

- 1 piece complete unit for construction (Degree of protection IP 65);
- 1 emergency stop button tamper-proof according to EN 418;
- Safety function by positive opening;
- Reset by pulling;
- Contacts: 1 NO, 1 NC.

H.2.8 Reactive Power Regulation

The scope of work includes the installation of an automatic reactive power regulation, consisting of switchboard with fusing and switching facilities, power capacitors and regulator. Fixed capacitors will not be permitted.

This equipment must guarantee a power factor of a minimum of 0,95 at the feeding point for all load conditions of the plant. The regulator has to be self-programming and must be capable of controlling min. 6 capacitor circuits. The capacity depends on the total load. This shall be calculated by the Contractor. The reactive power regulation must be automatically disconnected when the emergency generating unit is running.

The system shall provide status signals to the PLC and SCADA system.

H.2.9 Uninterruptable Power supply

H.2.9.1 System

The UPS system shall be comprised of single rectifier, battery charger and inverter modules. It shall supply clean, uninterrupted power to the critical loads and meet the specifications.

The Contractor shall assess the electrical load capacity of the UPS taking into account derating for non-linear loads and worst case ambient temperature conditions.

Transformers shall be manufactured using vacuum pressure impregnated insulation.

The UPS system shall be designed in such a way, that any spare part, printed circuit board, sub-assembly or component, can be replaced without any adjustment. The UPS cabinet shall be designed such that all components are removable from the front and cable entry by floor mounted gland plates.

The UPS shall be built on modular basis. The UPS shall include protection against input over voltages, load short-circuits, external or internal over-temperature, vibration and impacts during transport, etc. The UPS shall stop automatically if the DC voltage drops below a pre-set minimum value. Controls shall be micro-processor based and the following main controls shall be possible:

1. Rectifier/charger on/off
2. Inverter on/off
3. Forced shutdown
4. Forced transfer upon forced shutdown of inverter when the bypass power supply (mains 2) is outside tolerances
5. Self-test

H.2.9.2 Rectifier and Charger

The rectifier / charger shall be of solid-state type with fully controlled 6-pulse thyristor bridge and anti-harmonic chokes. It shall have 10 sec walk-in ramp for input current, adjustable battery current and voltage. It shall recharge a fully discharge battery in 24 hours. A boost charge facility shall be provided. A normally open contact rated at 240 VAC, 2 A, close on boost charge, shall be provided for remote monitoring. Input voltage ratings are as follows:

Mains 1 (input to rectifier/charger)

- Voltage : 240 VAC + 10 %;
- Wiring : Single Phase + Earth;
- Frequency : 50 Hz.

Mains 2 (input to static switch)

- Voltage : 240 VAC. + 10 %;
- Wiring : Single Phase + Earth;
- Frequency : 50 Hz.

Synchronisation Range: $\pm 0,75$ Hz

H.2.9.3 Battery

Unless otherwise specified in the Project Documentation, the battery shall be of sealed lead acid maintenance free type and sized for the pre-selected time with the UPS operating at rated load. The battery set shall be installed in similar cabinet finish as the UPS unit. The battery system shall be sized to maintain full load for a period of 2 hours.

H.2.9.4 Inverter

The inverter shall be of transistorised PWM type, for the specified UPS rated power at power factor 0,8. The output rating shall be as follows:

- Wiring: 3-phase, 4 wire and earth. Voltage 415 / 240 volts (± 1 %), 50 Hz ($\pm 0,25$ Hz);
- Transient Voltage Regulation: Voltage transients shall not exceed ± 5 % for a 100 %;
- Load step change and the return to steady state value shall be in less than 20 milliseconds;
- Harmonic distortion: Less than 4 % THD
- Efficiency: For 100 % load 92 %, For 50 % load 91 %
- Audible noise: < 65 dBA at a distance of 1,5 m

The output shall be synchronised in amplitude, phase & frequency to mains 2, when mains 2 is within the tolerance limits. The phase difference between inverter output and mains 2 shall be below 3° (electrical) in such condition so that the maximum gap while transfer to UPS from Mains 2 and vice versa occurs, shall be less than 167 micro seconds.

The inverter shall sustain 125 % overload for at least 10 minutes and 150 % overloads for 1 minute. After these delays, if the overload persists, the load shall be transferred to bypass supply without break if Mains 2 voltage is within the tolerance limits. The UPS shall check the load and if the load is below overload threshold, the inverter shall restart automatically and load shall be transferred back to inverter. A facility to inhibit automatic re-transfer shall be provided.

H.2.9.5 Static Switch

The static switch shall have anti-parallel connected thyristor bank for instantaneous load transfer between the inverter and the mains 2 supply.

A manual bypass switch system of full UPS shall be integrated into the UPS so that load can be transferred to mains supply WITHOUT break for maintenance of UPS. Procedure for transfer to maintenance bypass and back to UPS shall be controlled by the bypass menu of the UPS, thus eliminating possibility of causing disturbance of load by operator who is unaware of correct procedures.

H.2.9.6 Monitoring and Control

Monitors:

The following status information shall be monitored by indicating lights on the front panel of the UPS:

- a) Rectifier-charger on;
- b) Load on inverter;
- c) Load on Mains 2 bypass;
- d) Alarm;
- e) Inverter shutdown imminent;
- f) Boost charge.

An audible alarm shall warn the user of faults or operating problems. The system shall be equipped with an alarm off button. Metering values shall be displayed on an alpha-numeric display.

The following measurements shall be available:

- a) Inverter output voltage (L-L);
- b) Inverter output frequency;
- c) Inverter output currents;
- d) Voltage across battery terminals;
- e) Battery current (charge/discharge);
- f) Mains 1 (rectifier / charger) input voltages (L-L) ;
- g) Rectifier / charger input currents.

Remote Control and Monitoring:

Remote transmission shall be possible for all controls, monitors and measurement indication on the UPS unit to the site PLC. The UPS system shall provide a Bus interface e.g. Profibus or Modbus.

H.2.9.7 Modes of operation

On-line Configuration:

The UPS system shall operate as a true on-line system in the following modes:

1. Normal: The critical AC load is continuously powered by the UPS inverters. The rectifier/chargers derives power from the mains AC power supply source converting this to DC power to supply the inverters, while simultaneously float charging the battery system. Power supplied by the UPS inverters is, to within close tolerances, at rated voltage and frequency.
2. Emergency: Upon failure of the mains AC power supply source, the critical AC load is powered by the inverters which, without any switching, obtain power from the battery system. There shall be no interruption in power to the critical load upon failure or restoration of the mains AC power supply source.
3. Recharge: Upon restoration of the mains AC power supply source, power to the rectifier/chargers initially is restricted by a gradual power walk-in. Following this relatively short power walk-in period, the rectifier/chargers power the inverters and simultaneously recharge the battery. This shall be an automatic function and shall cause no interruption to the critical load.
4. Bypass: If the UPS system must be taken out of service for maintenance or repair, the static bypass switches in all UPS modules supplying the load shall transfer the load on their inverters simultaneously to the bypass source. The transfer process shall cause no interruption to the critical load.
5. Off-Battery: If the battery system only is taken out of service for maintenance, it is disconnected from the rectifier/charger and inverters by means of (an) external disconnect breaker(s). The UPS shall continue to function and meet all of the specified steady-state performance criteria, except for the power outage back-up time capability.

H.3. INSTALLATION WORKS

H.3.1 Wires and Cables

H.3.1.1 General

Wires and cables supply and installation works include the following:

- Cables installations for LV power receiving and step down facility;
- Cables installations for motor operation facility;
- Cables installations for instrumentation;
- Cables installations for supervisory and control system;
- Wire installations for grounding system.

The Contractor shall submit the technical documentation that refer to the specific cables of the supply containing all the pertinent information related with size and all electrical and physical characteristics of the cables and/or catalogue or fragment of catalogue with indication of the types of cables, conductor diameter, insulation thickness, etc.

Cables shall be single or multicore. All cables shall be of suitable voltage grade, copper cored and manufacturers test certificates shall be submitted to the Engineer before the cables are installed.

All cables used shall bear the manufacturers' original guarantee and shall be delivered on site in their original wrapping. The Contractor must obtain the Engineer's approval before unwrapping or installing any of the cables.

The Contractor shall pay particular attention to the appearance of all cable routing. Before start of the installation work the Engineer shall agree to the arrangements. The highest standards of neatness with respect to the visible cable routing and the arrangement and alignment of apparatus and fittings shall be observed.

When the Contractor proposes the use of junction boxes in auxiliary control cable circuits for marshalling a number of cables feeding a common item of equipment, full details shall be given to the Engineer. The Contractor shall not continue his activities until the Engineer gives written permission.

Such junction box shall be of the wall mounting type with a double set of terminals with cores ferruled and identified in accordance with the schematic and cable diagrams. The Contractor shall deliver and install all the necessary cable glands and sealing boxes to complete the installation.

All materials used in the manufacture of glands etc. shall have no effect on the cable core or armouring and shall be corrosion-proof. The conductors of each cable shall be taken direct to the terminals of the machine, instrument and equipment to be connected. Cable ends shall be sealed in suitable cable boxes bolted to terminal boxes.

Whenever it is necessary to remove the PVC sheathing of a cable, this must be done over a minimum length. Exposed copper sheath or armouring shall be covered with a PVC tape or sleeve or any other suitable means. A minimum length of 250 mm tail shall be left on all cables at outlet positions for connection of the components at the outlet.

Multi-core cables shall be terminated with approved glands and earth bonding washers. Black PVC shrouds shall be installed on glands. Care shall be exercised to ensure that manufacturers' minimum bending radiuses are not exceeded during installation.

For cables of 10 mm² or above terminators shall be executed by means of proprietary compression lugs that shall be fixed to the cable conductors in an approved manner by means of adequately sized crimping tools.

No wire of less than 2,5 mm² shall be used in the installation and no combining or splicing of cables shall be permitted. Only insulated cables shall be installed in conduit and trunking.

Cabling for different services shall be installed in separate conduits. Cables shall not be combined in trunking. Cables of different circuits in trunking shall be taped or bound at intervals of 1,5 m for easy identification. Cables shall not be packed or forced into trunking in such a manner as to damage or disfigure the insulation. This requirement is to be strictly followed.

H.3.1.2 Rating of Cables

The Contractor shall ensure that each cable is of sufficient rating for its normal and short-circuit fault level conditions. All calculations shall be done under the assumption of alternating current. To determine the rating and cross section required the following factors must be considered:

- Motor rating;
- Short circuit fault level;
- Conditions of ambient temperature relevant to the method of cable laying;
- Voltage drop;
- Voltage drop in motor circuits at the motor terminals, due to starting;
- Over-current settings of circuit breakers;
- Disposition of cabling whether in the air, ducts, cable trays, or in the ground;
- Number of cables and distance between cables in the same duct or tray.

The total voltage drop from the connection from the Electricity Company to the terminals of the equipment under the most severe circumstances foreseen may not exceed 5 % for the power installation and 2 % for the lighting installation.

The Contractor shall submit details of the cable size calculations to the Engineer and shall not proceed until the Engineer gives written permission.

H.3.1.3 Location and Routing

The position of all equipment and the routing of the cables shall be shown in the diagrams on the drawings, but the exact locations and routing shall be agreed with the Engineer before installation.

Where a number of cables approach a particular item of equipment, special care must be taken to ensure that the cables finally approach the equipment from a common direction and in an orderly and symmetrical manner.

The Contractor shall be responsible for measuring the required cable length. The cable shall be supplied in a suitable length and be continuous throughout its routing. Cable combining shall not be permitted without written permission given by the Engineer.

Excessive bundling of cables in large conduits shall not be permitted and the Contractor shall not exceed the requirements laid down in the local or international Standard and Regulations.

H.3.1.4 Cable Tagging

Cable numbers shall permanently identify each and every cable at each end and every 50 m. Cable markers shall comprise of black PVC oval markers and be fixed axially by UV resistant nylon tie wraps. Cable markers shall also be installed at entry and exit points of ducts and walls exits and all necessary other points to trace the route of the cable.

In addition, control cables and individual conductors shall be identified by means of suitable permanent ferrules, bearing the same number at both ends. Conductor identification shall occur at every point of termination using an approved system of ferrule markers. Numbering shall be read from the terminal outwards on all conductors. At those points of interconnection between wiring where a change of number cannot be avoided double numbers shall be provided on each wire. This identification shall also be provided on the wiring diagrams where the change is made.

H.3.1.5 Cable Entrances and Transits

All cable entrances, transits and jacket pipes are part of the order.

Cables entering or leaving buildings shall be laid in ducts that are sealed at the point of entry in the building. Sealing shall be done with a Multiple Cable Transit (MCT). Care must be taken that the PVC sheathing of the cables shall not be damaged. All entrances and transits must be watertight.

All cables shall be either clipped to walls, ceilings or building structures or run in trays or ladders. All cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be non-ferrous and so treated that they can withstand the conditions on site without corroding.

All cables, whether in or out of sight shall run vertically, horizontally or parallel to adjacent walls, beams or other structures.

Spacing of clips, saddles and cleats shall be in such a way that sagging during the lifetime of the cable will be prevented.

H.3.1.6 Insulated Low-voltage Cables

These Specifications cover the requirements for design and manufacture of low voltage power and control cables with copper conductors. The cables shall be used for AC and DC supplies, protection and measurement, control and signal and lighting circuits.

The cables shall be suitable for voltages up to 600 / 1000 volts and for continuous operation at conductor temperature of 70 C. The cables shall be designed, manufactured and tested according to the latest issue of IEC Publications or equivalent international standards. All manufacturers' references shall be marked at intervals of approx. 1 m on the outer PVC sheath. Conductors shall be identified by the colour of the insulation and numbering in accordance with approved international Standards.

H.3.1.7 Cable Terminations

The Contractor shall provide all materials for termination of low voltage and control cables. Cable terminal lugs shall be clamp type ring terminals, or crimped connectors suitable for stud termination or approved equivalent.

H.3.1.8 Power and Control Cable

This type of cable is used as a power and control cable in static installations, indoors, outdoors, underground, and in concrete.

Power and control cable shall be single or multi-wire conductors of copper wires, PVC core insulation, cores twisted concentrically, various core colours and comply with following specifications:

Medium voltage cables:

- Aluminium / copper conductors;
- XLPE insulation longitudinal and lateral;
- Outer sheath of PE or LLDPE;
- Nominal voltage: according to design requirement (3,3, 6,6, 10, 20, 33 kV);
- Maximal voltage (4, 8, 12, 24, 36 kV);
- Current frequency 50 Hz;
- Maximum temperature with full load 90 °C;
- Allowed short circuit temperature 250 °C;
- Burying depth in soil: 800 mm, under roadways: 1200 mm.

Low voltage cables 1 kV:

- Aluminium / copper conductors;
- XLPE insulation longitudinal and lateral;
- Outer sheath of PVC;
- Nominal voltage: 0,6 / 1 kV;
- Testing voltage 3,5 kV;
- Current frequency 50 Hz;
- Maximum temperature with full load 90 °C;
- Allowed short circuit temperature 250 °C;
- Burying depth in soil: 800mm, under roadways: 1200mm.

Low voltage cables for VFD:

- Aluminium / copper conductors;
- Concentric shield;
- PVC isolation;
- Outer sheath of PVC;
- Nominal voltage: 0,6 / 1 kV;
- Testing voltage 3,5 kV;
- Current frequency 50 Hz
- Maximum temperature with full load 70 °C;
- Allowed short circuit temperature 160 °C.

H.3.1.9 Signal Cable Inside

Single-wire conductor shall be of copper with, polyethylene core insulation and black polyethylene outer sheath and be of following types:

- Ölflex classic 110 black;
- J-Y(st)Y 2x2xXX;
- JZ-600;
- Ölflex classic CY.

H.3.1.10 Signal Cable Outside

Outside signal cables shall be single-wire conductor of copper with, polyethylene core insulation, petrolat jelly filling, laminated sheath of aluminium coated plastic tape and black polyethylene outer sheath of the following types:

- A-2YF(L)2Y (ST III BD);

- Ölflex classic 110 black.

H.3.1.11 Bus Cable / Ethernet Cable

LAN CAT.7 cables shall be for indoor and outdoor installation and of the following types:

- 4 x 2 x 23 AWG;
- 4 x 2 x AWG G24/7.

Profibus cables shall be for indoor and outdoor installation and of the following type:

- Unitronic BUS – Yv L2/FIP 1 x 2 x 0,64 mm.

H.3.2 Cable Installation

H.3.2.1 Cable Installation below Ground

All low voltage and control cables that are not laid above ground shall be laid in in corrugated rigid duct pipes. The maximum distance between cable pits shall not exceed 35 m. Cable pits in street areas shall be constructed to drive over. In each duct pipe trench, there shall be at least always one (1) spare duct pipe (diameter OD 110 mm).

Before commencing the excavation work the Contractor shall submit to the Engineer's approval the set of drawings with the routing of the underground cables. The concerned drawings shall indicate:

- The exact location of the cable run;
- The width and the depth of the cable trenches;
- The ground levels;
- Details regarding crossings with other pipes and the mutual distance of cables;
- The location of the jacket pipes (including reserve pipes).

The minimal horizontal distance between low voltage cable work and the remaining cable work is 200 mm.

Signal cables in the ground must have 25 % spare cores, with a minimum of 2 cores.

The Contractor shall prepare drawings giving the exact requirements for all cable trenches, detailing the width and depth of each trench and detailing road crossing cable ductwork to be provided. The drawings shall be prepared in conjunction with the Consultant and shall be approved in writing before issue to site.

The excavation and back filling of cable trench work shall form part of the work by the Contractor as well as supply and laying of road crossing and other ducts. The Contractor has to coordinate the different lots of cable laying and the excavating and back filling works.

The laying of all cables shall satisfy the following requirements:

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- Cable depths shall be assessed from the finished ground level unless otherwise directed by the Engineer;
- Before laying in cables the Contractor shall inspect the trenchwork to ensure that the trench bottom is of a smooth and firm contour and free from broken stones or rocks;
- Cable bedding within the trenches shall be formed by a 75 mm sand layer;
- Cables shall be laid with adequate separation and shall be “snaked” to avoid tension during backfilling operations and subsequent settlement;
- Before sanding and backfilling, all laid cables shall be inspected by the Engineer and a further inspection made following sanding and tiling;
- After cables have been laid, they shall be covered by a further 75 mm of sand which shall be well tamped around the cables;
- After sanding, concrete cable covers and red warning tapes shall be placed as required;
- When carrying out backfilling, the Contractor shall ensure that cable covers are undisturbed and that large rocks, stones and the like are eliminated from backfill soil.

H.3.2.2 Cables not in the Ground

All low voltage and control cables, which are not to be installed below ground, shall be installed on cable trays, cable rack or in metallic conduits. The Contractor shall provide and install all necessary cable trays, cable racks and cable conduits.

Cable glands of appropriate size shall be used at cable entrance into distribution panels and marshalling boxes.

Cable shield armour where applicable shall be properly grounded according to standard practice. Cable identification tags, sleeves shall be provided at cable terminations.

Single cables along walls shall be put in galvanised steel or grey impact proof Hostalith pipes of sufficient diameter. One cable per pipe, the pipes shall be laid without elbows. Interrupt the pipe circa 100 mm before a bend and continue the pipe circa 100 mm after the bend.

The beginning, end and each 300 mm of the pipes shall be attached with hot dip galvanised pipe brackets. Cables outside the building shall be laid in stainless steel pipes. The pipes shall be mounted with stainless steel pipe brackets.

Vertical protection tubes that are mounted outside shall be carried out till 200 mm under ground level. The protection tubes shall be drained out to ensure that water doesn't stay in the tubes. The topside of the protection tubes shall be sealed.

The horizontal assembly of four or more cables near each other shall be laid in a cable tray and vertically assembly of the cables shall be attached to a cable tray.

Cables in horizontal assembled cable trays can be laid unattached under the condition that cables are laid in a proper and orderly way and are joined together. If the cable trays exceed an angle of 30° the cables shall be attached each 400 mm with cable ties or hot dip galvanized pipe brackets.

Bushings of cables guiding systems shall be provided with rubber bushings or coupling nuts. Cables in cable trays or cable ladder shall be laid with the required bend radius in the cable trays and sufficient cable spreading shall be guaranteed.

Outgoing cables of a cable tray or cable ladder shall be protected to prevent damage throughout the complete length of the cables. Inside a prefabricated galvanized steel assembly system shall be used for the cables. This system shall also be used to assemble main switches and wall mounted devices that are not near the machine. If necessary the cables shall be adequately supported and relieved of tensile strain.

H.3.2.3 Cable Trays and Cable Ladders

The cable tray or rack, trunking or ducts shall include all necessary supports, fixing bolts and foundation bolts required to support the system and shall comply with following specifications:

- Dimensions: Width x Height standard: 100 - 600 x 80 – 110 mm)
- Material outdoor: stainless steel, covered;
- Material indoor: hot dip galvanized steel.

Cable trays, cable ladders and covers shall be of hot dip galvanized (layer thickness between 50 and 150 µm) sheet steel of at least 1 mm thick. The cable trays shall be carried out with stand-up edges of at least 60 mm high with perforated slots in the bottom and bends. The cable ladder shall be executed with stand-up longitudinal ribs of at least 15 mm high. The inside of the bends shall be fluidly.

The trays outside shall be carried out in stainless steel or synthetic material as agreed with the Engineer. For separation of low-voltage current / measuring signal cables and power supply cables a partition wall shall be applied.

The bends, tees, couplings, reducers etc. shall be of the same manufacture as the tray. The accessory curvatures shall be wide enough to fit the cables smoothly in the trays with the required bending radius.

Cable ladders shall be suitable for attaching cables with cable brackets. Maximum cable loading on a tray shall be in accordance with manufacturers' recommendations. The complete installation shall have around 25 % spare capacity on each tray. Cable trays and cable ladders shall be suspended with typical brackets and shall be suitable for a lateral attachment of the cables. The attachment of the tray shall be adjustable.

The suspension and support distance shall be in accordance with manufacturers' regulations of the cable tray or cable ladder. The maximum deflection shall not exceed 5mm with the maximum cable loading on the tray.

Deviations in suspensions shall be consulted with the Engineer. The deviation will be subject to approval by the Engineer. Cable trays and cable ladders shall be neatly aligned. Cable trays and cable ladders shall be carried out with covers unless they are situated in creeping spaces or nearby ceilings. The covers shall be attached with metal clips. All suspensions and mounting devices, nuts, washers etc. shall be made of the same material as the concerned cable tray or cable ladder.

Damages to cable trays or cable ladders including suspension etc. shall be recovered in conformity with the conserving regulations.

H.3.2.4 Cable Conduit Systems

Cable pipes shall comply with following specifications:

- Dimension: standard diameters 16, 20, 25, 32, 40, 50, 63 mm;
- Material outdoor: stainless steel;
- Material indoor: hot dip galvanized steel.

Approved conduit systems shall comply with IEC 60423 standard. All conduits and fittings shall be hot dip galvanized. Non-metallic conduit systems shall not be used without the written permission of the Engineer.

Conduits shall be run on the surface or sunk as specified and be neatly arranged. Ways shall be provided for additional conduit boards at all switchboards. The sizes of conduits used shall be determined by the number of cables to be drawn in as scheduled or as specified. But in no case conduits less than 16 mm diameter shall be used. Sunk and concealed conduit systems shall support fittings independently of any false ceiling.

All conduits shall be installed in an approved manner and arranged with adequate ventilation and drainage where necessary. The Contractor shall ensure that conduits drawn-in boxes and junction boxes are of sufficient capacity to allow all cables plus 15 % to be drawn in or withdrawn. Conduits shall be of the screwed pattern, galvanized by the hot dip galvanizing process. All conduit fittings not carrying accessories shall be supplied with flat covers fixed in position with round head brass screws.

Surface run conduits shall be supported in such a way that a maximum distance of 1,00 meter between two points shall not be exceeded. Where possible all bends and sets shall be formed in the conduit itself. Factory made bends are only installed after written permission of the Engineer. The radius of bends shall not be less than specified in the standards.

Standard junction or adaptable boxes shall be provided at all junctions and at sharp changes of direction in addition to any special positions to be called for by the Engineer on site. Inspection couplers may be used in long runs to facilitate drawing in cables.

Particular care must be taken to ensure that no water is allowed to enter a conduit. However, they shall be arranged with adequate ventilation and drainage where necessary as directed by the Engineer. Inaccessible junction boxes shall not be allowed. Fixing to surfaces of walls shall be by

means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in structural floors they shall be held in position with substantial fittings, make and type to be approved by the Engineer.

For the different voltage levels of the cables, separate compartments must be provided. Conduit entries shall be protected against ingress of moisture or debris during installation. The complete conduit system shall be cleaned from loose matter and dirt before cables are drawn in. Where conduits connect to switch boxes, drawn-in boxes and the like, the conduits must have a machined faced socket screwed on to the end which, when tightened, is flush with the outside of the box. The conduit is then to be secured to the apparatus by means of a screwed conduit socket in order to make a sound and tight mechanical joint. Conduits shall be bonded to earth.

H.3.3 Cable Testing

H.3.3.1 Tests on Cables during Manufacture

All cables under the Contract shall be subject to Routine Tests in accordance with the relevant IEC standards or equivalent international standards and manufacturers' specifications. Cables shall not be accepted on Site for installation until certificates giving proof of compliance with the Specifications and data of tests have been received and approved by the Engineer. A Certificate shall be required for each drum. Tests carried out on every drum at manufacturers premises shall include:

- Insulation resistance test;
- Core continuity and identification;
- Conductor resistance test.

H.3.3.2 Tests on Cables during Installation

During the installation at the Site the Engineer shall carry out inspections of the Works to ensure that the standards of workmanship meet the Specifications. In the event of any part of the cabling installation failing to meet these requirements, the Contractors Engineer or foreman shall immediately be informed and the Contractor shall remedy the deficiency to the satisfaction of the Engineer.

After completion of various parts of the installation the Contractor shall provide a Test Engineer, labour and materials to demonstrate to the Engineer that the cabling has been correctly installed.

It shall remain the responsibility of the Contractor to test the insulation of the cables, both between conductors and earthing during installation with a 'Megger'; '500 Volt hand generator.

The Contractor shall test all cables after installation to ensure correct phasing out of the conductors, continuity of the conductors, sheaths and armouring over the whole length of the cable.

All insulated conductors shall be electrically tested before (factory certificate & RSS certificate to be submitted by the Contractor) and after placement on site in the presence of the Engineer.

All circuits shall be tested with the circuit complete except for connections to equipment. All splices, stress cones on shielded cable, and terminal connector attachments shall be complete prior to testing.

Any circuit failing tests shall be replaced or repaired and then retested.

All equipment required for testing shall be provided by the Contractor.

Continuity, Identification, and Short Circuit Tests

All insulated conductors ≥ 230 VAC shall be tested for continuity and conductor identification. In addition, all insulated conductors of multi conductor cable shall be tested for short circuits. The Contractor shall furnish portable, battery powered, ring testers, and other test equipment as required to conduct these tests.

Continuity tests shall include all tests necessary to confirm that the conductor being investigated originates and terminates at the locations designated on the drawings.

Short circuit tests shall include all tests necessary to confirm that no conductor of a multi conductor cable is short circuited to another conductor in that cable.

Insulation Tests

Resistance from ground provided by the insulation on all site installed insulated conductors shall be measured. Measurement shall be accomplished as follows:

All 600 volt insulated conductors shall be tested with a 1.000 volt calibrated megger or an equivalent testing device. Insulation resistance measurements shall be made between each conductor and ground and between each conductor and all other conductors of the same circuit. The minimum acceptable resistance values shall be >100 MOhms.

Comprehensive insulation test reports have to be submitted and approved by the Engineer before energizing.

After energization a loop impedance measurement has to be executed for all 230 / 400 VAC cables. The test protocol shall include the Impedance and short circuit values of each cable and the corresponding fuse with minimum and maximum short circuit values.

H.3.4 Junction Boxes

Junction boxes shall be constructed of aluminium complete with lid and captive gasket with a minimum Index of protection IP 67. The necessary number and size of entries together with

terminals are to be designed according to circuit requirements. All junction boxes shall be clearly labelled and shall be included in the corresponding circuit diagram.

H.3.5 Cable Entries

Cable entries from one room to another room or from outside to inside shall be performed by watertight and fireproof cable penetration seals to provide an efficient barrier against fire, smoke, flooding and vermin.

The cable penetration system shall comprise a steel-mounting frame packed with insert blocks to accommodate the cables and fill out surplus room. After cable installation, the insert blocks shall be compressed to complete the sealing.

If required fire resistant sealing shall be provided.

H.3.6 Cable Glands

Cable glands shall be of the compression type and shall be of corrosion resistant metal material. The glands shall be sized for the cable. For the connection between motors and VFDs only special EMC cable glands shall be provided on both sides.

H.3.7 Earthing System and equipotential Bonding

Earthing installation shall be as per design drawings and local regulations and in accordance with international standards.

Following values shall not be exceeded:

- 2 Ohms for power system and lightning protection;
- 1 Ohm for signals and automation system

Before beginning of works, the resistance of the ground shall be determined, in order to select the required measures of earthing and lightning protection according. The result has to be submitted to the Engineer. The measurement log shall be submitted for approval of the Engineer. A 4-pole measurement procedure is required. A photo based documentation shall be provided for the earthing system. The system shall be based on the lightning protection and earthing concept of the plant.

Following materials shall be used for the earthing system:

- Outdoor: copper wire;
- Indoor: copper cable.

All the HV and LV electrical installation equipment, the electrical consumers and their connections elements, metal pipes, steel structures, metal basements and their connection screen, metal doors

and other metal parts as cable trays, pipes, rails, etc. within the system, that are not used as electrical conductors, shall be connected to the potential equalization system in order to avoid the risk of high electrical contact voltage.

In the required sections, the earthing networks shall be installed for the earthing of the electrical installation and the metal section of the structures. The earthing networks must be obtained by the connection of copper earthing conductors with a suitable cross-section and copper earthing electrodes with the diameter of 20 mm and a minimum length of 1,5 m. The concrete inspection holders must be installed for the tests and periodical inspection in the earthing network.

In the earthing networks, the connection of the earthing conductors to themselves and to the earthing electrodes must be made of corrosion resistant materials.

In the buildings and other structures, a main earthing terminal shall be installed to which all the main earthing conductors and earthing cables, the earthing busbar on the switchgear plant and main distribution switchboards, the equipment basement and earthing electrodes will be connected. The earthing connections to the electrical consumers and metal structures must be installed with copper conductors or copper cables with suitable cross-sections.

The components of the earthing system are to be individually connected to a potential bonding bus, so that they can be disconnected and tested separately at any time.

The moveable parts like the HV cubicle doors, the transformer room doors, the generator room doors, the doors of the main distribution switchboards and the secondary panels etc. shall be connected to the earthing system via flexible cables.

H.3.8 Lightning Protection

The plant shall be equipped with a complete lightning protection system according to DIN EN 62305 and the relevant local standards.

The buildings shall be equipped with lightning arrestors, with the minimum lightning protection level three. The Contractor shall submit a risk analysis together with the design of the lightning protection and earthing system.

The lightning protection shall be implemented at buildings and high structures by one or more arresters placed to top of them.

The chrome plated brass air terminals with a diameter of 20 mm and a minimum length of 500 mm must be used as lightning terminals. The air terminals shall be connected to the upper points of the buildings and the structures via suitable lightning terminal fixing parts.

The lightning protection conductors shall be suitable cross-section solid copper conductor or copper ribbon. The lightning protection conductors must be taken down with shortest cut by the suitable properly conductor holder from the building and the structures. The hardly turnings shall not be made at the conductors.

H.3.9 Raised Floor

Raised floor construction shall have a height according to the requirements, but at least 600 mm, suitable for switchgear stations. The load-bearing capacity is achieved by the panel material itself and by the understructure, consisting of bolted C-type stringers. All steel parts of the understructure have to be screwed together so that the construction is permanently conductive. Furthermore all steel parts must consist of galvanized material. The steel pedestal consists of base plate and pedestal head. The pedestal is fully adjustable in height (± 30 mm). Even under heavy loads, the pedestal shall be secured against vertical shifting. The module of understructure is 600 x 600 mm. The understructures for the switchgear cabinets have to be included, it shall be constructed in a way that the extension of switchgears is possible.

The access floor panel, dimension 600 x 600 mm, shall consist of wood material, approx. 40 mm thick, reinforced with 0,5 mm steel sheet in an advanced backing procedure. Panel edges are protected all around by synthetic trim against mechanical damage and humidity. The panel surface shall be finished in factory with suitable floor covering. In rooms in which there is risk of explosion and in MV rooms, access floor panels have to be screwed to the understructure, but allowing easy removal in case of maintenance.

Raised floors shall be complete, with all accessories, inclusive of:

- Cleaning and painting of the concrete floor and the wall in suitable manner;
- Skirting on the walls, to be fixed with screws allowing easy removal in case of maintenance;
- Hoisting gear for floor panels for each room with wall holder;
- 5% reserve floor panels.

The minimal concentrated load on walking area shall be 3.000 N, and the minimal distributed load 20.000 N/m².

The service includes the complete installation ready for operation, all mounting and installation material, inclusive accessories.

H.3.10 Small Power and Lighting

A small power and lighting distribution shall be provided for each building. All electrical circuits for lighting fixtures and sockets up to 32 A shall be equipped with residual current device ≤ 30 mA.

H.3.10.1 Light Fittings

Prior to installation works, the Contractor has to submit a comprehensive lighting calculation for indoor and outdoor lighting, including all datasheets for Engineers approval. The maintenance factor for the calculation shall not exceed 0,8.

All light fittings shall be of the LED type. Light fittings shall provide a protection degree according to the location of installation (IP 21 in office zones, IP 67 in wet / facility zones). If required for explosive air zones special ATEX compliant light fittings shall be used (Zone 0-2).

The required light intensity for all rooms and external lighting shall be designed in accordance with international standards. The general minimum lighting requirements for indoor installations shall be 150 lx at 1 m above ground. Furthermore the following particular minimum requirements apply:

- Staff room: 300 lx
- Switchgear room / control room: 500 lx
- Offices: 500 lx
- Laboratories: 500 lx
- Workshop: 300 lx

The light intensity shall be measured at the working level and test results submitted to the Engineer.

The lighting in each separate room shall be connected to one circuit, the socket installation to two circuits.

Where light fixtures in basement corridors cannot be fastened to the ceiling, these shall either be suspended or fastened to the wall as directed by the Engineer.

H.3.10.2 Installation and Connection of Light Fittings

Installation and connection of the light fittings shall be with continuous-row arrangements, the fluorescent lamp light fittings (even when arranged with spacing) shall always be mounted to supporting channels after the pendants have been attached. The light fittings including supporting channels and pendants shall be screwed to the hall structure (double T) using clamping devices. Drilling of holes must be approved by the Engineer.

The material required for installation must at least be electro-galvanized or cadmium-plated. The clamping device shall be of hot dipped galvanized steel.

H.3.10.3 Emergency Lights

Emergency lights shall be provided in each room. Emergency light fitting, including charger shall be with built in gas light maintenance free battery, able to supply the full capacity for three hours. The casing shall be made of plastic material. The emergency lights shall provide service within 15 sec. after power failure.

Emergency lights shall provide minimum 1 lx at the ground to ensure safe evacuation in case of an emergency event. The Contractor has to provide a risk report in order to identify rooms with high level requirements on emergency lights.

Portable emergency light fitting which can be separated from the fitting, with built in gas light maintenance free battery, able to supply the full capacity for two hours, including charger, shall be provided for electrical rooms and pump rooms.

H.3.10.4 Emergency Exit Lights

Each emergency exit shall be equipped with emergency exit light in accordance with the safety concept of the plant. Emergency exit lights shall include charger with built in gas light maintenance free battery, able to supply the full capacity for three hours.

H.3.10.5 Socket / Outlet

The following may be used:

- 400 V, socket outlets to CEE with VDE sign and equipped with three phases, neutral and earth wire for 16 and 32 A, of the surface-mounting type. Socket outlets of the 6 h type including plug shall be supplied. The minimum degree of protection for the socket outlets is IP 44;
- 230 V, CEE type receptacles, 16 A, impact-proof plastic material, complete, including plug and mounting steel bracket;
- 230 V, CEE type receptacles, 16 A, waterproof;
- 230 V, BS-type (safety-wire) duplex or single receptacle, damp-proof, surface or flush-type, 16 A, white, with hinged cover;
- 230 V, duplex or single BS type (safety-wire) duplex receptacle, damp-proof, as above, but flush-type.

H.3.10.6 Structured Cabling

A structured cabling network shall be installed for the connection of computers and telephones. The system comprises CAT7 cabling and CAT6e network components including network panels. The maximum cable length for a copper cable link shall not exceed 90 m. For the outside connection Fibre Optical Cables shall be used. The network shall provide Gigabit communication to all parts and buildings of the plant.

A central software shall enable control, management and diagnostics of the network. It shall be possible to create VLAN and control the ports of the network.

H.3.10.7 Switching Equipment

The following may be used:

- Installation switch, as toggle switch type, for concealed or exposed installation, as two-way switch, 1-pole, 10 A, 250 VAC, with square cover plate, fastening with screws;

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- Installation switch, as toggle switch type, for concealed or exposed installation, drip water protected, as disconnecting switch, 1-pole, 10 A, 250 VAC, with square cover plate, fastening with screws;
- Installation switch, as toggle switch type, for concealed or exposed installation, drip water protected, as disconnecting switch, 1-pole, 10 A, 250 VAC, with housing made of insulating material, with one each line inlet;
- Installation switch with VDE test mark as toggle switch for concealed or exposed installation, drip water protected, as 3-way switch, 1-pole, 10 A, 250 VAC, with housing made of insulating material, with one each line inlet;
- Luminous batons for keying circuit 10 A, for concealed or exposed installation with installation box and cover;
- Twilight switch with adjusting switching range from 5 to 30 Lux, and 10 A, 250 V, with cast aluminium housing, safety code IP 54, for wall mounting.

H.3.10.8 Outdoor Installations

The Contractor shall provide the complete outdoor installations, consisting of outdoor lighting and combined outdoor socket outlets for portable drives, tools and general purposes. The offered equipment must be complete and functioning and shall meet all relevant international and local standards and regulations.

The Contractor shall submit to the Engineer's approval a layout plan of the plant showing the locations of each device before start of works.

H.3.10.8.1 Street Lights (Outdoor Lighting Facilities)

External lighting shall be provided for the whole of the following areas:

- All roads and parking areas;
- Access roads to buildings and facilities;
- Access footpaths and pathways to buildings and facilities;
- Access to buildings and plant facilities (walking platforms, stairs, ladders, ...).

Supply and Circuit

The supply of the lighting facilities shall be carried out in a decentralized way; the circuit, however, will be actuated from a central point by means of a photoelectric cell or by hand. The lighting concept shall consider the highest level of protection for operators and staff.

Lighting Standards

- Main entrance to building 50 lux;
- Yards, roads, footpaths, ... 30 lux;

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- The road, parking areas and access doors to buildings shall be provided with solar powered LED luminaries on 8 m poles at intervals of 30 to 40 m (depending on the necessary illumination level). The solar power system shall ensure continuous operation of the luminary > 3 days without sunlight.
- Foundations of the lighting poles shall be according to the manufacturer's specifications ;
- All poles shall be interconnected with the earthing system.

The Contractor shall submit to the Engineer's approval the external lighting plan and the calculation of the light intensities.

H.3.10.8.2 Outdoor Socket Outlets

A sufficient number of power-combined sockets shall be installed at suitable outdoor locations within the area of the plant. They have to be supplied by the nearest building distribution and shall be suitable for maintenance and repair purposes. The distance between two socket outlets may not exceed 80 m at any point of the plant.

Each power-combined socket is to be installed within a protective watertight housing (IP 67) made of corrosion resistant sheet steel. It shall be fixed to a wall or a stainless-steel pole with concrete foundation. Each power-combined socket shall be equipped with the following devices, all mounted within a hard rubber or plastic casing:

- 1 moulded-case circuit breaker 40 A;
- connection block;
- 1 earth leakage circuit breaker, 4-pole, 40 A / 30 mA;
- 1 earth leakage circuit breaker, 2-pole, 40 A / 30 mA;
- 3 miniature circuit breakers 16 A;
- 2 CEE-type sockets, 5-pole, 3-phase, P 54, 3 x 16 A;
- 2 single phase sockets, 3-pole, 16 A;
- 1 heater with thermostat, 60 W;
- earthing and neutral bus.

H.3.10.8.3 Cabling, Wiring for Building- and Outdoor-Installations

The Contractor shall provide the complete cabling and wiring for building and outdoor installations of the whole plant with all required indoor and outdoor installations. He shall deliver and install all required auxiliary material as cable trenches, cable ducts, trays, conduits, terminal boxes, watertight bushings, etc. as specified hereinafter.

H.3.10.9 Telephone System

The Contractor shall deliver and install a modern and state of the art IP based telephone system. It must comply with all relevant international and local standards and regulations and all conditions for

the connection to the public telephone network of the local telecommunication services company. The Contractor shall carry out all required coordination and clarification with the local telecommunication services company at no extra costs. All costs, taxes and charges to be paid to the telecommunication company for the connection to the public telephone network must be included in the offered price.

The system must be suitable for future system-extensions without hardware or software efforts. The technical limit of extension shall be stated in the offer.

Telephone sets shall be connected to the system via RJ 45 telephone socket outlets according to the relevant standards, in order to provide the exchange of telephone sets without any hardware or software efforts. The service includes all required devices, cabinets, telephone sets, installations, accessories and any further equipment, that may be required to realize a complete and functioning telephone system.

Central telephone unit

The central unit shall provide IP based telecommunication service for the entire plant and shall comply with following requirements:

- suitable for connection of all required extensions, regarding the reserve as mentioned above;
- interface for connection of auxiliary devices (e.g. PC, Printer, etc.);
- power supply 230 VAC, 50 Hz;
- emergency power supply UPS.

The following function shall be provided:

- storage of telephone charges for all public lines and extensions, including data output to printer or PC;
- free assignment of number to each extension;
- free calling between the extensions;
- assignment of restrictions for outgoing calls for each extension;
- call transfer to enable any extension to divert a call to any other extension;
- automatic calling back for busy extensions;
- enquiry call;
- announcement with musical background for standby of incoming exchange or extension lines, repeated spoken text "Please hold the line" both in English and local language.

The software shall be implemented in non-volatile memory within the unit. The service includes the complete programming, implementation, configuration, test, documentation and introduction of the operating personnel.

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The complete unit shall be installed in a suitable cabinet including racks, power supply, overvoltage protection for all power, signal and communication lines, marshalling unit for all lines with 30 % spatial reserve, complete wiring and installation, all required material.

Telephone Sets

Telephone sets have to be supplied in a sufficient number to provide a convenient internal and external communication. The central control room, all office rooms or other administration rooms shall be equipped with comfortable telephone sets, providing the following characteristics:

- alphanumeric LCD display;
- alphanumeric telephone directory for at least 20 numbers;
- repetition of calls;
- indication of telephone charge;
- modern design;
- rugged construction.

Each LV and HV panel room, important machinery rooms and further rooms as required have to be supplied with telephone sets for wall mounting, meeting the following characteristics:

- repetition of calls;
- switchable dialing type (multi-frequency-type);
- programmable storage for 10 numbers;
- stable design.

In areas with potentially explosive atmosphere only explosion proof components may be used for the telephone system.

H.4. INSTRUMENTATION

H.4.1 General Requirements

All instruments shall be provided with 24 VDC power supply if applicable. All devices relevant for process shall be supplied by the UPS system.

All equipment shall be protected against aggressive and/or corrosive environment. All instruments shall be installed in the locations shown on the Contractors drawings and where connections are to be made into pipelines, each installation shall be complete with the necessary manifolds, isolating valves, drain valves, test points, sample cocks, etc., as appropriate. Instruments shall be easily accessible for maintenance and calibration. In all cases it shall be possible to isolate and remove the instrument, and fit check gauges, or take samples as appropriate.

All analogue transmitters, receivers and direct wire transmission systems shall have at least a signal level of 0/4 to 20 mA + HART, unless otherwise specified in detailed technical specifications. Profibus and Profinet communication is also possible.

A consistent system shall be installed. The parameterization for each measuring device shall be documented and provided to the Employer in the form of a software file.

All parameter settings shall be stored on a central server system. Parameter settings shall be implemented in change management of the plant.

All measuring transmitters and signal processors, power and signalling lines shall be equipped with overvoltage protection for all; cable inlets shall be watertight and shall fit accurately to the cable size. Transmitters shall be installed together with the overvoltage protection to a mounting pole with protective housing against sunlight and weather. The lifespan and reading of display shall not be disturbed by sunlight.

The distance between the sensor and the transmitter shall be kept as short as possible but with sufficient cable length for easy maintenance of the sensor. Extra lengths of cables if required shall be arranged orderly on cable holders next to measuring transmitters.

The supplies shall include all accessories and materials which are necessary for the correct operation of measurements, adjustments and on site calibration. The overall accuracy of the instruments shall be 1 % of the measuring range.

Measuring devices can be in compact or remote version, with basic or advanced functionalities depending on the measuring point and the importance of the measurement itself for process control.

H.4.1.1 Process Device Management

It shall be possible to configure and parameterize all smart field devices (sensors, actuators, remote I/Os) from the same unique platform, as integrated part of the central Process Control System. It shall be possible to operate and parameterize field devices and components remotely via central parameterization software installed on Engineering or Maintenance station and locally (in the field) via mobile Client (tablet) connected to central parameterization software via local Wi-fi network. All changes made in field devices (remotely or locally) should be automatically centrally stored and updated. It must be possible to define access rights for monitoring and parameterizing. The communication with the devices must be possible with PROFIBUS DP, HART, Modbus, Ethernet and PROFINET. With the software it should be possible to create project-specific field device libraries, to read device parameters and to change, identify and assign field devices, check, read diagnostics and device status data and to simulate device behaviour. Changes to field device data such as parameters, limits and alarm settings must be documented globally and device specific in a user-related Logbook. It shall be possible to assign various roles with defined function privileges to users.

H.4.1.2 Integration of Process Instrumentation in a Process Control System

During equipment selection, preference should be given to devices that have a higher level of integration into the process control system through dedicated and pretested software libraries. This functionality will be considered as an advantage, due to fact that when it is implemented it will increase overall quality of the offered technical solution.

A block library must be made available for main process instrumentation used in a project that enables the integration of these devices into a process control system.

The block library is to be made up of driver blocks, diagnostic blocks and faceplates for the various devices.

The faceplates are used in the operator stations of the process control system as the user interface for the supported process instrumentation, so that the technologically relevant values and functions of these devices can be displayed and operated as objects of that PCS.

The block library is to be provided as engineering and runtime software with a single license for one automation system (one installation).

Bidirectional communication links must be provided on the system side between faceplates and blocks, as well as between blocks and process instrumentation

H.4.2 Installation Approval

Where there is no detail in the Specifications or associated drawings regarding the exact location or method of installation of measuring equipment, sensors, or other site mounted equipment, the

Contractor shall submit details of his proposed installation to the Engineer for approval and obtain this approval before starting any installation work.

H.4.3 Cables and Cabling

All cables necessary for the complete installation shall be provided and installed in accordance with the requirements of Section LV switchboards and motor-control gear. All signal and control cables (also for PLC) shall be shielded.

All multi-pair cables, except those connected to remotely controlled actuators, shall include a minimum of 25 % spare cores. This spare capacity shall be over and above any cores that may be required for proposed future installations or extensions. Spare cores in addition to the above may be required in some cables to cater for the spare alarm channels.

There shall be a separate multi-core cable between each motorized valve actuator and the local distribution enclosure or control panel. All such cables shall include a minimum of 2 Nos. spare cores except those associated with actuators having remote control, which shall have a minimum of 12 Nos. cores. All cores, even spare cores, in the cables shall be connected to terminals at both ends.

H.4.4 Instrumentation and Control Equipment Power Supply

All instrumentation, monitoring and control circuits and equipment shall be supplied at a voltage not exceeding 55 volts to earth. These supplies shall be from one of the following:

- A battery / charger unit, typically of 24-volt nominal output, but under no circumstances exceeding 48 volts nominal output;
- A double wound transformer having a fused primary, a 55-0-55 volt secondary with the centre point earthed and each secondary line fused;
- A transformer / rectifier system, comprising a double wound transformer with a fused primary and a secondary having one end earthed, together with a full wave rectifier unit incorporating voltage stabilization if necessary.

The mean voltage of the rectified output shall not exceed the nominal output from the instrumentation battery/charger units. Equipment such as battery/chargers, no break and control power supplies, inverters etc. shall be supplied as necessary to maintain the required electrical supplies to essential instrumentation, monitoring and control systems which are to be kept in operation during a mains power failure. Such essential equipment comprises flow measuring, indicating, recording and integrating equipment or as otherwise detailed in the application clauses.

H.4.5 Field Devices

H.4.5.1 General

Sensors shall be manufactured from durable, corrosion free material, suitable for the installation environment, the local climate and the liquid controlled.

Sensors shall have a minimum protection equal to classes IP 54 or IP 68 (if subject to submersion) and cable or other feed through entry shall not violate the classification.

Sensors shall be connected to a measuring transducer. The transducer shall be equipped with an output of 4 – 20 mA and one adjustable limiting value switch for dry run protection, overflow, etc. This switching contact shall be incorporated into the relay technique of the control.

Supporting steelwork shall be adequate and allow access for maintenance, repair or replacement and shall not hinder the proper functioning of the instrument.

Control units shall be suitable for rack mounting and shall be installed in an appropriate control room. Field control units shall be housed in appropriate field cabinets with a window for control lamps or indicators. The protection class shall be minimum IP 65.

Field cabinets shall have a roof as protection against the elements and a housing in material resistant to strong sunlight or be mounted inside protection hoods protecting the instrument but not reducing the accessibility. The display must be possible to read in strong sunlight as well as at night.

Analogue outputs shall be provided with linear proportionality to the depth range.

When there is demand on local show of measured value, local display shall be included in instrument. Where display for instrument is impossible to see from ground level or platform it shall have an external local display installed. Instrument display and external local display shall be mounted 1,4 m above ground / platform. External local display feed 24 VDC by twin lead, 4-20 mA measure signal.

Delivery of all instruments shall include all necessary mounting details for easy maintenance and accessibility.

All measurement signals, analogue and digital, shall be connected to the process control system.

For flow measuring and analysis (oxygen, pH, redox potential, nitrate, ammonia, suspended solids, ...) there must be a local switch, which will freeze the signals during calibration.

H.4.5.2 Float Switches

Float switches shall be the pendant type with the float suspended on a flexible cable, such that with the float free of the liquid the float and cable hang vertically, but with a rising liquid level the float shall rise and tend to invert.

The float shall be of robust design and comprise a mercury switch having changeover contacts encapsulated in hard plastic foam and connected to a 3 core cable. The whole assembly shall be covered and hermetically sealed in Hypalon or similar material. With the tilting action that occurs on rising level, the contracts shall change over, but there shall be a dead band between opening one contact and closing the other, during which period both contacts shall be open. This dead band shall operate over an arc approximately 20° either side of the horizontal.

The contacts shall be rated for a minimum of 5 A at 230 V. The voltage on the contacts shall not exceed 55 volts (nominal) to earth.

In all applications the installation shall be complete with approved means of preventing the float (and lead) from movement due to wind or liquid turbulence.

Where float switches are to be used in applications under which they may be submerged during normal operation (e.g. pump control and/or low level alarm); they shall be attached to a weighted chain to minimize movement due to turbulence and also to provide means of raising the units for maintenance and repair. All brackets, fixings, etc. as necessary for the complete installation shall be provided.

The chain / float assembly shall be installed such that the point of suspension is not less than 400 mm from any side wall.

H.4.5.3 Electromagnetic Flow Meters

Electromagnetic flow meters consist of a sensor and transmitter and optionally a cable and a mounting accessories in remote version. They must comply with following requirements:

- Possibility of simple mounting in compact or remote version, supporting easy adoption from compact design to remote and vice versa. This adoption should be possible on site, without dismounting the sensor from the pipe, only by adding / removing a sensor cable and transmitter mounting accessories, during flowmeter installation or later in operation, if requested;
- It must be possible to shorten sensor cables on site during installation;
- Possibility to easily achieve IP 68 protection of sensor at the installation site, after electrical connection of the sensor, using a sealing gel and without compromising the manufacturer's warranty;
- Possibility to verify the flow sensor on site without interrupting the process and removing the sensor from the installation site using a verification tool and with generating a certificate of verification;

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- Max. measurement error $\pm 0,4\% \pm 1 \text{ mm / s}$ (incl. sensor) or $\pm 0,2\% \pm 1 \text{ mm / s}$ (incl. sensor) if increased accuracy is required at some positions.

Flow meter sensor:

- Lining of material recommended for wastewater;
- Two-way flow measurement (forward, backward, sum);
- Flash memory for storing calibration and verification data and specific user settings;
- Suitable for direct burial and constant work under water;
- with conical design of the inner lining for Improved accuracy at low flows;
- Integrated electrodes for earthing and measuring made of Hastelloy C material, possibility of detecting unfilled pipeline;
- ambient temperature - 40 + 70 °C;
- fluid temperature 0 +70 °C;
- In accordance with PED-97 / 23EG.

Flow transmitter:

- Power supply: 115 ... 230 AC + 10 % - 15 %, 50 ... 60 Hz;
- Output signal, 0/4 ... 20 mA + HART, pulse output, status output;
- Max. measurement error: min $\pm 0,4 \%$ or $\pm 0,2 \%$ of the measuring range $\pm 1 \text{ mm/s}$;
- Possibility to replace the transmitter without losing sensor data and the ability to connect one transmitter to different sensors of the same type;
- Housing material: Glass fiber reinforced polyamide;
- Alphanumeric display with keyboard and backlight, 3 x 20 characters to indicate flow values, total values, settings and errors;
- Advanced self-diagnostics for signaling and recording errors;
- Possibility of on-site flow transmitter verification;
- Frequency 0 ... 10 kHz, 50 % duty cycle (unidirectional / bidirectional).
- Time constant 0.1... 30 s, adjustable;
- Degree of protection: IP 67.

The flow meter must be mounted to the pipes, at a location where no turbulent disturbances may cause false results. Mounting material, construction pipes, replacement pipes to install while the sensor is removed, telescopic pipes to ease the removal of the sensor, earthing system, reference electrode system and all electrical connections have to be provided. The measuring transmitter shall be mounted separately so that it can easily be checked and calibrated.

Electromagnetic flow meters shall be preferably used. Other kinds of flow measurement shall only be in-stalled, if electromagnetic flow meters are not applicable (e.g. in open channels, concrete pipes, etc.).

H.4.5.4 Ultrasonic Flow Meter “on pipe”

Ultra-sonic flow measuring equipment for "on-pipe" applications shall operate on the phase difference technique employing 2 No. ultra-sonic probes displaced longitudinally and mounted on opposite sides of the pipe to detect the difference between the upstream and downstream flight times. The equipment shall include acoustic transducers and a transmitter, and shall be installed complete with all necessary fittings, cables and connectors. The acoustic transducers shall be non-intrusive and arranged so that they may be removed without shutting down the process line. All items of equipment attached to the pipe and/or pipe insert shall be of noncorrosive material.

The transmitter shall process the signals from the acoustic transducers and shall:

- provide an output of 0/4-20 mA proportional to flow,
- be suitable for direct or wall mounting with up to 30 m of cable,
- incorporate contacts to initiate an alarm in the event of mal-function,
- include facilities for field checking and zero adjustment.

The complete system shall operate with a minimum accuracy of $\pm 1,5$ % of full scale deflection over the full ambient temperature range. A test certificate shall be provided for each set of equipment.

H.4.5.5 Ultrasonic Flow Meter - Venturi

Ultrasonic flow meters may be used as alternative to electromagnetic flow meters in pipes for flow measurement in open channels, where electromagnetic flow meter as specified above is not suitable. The measurement in open channels shall combine an ultrasonic water level measurement and a flume (Khafagi-venturi or similar).

The ultrasonic level meter should be in remote version with appropriate cable length between sensor and controller.

Controller characteristics:

- Possibility of measuring levels, volume, distance and integrated function for measuring the flow in the open channel with predefined standard profile shapes and the possibility of free configuration of the curve of the dependence of the flow value on the level;
- Level measurement accuracy: ± 1 mm in the range of 3 m;
- Housing material: Polycarbonate;
- Mounting accessories for pipe (vertical and horizontal), wall and DIN rail;
- Integrated local display with backlight and adjustment keys;
- Digital receiver for signal processing from level sensors;
- Advanced diagnostics and level signal processing capabilities:
 - possibility to adjust the echo profile of the level - locally (on the display) and using additional software;
 - suppression of false echo signals;

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- integrated data logger for viewing data on measured values, alarms, daily statistics (min / max / mean flow, daily totalizer, min / max temperature);
- alarm of upper and lower flow limits;
- advanced pump control algorithms;
- sensor submersion detection.
- One current output: 4 ... 20 mA + HART;
- Two digital inputs: 0 ... 50 V DC;
- Three relay outputs:
 - SPDT Form C, normally open or closed, 1 A at 250 VAC or 3 A at 30 VDC;
 - 2 SPST Form A, normally open, 5 A at 250 VAC or 3 A at 30 VDC;
- Ambient temperature -20 - +50 °C;
- Power supply: 100... 230 VAC;
- Degree of mechanical protection: IP 65.

Ultrasonic sensor characteristics for continuous level measurement:

- Integrated temperature sensor for compensation;
- Temperature: - 20 ° C to + 50 ° C;
- Radiation angle: up to 10°;
- Frequency: 44 kHz
- Degree of protection: IP 68;
- Connection to the processor: using a cable;
- Housing material: weather-resistant plastic.

The components of the Venturi channel have to be delivered and integrated into the concrete structure of the channel during the time of construction. The inlet stretch and outlet stretch have to be according to the manufacturers' specifications as to achieve the accuracy and repeatability certified for cost-accounting purposes. The installed meter shall be resistant against gases, humidity and weathering. The function of the meter should not be affected by these phenomena.

The sensor shall be mounted above the channels' middle to a cantilever that is fixed to poles on both sides of the channel. The distance to the water surface must be more than the sensors block distance. The measuring ultrasonic signal shall not be disturbed by any fittings inside the channel to achieve reliable measurements. The manufacturer shall calibrate the flow meter on site. The Contractor shall submit a certificate stating the accuracy at least at 10 different flow rates within the total range after installation of the flow meter.

All fittings must be easy to access and to remove for maintenance or repair. The scope of supply shall include all mounting material.

H.4.5.6 Hydrostatic Level Meter

Submersible probe for hydrostatic measurement of water levels in tanks and process vessels.

The probe shall have a diameter of not less than 25 mm with a ceramic diaphragm (Al_2O_3 ceramic, 99,6 %) and a stainless steel housing 1.4404 / 316L or 1.4539 / 904 L depending on the type of fluid.

For measuring ranges in accordance with the needs of the application, accuracy class 0,15 % and long-term stability up to 0,15 %.

Degree of protection of the probe is IP 68 according to IEC 60529. with appropriate cable, with integrated moisture filter and FPM seals for use in wastewater.

4 to 20 mA output signal, two-wire system, 10 to 33 VDC power supply.

Terminal box and terminals in accordance with the manufacturer's standard.

For process temperatures from - 10 to + 80 °C. and storage temperatures from - 20 to + 80 °C.

Local display:

- universal digital panel display for process instrumentation;
- easy adjustment and programming with front buttons or separately with software;
- universal input: current (0 / 4-20 mA), voltage, thermocouple and RTD;
- output: 4-20 mA current and 2 relays;
- accuracy 0,1 % full scale;
- power supply: 85 to 256 VAC or 12 to 36 VDC / 12 to 24 VAC with the possibility of powering the transmitter;
- degree of protection IP 65 (front);
- operating temperature from - 40 to + 65 °C.

Mounting and installation should be executed in accordance with the local requirements and conditions. Housing and mounting material shall be made of high grade steel (1.4301).

H.4.5.7 Ultrasonic Level Meter

Depending on the measuring position it is possible to use compact and remote ultrasonic level measurement. Sludge blanket level measurement in settlement tank is also described in particular. Below are the characteristics for all 3 types of devices:

H.4.5.7.1 Compact Design

Ultrasonic level meter with HART version 7. Two-wire device with current 4-20 mA output, powered from a power loop for level and volume or flow measurement applications for liquids or bulk materials.

Easy installation and commissioning with 4 buttons and 5-digit display with bargraph or software.

Measuring range from 0,2 to 12 meters, frequency 54 kHz, accuracy $\pm 0,15\%$ or 6 mm, resolution ≤ 3 mm, beam angle 10 degrees, operating temperatures from - 40 to + 85 °C. Integrated temperature compensation.

Power supply from 10,5 to 30 VDC, degree of protection IP 66 or IP 68, sensor material ETFE or PVDF copolymer, housing material PBT. EEPROM memory.

Possibility to adjust at least three measurement response speeds (from 0,1 meter per minute to 10 meters per minute).

Possibility to use automatic and dynamic removal of false echo due to known obstructions in buildings.

H.4.5.7.2 Remote Design

Ultrasonic level meter in remote version consists of transmitter and sensor connected by a sensor cable of appropriate length.

Transmitter characteristics

- Ability to measure levels, volume and distance;
- Level measurement accuracy: ± 1 mm + 0,2 % of measuring range;
- Housing material: Polycarbonate;
- Mounting accessories for pipe (vertical and horizontal), wall and DIN rail;
- Integrated local display with backlight and adjustment keys;
- Digital receiver for signal processing from level sensors;
- Advanced diagnostics and level signal processing capabilities:
 - Possibility to adjust the echo profile of the level - locally (on the display) and using additional software;
 - Suppression of false echo signals;
 - Integrated data logger for viewing data on measured values, alarms, daily statistics;
 - Alarm of upper and lower level limit values;
 - Advanced pump control algorithms (Energy saving algorithms, cyclic pump start,...);
 - sensor immersion detection.
- One current output: 4 ... 20 mA + HART;
- Two digital inputs: 0 ... 50 VDC;

- Three relay outputs:
 - SPDT Form C, normally open or closed, 1 A at 250 VAC or 3 A at 30 VDC;
 - 2 SPST Form A, normally open, 5 A at 250 VAC or 3 A at 30 VDC;
- Ambient temperature - 20 - + 50 °C;
- Power supply: 100... 230 VAC;
- Degree of mechanical protection: IP 65.

Ultrasonic level sensor characteristics:

- Integrated temperature sensor for compensation;
- Temperature: - 20 °C to + 50 °C;
- Radiation angle: up to 10°;
- Frequency: 44 kHz
- Degree of protection: IP 68;
- Connection to the processor: using a cable;
- Housing material: weather-resistant plastic.

H.4.5.7.3 Sludge Levels Measurement in Settlement Tanks

Measuring sludge blanket levels in settlement tanks is one of the applications of ultrasonic level meters that has its own specifics. The sensor is completely immersed in water so that the ultrasound wave travels completely through the water. Dedicated mounting accessories must be implemented

Probe for monitoring the level or depth (height from the tank floor or depth of the water surface) of a sludge blanket. The method of measuring the sludge level will be by ultrasonic pulse directed toward the sludge blanket in the tank. The measurement is without contact between the probe and the sludge. The probe defines the sludge blanket based on user-selected sludge concentration or "blanket threshold". It is equipped with an exchangeable magnetic coupled wiper that cleans the probe. A position sensor that also compensates for angle when the probe is not mounted exactly vertically is placed in the sensor. The probe automatically compensates for temperature. A visual performance LED indicator light indicates proper performance. The probe is factory calibrated. The probe automatically detects deterioration of disrupted sedimentation. It senses the ultrasonic echo return with the information of the separation layer independent of density.

The probe shall be connected to a digital controller.

The system shall include the capability to remotely monitor sensors on any browser-enabled device and present diagnostics on the overall health of the measurements (on predictive diagnostics-enabled sensors), as well as upcoming and required maintenance - reducing user risk and downtime.

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Sensor characteristics:

- Measuring principle Ultrasonic measurement;
- Measuring range 0.2 – 12 m sludge level;
- Resolution 0,03 m sludge level;
- Accuracy 0,1 m;
- Operating temperature range 0 – 50 °C;
- Pressure range $\leq 0,3$ bar or ≤ 3 m;
- Power requirements (Voltage) 12 V, 2,4 W, provided by Digital Controller;
- Response time 10 to 1800 s adjustable;
- Flow Max. 3 m/s (the presence of air bubbles affects the measurement);
- Mounting configurations Fixed pole mount, pivot mount or chain mount, depending on application;
- Calibration method One-off on commissioning, automatic;
- Material POM; wiper magnet encapsulating compound: epoxy resin; wiper rubber: silicone rubber.

Controller characteristics:

- Display Graphic dot matrix LCD with LED backlighting, transreflective;
- Display size 48 x 68 mm;
- Display resolution 240 x 160 pixels;
- Power requirements (Voltage) 100 – 240 VAC, 24 VDC;
- Power requirements (Hz) 50/60 Hz;
- Operating temperature range - 20 – 60 °C at 0 to 95 % RH non-condensing;
- Storage conditions - 20 – 70 °C;
- Analogue outputs Two (five with optional expansion module) to isolated current outputs, max 550 Ω , accuracy: $\pm 0,1$ % of FS (20 mA) at 25 °C, $\pm 0,5$ % of FS over - 20 °C to 60 °C range;
- Operational mode: measurement or calculated value;
- Analogue output functional mode ;
- Linear, logarithmic, bi-linear, PID;
- Security levels 2 password-protected levels;
- Mounting configurations wall, pole, or panel mounting;
- Enclosure waterproof rating IP 66 / NEMA 4X;
- Conduit openings 1/2" NPT conduit;

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- Relay operational mode: Primary or secondary measurement, calculated value (dual channel only) or timer;
- Relay functions Scheduler (timer), alarm, feeder control, event control, pulse width modulation, frequency control, and warning;
- Relays Four electromechanical SPDT (Form C) contacts, 1200 W, 5 A;
- Communication: HART or Profibus.

H.4.5.8 Radar Level Meter

Radar level measurement shall comply with following requirements:

- Measuring range: up to 15 m;
- Deviation: ± 2 mm;
- Process connection: thread G 1½ A or 1½ NPT;
- Process pressure: -1 ... 3 bar;
- Process temperature: - 40 ... + 80 °C;
- Ambient temperature: - 40 ... +80 °C;
- Operating voltage: 12 ... 30 VDC;
- Casing: stainless steel, PVDF;
- Degree of protection: IP 68;
- Two-wire electronics: 4 ... 20 mA + HART
- Integrated function Dynamic adjustment of the echo curve for false signal suppression during level changes.

H.4.5.9 Pressure Gauges / Manometers

Pressure in pipes, etc. shall be measured and indicated by pressure gauges suitable for the particular duty.

Pressure gauges / manometers shall be of the glycerine filled type and be sealed against the medium to be measured. Pressure gauges / manometers for fluids and gases shall be of the Bourdon type.

Pressure gauge and pressure receiving cell shall be separated, but interconnected by small-bore coiled pipe.

Pressure gauges / manometers shall be complete with pressure receiver, three-way-valve and tubing all made from suitable stainless steel material.

Mounting and installation should be executed in accordance with the local requirements and conditions.

H.4.5.10 Pressure Measurement

Depending on measuring position and process requirements, it is possible to use two versions of the pressure gauges - basic and advanced pressure gauges.

H.4.5.10.1 Basic Pressure Transmitter

Basic pressure transmitters (also known as cigar or pencil pressure gauges) do not have diagnostic capabilities or adjustment of measuring scale.

The sensor shall comply with following requirements:

- Medium temperature range: - 30 °C ... + 100 °C;
- Piezo-resistant measuring cell made of SSt 1.4016;
- Diaphragm material: SSt;
- Measurement accuracy: $\leq 0,25$ %;
- Permissible overpressure: 300 %;
- Output signal: 0/4...20 mA;
- High grade steel housing: SSt 1.4404;
- Degree of protection: IP 65.

If a local indication and additional functionality in the form of local alarm of limit values is required, then it is necessary to install an appropriate local indicator

H.4.5.10.2 Advanced Pressure Transmitter

Advanced pressure transmitters or "SMART" pressure transmitters have the possibility of advanced diagnostics, change of the measuring range scale, integrated display and buttons for local adjustment, integrated HART protocol and other advanced functionalities.

- Medium temperature range: - 30 °C ... + 100 °C;
- Piezo-resistant measuring cell;
- Diaphragm from SSt;
- Measurement accuracy: $\leq 0,065$ %;
- Scalability of measuring range: 100 : 1;
- Response time: 110 ms;
- Output signal: 4 ... 20 mA + HART 7;
- Housing material: wetted parts made of SSt or other suitable material for selected medium, non wetted parts made of aluminium or manufacturer standard
- Diagnostic functions in accordance with NAMUR recommendations NE107
- Degree of protection: IP 65 or IP 66.

Each unit shall be supplied complete with:

- lines of stainless steel sensors;
- a local indicator which shall have a separate 3-way-valve (if not incorporated within the transmitter);
- a test point with separate 3-way-valve;
- a 3-way-valve for the transmitter.

The sensor shall be mounted to a suitable flange fitting with shutoff valve and vent valve. Mounting and installation should be executed in accordance with the local requirements and conditions. The material of the mounting device shall be suitable to the material of the respective tank or pipe. All fittings must be easy to access and to remove for maintenance or repair. The scope of supply includes all mounting material.

H.4.5.11 Leakage Detection

Leakage detection shall be with intrinsically safe signal circuit for connecting to conductive sensors and shall comply with following requirements:

- Low-cost level limit switch for conductive liquids;
- Line monitoring up to the sensor;
- Configurable sensitivity range;
- Alarm relay can be switched as second level relay;
- Compact housing for simple series mounting on standard rails in cabinets;
- Easy wiring thanks to pluggable terminal blocks;
- Connection to various feed voltages;
- Two-point control and level limit detection.

H.4.5.12 Temperature Measurements

The temperature-measuring unit consists of a sensor and the transmitter. The sensor is mounted to the channel or the pipe with a suitable flanged fitting, whereby the sensor shall be installed within a protective pipe that allows the sensor to be taken out without interruption of the process.

Capillary remote thermometers shall be with a case diameter of preferably 100 mm and must be mounted on fixtures or instrument panels in such a way that they are protected from vibration, jarring and sprayed water. The capillary tube must be laid in a protected position.

Resistance thermometers (Pt-100) in accordance with IEC 751 may be used for measuring the temperature of motor windings, water, brine temperature and similar applications. All resistance thermometers shall be wired according to the four-conductor principle.

Thermometers shall generally be fitted in protective wells. They shall be provided with weatherproof terminal heads and shall be installed so as to totally prevent the ingress of foreign matter.

For all pipework a minimum immersion depth of 55 mm in the internal pipeline cross-section and a minimum distance of 15 mm from the opposite pipe wall must be provided. If the diameter of the pipeline does not allow the thermometer to be inserted perpendicular to the pipe axis while still maintaining the above mentioned distances, another solution must be found in co-operation with the Engineer.

Locally mounted temperature transmitters shall be used for remote indication and functions. Head mounted temperature transmitters may also be used.

The transmitter shall comply with following requirements:

- Output: 0/4...20 mA + HART;
- Field-mounted housing or transmitter in sensor head;
- Degree of protection: IP 65.

If a local indication and additional functionality in the form of local alarm of limit values is required, then it is necessary to install an appropriate local indicator

The service includes installation, all fittings and mounting material. All fittings must be easy to access and to remove for maintenance or repair.

H.4.5.13 pH-Meter

The pH-probe consists of a measuring electrode with membrane glass, a reference electrode and a temperature sensor Pt 100 for temperature compensation and temperature measurement, all combined in one sensor. The sensor body is made of high quality steel resistant to mechanical loads.

The sensor is mounted inside and protected by a high quality steel armature. An adequate measuring transmitter is required with automatic temperature compensation and self-monitoring. The sensor is mounted to the channel or the pipe with a suitable flanged fitting, whereby the sensor shall be installed within a protective pipe that allows the sensor to be taken out without interruption of the process.

The pH-probe shall comply with following requirements:

- Measuring range: pH 1...12;
- Temperature range: - 5 °C...+ 80 °C;
- Permissible pressure: 6 bar;
- Temperature compensation: - 10 °C...+ 55 °C;
- Digital communication with transmitter resistant to interference;
- Min 10 m cable with fast connector.

The armature shall comply with following requirements:

- Shaft length according to on site conditions;

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- Preamplifier and shielded coaxial connecting cable with watertight and reliable connectors for probe, amplifier and measuring transmitter;
- Submersible armature, self-cleaning, to be lowered into the medium from suitable high grade steel fitting.

The measuring transmitter shall comply with following requirements:

- Display: LCD, range pH 0...14, - 5 °C...+ 80 °C, status-indication, 4 digits;
- Output: 4 x 0/4...20 mA for pH value and temperature;
- Output signal: 1 status contact, potential-free;
- Field-mounted housing;
- Degree of protection: IP 65.

The scope of supply includes one complete spare sensor as well as materials and calibration solutions for two years of operation. All fittings must be easy to access and to remove for calibration, maintenance or repair. The scope of supply includes all mounting material is also included.

H.4.5.14 Oxygen Measuring Device (DO-Meter)

The scope of supply includes the oxygen measurement sensor and a transmitter with all accessories.

Dissolved oxygen measurement shall be carried out by use of oxygen sensitive molecules integrated in a fluorescence layer which is in contact with the medium in combination with an optical sensor.

The transmitter should be a continuously working microprocessor-based O₂-transmitter. An alternative value can be provided to the control system by an extra switch to avoid control errors, if the oxygen measurement is not working due to maintenance or repair.

The probe shall comply with following requirements:

- Automatic zero calibration;
- Self monitoring;
- Construction: Compact probe with cable and plug-in;
- Mechanical fitting: Screw-in thread R1";
- Flow rate: > 0,005 m/s;
- Measuring range: 0-20 mg O₂/l
- Max. permissible temperature: 50 °C;
- Temperature compensation: 0 – 50 °C by two thermistors;M
- Degree of protection: IP 68;

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- Accessories for 2 years of operation;
- Digital communication with transmitter resistant to interference;
- Min 10 m cable with fast connector.

The measuring transmitter shall comply with following requirements:

- Automatic calibration;
- Automatic air-pressure compensation;
- Self monitoring;
- Display: LCD, selectable scale, 4 digits;
- Input: Socket for plug-in from the probe;
- Output signals: 0/4...20 mA, 4 status contact, potential-free;
- Field-mounted housing;
- Degree of protection: IP 65;
- High grade steel protective roof.

The sensor shall be fixed to a submerged fitting made of high quality steel that can be lowered into the water from a high grade steel cantilever mounted to the edge of the tank. Before installation the best location shall be determined to achieve a reliable measurement.

All fittings must be easy to access and to remove for calibration, maintenance or repair. The scope of supply includes all mounting material.

H.4.5.15 Turbidity / Suspended Solids Measuring Device

Turbidity / suspended solid measurement shall be carried out by use of self-cleaning measuring probe suitable for measurement in basins or in pipes. The turbidity value is obtained by 90° and 135° scattered light measurement. The probe is connected to a measuring transmitter which is programmable for output in engineering units, i.e. g/l, mg/l, ppm, %, NTU.

The probe shall comply with following requirements:

- Automatic temperature and ambient light compensation;
- Drift compensation;
- Automatic cleaning by mechanical cleaning device (wiper), time interval programmable via transmitter;
- Material: stainless steel (1.4571);
- Admissible temperature: 0 °C.....50 °C;
- Measuring range programmable via the transmitter, adjusted according to the required purpose;
- Linear characteristic;
- Accuracy for turbidity:: $\leq \pm 2 \%$ or 0,1 FNU;

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- Accuracy for SS: $\leq \pm 5 \%$;
- Digital communication with transmitter resistant to interference;
- Min 10 m cable with fast connector.

The measuring transmitter shall comply with following requirements:

- Measuring range: suitable for the required purpose;
- Display: LCD, 4 digits;
- Output signals: 0/4...20 mA, 1 status contact, potential-free;
- 2 user selectable relay contacts;
- Power consumption: Max. 10 VA
- Plug connector to the probe;
- Keypad and alphanumeric LCD display for programming via menus;
- Field housing, degree of protection IP 65.

If used for measurement in basins, the sensor shall be fixed to a submerged fitting made of high quality steel that can be lowered into the medium from a high grade steel cantilever mounted to the edge of the channel. If used for measurement in pipes, the respective fittings have to be included in the offer.

All fittings must be easy to access and to remove for calibration, maintenance or repair. The scope of supply includes all mounting material.

H.4.5.16 Conductivity Measuring Device

Conductivity measurement shall be made by inductive conductivity measurement with integrated temperature sensor Pt100 for automatic temperature compensation.

The conductivity sensor shall comply with following requirements:

- Mechanical fitting: Screw-in thread R1";
- Max. permissible temperature: 90 °C;
- Max. permissible pressure: 16 bar;
- Measuring range: suitable for the required purpose;
- Electrical connection to the transmitter by cable with plug (IP 65);
- Digital communication with transmitter resistant to interference;
- Min 10 m cable with fast connector.

The measuring transmitter shall comply with following requirements:

- Front operation panel;
- LCD-Display;
- Accuracy: $\pm (5 \mu\text{S/cm} + 0,5\% \text{ of measured value})$;;

- Output signal: 0/4...20 mA, 1 status contact, potential-free;
- Field-mounted housing.

The sensor shall be fixed to a submerged armature of sufficient shaft length made of PVC that can be lowered into the water from a high grade steel cantilever mounted to the edge of the channel.

All fittings must be easy to access and to remove for calibration, maintenance or repair. The scope of supply includes all mounting material.

H.4.5.17 H₂S Measurement

The H₂S measurement system shall ensure a continuous measurement of the H₂S concentration in the atmosphere and the setting of acoustic and optical alarms for selected thresholds. It shall consist of following main components:

- Sensing head;
- Control module;
- Front display panel.

The H₂S measurement system shall provide following features:

- Suitable for field installation;
- Protection class II 1G EEx ia IIC T6;
- Useable in zone 0 area;
- Zero and sensitivity adjustment at the remote sensing head without opening the housing;
- Allow for one man calibration;
- Switch for alarm suppression during one-man calibration and service.

The H₂S measurement system shall comply with following requirements:

- Designed for various H₂S measuring ranges;
- Minimum two adjustable alarm threshold;
- Permissible ambient temperature: - 10 °C.....+ 55 °C;
- Digital display indicating measured value and threshold values ;
- SPDT contacts for each alarm threshold and failure alarm;
- Min lifetime of the sensor: 24 months;
- Output signal: 0/4...20 mA;
- Approved for use in potentially explosive atmosphere according to Directive 94/9/EC [ATEX 100a], EN 50014 and EN 50020. Class of protection: II 1G EEx ia IIC T6;
- Field-mounted housing;
- Degree of protection: IP 65.

The scope of supply and works includes the complete installation including all accessories, mounting of material and calibration with original test-gas by the manufacturer. A test kit for calibration by the plant personnel also has to be included.

Alarms have to be transmitted to the central control system.

H.4.5.18 Explosive Atmosphere Detector

Explosive atmosphere detectors shall be installed in each building with potential explosive atmospheres. They shall use the principle of infrared light absorption to determine the concentration of explosive gas in the air and set acoustic and optical alarm when the adjustable threshold concentration is reached.

The field sensor shall comply with following requirements:

- Infrared absorption measurement of explosive gases and vapour without moving parts;
- Output signal: 0/4...20 mA;
- Gas access by diffusion;
- Measuring range adjustable:
 - 5...100 % of the explosive limit;
 - 1000 .. 9999 ppm;
 - 1 ... 4,4 Vol %;
- Linearisation adjustable for methane, ethane, propane;
- on-site calibration via alphanumeric display;
- Explosion protection EEXem(ib) d IIB+H2 T4 ;
- Relative humidity: 0...95 %;
- Degree of Protection: IP 65.

The measuring transmitter shall be designed as plug-in card and provide the following functions:

- two adjustable alarm thresholds;
- indication of the actual measuring value;
- 3 potential-free contacts for 1st and 2nd alarm and calibration fault.

Calibration chambers and test-gas with approx. 40 % of the explosive limit methane have to be provides in a sufficient number for the calibration of all delivered units. The scope of supply and works includes non-corrosive mounting material, mounting, adjustment and calibration.

H.4.5.19 Gas-flow Meter

Air and gas flow measurement shall be carried out by vortex low head loss flow meter. The measuring sensor shall either be flanged or flanged between flanges. Flanges shall be PN10 in

accordance with EN 1092. Meter body and sensor shall be made of stainless steel suitable for the measured media, i.e. stainless steel grade 1.4571.

A permanent raised arrow shall be marked on the meter body indicating the flow direction.

The flow meter shall be provided complete with amplifier, converter, transmitter and the required connection cables and shall comply with following requirements:

- Output signal: 4...20 mA;
- Protection class: IP 65;
- Maximum pressure losses: < 20-50 mbar;
- Accuracy: minimum $\pm 1\%$;
- Air temperature range: - 50 °C + 100 °C;
- Ambient temperature: 0 °C + 50 °C.

Vibration, temperature and pressure compensation shall be suitable for a maximum air velocity not exceeding 50 m/s.

H.4.5.20 Sampling System for Inlet and Outlet

Automatic sampling systems shall be installed at the inlet and outlet of wastewater treatment plants to collect automatically water samples. Samples shall be taken at locations that guarantee the collection of representative samples. The sampling system shall be installed next to the respective channel on a concrete foundation. It shall be controlled by a microprocessor that allows time-, quantity- or event-controlled sampling sequences. For this purpose, the electrical signal from the respective flow measurement must be transmitted to the sampling system. The instrument is supplied with a vacuum diaphragm pump that sucks water into a dosing chamber. After the pump has been turned off, an adjustable amount of water is filled into a PE bottle by a distribution system that is switched either time based or on the number of samples per bottle. A built in refrigerator keeps the temperature of the samples at approx. + 4°C (adjustable).

The automatic sampler shall comply with following requirements:

- Lockable high grade steel housing, isolated;
- Weather and sun protection roof, made of high grade steel;
- High grade steel base construction;
- Impulse and analogue signal-input 0/4...20 mA for flow- and volume-proportional sampling;
- Sample collection system with 12 PE bottles, each with a volume of 2 l;
- Cooling of the collected samples, suitable for the local ambient temperature;
- Variable dosing volume 20...200 ml;
- Dosing chamber easily accessible and cleanable;
- Waterproof operating panel and LCD display;
- Output signal, 1 status contact, potential-free.

The scope of supply and works includes the mounting material, the intake and drain pipes and hoses of ample length with a sampling filter of PVC and stainless steel to protect the sampler from being blocked or getting dirty.

H.4.5.21 Online Phosphate Analyser

Analyser with predictive diagnostics for measuring ortho-phosphate in water. The method of measuring phosphate is by molybdovanadate yellow colorimetric method. The analyser performs a zero point calibration automatically without the use of standard solution. Accuracy is maintained by compensating for background colour of the sample at the beginning of every measurement cycle. A self-cleaning process is performed automatically. Capable of measuring as frequently as every 5 minutes. The analyser is equipped with self-diagnostic routines. Includes a humidity sensor to detect leakage and automatically initiate a safe shutdown. Uses a radial piston pump. The analyser requires a universal digital controller.

The analyser has built in predictive diagnostics capability which increases available operation time. The predictive diagnostics produces alerts for upcoming maintenance tasks by monitoring the instrument's internal components and tracking service requirements. When connected to a properly equipped controller the controller will display status indicators for each sensor with predictive diagnostics capability.

Includes the capability to remotely monitor sensors on any browser-enabled device and present diagnostics on the overall health of the measurements (on predictive diagnostics-enabled sensors), as well as upcoming and required maintenance - reducing user risk and downtime. It includes the capability to connect to a laboratory spectrophotometer to correct process measurements based on lab samples, without having to remove the process sensor from the water.

Technical Data:

- Measurement method Photometric method using vanadate-molybdate;
- Measuring range 0,05 – 15,0 mg/l PO₄-P;
- Detection limit 0,05 mg/l PO₄-P;
- Accuracy $\pm 2 \% \pm 0,05 \text{ mg/l}$;
- Reproducibility $2 \% + 0,05 \text{ mg/l}$;
- Reagent consumption 500 ml/month;
- pH range 5 – 9 pH;
- Pressure range -30 – 50 mbar with continuous sample preparation; at overflow vessel;
- Response time < 5 min;
- Measuring interval 5 – 120 min (fixed values selectable);
- Operating conditions Indoor model: 5 – 40 °C; 95 % relative humidity, non-condensing
- Outdoor model: - 20 – 45 °C; 95 % relative humidity, non-condensing;

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- Sample temperature 4 – 45 °C;
- Sample quality: Ultra filtrated or comparable;
- Flow 1 - 20 l/h Sample (free of suspended solids);
- Power requirements (Voltage): 115 or 230 VAC, power provided by the universal controller or a separate power box;
- Power requirements (Hz) 50 Hz.

Sample preparation / filtration system for PO₄-P analyser is mandatory.

Immersed stand-alone sample preparation instrument to continually extract samples directly from process water through ultra-filtration membranes (0,15 µm), with automatic cleaning, and always accessible tubing and 2 alarm relays in case of flow decrease, Multichannel options 1 / 2 channels.

Position includes all necessary mounting equipment and chemicals necessary for work.

H.4.5.22 Online Ammonium Analyser

Analyser with predictive diagnostics for monitoring of NH₄-N and NH₄ in water. The method of measuring is by gas selective electrode (GSE) that uses liquid to gas- phase conversion. The analyser calibrates and cleans itself automatically. Is capable of measuring as frequently as every 5 minutes and is equipped with self-diagnostic routines. Includes a humidity sensor to detect leakage and automatically initiate a safe shutdown. The analyser requires a universal digital controller.

The analyser has built in predictive diagnostics capability which increases available operation time. The predictive diagnostics produces alerts for upcoming maintenance tasks by monitoring the instrument's internal components and tracking service requirements. When connected to a properly equipped controller the controller will display status indicators for each sensor with predictive diagnostics capability.

Includes the capability to remotely monitor sensors on any browser-enabled device and present diagnostics on the overall health of the measurements (on predictive diagnostics-enabled sensors), as well as upcoming and required maintenance - reducing user risk and downtime.

Technical Data:

- Measurement method GSE (Gas Selective Electrode) with screw-on membrane cap;
- Measuring range 0,05 – 20,0 mg/l NH₄-N;
- Detection limit 0,05 mg/l NH₄-N;
- Accuracy Using standard solutions: 3 % + 0,05 mg/l;
- Reproducibility 2 % + 0,05 mg/l;
- Response time < 5 min;
- Measuring interval 5 – 120 min , adjustable per 5 min;
- pH range 5 - 9 pH;

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- Pressure range 30 – 50 mbar with continuous sample preparation; at overflow vessel;
- Operating conditions Indoor model: 5 – 40 °C; 95 % relative humidity, non-condensing;
- Outdoor model: - 20 – 45 °C; 95 % relative humidity, non-condensing;
- Sample temperature 4 – 45 °C;
- Sample temperature Sample quality: Ultra filtrated or comparable
- Flow 1 – 20 l/h sample (free of suspended solids);
- Power requirements (Voltage): 115 or 230 VAC, power provided by the universal controller or a separate power box
- Power requirements (Hz) 50 Hz.

Sample preparation/filtration system for NH₄-N analyser is mandatory.

Immersed stand-alone sample preparation instrument to continually extract samples directly from process water through ultra-filtration membranes (0,15 µm), with automatic cleaning, and always accessible tubing and 2 alarm relays in case of flow decrease, Multichannel options 1 / 2 channels

Position includes all necessary mounting equipment and chemicals necessary for work.

H.4.5.23 Online Nitrate Analyser

UV Nitrate Sensor. Process sensor for continuous measurement of nitrate in water. The method of measuring nitrate will be ultraviolet (UV) light absorption below 250 nm. The integrated cleaning system uses wiper technology. It allows the sensor to measure nitrate in media with Suspended Solids contents.

Technical Data:

- Measuring principle UV absorption measurement (unique 2-beam technique);
- Path Length 5 mm;
- Measuring range 1 - 20 mg/l NO₃-N / 5-100 mg/l NO₃;
- Detection limit 1 mg/l NO₃-N (with standard solutions);
- Accuracy ± 5 % of measured value + 0.5 mg/l (with standard solutions);
- Resolution 0,1 mg/l;
- Sludge Compensation No;
- Measuring interval 5 – 30 min (fixed values selectable);
- Response time 5 min;
- Available with Bypass Yes;
- Material Sensor enclosure: stainless steel 316, 1.4581, single sealed body Wiper axle: stainless steel 1.4571;

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- Cable gland: stainless steel 1.4305 Cable gland seal: PVDF;
- Profile carrier: stainless steel 1.4310 Wiper arm: stainless steel 1.4581
Wiper profile: Silicone;
- Measuring window: Suprasil (quartz glass);
- Functional verification Using standard solutions;
- Service interval 6 months or as experience dictates;
- Maintenance requirements 1 hour / month;
- Operating temperature range 2 – 40 °C;
- Pressure range ≤ 0,5 bar
- Cable length 10 m fixed cable at sensor

H.4.5.24 Analyser Transmitters

To create the optimal configuration and arrangement of analysers in the plant, the use of two types of transmitters is planned depending on the needs at the place of measurement and the specifics of the devices that are located there. The combination of these devices should make the optimal configuration.

Universal Multi-Parameter Controller

Modular single or dual channel controller that works with analog sensor modules and/or digital sensors to provide connectivity for over 17 water quality monitoring parameters. Digital sensors give plug-and-play connection capability. Controller should be available with either AC power (100-240 VAC, 50/60 Hz) or 24 VDC power. 4 powered relays with seven options for programming control. Enclosure is IP66/NEMA

4 x rated and can be mounted in a Class 1 Division 2 environment. Option of up to five (5) 0/4-20 mA outputs with programming ability of alarms and seven separate options for programming control. Can be configured with Profibus, or Hart digital communications. Controller is equipped with ability to provide on-screen error and warning messages.

Technical Data:

- Display Graphic dot matrix LCD with LED backlighting, transreflective;
- Display resolution 240 x 160 pixels;
- Power requirements (Voltage) 100 – 240 VAC, 24 VDC;
- Power requirements (Hz) 50/60 Hz
- Operating temperature range - 20 – 60 °C at 0 to 95 % RH non-condensing;
- Storage conditions - 20 – 70 °C

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- Analogue outputs Two (five with optional expansion module) to isolated current outputs, max 550 Ω , accuracy: $\pm 0,1$ % of FS (20 mA) at 25 °C, $\pm 0,5$ % of FS over - 20 °C to 60 °C range;
- Operational mode: Measurement or calculated value;
- Analogue output functional mode: Linear, logarithmic, bi-linear, PID;
- Security levels 2 password-protected levels;
- Mounting configurations Wall, pole, or panel mounting;
- Enclosure waterproof rating IP66 / NEMA 4X;
- Conduit openings 1/2" NPT conduit;
- Relay: Operational mode Primary or secondary measurement, calculated value (dual channel only) or timer;
- Relay functions Scheduler (timer), alarm, feeder control, event control, pulse width modulation, frequency control, and warning;
- Relays Four electromechanical SPDT (Form C) contacts, 1200 W, 5 A;
- Communication: digital HART or Profibus

Advanced Multi-Parameter Controller with predictive diagnostics capability

Multi-parameter Advanced controller capable of measuring up to 17 individual water quality parameters. Digital sensors give plug-and-play connection capability. Data output should be available via Profibus DP, GPRS/ GSM wireless communication, or Ethernet/LAN. Controller is 110-240 VAC, 50/60 Hz powered. 4 powered relays with seven options for programming control of the relays. Option of up to twelve (12) 0/4-20 mA outputs with programming ability of alarms and seven separate options for programming control of the outputs. Enclosure is IP65 rated. Utilises display and probe modules. One display module is capable of working with up to four probe modules on the same network. Each network is capable of managing up to 32 sensors. Controller has the option for built in predictive diagnostics capability that increases available operation time of the sensors. The predictive diagnostics produces alerts for upcoming maintenance tasks by monitoring the instrument's internal components and tracking service requirements. When equipped with this option the controller will display status indicators for each sensor with predictive diagnostics capability.

Technical Data:

- Operating temperature range: - 20 – 55 °C / 0 to 95 % relative humidity, non-condensing;
- Storage conditions: - 20 – 70 °C / 0 to 95 % relative humidity, non-condensing;
- Power requirements (Voltage): 100 – 240 VAC, 24 VDC;
- Power requirements (Hz): 50/60 Hz
- Display: ¼ inch VGA graphical backlit TFT colour glass/glass touchscreen, high resistance 320 x 240 pixels;

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- Alarm: Low alarm point, low alarm point deadband, high alarm point, high alarm point deadband, off delay, and on delay;
- Relays: Up to four SPDT, user-configurable contacts rated 100 to 230 V AC, 5 Amp resistive maximum per probe module. Additional relays are available with additional probe modules;
- Inputs: Up to 12 analogue 0-20 mA, maximum impedance 500 Ohms per probe module. Additional inputs are available with additional probe modules;
- Outputs: Up to 12 analogue 0/4-20 mA, maximum impedance 500 Ohms per probe module;
- Additional analogue outputs with additional probe modules. Optional digital communications via Modbus (RS485) and Profibus DP/V1;
- Analogue output functional mode PID, high/low phasing, setpoint, deadband, overfeed timer, off delay, on delay;
- Communication : Profibus DP/V1 (certified) ;
- GSM/GPRS Quad-band cellular module (FCC and IC approved, EU and US only) Ethernet service port, RJ45, 10 MB/s;
- Mounting configurations Surface, panel, and pipe (horizontal and vertical) with optional sun shield
- Enclosure waterproof rating: IP 65;
- Material: ABS (display module) and metal (probe module) enclosure with corrosion resistant finish.

H.5. PROCESS CONTROL SYSTEM

H.5.1 General

The process automation system shall be a Distributed Control System (DCS) with graphic engineering and documentation in accordance with IEC 61131-3 and additionally support industry language Continuous Function Charts (CFC). The system consists of Automation stations (PLCs for process control) and operator stations for process visualization. The system must support CiR (Configuration in Run) and support online changes. System shall provide high controller performance and capacity with hot swappable-, standard, remote-, intrinsically safe and SIL 2/3 safety inputs/outputs (I/O) where needed. System shall comply to IEC 61508 (up to SIL 3) functional safety for industry. The engineering system shall have a uniform database ensuring that data, which has been entered once by the user, shall be available to all tools throughout the system, thus ensuring that there is a single point of entry for the system database. The system must offer integrated fail-safe features in runtime and engineering. Programming must be based on library of standard, pretested, prebuilt control algorithms for process control with their associated HMI faceplates/symbols including: PID blocks, motor, valve, analogue, digital, alarm blocks. The system shall have blocks specially designed for water industry, including water templates. Integration of main process devices (process instrumentation, VFD, Soft starters, ...) must be supported by standardized libraries to improve control, uniform look and feel, diagnostic and device maintenance.

Plant architecture shall be approved and available as blueprint. The system shall have HMI hierarchy with process object view with automatic generation of faceplates including alarms and trends. The vendor system must contain a high-performance Human Machine Interface (HMI) product which is owned, developed, manufactured and tested by the vendor.

DCS system shall provide a client-server architecture, with redundant servers, 3 clients, engineering station, maintenance station, web server, 5 web clients., process history for long term archiving. Process signals shall be acquired via decentralized peripheries. Redundant CPUs (automation stations) shall be implemented for each technological cell, 3 pairs in total.

Visualization shall be KPI-based process visualization in plant overview pictures that enables a topology and task-oriented structure of the plant hierarchy. They assist the operator in identifying and responding to trends and patterns in the process, before an alarm is triggered. In addition to simple engineering in conjunction with the standard library of the process automation system, the software also offers group representations of different process tag types for the operator.

The system shall have Web server expandable with 5 web clients. Web server shall be located between front and back firewall. Web Clients shall not require a full installation of HMI software, but should be operational simply by loading Internet browser over the internet. The System shall allow mobile operation and monitoring with all commercially available mobile devices. No software installation on the end devices is required and the mobile devices have to support simply HTML 5 compatible browsers.

The complete user program shall be available on engineering station.

H.5.2 Automation Station Panels

H.5.2.1 General

Prior to ordering equipment and commencement of installation work all relevant drawings, calculations, documents etc. must be approved by the Engineer.

The power supply for PLC and process control equipment in the control room has to be realized by UPS system maintaining the load for a minimum of 2 hours.

All incoming and outgoing cables from the cabinets shall be connected at terminal blocks. All I/O-circuits shall be individually breakable by breakable terminal blocks or fuse terminal blocks. Measuring of signals must be possible from terminal blocks by using miniature banana plugs.

Differential potential durability of galvanic isolation shall be 1,5 kV. All electronic sources in the system shall be able to withstand short-circuiting.

Exi-barrier prevents Exi-circuits voltage to raise over 60 V even in fault situation. Exi-barriers are to be employed in instrumentation and data cabling where cables are going into explosion classified (Ex) area. Ex-circuit connectors and Exi-wiring shall be located separately to own cable conduit inside cabinet and marked by light blue colour.

H.5.2.2 PLC Interconnection

All PLCs of the plant shall be interconnected via a local PLC network. The PLC connection network shall be IP-Ethernet / Profinet based. Inside connections shall be realized using copper network cable whereas outside connections shall be realized using fibre optical cables only. The interconnection shall be realized as a ring system for redundant communication. The status of communication shall be monitored online within the SCADA system.

H.5.2.3 Panel Wiring

Panel wiring shall be carried out using cables installed in a neat, systematic manner, securely fixed and supported on insulated cleats or trunking, and arranged so as not to impede access to any internally mounted equipment.

Analogue signal cables and DC control cables at voltages not exceeding 48 volts (nominal), may be run together in the same cable bunch or trunking; but these cables shall be run separately from all other cables. In any cubicle, panel, or structure which is not fully enclosed (such as some mimic diagram structures), all cabling which is or may be at a voltage in excess of 55 volts (nominal) to earth, shall be run in conduit.

For all cables, the sizing shall be fully adequate for the possible maximum loading, and derating shall be applied as appropriate for cable bunching and ambient temperature.

Terminations shall be restricted to one wire per terminal. Cabling to door mounted equipment shall be protected in flexible cable conduit(s) and created to form a loom with a loop of adequate length to allow easy door opening without causing strain to the components or cable.

Sharp edges of cubicles, trunking, components etc., which may be in contact with cables, shall be protected to avoid damage to cable insulation.

H.5.2.4 Panel Earthing

A copper earthing bar shall be provided and bonded electrically to the main frame. It shall be provided with suitable brass screw terminals for the connection of the metal cladding, instrument frames, gland plates, cable tray, the armouring of all incoming cables and the site earthing system.

H.5.2.5 Indoor Panels

All instrumentation, monitoring and control panels, designed for use within buildings shall be constructed of prime quality, cold rolled and annealed mild steel or zinc coated sheet steel, of adequate thickness welded and braced to form a rigid structure. The minimum sheet steel thickness shall be 1,6 mm, with panel fronts and desktops being thicker (2,00 mm minimum) to provide the necessary strength to prevent buckling. Panel fronts shall be flat and free of bow and ripple. External corners and edges shall be rounded to give a smooth overall appearance. No design involving the use of externally visible assembly bolts or screws will be accepted. All floor-standing enclosures shall be constructed with a 60 mm deep plinth arranged to provide a recessed kicking strip at the front.

Equipment mounting panels shall be not less than 2 mm thick and shall be strengthened and/or braced to avoid any distortion or vibration. Equipment mounting plates and brackets shall if necessary be hinged to provide quick and easy access to equipment securing screws, terminals and wiring.

Doors and access panels shall be adequately braced or strengthened to avoid any buckling or twisting. Doors shall be of folded and welded construction mounted on lift-off hinges, with one hinge engaging before the other. Where necessary, removable access covers secured by quick release fasteners shall be provided. All doors and access panels shall close onto neoprene or soft rubber sealing strips which shall be held in place mechanically and not by adhesive. All doors shall be lockable. Where 'walk-in panels or structures are provided, these shall be fitted with lockable car type handles operable from inside even when locked.

The external colour shall be as approved by the Engineer. The design and construction shall be such as to provide an enclosure of superior quality, which shall match all other panels in the same location in style, appearance and finish, and have environmental protection to IP 54. In cubicles for

PLC (Programmable Logic Controllers) the temperature shall be between + 10 °C and + 30 °C. The relative humidity shall not exceed 85 %.

Each enclosure shall be fitted with one or more heaters to prevent condensation and assist ventilation. The heaters shall be so arranged and located that no deterioration can be caused to any equipment or wiring. The surface temperature of any part that may be accidentally contacted shall not exceed 65 °C. The heating circuit shall be supplied via a fuse, an isolator and an Off/Auto switch. In the 'Off' position the heater shall be isolated and in the 'Auto' position a thermostat or humidistat shall control the heater. All switches and controls shall be mounted within the enclosure.

If required a cubicle AC unit shall be provided. The Contractor shall provide a heat calculation for each cubicle.

H.5.2.6 Outdoor Panels

All instrumentation and control cubicles, kiosks etc. designed for outside use shall be manufactured having walls of double skinned, resin-bonded fibreglass, with a totally encapsulated infill of non-corroding alloy. Box sections shall be encapsulated into door edges and doorframes. Hinges shall be of high tensile, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel reinforced surfaces. The doorsill shall be protected by a non-corroding alloy material. Colour impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and 'colour fast' finishes. The finish colour, both internal and external shall be glossy white. Door-mounted meters and transparent windows shall be of glass, which shall be protected from harmful direct sunshine by orientation or other approved means.

All internal equipment shall be mounted on supports built into the fibreglass structure. Fixing bolts through the skin will not be accepted. Each cubicle shall be constructed to provide environmental protection to IP 55. Each outdoor panel shall be provided with sunshade.

Each enclosure shall be fitted with one or more heaters to prevent condensation and assist ventilation. The heaters shall be so arranged and located that no deterioration can be caused to any equipment or wiring. The surface temperature of any part that may be accidentally contacted shall not exceed 65 °C. The heating circuit shall be supplied via a fuse, an isolator and an Off/Auto switch. In the 'Off' position the heater shall be isolated and in the 'Auto' position a thermostat or humidistat shall control the heater. All switches and controls shall be mounted within the enclosure.

If required a cubicle AC unit shall be provided. The Contractor shall provide a heat calculation for each cubicle.

H.5.2.7 Protection

Overvoltage protection shall be provided for the PLC system.

The measured values shall be protected by surge protectors. The digital inputs / outputs controlled from outside shall also be protected against power surges using relays and opto-couplers. In addition, the power supply shall be protected against voltage surges.

H.5.2.8 Automation Station (Hardware)

All process signals should be acquired by remote I/O peripherals and then transferred to the appropriate main CPU via Profinet. All programming logic and signal processing shall be implemented in CPUs using predefined and pretested function blocks.

Automation stations shall be delivered and mounted completely as a functional package with mounting rack, power supply, CPUs, communication cards, protection devices, circuit breakers, monitoring devices, cables, wires, terminals, fitting materials, etc. including the wiring of the cabinets.

PLCs which come as part of the package units (Screens, CHP, etc) shall be seamlessly integrated in the control system.

Remote I/O peripherals shall have a 30 % spare capacity in the mounting racks for future I/O-modules extensions.

One system clock for time synchronization shall be available for the complete control system

All items shall be supplied as complete and functional units, including delivery, mounting, wiring and connecting. The service includes the technical project planning, preparation and submission of all documentation and their careful storage within the switch gear cabinet.

A clear and suitable arrangement of the panels shall be realized according to the process.

H.5.2.8.1 Central Processing Unit (CPU)

The central controller shall be a highly available and modular process automation system with a quantity structure up to max. 100 measuring points / drives (expandable to ≥ 2000). The CPU should be capable of processing standard and fail-safe signals (if needed). The capacity shall be expandable at any time. Controller shall consist of redundant central processor units (2 in total) with redundant power supply (2 in total) mounted on steel rack. Each Central unit must have integrated interfaces: 2x PROFINET or for TCP / IP, 1x PROFIBUS interface.

Graphical programming with continuous function chart, integrated retentive program memory min. 48 MB, min. 32 MB RAM for Programme and Data, complete remanence of the main memory, eg: via backup batteries, average processing time approx. 100 μ s per standard measuring point, precise time stamping, password protection, real-time clock, test and commissioning function via status / control of variables, independent storage of approx. 3000 system messages, separate SysLog memory for min. 3000 entries, up to 4 security information and event management servers (SIEM) can be connected to the SysLog memory, NTP time synchronization.

Degree of protection IP 20, ambient temperature 0 – 60 °C.

H.5.2.8.2 Digital Inputs (DI)

Power supply: 24 VDC.

Signals: 8 ch input module.

LED status display for channel-specific status information and module. Protection against short circuit on the sensor supply. Input delay parametrizable by channel; 0,05 ms to 20 ms. Diagnosis supported channel by channel: Missing load voltage, Short circuit, Wire break.

H.5.2.8.3 Digital Outputs (DO)

Power supply: 24 VDC.

Signals: 8 ch input module.

LED status display for channel-specific status information and module. Protection against short circuit. Diagnosis supported channel by channel: Missing load voltage, Short circuit, Wire break.

H.5.2.8.4 Analogue Inputs (AI)

Power supply: 24 VDC.

Signals: 4 ch (4..20 mA), HART.

Resolution: 16 bit

LED status display for channel-specific status information and module. Protection against short circuit on the sensor supply. Type/range of measurement parametrizable by channel. Diagnosis supported channel by channel: Missing load voltage, Short circuit, Wire break, overflow, underflow.

H.5.2.8.5 Analogue Outputs (AO)

Power supply: 24 VDC

Signals: 2 ch or 4 ch with HART where needed.

Resolution: 16 bit.

LED status display for channel-specific status information and module. Protection against short circuit on the sensor supply. Output type/range parametrizable by channel. Diagnosis supported by module: Missing load voltage, Short circuit, Wire break, overflow, underflow.

H.5.2.8.6 Communications Processor (CP-PB)

The Communications Processor shall have an electrical interface to connect the CPU and the power line to PROFIBUS up to 12 Mbit/s (45,45 Kbit/s inclusive)

The communication processor and CPU shall allow for programming and configuring via PROFIBUS, cross-network communication between programming devices through PLC routing and module replacement without requiring a programming device.

The communication processor and CPU shall offer following communication services for the PLC:

- PROFIBUS DP (master or slave);
- PLC communication (client, server);
- Open communication (SEND / RECEIVE);
- Extensive diagnostic options are available via PLC programme.

H.5.2.8.7 Communications Processor (CP-IE)

The connection of PLC controllers via communications processors shall permit the direct integration of the controllers into Industrial Ethernet. The communications processors shall have multi-protocol capability and support the following protocols:

- PLC communication;
- open communication (SEND / RECEIVE);
- PROFINET communication;
- IT communication;
- Even connects small applications to Industrial Ethernet.

H.5.2.8.8 Remote I/O

Remote I/O shall be used for acquiring all process signals in the plant. It shall communicate with the main CPU via Profinet. Remote I/O shall support hot-swap functionality. It must be possible to modify one I/O periphery without influencing the rest of the system which can stay undisturbedly in run.

I/O cards shall support extensive channel-specific diagnostics, for example short circuit, wire break, supply voltage, channel fault LED. Diagnostics shall be visualized and available in central control system.

- The remote I/O unit shall comprise Interface module (IM);
- BUS adapter;
- I/O units as specified above.

H.5.2.8.9 Interface Module

Interface module can be installed in safe and also in ex areas zone 2. It shall support media redundancy processing MRP. LED for indicating diagnoses on secondary module errors. It must be possible for Remote periphery to be in RUN with gaps

Module can be exchangeable under power (multiple modules). The remote I/O shall support expansion of up to 64 IO-modules. Interface module shall support failsafe modules, alone, or in combination with non-failsafe modules

H.5.2.9 Human Machine Interface (HMI)

Each cabinet with the main controller shall be equipped with a HMI device (panel PC). HMI devices shall have the same look and feel in terms of visualization and possibility of the same functionalities as the operators on the operator station. It shall be possible to restrict some of the functionalities according to the access rights managed centrally.

HMI device shall additionally ensure:

- 22" touch panel;
- restriction to the programme code;
- monitoring and parameterising functionalities according to access rights.

H.5.2.10 PLC Software

PLC programming shall be in accordance with programming languages as per IEC 61131-3 and industry language Continuous Function Charts (CFC). For programming of process objects (I/O signals, motors, valves...) standardized and pretested function blocks shall be used with the standardized visualization. Blocks shall be used, tested and adjusted to water industry. All blocks shall execute in the main CPUs. Visualization pictures shall be generated automatically with the PLC software compilation and shall be uniform.

The scope of works includes the preparation and implementation of the software according to the required amount of data. A memory spare of at least 30 % shall be provided for further software extension. The software and the respective hardware shall be state of the art at time of delivery, of the most advanced technology and optimally tuned to each other.

The correct function of the programmes shall be tested and optimized in all parts of the process while the machinery is working.

The price includes the complete software package, technical clarifications, project planning, programming, testing and generation of the complete documentation, start-up, test run and optimization.

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The software shall be delivered on an electronic memory medium (i.e. DVD, memory stick etc.) including implementation and test run on the PLC. The software code shall include all comments. It shall be protected by password protection to prohibit any future changes by third parties.

The software shall include but not be limited to the following features:

- system analysis;
- production detailed instruction lists, functional diagrams, etc. in accordance with the approved system specifications;
- programming of the automation system;
- testing and start-up process of the system including simultaneous operation and integration test;
- all assembly, service and maintenance instructions as well as a hard copy printout of the programme including electronic memory medium.

The programme processing shall be alarm-controlled. Limit values shall be formed (produced, generated) by means of analogue value quantity processing of the corresponding metering data for the switching points of pumps, error messages, etc..

The software must comply with the requirements for the linkage of the SCADA.

Prior to starting with the programming, a duty-specification for the overall system shall be submitted to the Engineer's approval. It shall contain following items:

- functional description of the programme, commenting the programme runs and steps in plain language;
- activation/de-activation of the programme;
- prerequisites for destination-compatible operation (pre-selector switch, release information from other system components);
- generation of "On / Alarm / Failure Messages";
- alternative strategies in case of failure of the required metering values;
- pre-processing for the data traffic.

The proposed features shall be discussed in all details with the Employer and the Engineer. Results of the discussions shall be included into the duty specification.

Later on, the user shall be able to refer to the revised duty specification as a user manual containing information with respect to possible reasons for failure.

The PLC programme shall be well documented with synonyms used for internal and external signals and bits, and with comments for each rung or network. The synonyms shall correspond with the tag number system of the plant. The complete source code of each PLC under this contract shall be handed over to the client as a softcopy including all required passwords.

As basis for programming, the Contractor shall develop a detailed program description concerning the function of the programmes and the programming structure. The Engineer shall approve this description before the programming work is started.

H.5.2.10.1 Programme Functions

The PLC(s) shall be programmed to prevent start-up of more than one motor at a time as well during start-up of PLC as during normal cyclic operation. The time delay from start of one motor to start of the next motor shall be about 5 sec.

H.5.2.10.2 Alternating and automatic Take Over

Sub programmes for process functions including parallel identical components shall ensure alternating of components once a day and automatic take over in case of faults on one component. E.g. a pumping station with three identical pumps P1, P2 and P3 should operate so that one day P1 is primary pump, P2 is secondary and P3 is the tertiary pump and the next day P2 will be the primary pump, P3 the secondary pump etc. If a fault occurs at P1 or P1 is switched to manual operation, the PLC program shall ignore P1 and substitute it with the P2 etc.

H.5.2.10.3 Automatic Control

Where automatic control is based on analogue values, PID control algorithms shall be used in the PLC. All PID control parameters shall be adjustable from the SCADA. PID controllers should for example control levels in tanks.

H.5.3 Remote Communication

For communication with external parts of the system (e.g. reservoirs, pumping stations, valve chamber, etc,) a state of the art remote communication shall be available. The plant PLC and remote communication system shall be delivered, installed and commissioned by one vendor.

The PLC for remote stations shall include but not be limited to the following requirements:

- Microprocessor based controller to execute program instructions, store data and control data transfer;
- CPU for local operation of the process;
- I/O subsystem for connection of instruments and signals;
- Power supply;
- Redundant communication interface (LTE / GPRS / DSL / static cable connection) and local data buffer up to 4 days;
- Modular expandability of the system;
- UPS system 2 h.

The remote communication shall be based on IEC 60870-5-104 protocol (Ethernet). All data transmission systems have to be secured by use of firewalls and VPN connections. Full access to the remote station by SCADA shall be available.

H.5.4 Service Notebook

An industrial laptop shall be delivered for service technicians. It shall have eighth-generation Intel® Core™ i processor (Coffee Lake) and high-speed RAM (DDR4 RAM). It shall have robust enclosure made of light-weight stable injection-molded magnesium with rubber-protected corners and retractable carry-handle. It shall be used for commissioning, service or maintenance of automation systems, with all commonly used interfaces for industrial applications. It shall be used for service tasks. It can also be connected as client to the central maintenance server station for process instrumentation setting via WLAN. This way service engineer is locally present, but all the changes and settings are executed from central maintenance server and all the changes shall be stored centrally – separate Tablet device can also be used for this functionality.

H.5.5 Process Control System Visualisation

H.5.5.1 Computer System (Engineering Station and Operator station)

The Operator Interface consoles use standard PC technology with state-of-the-art hardware based on a Microsoft Windows operating system, and industrial Ethernet communications. PC components are suitably industrialised suitable for control room and process area installation. In The multi-monitor workstation shall allow user configurable layouts. It shall be possible to dedicate monitor to the operator interface. Additionally, it shall be possible to use the other monitor to view other applications without interfering with the viewing of operator process graphics and displays. The operator system and Process control software shall come preinstalled on the workstations.

Primary engineering workstation shall come in 19" format. They are UL-certified and have the CE mark for use in residential, business and commercial environments. They enable high packing density in the control cabinet and save a significant amount of space in the control room due to their low overall height. They have a painted all-metal enclosure which is particularly protected against dust by a filter and pressurized ventilation. This mechanically and electromechanically rugged enclosure has a service-friendly design. They can be installed or positioned horizontally or vertically. This Industrial Workstations are suitable for reliable 24-hour continuous operation. It shall withstand shocks up to 5 g and vibrations up to 0,5 g can be tolerated during operation. It shall provide dust protection through fan-controlled overpressure ventilation across a filter. Replacement of front fan and dust filter without a tool. Card retainers for securing modules, especially for protection against vibration and shock

The Contractor shall deliver, install, connect, programme, test and commission a complete state-of-the-art, at time of delivery, process-control computer system with redundant Server system. This system shall comprise all hardware and software components to fulfil at least all the following requirements:

- It shall receive data from and send data to PLC control systems via an interface unit;
- the software of the process computer system shall consist mainly of the following blocks:
 - complete computer operating software system;
 - complete process interfacing and process control software system;
 - complete data processing and recording software system;
 - complete software system for system generation, maintenance, and data back-up;
 - complete software to run the computer network;
 - complete interfacing software to run standard data processing PC software like word-processing, database, spreadsheet, presentation, etc.

The process viewing computer shall be suitable for use in the control room, shall be equipped with keyboard, mouse, high resolution colour LCD screen and printer and shall have at least following features:

- adequate Hard disk capacity for data recording for approx. 2 years;
- English keyboard;
- track ball or optical mouse with 3 keys;
- operating system;
- DVD-RW system;
- interface for connection to the PLC system, incl. driver software.

The Graphical Plant Display Images (GPI) shall be displayed on a high resolution 27" colour LCD screen with a refresh frequency of at least 100 Hz and at least HD resolution. It shall provide a low radiation, non-reflecting screen surface. The supply shall include the controller card installed in the computer and the connecting cable.

Hard copies and reports shall be printed with a colour printer on paper DIN A3 size. It shall provide a printing speed of approx. 45 pages/minute.

An Uninterrupted Power Supply (UPS) for the Process Control System and for the PLC shall be included in the scope of supply. The duration of power supply after general power failure shall be 120 minutes. The nominal power output of the UPS shall be calculated by the Contractor, the minimum capacity shall be 3 kVA. The system must be equipped with an emergency change-over switching unit (bypass) and a closed battery service life for 10 years without maintenance.

H.5.5.2 Process Control System Visualisation Switchboard

All components of the visualisation system (Server, UPS, Switches, etc) shall be installed in 19" panels. The panels shall be installed within a server room including HVAC system.

H.5.5.3 Video Wall

For better process monitoring, it is requested to provide following visualisation devices:

1. Video wall consisting of 4 monitors with a diagonal of 65 inches placed in a single unit in the control room, for improved process visualization and control. Monitors / TVs must be recommended for a video wall, with a narrow frame and for 24-7 operation. To control the video wall, a suitable video controller that will control the settings and display must be installed.
2. 86 inch interactive touch screen located in the meeting / conference room. This touch screen must have the ability to display data for process visualization (read only), as well to be used for other purposes – meetings, presentations, visiting clients and all other activities that should not interfere with operators in control room.

H.5.5.4 Industrial Communication

The communication for the plant shall be based on state of the art TCP/IP based communication via copper network and fibre optical cables (FOC). The speed shall be 1 GBit/s.

All network components shall be fully integrated and central manageable by the SCADA software system. All active network devices shall be of the same manufacturer. The following functions shall be available:

- Central management tool;
- Administration of network (LAN, VLAN, WLAN);
- Maintenance tool;
- Reporting function (traffic, etc);
- Diagnostic function.

The communication system shall be high available and of the redundant type. The system shall be divided into system bus, terminal bus and fieldbus.

The Contractor shall provide and submit to the Engineer a detailed analysis of the network traffic prior to installation works. After installation and commissioning of the system, the Contractor has to provide a system network analyses report based on measured values.

Switches and Wi-Fi access points used in the network must be designed for industrial environment, with built-in digital inputs for network faults alarming, signalling contacts to alert users of port or power supply failure, redundant power supplies, high speed networking fail-over times of 200 ms or less, extended temperature range - 40 °C to 70 °C. Switches must be tested and released for DCS system.

Wi-Fi network will be used to set up local wireless network for client (PCs, tablets) access to the operator network. Clients would have necessary software for making maintenance changes which would be stored centrally. Firewall security must be implemented to avoid unauthorized access.

Network management system shall enable central monitoring and management of industrial networks and topological representation. It shall be possible to fully visualize and monitor networks using SNMP, SSH and HTTPS, PROFINET for diagnostics. It shall support policy-based approach,

meaning configuration can take place independently of the type of devices in the network, and regular backups of the device configurations can be made. It shall support central function for a firmware update / upgrade in the network infrastructure, central user administration and documentation inventory. The network diagnosis shall also be seamlessly integrated into higher-level DCS system. NMS also enables configuration of the network infrastructure and topological representation. It shall support presentation of statistics of any period, validation of network parameters.

H.5.5.4.1 Firewall

Firewall Functionality:

- Firewall appliance must support configuration of three security zones: external, private and optional (DMZ). Firewall appliance system must support static and dynamic IP addresses (DHCP and PPPoE) on the external interface;
- Firewall appliance has DHCP relay settings that allow the addition of up to three DHCP servers with the ability to perform concurrent communication to up to 3 DHCP servers;
- Firewall appliance can enable DHCPv6 on an external interface;
- Firewall appliance throughput (UDP 1518) must support 49.6 Gbps firewall throughput and 5.2 Gbps UTM throughput (combined GAV and IPS) in full scan;
- Firewall appliance must be a UTM, incorporating URL filtering, IPS, GAV and Application Control;
- Firewall appliance must be a next-generation firewall, incorporating URL filtering, IPS, next-generation antivirus, application control;
- Firewall appliance must support implementation of security policies in application layer (Layer 7), also known as application proxies.

Networking Capabilities:

- Firewall appliance provides the following number of interfaces: Minimum 8*10/100/1000 BaseT interfaces and additionally one 10/100 BaseT; these interfaces should be configured as any of the three types of required security zones;
- Firewall appliance must have a possibility to expand number of interfaces to: Minimum 24*10/100/1000 BaseT interfaces, 16*1000 BaseSX interfaces, 8*10Gb interfaces and 40*10 Gb interfaces;
- Firewall appliance supports multi-wan configurations, at least four external connections to the Internet;
- Firewall appliance interfaces must be able to operate in fail-over mode;
- Firewall appliance supports ability to fail-over to a modem;
- Firewall appliance supports ability to configure modem as an interface for use in WAN failover;
- Firewall appliance supports external interfaces that can operate in round-robin mode and round-robin mode with configurable weights;

- Firewall appliance supports external interfaces and must also function as an "overflow" allowing the use of external links when the capacity of the principal has been exceeded.

H.5.6 Visualization

Operation stations shall consist of:

- Operator stations – visualization of the process, for monitoring and control functions;
- Engineering station - for engineering of automation System (AS) and operator station (OS). The changes can be made online while plant is in the operation. The station shall also have maintenance functionalities in terms of monitoring and diagnostics of smart devices like process instrumentation and peripherals. Diagnostics shall be visualized and available on operator stations and mobile clients (tablets);
- Maintenance station:
 - Network management system – for diagnostics and management of network and industrial network devices. The network diagnostics can be seamlessly integrated into DCS system
 - Energy management system - software for acquiring, processing, archiving and reporting data of energy consumption. System shall have open interfaces for integration into DCS
 - Advanced Long-term archiving, analysis and reporting tool – software for acquisition, display, analysis and documentation of operating data, must be seamlessly integrated into DCS
- Web server expandable with web clients for remote access of client via tablets or PCs with the same look and feel as the operators on the Operating stations and with maintenance functionalities. Remote clients shall be able to access the system via local Wi-Fi network or via Web.

The workstation shall be supplied with a full library of process-oriented objects for the development of process graphics including but not limited to pipes, motors, valves, pumps, tanks, fans, indicators, sensors, and electrical symbols. These objects shall be provided in various formats (static, capable of being dynamically linked to the control strategy, 2-D, and 3-D).

Pre-engineered graphics symbols shall be provided for all process control elements in the standard control library (PID Controller, Valves, Motors, etc.). These pre-engineered symbols shall be designed to call up their associated faceplate and to represent the dynamic behaviors of the underlying control element, without requiring any additional configuration effort. Faceplates shall be generated automatically by the system for each function block / chart provided in the process control library (PID Controller, Motor etc.). Faceplates shall be linked to a corresponding HMI symbol such as a motor or valve. The symbol shall be programmed automatically by the system to call-up the appropriate faceplate without requiring any manual engineering steps. Integration of main process devices (process instrumentation, VFD, Soft starters, ...) must be supported by standardized libraries to improve control, uniform look and feel, diagnostic and device maintenance.

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System shall be capable of automatically generating HMI representations of SFCs (aka SFC Visualization) directly from the control strategy, without additional engineering. These screens shall allow operators to monitor the status and interact with an SFC directly from an operator console.

The software consists of the operating software and the application software including all the engineering and programming. All services of the Contractor must be performed in coordination with the Employer and the Engineer.

In addition to the above indicated general requirements, the scope of supply shall include following features and services:

- compilation and submission of a detailed list of all requirements for and the complete functions of the computer system;
- all manuals in English language;
- all data processing and data presentation in English language;
- fully graphical man-machine interface;
- operation via menus;
- password system for special functions;
- clearly defined and completely documented interfacing of all software modules;
- hardware independent software on the basis of standardized operating systems (MS-Windows) with multi-user and multi-task function. This software has to be state of the art at time of delivery;
- possibility to add and connect third-party software by the Employer at any time without compromising the other functions of the software;
- all data to be stored for 6 months in a data base (Open Data Base Connection ODBC/SQL);
- the software system shall be conceived as an open system that may be extended without modifications of the existing software modules;
- data exchange with the PLC-system;
- display of all process data as dynamic graphic plant images, trend curves, etc.;
- extensive and expressive processing of alarm and warning signals with precise and comprehensive messages and suggestions for required actions;
- maintenance, additions or modifications of the software and the recorded process data also via menu-operated software without interruption of the process control or other software tasks;
- operating hour counters for all motors, giving a warning if maintenance intervals are exceeded;
- all process data shall be pre-processed, stored, and recorded in such a way that standard third-party software can be directly applied for further data-processing like: word processing, data-base applications, spreadsheet applications, graphical applications;
- reports have to be generated, displayed at the monitor screens and printed automatically. The data to be printed shall be software selectable;

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- selection of analogue data to be sent to external dotted line recorders for continuous recording;
- hardcopy of all monitor displays on the colour printer;
- maintenance software to create, modify, delete and install all data to control the flow of process data and their handling and presentation including creation, etc. of the dynamic graphic plant images;
- processing of analogue values and counter values;
- processing of set points and information;
- processing of commands;
- arithmetic values and logic expressions;
- counter for operating hours and operating cycles;
- manual input of laboratory data;
- process graphics;
- trends;
- reports;
- event log and alarm list;
- archiving and data storage;
- OPC Client;
- Web access for 5 Clients;
- Maintenance System.

The operation of the complete software system shall be easy to learn and to handle by the personnel. All functions shall be menu-selectable, error-safe and self-explanatory.

An automatic backup function shall be installed on the system. Full back up und incremental back up function shall be available. After final completion a full back up has to be provided.

H.5.6.1 Process Data Points

The system licenses shall provide a spare capacity of 20 % in data points for future extension.

Before programming the computer system, the Contractor shall submit complete lists of all process data points that contain all information about the origin of the data, their processing, presentation and their unique identification number.

H.5.6.2 Reports and Long Term Data Storage

This software tool shall be designed for the plant-wide, cross-plant and long-term archiving of operating data as well as its analysis, interpretation and indelible logging. It shall provide the plant operator with excellent support for plant optimization and energy monitoring (according to ISO 50001) and for the fulfilment of reporting obligations.

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The following modules shall be included:

- More than 250.000 data points, time-based or change-dependent recording, arithmetic operations, high performance with resolution in the millisecond range, high data security due to TLC (Three Level Cache);
- Data acquisition from any sources and very high data security (even with interrupted connections) and optional time stamp transfer; data transfer from various measuring instruments;
- Interface for printing of reports and logs with input facility for manual laboratory values;
- Presentation and analysis of measured values and statistical values in trends;
- Generation of all required fault and message reports as well as comprehensive statistics;
- Administration module for automatic printing of reports including sending by email.

The following reports shall be produced, shown, previewed at the monitors and printed:

- Daily Report;
- Monthly Report;
- Annual Report;
- Report of all Faults / Alarm report;
- Report of all Status Signals;
- Report of the Maintenance Status of all Units
- Report of Energy demand (according to ISO 50001)

The report generating software shall provide all tools to set up reports that are clearly arranged, expressive and explicit. The report function shall provide predefined reports modifiable by the Employer's staff.

If reports are indicated as trend curves, the time interval shall be adjustable from 1 h to 100 days and each part of the curve can be zoomed up to highest scale. For each curve at least 4 measuring signals (e.g. level, flow, current), 3 fixed values (e.g. limit-levels) and explanation texts shall be stored.

The system shall support user defined sets of trends so that commonly viewed historical information can be defined in trends once and easily accessed by selecting a pre-configured screen target incorporated in the graphic display. There should be no practical limit to the number of trends that can be defined.

Each trend screen shall support up to 8 separate pens. Selection of points to be trended shall be menu driven.

Historical trends shall support seamless integration of both real-time and historical data within a single trend window, with seamless movement between the two. In the event that the screen is scrolled to the left, then historical values will be recalled from historical data files. Scrolling the trend far enough to the right will result in current real-time data being displayed as it is collected.

Zoom in/out and moving forwards and backwards in time shall be possible with no more than two operator actions. A mechanism for selecting a location on the trend, such as a hairline cursor and reading the numeric values of the trends at that point in time shall be provided.

It shall be possible to call up new historic trends and configure them online from the Operator Interface. Pre-configured real-time trends shall be available from a faceplate.

H.5.6.3 Graphical Plant Display Images (GPI)

All process data shall be presented symbolically in the form of high resolution graphical images at the monitors. All components of the plant shall be shown in such a way that they can be easily recognized even by inexperienced plant personnel. All displayed data shall be dynamically updated at least once every second, so that the data on a visible GPI are virtually up-to-date at any moment. The time from the selection of a specific GPI until it is fully displayed and updated, should be maximum 1 second. By usage of keyboard or mouse the personnel can choose a particular GPI, scroll and zoom on a specific point of interest. After a specific object is selected by a mouse click, more data about this object are shown and a menu with further commands is displayed. By using this method the motors can be operated, set points can be adjusted, information about the handling of the process data can be programmed and inspected, memos can be inserted by the operating personnel (e.g. to inform other staff members, to remind about faults, experiences etc.). These memos shall appear whenever the specific subject is selected.

Digital process data shall be presented in the following ways:

- as symbols or texts with changing colours;
- as alphanumeric text to appear or change;
- as changes of the display of analogue data (e.g. alarms).

Analogue process data shall be presented in the following ways:

- as numbers with designation of the physical units or %;
- as thermometer-like bars (vertical or horizontal);
- as instruments with moving pointers;
- as freely defined areas (such as filling tanks);
- as changing colours of areas (e.g. exceeding limits);
- as trend curves over the time axis;
- as curves of an analogue value over another value (xy-trend).

For each analogue signal at least two limit values and one hysteresis value can be adjusted.

Alarm and warning signals with precise and comprehensive messages and suggestions for required actions shall be indicated within the actual GPI. For each possible alarm or warning the priority and the need of acknowledgement can be selected.

The GPI shall be programmed and implemented as follows:

1. The Contractor shall make himself familiar with the exact functions of the plant;
2. The GPI shall be designed by the Contractor after a discussion with the Employer about the general concept of the GPI. Afterwards the Contractor shall present a first proposal of the GPI as a coloured paper print. This proposal shall be discussed with the Employer corrected and a first revision shall be submitted. This process may be repeated until the third revision of the GPI is accepted;
3. Then the GPI is installed into the process computer as a first proposal of the final GPI;
4. Afterwards 2 revisions may be necessary until the GPI is preliminary accepted by the Employer. After 3 months of continuous operation of the computer by the STP personnel, the GPI shall be submitted for final acceptance. If not accepted, the GPI shall undergo another 2 revisions for correction if the Employer desires further changes;
5. The GPI shall be finally handed over as coloured paper prints, as implemented GPI within the computer and on 2 separate storage devices for storage.

H.5.6.3.1 P&I Process Picture

An overview picture based on the general block diagram shall be provided as overview of the plant an initial picture of the SCADA system.

Based on the P&I diagrams of the process design, the SCADA shall provide an adequate number of pictures.

The navigation between the pictures shall be based on a overview / content picture.

H.5.6.3.2 Power Supply Picture

Based on the single line diagramme of the plant a picture of the electrical supply shall be included within SCADA providing the following details:

- Status of Breakers;
- Measuring signals (Voltage, Current, Power);
- Status of supply (public supply, gen sets, CHP, etc.);
- Fault conditions of switchboards.

H.5.6.3.3 PLC Picture

Based on the automation scheme of the plant, a picture of the PLC system shall be included providing the following information:

- Status for each PLC of the plant;
- Communication errors;
- Fault conditions of PLC panels.

H.5.6.3.4 Single Picture for all Electrical Motors

The Single pictures for all electrical motors (pumps, valves etc.) shall include following information:

- Name: e.g. Inlet Pumping 1
- Tag ID: ID Number
- Button: Manual mode - 0 - Auto
- Indicator lamp:
 - Green: Motor ready and running
 - Red: Motor default
 - Yellow: Summary failure indication
- Button: Hours of operation
- Button: Power input / current consumption

H.5.6.3.5 Single Picture for Measurement

The Single pictures for all measurement (flow meter, level meter, physical-chemical parameter, etc.) shall include following information:

- Name: e.g. Level Inlet tank
- Tag ID: ID-number
- Button: measured value [m]
- Button: limit value MIN MIN [m]
- Button: limit value MIN [m]
- Button: limit value MAX [m]
- Button: limit value MAX MAX [m]
- Button: limit value for start pump (adjustable)
- Button: limit value for stop pump (adjustable)

H.5.6.3.6 Curves

The SCADA System shall provide for the possibility to visualise at least 5 curves each in individual colours in the same picture. It should be possible to generate stable curve images, which among other things should be obtainable for viewing through the menu, function keys or by indicating the curve name or number. Moreover it should be possible for operators to generate additional curve images.

On the curves should be indicated scaling, units, y-axes and tag number and description in the same colour as the curve. It should be possible to get values for a curve from the historical database of the system or historical data stored in archive files. Both historical and dynamical curve images should be shown. In dynamic curve images, new collected / stored data should be added.

Curve images shall be shown on the basis of a combination of historical and dynamic data. Zoom functions in x- and y-axis direction shall be available. Zoom in and out on x-axis in resolution from 100 % to 2 % of the period. Zoom in and out on y-axis in some pictures shall be possible within the spot's scale area. Scaling shall be freely selectable (independent of process signal scaling).

It shall be possible to activate a line of sight, where time connected values are indicated. Time and process values shall be shown on the curve image and in the print out. Line of sight shall be freely movable along the x-axis direction.

Plotting of a curve image shall be possible by activation of a function key. Curve plot shall be in full graphic quality.

H.5.6.4 Alarm Management

Alarm management on the computer screen shall be carried out as follows:

- Alarms shall be registered in the main station computer within 5 sec;
- Alarms shall be saved in a queue sorted according to priority and time of event;
- It must be possible to acknowledge alarms via a component or alarm list;
- It must be possible to acknowledge alarms individually or in groups;
- Acknowledged alarms shall disappear from the alarm line and shall be transferred to the alarm list. Alarms shall remain in the alarm list, until they are deactivated (corrected);
- Alarms shall be shown in the graphical process image. Alarms shall be provided with alarm identification, e.g. first in enlarged part image of the process image;
- Alarm list shall be updated dynamically and update time must not exceed 10 sec;
- It shall be possible to assign priorities to all alarms according to the supervision agreement. It shall be provisioned that alarms are split up in up to 3 priorities. It shall be possible to freely change alarm priorities from the computer screen.

Following data shall be saved in the alarm database:

- Time of alarm occurrence in whole sec., day, month and year;
- Level;
- TAG No;
- Description of component;
- Alarm text or fault message text of at least 30 characters;
- Time of acknowledgement;
- Identification of operator who acknowledged the alarm;
- Time of out-going alarm.

Content of the alarm list (on screen or in print) shall be freely selectable between the information in the alarm database. Sorting criteria for alarm list shall be freely definable by the operator.

It shall be possible to change alarm settings for measurements under normal operation. It must be provisioned that after acknowledgement of the alarm, process image objects can change colour and flash red. Standing acknowledged alarms shall flash red, until the fault is corrected.

Alarms shall be reported immediately even during running of other functions such as print out / generation of reports etc.

It shall be possible to lock (suppress) and release pending alarms. Alarm list shall state time of locking and releasing of alarms. When the alarm is locked, it shall be shown as standing but acknowledged, e.g. by changing to a different colour.

In general, it shall be possible to define whether the alarms which are not acknowledged shall be registered in the alarm database with a new time of "in" and "out", or if a new registration shall take place only after acknowledgement of alarms.

At acknowledgement of alarms time and operator name shall be registered in the SCADA database. Passing alarms must also be acknowledged. Alarm status shall appear clearly from the alarm list e.g. by change of colour of unacknowledged alarms.

H.5.6.5 Operation and Maintenance System

It shall be possible to configure and parameterise all smart field devices (sensors, actuators, etc.) from the same unique platform, as integrated part of the central control system. It shall be possible to operate and parameterise field devices and components remotely via central parametrization software installed on Engineering or Maintenance station and locally (in the field) via mobile Client (tablet) connected to central parametrization software via local Wi-fi network. All changes made in field devices (remotely or locally) should be automatically centrally stored and updated. It must be possible to define access rights for monitoring and parametrizing. The communication with the devices must be possible with PROFIBUS DP, HART, Modbus, Ethernet and PROFINET. With the software it should be possible to create project-specific field device libraries, to read device parameters and to change, identify and assign field devices, check, read diagnostics and device status data and to simulate device behaviour. Changes to field device data such as parameters, limits and alarm settings must be documented globally and device specific in a user-related Logbook. It shall be possible to assign various roles with defined function privileges to users

The process control system shall be programmed to be used as support for planned operation and maintenance (O&M system) for all equipment. The system should be elaborated in a way to make possible storing of following information for each equipment:

- Equipment designation;
- Type and number of equipment;
- Supplier / service company name, address and telephone number;
- Date of last servicing;
- Free text of minimum 200 characters;
- Total operation time: Operation time shall be updated automatically at least once a day;

- Operation time since the last servicing: Operation time shall be calculated and updated at least once a day.

It should be possible to state service intervals both in number of operation hours and in calendar time. The system shall generate an alarm or print out a "service card" either when the number of operation hours since the last servicing is exceeded or when the calendar time since the last servicing is exceeded. It should be possible to state both calendar time and operation period as O&M parameter for the same component.

H.5.6.6 Data Storage and Retrieval

All data shall be stored together with time stamps in the archives on the hard disks of the main process computers. The databank can be searched with software filters in order to collect specific information about particular dates, machines, faults, conditions and so on.

The data shall be treated as per regulation. This means they have to be gathered every 1 minute and stored for 36 days. The data shall then be compressed to:

- 5 minute intervals stored for 10 days;
- 15 minute intervals stored for 35 days;
- 30 minute intervals stored for 100 days;
- 60 minute intervals stored for 400 days;
- daily intervals stored for 1825 days;
- monthly intervals stored for 240 months;
- yearly intervals stored for 25 years.

H.5.6.7 Alarm, Events and Messages

The alarm system shall provide complete alarm and event management with a user definable message structure. The alarm system shall support definition of up to 16 message sub-classes and 16 message types. Alarm messages shall be time-stamped in the controller. The alarm system shall record any change of state that the system detects including:

- Any violation of limits;
- Any change of state of a device connected to the system including all of its peripherals;
- The failure of any communications channel used by the system;
- The failure of system's hardware, which results in an automatic fail-over of the system's functions from the active to standby device.

The alarm system shall display alarm messages in a manner to facilitate easy interpretation of the current alarm status including but not limited to:

- Different text colour and background colour for those points that are in alarm, those that have been acknowledged, and those that are no longer in alarm;

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- Flashing of the current alarm message(s) in the alarm list.

It shall be possible to manually inhibit alarms on a point-by-point, group or system-wide basis. This capability shall be protected by system access control. These actions shall be logged. A list of suppressed alarms shall be available at the operator station.

Alarms are classified into 2 categories:

- Process alarms are generated from changing alarm attributes of process I/O point or any calculated point;
- System alarms generated from failures of individual system components shall result in the generation of an alarm message.

All alarms shall be stored in the history files with the capability to archive these to removable media. The system shall provide the possibility to recall these alarms in visible display lists and printed lists according to selectable filtering options.

The alarm management system shall offer the possibility to send error messages fully automatically to a variety of possible recipients in a variety of ways:

- Android smart phones with ACC-App via SMS, Internet and WLAN;
- iPhones with ACC app via Internet;
- SMS on cell phones;
- text messages to Ascom and Funktel pagers;
- voice output on telephones via ISDN and VoIP;
- text messages and voice output on telephones;
- email to suitable receivers.

The alarm management system shall offer following functions:

- integrated shift and personnel management for time-dependent delivery of messages to different persons;
- comprehensive escalation system for reliable delivery of messages even if individual receivers cannot be reached;
- redundancy for fault-tolerant systems;
- alarm filter for suppressing message bursts, follow-on messages, and chatter messages;
- system monitoring for monitoring alerting functions by means of cyclic hardware and software component testing;
- logging of changes to the configuration such as deletion of a telephone number or reorganizing the call sequence.

H.5.6.8 Process History

For the long-term archiving process history shall be used. It is a fully integrated archiving system to manage historical data with capabilities to support the following is required:

- Archiving of process values, messages;
- Post-processing (mean value, maximum / minimum value, rate of change, data compression, filtering);
- Query and visualization.

The system must be able to capture data according to a specific project configuration. It must also be able to respond to data request requests in a timely manner, without interfering with data collection or otherwise compromising performance.

The system shall provide the ability to select, add to and configure for archiving any variable in the process automation system. Variables that are configured or modified in the process automation system must be automatically displayed in the system for historical data management without additional configuration.

Users must be able to access data without the need for process automation system expertise or anyone else.

The historical data management system shall include the following two archiving systems:

- Short-term archiving: A local component that runs on the HMI server to record data from the process control system;
- Long-term archiving or the history: The long-term archiving system is executed on a dedicated machine and archives the data of the short-term archive for a longer period of time.

The long-term archiving system must use a relational Microsoft SQL database management system (RDBMS) in real time to store all process-relevant information.

The long-term archiving system must manage all activities to ensure continuous access to archive data as long as needed. The long-term archiving system can be connected via an interface with higher-level systems (e.g. MES) as well as with other systems that require process automation system data.

Under no circumstances it shall be possible for users to gain data access to the process automation system data network, server or automation system, etc., via the long-term archiving system.

The HMI can display data from the short- and long-term archiving system in different ways, such as trends and tables:

No data loss: if a connection is lost between the history and the HMI Server, the data is continuously stored and secured on the HMI Server (local storage and transfer principle). Once the

connection is restored, all missing data is automatically transferred from the HMI server to the history.

The history shall have a function for archiving values including, but not limited to the following values:

- Actual value;
- Maximum value;
- Minimum value,
- Sum;
- Average.

The history must provide the ability to archive binary values on either a rising or falling edge.

Backup/restore of the history database:

The system shall provide functionalities for backup/restore of the database to removable storage media or to an alternative storage location. The Backup Utility shall be able to perform database backups based on any of the following configurable criteria:

- Manual creation of complete database backups;
- Automatic creation of complete database backups.

The restore function must be able to create the database in the same paths as the original database.

H.6. SAFETY EQUIPMENT

H.6.1 Fire Alarm System

A fire alarm system should be installed at all rooms where flammable material is handled or stored especially at the diesel generating station, all fuel tank rooms, biogas storage and biogas handling rooms, storage rooms for fuel, paint, solvent or other flammable material. The administration building and workshops shall also be protected by the fire alarm system.

It shall consist of a central fire alarm unit, a sufficient number of smoke and heat detectors in all endangered rooms, manual fire alarm boxes, optical and acoustic alarm devices, complete cabling and any further equipment to realize a complete and functioning fire alarm system according to EN 54, DIN 14675, VDE 0833 and the relevant local standards.

The cabling shall be carried out with signal cables, conductors at least 0,8 mm diameter, marked red along the entire length. The service also includes software, programming, adjustments, installation, configuration, tests, mounting and mounting material.

H.6.1.1 Central Fire Alarm Unit

The unit has to meet all relevant international and local standards and must be suitable for the connection of automatic and manual alarm devices and shall comply with following specifications:

- power supply: 230 VAC, 50 Hz;
- operating voltage: 12 V;
- emergency power supply: 2 x 24 hours, with lead-acid-battery;
- degree of protection: IP 30;
- installation in a wall mounted cabinet
- front surface with keyboard, lighted LCD display (2 lines) for indication of status, alarm counting, date, time, etc.;
- free programmable additional texts to be assigned to single events or detectors;
- self-diagnosis and acoustic alarm for internal faults;
- cyclical polling of all detectors (approx. every 0,5 second);
- multiple polling with noise suppression by plausibility check;
- overvoltage protection for all detector line inputs;
- output contact for each detector line status;
- output contacts for alarm and faults;
- switching of detector lines via the keyboard;
- easy revision for all detector lines;
- sufficient interfaces for connection of remote control panel, indicating panels, printer, etc.

In addition to the optical and acoustic indication as specified below, alarms have to be transmitted to the central control system.

H.6.1.2 Manual Break Glass Points

Manual Break Glasses shall be installed next to each Emergency Exit They shall be red coloured, for installation in dry rooms according to DIN 14675 and provide the following features:

- integrated evaluation logic;
- programmable address;
- red plastic housing (colour RAL 3000);
- wall mounting;
- Labelling "Fire Alarm" in English and local language
- 5 mm LED for release indication;
- ambient temperature: - 30 ... + 70 °C.

H.6.1.3 Fire Detectors

Fire detectors shall be multiple-type smoke and heat detectors of the scattered-light-, ionization- and temperature-difference-type with integrated evaluation logic. They shall have following characteristics:

- locating primary and secondary alarms;
- locating faulty or dirty detectors;
- infinitely variable adjustment of ambient conditions;
- automatic sensitivity control;
- signal analysis by combination of sensors;
- reproducible detection for all kinds of fire;
- status indication by LED.

The service includes the complete installation with socket, cable connection, adjustment, mounting and all required material.

For areas with restricted access (transformer rooms, height of room > 6 m) smoke aspiration systems shall be installed to enable maintenance.

H.6.1.4 Alarm Devices

Indoor and Outdoor alarm devices have to be installed at each access door to the buildings and shall have following characteristics:

- Outdoor:
 - Flash light;

- Acoustic alarm.
- Indoor:
 - Flash light (for pump room and gen set room only);
 - Acoustic alarm.

Acoustic alarm horns shall comply with DIN 33404, part 1, and provide following features:

- programmable steady or changing tone;
- sound level: approx. 100 dB(A) at 1 m;
- degree of protection: IP 42;
- red plastic housing.

In addition a siren with red flashing light has to be used for optical and visible signalisation at the outside of each protected building. It must be suitable for outdoor installation (IP 66).

H.6.2 Gas Detection System

The Gas detection system shall measure and display the gas concentration and shall provide audio and visual alarms when pre-set limits are exceeded. Relay output for alarms and malfunction indications and analogue signal representing gas concentrations shall be provided.

The system shall be configured for fail-safe operation. Failure of a sensor shall generate an alarm. The system shall consist of a sensor, control module, and calibration check kit including sensor separation accessories and calibration gas tanks. Alternatively 24 VDC loop powered gas detectors with 4-20 mA output are also acceptable. Sensor and transmitter location shall be as required in the fire protection and security concept.

The gas detection system shall operate from 24 VDC power supply, which shall be battery backed for a minimum of 48 hours. The electrochemical sensors shall have a minimum operational life of one year. Gas concentration signals and malfunction alarms shall be interfaced with the RTU for remote monitoring.

The control module shall amplify the sensor current signal through a solid-state amplifier for display and alarm functions. The control module shall include a two or three-digit led display per channel. It shall also provide a minimum of three digital alarm outputs: low, high, malfunction and an analogue 4-20 mA output signal per channel.

Gas detectors should be located as close to potential leak or gas generation points as possible. The presence and concentrations of gases that must be detected should be considered with respect to the following conditions when designing gas detection installations:

- Air currents: Detectors should be positioned where prevailing air currents contain the fullest possible concentrations of gas;

- Relative weight of gas: Detectors should be located near the floor for heavier-than-air gases or vapours, and near the ceiling or roof to detect lighter-than-air gases such as methane and natural gas. Vapours from all liquids are heavier than air;
- Heat: Standard diffusion type detectors are designed to operate within a specific ambient temperature range and must not be located outside this range;
- Water, moisture, dust and dirt: Detectors should be positioned where water cannot enter and fill the housing to prevent exposure of the sensor element to air. Likewise, exposure to moisture, dust and dirt should be minimised by locating detectors away from points where large amounts of such contaminants fill the air. Small overhanging or surrounding covers may be devised to protect detectors from the intrusions of dust and dirt in severe environments;

Permanent installations shall initiate safety systems such as ventilation fans etc., when high concentration of hazardous gas is detected.

H.6.3 Intrusion Alarm System

A burglar alarm system shall be installed at all rooms with doors or windows to the outside of the administration building.

It shall consist of a central burglar alarm unit and a sufficient number of motion detectors, plunger contacts and magnetic contacts in all endangered rooms, optical and acoustic signaling devices, complete cabling and any further equipment to realize a complete and functioning intrusion alarm system according to the relevant local standards.

The service also includes software, programming, adjustments, installation, configuration, and tests, mounting and mounting material.

Central Intrusion Alarm Unit

The unit shall meet all relevant VdS, DIN, VDE and local standards and must be suitable for the connection of automatic and manual alarm devices. It shall provide the following characteristics:

- power supply: 230 VAC, 50 Hz;
- emergency power supply: 2 x 24 hours, with lead-acid-battery;
- degree of protection: IP 30;
- installation in a wall mounted cabinet;
- front surface with keyboard, lighted LCD display (2 lines) for indication of status, alarm counting, date, time, etc.;
- free programmable additional texts to be assigned to single events or detectors;
- self-diagnosis and acoustic alarm for internal faults;
- multiple polling with noise suppression by plausibility check;
- overvoltage protection for all detector line inputs;

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- output contacts for alarm and faults;
- switching of detector lines via the keyboard;
- easy revision for all detector lines;
- sufficient interfaces for connection of remote control panel, indicating panels, printer, etc.

In addition to the optical and acoustic indication as specified below, alarms have to be transmitted to the central control system and must be indicated and processed as any other fault of the plant.

Motion Detectors

Infrared motion detector shall comply with VdS Class: B and VdS No.: G 101514.

The infrared motion detector is used to monitor interior spaces. Using optical mirrors it detects infrared heat rays, in wave lengths emitted by the human body.

The new TRAP technology (Threshold Regulated Algorithm with Power-management) offers excellent protection against false alarms and outstanding detection characteristics. Alarm criteria are distinguished very efficiently from false alarms. Simultaneously energy consumption is kept to a minimum.

The motion detector is designed for connection to intrusion alarm central units with detectorbus and shall have following characteristics:

- Detection range 15 m;
- Power supply: 9 – 15 VDC;
- Quiescent current take up idle approx: 0,9 mA;
- Current take up each LED approx.: 10,9 mA;

The service includes the complete installation with socket, cable connection, adjustment, mounting and all required material.

Plunger Contact

Plunger contact shall comply with VdS Class: C and VdS No.: G 100023.

Plunger contact shall be of dust and waterproof design (IP 67) with integrated cable. The plunger contact is used to monitor that doors are closed. It consists of a micro-switch installed in an aluminium housing with lever mechanism. The plunger contact is built into the lock plate and activated by the lock bolt. The switching point can be set via a screw as a function of the bolt travel.

Plunger contacts shall comply with following characteristics:

- Index of protection: IP 67
- Loading capacity of the contacts: max. 30 VDC / 100 mA.

The service includes the complete installation with socket, cable connection, adjustment, mounting and all required material.

Magnetic Contact

Magnetic contact in Set with surface housing according to VdS Class: B and VdS No.: G 104511

The magnetic contact monitors the opening of doors, windows, junctions, etc. It consists of a reed switch in a cylindrical plastic housing and a permanent bar magnet. For surface mounting this set includes 2 surface mounting housings and 2 spacer blocks each of 2,5 mm and 5 mm.

Magnetic contacts shall comply with following characteristics:

- Connection cable: 4 x 0,14 mm² with equal coloured wires;
- Connection cable for LSA-Plus-technic;
- Cable diameter: 4 mm;
- Loading capacity of the contacts: 30 V / 0,1 A;
- Index of protection: IP 68;
- Operating temperature: - 25 to + 60 °C.

The service includes the complete installation with socket, cable connection, adjustment, mounting and all required material.

HF Reader

HF reader according to VdS Class: C

The HF reader units are designed for connection to the intruder alarm systems with an interface. The operating status is shown directly at the reader unit by means of dual LED and piezo-electric sound emitters. With the combi-reader units an AND/OR association between identification chips is always possible.

In-wall assembly kits are available for flush mounting, consisting of a plaster box, mounting frame and cover. Activation of the HF reader is performed without contact via an authorised HF transponder.

HF Reader shall comply with following characteristics:

- Connection cable: 4 m;
- Environment protection category approved to VdS 2110: Class IV.

This includes a reasonable amount of HF key transponders for the staff.

The identification chips have a permanently programmed authorisation memory for identification by the intruder alarm systems with interfaces.

Each identification chip has its own unique code derived from 10 million possible combinations.

The HF key transponder does not require its own energy supply and can thus be used at any time. Information is transferred to the HF reader unit without contact. This type is particularly suitable for marking with an incremental number. For this, the transponder is provided with a circular area with a white background.

The service includes the complete installation with socket, cable connection, adjustment, mounting and all required material.

Signalling devices

For indoor mounting at the administration building, acoustic alarm horns according to DIN 33404, part 1, have to be supplied, providing the following features:

- programmable steady or changing tone;
- sound level: approx. 100 dB(A) at 1 m;
- degree of protection: IP 42;
- red plastic housing.

In addition a siren with red flashing light shall be used for optical and visible signalling at the outside of each protected building. It must be suitable for outdoor installation (IP 66).

H.6.4 CCTV System

The Contractor shall supply, install, test & commission a state of the art digital TCP/IP-based CCTV monitoring system. The system should be a stand-alone system that is capable of being linked to a site wide system. A typical CCTV system for a building should comprise of colour cameras, lenses, monitors, pan & tilt units, time lapse VCRs and all necessary cables & accessories for a fully functional system.

The CCTV System shall be state of the art (HD) and compliant with best latest practices and local regulations. All installed cameras shall be Pan/Tilt/Zoom (PTZ) type to ensure full coverage of all locations. In areas of high risk of gas, such as the sludge treatment facilities, ex-proof camera and cable installations shall be included.

The system shall cover the complete fence of the plant as well as all entrances

The system shall be located in the Control room and should be integrated. The system should be comprised of the following components:

- HD resolution IP cameras;
- HD DOME IP cameras for outside, infrared sensitive;
- LED infrared emitters for outside installations;
- Pan, Tilt & Zoom controllers;

- Video Monitors, Plasma Screens or Video Walls;
- Video storage;
- Interfaces to SCADA installations.

The following functions shall be provided by the system:

- motion detection;
- automatic sampling with event trigger;
- comprehensive software;

The CCTV system shall be connected using a TCP/IP based network. Copper cables (CAT7) shall be used for internal installation up to 90 m. For outside installations or longer distances fibre optical cable shall be installed.

H.6.5 Access Control

The Contractor shall design and deliver a state of the art access control system for the plant and corresponding structures. The system shall be software based and easy to handle.

The system comprises RFID access devices (cards or chips), electronic locks with user interface for all entrances and the central management software station. It must be possible for each single access device to manage the access rights to the different zones of the plant by software. Even in case of a lost device, the card can easily be disabled. The user interface at the doors shall give direct response to the user e.g. by green/red lights and/or sound.

The central management station shall be provided with server hardware and shall be installed in the central control room of the plant. The system shall be expandable and built for management of unlimited number of users.

The system shall be TCP/IP based with wireless LAN access points. The following doors shall be equipped as a minimum requirement:

- main plant access / gate;
- entrance doors to all buildings;
- control rooms;
- offices;
- switchgear rooms;
- technical rooms;
- laboratories.

H.7. TEST AND APPROVAL PROCEDURE

H.7.1 General

The Contractor shall request inspection and testing of all items of plant, mechanical and electrical works and shall give the Engineer four (4) weeks' notice that the equipment is ready for testing and of his intention to carry out tests in accordance with Contract provisions.

If any of the tests are beyond the resources of the Contractor or the Manufacturer, the Contractor shall make arrangements for these to be carried out elsewhere on suitable testing facilities.

The Contractor shall carry out tests as stated in the applicable National or International Standards (EN, ISO or IEC), for performance tests and such other tests that are stated and as may be deemed necessary by the Engineer, to proof that the Works comply with the Specifications set forth by the Contract Document as a whole. Each test certificate shall be in accordance with the Contract provisions, and shall contain concise information of the test; e.g. (Contract number and details, pay item number, prevailing specifications, manufacturer, type, model, serial number etc.) for unambiguous identification of the material or equipment tested and the extent of the certificate's validity.

The Contractor shall be responsible to fully document all tests carried out and readings taken and to keep a neat record of all tests.

However, no inspection, release or approval of any part of the Works by the Engineer, shall release the Contractor from any of his obligations under the Contract.

Whenever tests and inspections have been completed to the Engineer's satisfaction and when the test certificates, (including reports, notes, tables, graphical representations of results etc. as technical annexes) have been checked and deemed complete, the Engineer shall confirm acceptance in writing.

Where witnessed tests are not required by the Contract or waived by the Engineer, the complete test certificates including technical annexes shall be forwarded to the Engineer:

- a) either within two (02) weeks after shipment of the respective goods together with any other commercial document issued at the time of shipment;
- b) or within two (02) weeks after receipt of such waiver.

The Engineer may require the Contractor to remedy a failed test or inspection may require through supply of new parts from the manufacturer or return to manufacturer's plant of damaged parts for repairs if such repairs are still technically deemed feasible by the Engineer.

Any equipment used in testing shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

The Contractor shall make sure that all sub-contractors are given copies of the relevant parts of the Specifications. Full details of the testing method proposed for each item shall be submitted to the Engineer.

H.7.2 Cost for Testing

The Contractor shall bear all costs of Third Party as may be required from time to time and of the Engineer if required to carry out inspections at places other than on the site or in the Contractor's storage facilities close to the site. Such costs of the Engineer shall comprise the per-day-fee, travel and accommodation cost and all other incidental costs occurring during the performance of test and inspection.

H.7.3 Test Instruments and Equipment

The Contractor shall satisfy the Engineer as to the accuracy of all instruments required for the tests.

kW-meters and kVAR-meters shall be checked for correct rotation and creep tests shall be carried out to ensure that the meter is inoperative with voltage alone if the secondary of the current transformers is left connected with the primary current interrupted.

H.7.4 Factory Tests

These are inspections and tests, at the place of manufacturing and apply for mechanical (e.g. pumps) and electrical items of equipment (e.g. instruments). Factory tests shall be carried out by the manufacturer according to the relevant standards and the manufacturer shall issue the relevant certificates.

The Engineer or his representative reserves the right to carry out pre-shipment inspections and witnessed testing at the manufacturer's facilities. All items of the plant shall be liable to works inspection at reasonable times by duly authorised representatives of the Engineer.

Each consignment of material and equipment delivered to the Site shall have been tested at the manufacturer's facilities or other approved place in accordance with the appropriate standard. The Contractor shall provide the Engineer with the manufacturer's test report for each such consignment before delivery to Site.

Whilst the Engineer shall be provided with facilities to witness testing and/or inspection of all items of equipment at the manufacturer's works, he may at his discretion advise that part of the tests shall proceed in his absence, the tests shall be made as if in his presence.

The Contractor shall submit to the Engineer a duly countersigned copy of the readings of any witnessed test and, within two weeks after completion of any witnessed or unwitnessed tests, a complete test certificate.

The Contractor shall submit to the Engineer un-witnessed factory test certificates where applicable giving a detailed record of all tests performed.

If after inspecting, examining, or testing of any material or equipment, the Engineer shall decide that such items or any part thereof is defective, or not in accordance with the Specification or performance requirements, he may reject the said items or part thereof, giving to the manufacturer within a reasonable time, notice in writing of such rejection, stating therein the ground upon which the said decision is based..

As and when the Engineer is satisfied that the equipment shall have passed the required tests he shall notify the Contractor in writing to that effect.

Copies of test certificates shall be included in the As-Built Documentation as detailed elsewhere.

H.7.5 Material and Design Qualification (DQ)

The Contractor has to submit the complete electrical design including material specification for Engineer's approval prior to any installation work and material order.

Shop Drawings

The Contractor shall submit complete shop drawings of all electrical and I&C equipment in accordance with this specification. Such shop drawings shall include all electrical and I&C requirements, weights, wheel loads, dimensions, and clearances required. Trade mark, model, and catalogue number, destination, description and testing data shall be indicated.

H.7.6 Factory Acceptance Test (FAT)

Prior to installation on site, the Contractor has to request for the factory acceptance test (FAT) by the Engineer. FAT shall comprise but not be limited to the main components of the electrical system e.g. MCC, electrical panels, gen set. The Contractor has to submit a request for FAT minimum 2 weeks prior to scheduled FAT date. The Contractor is responsible to organize FAT test protocols. FAT tests shall be confirmed by the signatures of the Contractor and the Engineer.

H.7.7 Installation Qualification (IQ)

After installation on site but prior to energization and commissioning of all components, the Contractor has to request for installation qualification (IQ) by the Engineer. The Contractor executes the tests and he is responsible to organize the IQ test protocols. IQ tests shall be confirmed by signature of the Contractor and the Engineer. Confirmed IQ protocols are prerequisite for commissioning.

H.7.8 Operation Qualification (OQ)

After commissioning and internal test procedure the Contractor has to request for operation qualification (OQ) by the Engineer.

The internal test procedure prior to OQ comprises but is not limited to:

1. System setup

All components of the system shall be set up as per design. A signed setup protocol shall be provided by the Contractor as part of the OQ.

2. Loop check

After the entire system has been installed ready for operation, a comprehensive data link test has to be executed. The link test comprises a complete functional test procedure from the sensor to PLC and to the SCADA (display, messaging system, archives, logs). The Contractor executes the tests and he is responsible to organize the loop check protocols. A signed loop check protocol shall be provided by the Contractor as part of the OQ. They are also part of the final acceptance inspection.

3. Functional test

After commissioning, the Contractor has to execute the functional test of the systems. All interfaces and interlocks of the system shall be fully tested. The Contractor executes the tests and he is responsible to organize the loop check protocols. A signed functional test protocol shall be provided by the Contractor as part of the OQ.

The OQ plan and schedule has to be clarified and approved by the Engineer, who will attend the test procedures.

In case that at the time of Tests on Completion connections to the public power supply have not been completed by the public electricity provider, the tests shall be carried out with power generated from the stand-by generating sets.

The Contractor shall provide for the tests:

- All skilled and qualified operating and test staff for the testing of all equipment;
- Provisions and disposal of all services, lubricants, and fuels and electricity;
- All measuring and testing instruments to demonstrate that the equipment fulfils the requirements, in particular instruments to monitor transient processes such as surges, etc.

H.7.9 Final Acceptance Test

All parts of the previous test procedure are prerequisite for final acceptance test of the system. The Contractor is responsible to provide all necessary documents and has to request for final acceptance test at least two weeks prior to schedule inspection date.

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The Contractor, on completion of testing and commissioning of the installation/system shall submit to the Engineer all test results accompanied with the completion certificate as stipulated in Appendix 6 of 16th Edition of the IEE Wiring Regulations – BS 7671: 2008. The installation / system shall not be considered complete without this certificate. If the Contractor fails to produce these documents within one month from the date of Tests on Completion, the Engineer may employ the services of Third Party to produce these documents and all costs shall be borne by the Contractor.

**Bidding Documents for the
Construction of the Wastewater Treatment Plant, Sewage
Sludge Treatment Plant and Sewage Sludge Incineration
Plant for the City of Podgorica**

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- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
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List of Acronyms

AGI	Arbeits-Gemeinschaft Industriebau (Association of German enterprises)	ISO	International Standardization Organisation
CE	European Certification	PN	Nominal Pressure
DIN	Deutsche Industrienorm (German Standard)	SI	International System of Units
DN	Nominal Diameter	SSIP	Sewage Sludge Incineration Plant
EN	European Standard	TIG	Tungsten Inert Gas welding
EU	European Union	Zn	zinc
FGT	Flue Gas Treatment		
IEC	International Electrotechnical Commission		

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand separator.

I.1 GENERAL

I.1.1 Scope of the Specifications

The technical specifications defined in this part (Part I) apply especially for the Sewage Sludge Incineration Plant (SSIP) and may differ from the previous Parts C to H, or even contradict them. The specifications defined here take precedence for this section of the plant.

I.1.2 Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the decimal comma is used and the dot is used as thousand-digit separator.

I.1.3 SI-Units

All measurement units in documents, markings, interfaces and drawings are according to the International System of Units (SI-Units).

I.2 SLUDGE INCINERATION

I.2.1 General Remarks

The following particularities need to be given special attention:

- Equipment in contact with sewage sludge see Section I.6.2;
- Wind bracings see Section I.3.1.3.10;
- Minimum load-bearing capacity of the platforms see Section I.3.1.3.9;
- Step size see Section I.3.1.3.6;
- Concrete bases see Section I.2.4.

I.2.2 Screw Conveyors

All screw conveyors are with reversible direct-driven shaftless screws. They are usually positioned horizontally, but if required, could also be positioned vertically based on the type of sludge transport. Upward diagonal transport is not permitted.

I.2.3 Manholes

All manholes are designed at least according to the following standards:

- the clear width is at least 600 mm;
- FGT system:
 - the clear width is at least 800 mm;
 - in case of rectangular openings at least 600 mm clear width and 0,5 m² total open area;
- lower edge not more than 500 mm above the floor;
- handles inside as well as – if necessary – steps, stages and platforms inside and outside.

I.2.4 Concrete Bases

All components are always mounted on at least 200 mm high concrete bases as a corrosion protection and are not fitted directly on the floor.

I.3 STEEL CONSTRUCTIONS

I.3.1 Platforms and Stairways

I.3.1.1 Preliminary Remarks

The guidelines of these specifications describe the default solution and provide assistance in finding specific solutions. In individual cases, further requirements are possible for operational reasons, by concretizing the workplace health and safety regulation or due to conditions imposed by the competent authorities.

This document does not claim to be complete and does not release the contractor from its responsibility for static and constructional safety in compliance with the applicable regulations and generally accepted rules of engineering.

In principle, it is permitted to carry out constructions deviating from the project standard if

- only detail points are differently developed, which have no influence on the overall optical impression and the connection of other systems;
- in individual cases the standard solution is not applicable;
- at least equivalent solutions are chosen with regard to work safety, usability and reliability.

In the case of a different design, approval must always be obtained from the contractor, unless the first bullet point applies.

I.3.1.2 General Information

Platforms and stairways are to be provided in all mechanical, process and electrical installations inside and outside the buildings, if the structural accessibility is not possible elsewhere. All operating, maintenance and monitoring equipment must be easily and safely accessible. The same is applicable to escape and rescue routes.

In particular, safe access must be guaranteed by appropriate expansion to all:

- manholes, inspection and cleaning openings and system components that require regular inspection or maintenance;
- devices which normally or in the event of an impairment must be operated by hand;
- pipe connections for internal inspection during the legally prescribed tests.

In all parts of the plant, the defined main platforms, which are not constructed in solid concrete for assembly and repair reasons, have to be designed as large as possible, whereby the requirements of main inspections are taken into account.

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The platform expansion must take into account that during the annual revisions the required material as well as all scaffolding parts etc. are temporarily stored in the surroundings of the access openings or manholes. The storage of dismantled parts must also be taken into account.

All operation, maintenance and control areas should be directly accessible through the main levels. If good access to the system components to be operated or maintained is not possible from the main levels, intermediate levels with different elevation levels can be installed. These intermediate levels must be connected to the main levels by stairs.

Maximum permitted escape route lengths and the accessibility of safety exits or to safety and escape staircases must be considered.

Columns of platforms, stairs and steel structures standing on concrete levels must be designed so that they are placed on a concrete socket 100 mm above the floor.

Platforms that are frequently or regularly used must be accessible via stairways.

The platforms and stairs are spaciouly designed and allow access to all process components including measurements and valves. The platforms and stairs are designed as escape routes.

I.3.1.3 Design Guidelines

I.3.1.3.1 Main Levels

The following main levels are defined:

- + 0,00 m;
- + 5,18 m;
- + 8,14 m;
- + 11,10 m;
- + 14,80 m;
- + 21,83 m;

Further main levels are defined in the project planning. All height nodes must be a multiple of 185 mm (step size).

I.3.1.3.2 Supporting Structure

Stairways, platforms etc. including the supporting structure must be made of stable steel profiles. The horizontal platforms and platform frames can be attached to existing solid construction elements as long as it is statically permissible.

Supporting structures, railings etc. must be given a corrosion protection coat in accordance to these specifications.

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In general, the standard profile for the clear passage of 1.000 mm x 2.200 mm should be observed. A minimum clearance of 800 mm x 2.100 mm is permissible if no regular walkways are necessary.

I.3.1.3.3 Grating

Gratings should comply to DIN 24537 and be constructed with twisted crossbar, mesh size 30 x 30 mm, bearing bars 40 x 3 mm and hot-dip galvanized.

The connection to the supporting structure is made by means of socket pins and bolted-on top plate.

The use of heavier gratings due to higher loads (possibly wheel loads) is marked on the steel construction overview drawings.

I.3.1.3.4 Metal Covers

If the employer has not specified anything else about metal covers, hot-dip galvanized rough sheet / warded sheet 6/8 mm are used. Connections to the supporting structure are made by clamp connection or tack welding.

I.3.1.3.5 Foot Protection

All platforms and stairways must always be secured by foot protection ledges. This also applies, regardless of the distance, to adjacent walls, concrete foundations, etc.

The distance between wall and foot protection strip must not exceed 40 mm.

The foot protection ledge is constructively connected with the grating and forms a unit. The baseboard is 100 mm high, in relation to the upper edge of the grating.

I.3.1.3.6 Stairways

All stairs in the plant must be designed in accordance with the valid regulations. They must have a uniform step size. The height of steps is fixed to 185 mm, the depth of steps is fixed to 270 mm as shown in **Annex 1**. Steps are to be executed over the entire length with a safety edge, if the implementation of steps in **Annex 1** is not feasible.

The width of the main stairs is 1.000 mm. After a maximum of 18 steps a platform must be arranged. This does not apply to maintenance stairs that run parallel to inclined installations (e.g. conveyer belts).

I.3.1.3.7 Climbing Ladders

As the only access to a platform, climbing ladders are only permitted in justified cases after explicit and documented approval by the employer.

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A climbing ladder is not permitted if:

- a stairway is required by legal regulations;
- a permanent workplace is to be achieved or a regular inspection is to be carried out in each shift;
- a large number of workers are working there when needed;
- objects or loads must be carried.

I.3.1.3.8 Railing

When designing the railing, care must always be taken that railing connections, extensions or constrictions are rounded off and do not have any sharp edges that could cause a risk of injury.

Openings in the railing (ladder access or similar) must be secured by self-closing drop brackets / doors.

The standard height of railings is 1,10 m.

I.3.1.3.9 Walkways / Platforms

The standard width of main traffic routes and gangways is 1,0 m, of repair platforms at least 1,20 m, unless continuous expansion is planned or a larger dimension is required for reasons of transporting plant components.

Subordinate gangways (e.g. for inspection purposes) including stairs can be 800 mm wide.

The inclination of a gangway should not exceed 20°. From an inclination of 10° upwards, square steel 20 x 20 mm must be used as tread strips at intervals of $2 \times s + a$ 630 mm in accordance with the step size formula.

The main levels are to be extended as extensively and continuously as possible and connected to the emergency staircases provided by the employer.

The minimum load-bearing capacity of the platforms is 500 kg/m².

I.3.1.3.10 Wind bracings

With the exception of facades wind bracings are only allowed to start in heights of at least 3 m on all stages.

I.3.1.4 Standard solutions

The standard solutions in **Annex 1** must be taken into account when designing the platforms and stairways.

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I.3.2 Steel Construction

I.3.2.1 Materials

I.3.2.1.1 General Information

All materials used must comply with the valid DIN / EN regulations.

Rolled profiles must always be used. Cross sections welded together from metal sheets and rolled sections may only be used with the employer's approval.

When designing steel structures (pipe bridges, buildings or supporting structures for equipment) the most cost-efficient steel quality must be used.

I.3.2.1.2 Steel Qualities

Steel of the following qualities has to be used (according to EN 10025)

- For all subordinate structural parts such as purlins, crossbars, stairs, ladders etc:
 - Steel S235JR, WN 1.0037 (or S275JR, WN 1.0044);
- For welded normal construction parts;
- For crane rail beams also normal annealed material - if required:
 - steel S235JRG2, WN 1.0038 (or S275J0, WN 1.0143);
- For highly stressed welded structural parts, if required also normalized:
 - steel S235J0, WN 1.0114; S235J2G3, WN 1.0116) (or S275J0, WN 1.0143; S275J2G3, WN 1.0144);
- In special cases:
 - steel S355J0, WN 1.0553; S355J2+N, WN 1.0570;
- In special cases, material in accordance with EN 10025 must be used for crane rails in workshops and production buildings:
 - Steel E335, WN 1.0060f.

Requirements for steel qualities and thicknesses at low temperatures see EN 10028, EN 10223 and EN 10269.

I.3.2.2 Design Guidelines for Steel Structures

I.3.2.2.1 General Information

The design work for steel structures is divided into 3 sections:

- Preparation of steel design drawings with information on the main supporting structures and load details.

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- Preparation of the structural analysis with detailed information on main connections, moment, shear force and normal force connections, connections and foundation loads as well as specification of positions and profile data in the steel design drawings. For dynamically stressed components, proof of operational strength is required.
- Production of fabrication drawings with specification of the standard connections in coordination with the person responsible for the static calculation as well as preparation of steel construction parts lists.

The division of tasks is specified by contract.

I.3.2.2.2 General Design Guidelines

The stiffening of supporting structures of scaffolds and pipe bridges should - if possible - be carried out by bracing fields, whereby traffic routes and possibly required assembly openings must be taken into account.

The determination of the type and position of the bracing, framework or bay must be approved by the employer.

The design and execution of the steel structures should comply with the standard drawings applicable to the project.

Site joints must always be made as bolted joints.

During detail engineering and construction of steel structures, care must be taken to avoid dead corners from which water cannot run off completely or where drying is severely hindered by insufficient air movement. Where necessary, holes must be provided for the drainage of water.

The construction is to be designed in accordance with EN ISO 12944 for corrosion protection.

All welding seams which are outdoors or are particularly susceptible to corrosion must be welded continuously. All recessed corners must be rounded off.

I.3.2.2.3 Pipe Bridges and Pipe Support Structures

The distances between fixed points should be arranged in the middle of pipe bridges if possible. The distances between fixed points should be selected in accordance with the temperature expansions in such a way that compatibility between pipelines and pipe bridge constructions is ensured.

The constructions of crossing pipe bridges are not to be connected with each other. In the case of pipe bridges, the clear passage height over plant roads should be 4,50 m. In exceptions, the clear passage height / clearance height is 3,50 m.

In the case of pipe bridges over public main roads or railway tracks, the clear passage heights must be determined in accordance with the requirements of the local approval authorities.

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Individual support structures for pipelines are normally recorded as pipeline support material up to a height of 1,0 m. For greater heights, individual steel supports clamped at the base point must be provided. Depending on the number of pipelines and the local conditions, a decision must be made on the basis of economic criteria between individual supports and tubular bridge frame constructions.

I.3.2.2.4 Covering Pits

Pits are to be covered with grating or with caterpillar plate / warded plate, depending on operational requirements. The cover should rest in a support frame. Parts of the cover marked as "Removable" are to be attached to the supporting structure with clamp connections.

I.3.2.2.5 Jib Crane

For frequent lifting of built-in parts on columns or for frequent filling of vessels with catalyst, chemicals or similar, a jib crane must be installed at a suitable location.

I.3.2.2.6 Cable Trays

Cable trays should comply with the specifications for electrical / measurement and control technology. Shape and dimensions are determined according to the number of cables to be supported.

When installing cable trays under the cross members of pipe bridge frames, the clear passage height required for pipe bridges must not be reduced.

Cable trays should not be routed over pumps, heat exchangers or fire-endangered system components.

I.3.2.2.7 Trolley Beams and Crane Runways

For equipment parts such as covers of heat exchangers, tube bundles, ventilators and compressor housings, rotors, cylinders, etc., which cannot be reached by truck-mounted crane, trolley supports including the trolley must be provided.

Trolley beams, crane runways and their supporting structures must be dimensioned for the relevant loads (hook load, oscillation coefficient, side impact and, if necessary, impact load).

Where several trolley girders are required locally, the installation of an overhead travelling crane should be considered as an alternative and has to be discussed and approved by the employer.

As a rule, no pulley blocks are to be provided and trolleys without a motor drive should be used.

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I.3.2.2.8 Corrosion Protection

Corrosion protection for steel structures must be carried out in accordance with specifications for coating and galvanizing work.

Unless otherwise specified, all steel structures are delivered with a factory primer coat.

If, for operational reasons, hot dip galvanizing is required for individual structural parts, these parts must be specially marked on the drawings. In the case of supporting beams for reinforced steel-concrete ceilings on which aggressive leakages are possible, the flanges should not be embedded in concrete or sheathed, but the ceiling should rest on the flanges. This is to maintain the possibility to inspect the supporting structure.

I.3.2.2.9 Minimum Dimensions

Minimum dimensions of load-transmitting structural components:

- 8 mm: Thickness for gusset plates;
- 5 mm: Thickness for all other construction parts, except for the web thickness of the rolled sections IPE 180 and IPE 140;
- 50 mm: leg length for angles;
- 20 mm: Height of the stage girders with bolted railing posts;
- 15 mm: Thickness for base plates.

I.3.2.2.10 Minimum Distances to other Components / Clearances

Clear passage height for steel constructions in general at least 2,20 m, in the area of accesses at least 2,75 m.

Required free space when removing horizontal tube bundle or tube coil heat exchangers:

- Minimum distance from the heat exchanger: 1,20 m + heat exchanger length
- Lateral minimum distance: 0,30 m

I.3.2.2.11 Recommended deflections

The permissible deflections consist of imperfections (possibly superelevations) and deformations under load effects. If superelevations of main supporting structures are required, the deformation from permanent load has to be compensated.

The following limit values are only intended as a guide. The functionality of the structure must be ensured by the deformations.

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Table 1: Deflection/Shift limit values.

Type of construction		Crossbars Deflection or horizontal shift
Pipe bridges and pipe supports	Crossbars	L/300
	Supports	H/200
	Side member	L/300
Apparatus scaffolds	Crossbars	L/300
	Supports	H/200
Stages and catwalks	Grating	L/200
	Checker Plates	L/150
	Supporters	L/300
Buildings like warehouses and roofs without crane tracks.	Purlin, Roof coverings	L/200
	Truss girders	L/300
	Wall Arrows	L/300
Platforms, supports for machines with dynamic forces	Supporters	L/500
Crane girder for crane runways lighter version (< 100 KN) also for cantilevered parts		L/800
Crane girder for crane tracks heavier Design (> 100 KN)	Crane girder due to vertical load	V1000
	horizontal deformation due to horizontal joint	V1500
Buildings and halls with Crane runways	Supports at crane runway height due to vertical loads, Wind loads and horizontal impact	H/400

L = span of horizontal beams
H = total height

Support structures for special crane runway designs must be designed in accordance with the requirements of the crane runway supplier with regard to permissible bending and deformation of the supporting structures.

When calculating the deformation of support structures such as apparatus frames, columns or similarly high slender structures, it must be checked whether the values determined meet the operating conditions (to be agreed with the plant engineering) and safety requirements. If necessary, the specified values of the recommended deflections are to be reduced, also under the vibration aspect.

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I.3.2.2.12 Connections

All main connections such as frame corners, connections between main supporting structures and bracings or similar are to be designed as HV bolted connections.

Subordinate connections, such as connections of platform components, purlins, wall ledgers, intermediate beams, railings, stair treads are designed as bolt connections with untreated bolts.

Any welding connections required on site may only be carried out with the approval of the employer.

Unless otherwise required, all bolt connections must be made with at least 2 bolts.

Self-tapping steel bolts must not be used to fasten load-bearing steel structures.

When connecting components that transmit vibration forces, lock nuts type PAL must be used (e.g. support beams of machines, crane beams, beams of trolleys).

Galvanized hexagon head bolts with 2 nuts are to be used for anchoring equipment parts. Unless otherwise specified, these bolts must be supplied by the steel construction supplier.

I.3.2.2.13 Manufacturing of Steel Structures

Material for order-related production

The material supplied should be new and free of defects and should correspond to the specifications made on the fabrication drawings.

Ordering material

The material order must be placed in good time in coordination with the general production program.

Material quality / certificates

The steel construction supplier must request rolling and testing certificates for all steel products and bolts in accordance with the relevant guidelines and regulations. These documents must be available during inspections by the employer and are to be handed over to the employer upon delivery of the steel structures.

Material testing

For materials that cannot be identified correctly, the employer reserves the right to carry out a material test (notch impact, etc.) at the expense of the steel construction supplier.

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Material identification

The contractor shall ensure that the roll identification of all materials is maintained throughout all stages of manufacturing. For steel parts to be galvanized, a suitable marking is selected so that no defects in the galvanizing process occur.

Before starting production, the quality of the material must be checked according to the marking. If steel with different grades is used in a construction, the parts should be identifiable by the markings. .

I.3.2.2.14 Manufacturing

General information

Production must not be started unless the following conditions are met:

- Quality assurance plan approved by the employer
- Workshop drawings approved by the employer
- Welding and testing plans approved by the employer
- Presentation of all rolling and material certificates

All manufacturing operations have to be in accordance with the applicable regulations and the production drawings.

Cutting and Bending

Saw cuts are to be made on sectional steel. For other steel parts, machine cutting or flame cutting may be used, in which case the torch must be guided automatically.

Hands-free flame cutting is only permitted for small cuts.

For bending, a suitable method and appropriate tools must be selected in order to achieve an even arch surface free of cracks and without affecting the static characteristics.

Straightening of warped beams

Bent parts must be straightened by suitable mechanical methods or by local heating.

In the heating method, the temperature must not exceed the limit values specified by the corresponding EN standard.

Holes for bolt connections

The punching of holes for bolts grade 4.6 is permitted if the thickness of the steel is not greater than 10 mm and if the requirements of the rule setters recommend the use of EN 1090-2 are fulfilled.

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For dynamically stressed constructions (crane runway etc.) all holes must be drilled and carefully deburred.

Holes for HV bolts must be drilled. The dimensional accuracy (position and diameter) should meet the requirements of the EN regulations.

Gas or electrical flame cutting of bolt holes is not permitted.

Welding work in the factory

The qualification to weld steel structures is recommended according to the rules setter Application of EN 1090-2.

Before work begins, a detailed welding and testing plan for welding the various structural parts must be drawn up in accordance with the connection details on the factory drawings and in accordance with the EN regulations. The welding and testing plan must contain all information on the type, execution and sequence of the welding work including the welding consumables in accordance with the requirements of the rule setters.

Furthermore, it must contain the requirements of EN 25817 for ensuring the quality of welding work.

Bolted connections

Bolt connections must always be provided as assembly connections.

If bolt connections are designed as factory connections, the following requirements must be met:

- Bolts, strength class 4.6

The contact surfaces are to be made corrosion-resistant as shear/bore soffit connections.

- HV bolts, property class 10.9

The HV bolts are to be used for bending resistant connections.

The shear force transmission (pressure zone) takes place after the shear/furrow connections, which are to be made corrosion-resistant with the contact surfaces.

Non-slip connections may only be used with the written approval of the employer.

HV bolts

HV bolts must be tightened with a torque wrench according to the pre-tensioning forces indicated on the factory drawings.

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I.3.2.2.15 Deliveries

Marking of steel structures

All components and individual parts must be marked.

Additional deliveries

All small parts required for assembly, such as bolts, washers and nuts must be supplied in sufficient quantity plus a reserve, depending on requirements.

Transport

The scope of transport work is determined by contract in each case.

Transport dimensions and weights of prefabricated structural parts are organized by the contractor for the transport to the construction site. Any necessary coordination discussions with the authorities regarding excess length, excess width or heavy load transport have to be conducted by the contractor and he must obtain the necessary permits.

All steel construction parts or individual parts which are delivered "ready for assembly" do not show any twisting, curvature, rolled fibres or other deformations.

I.3.2.2.16 Execution on the construction site

Welded joints

The qualification to welded steel structures according to EN 1993 must be proven.

Samples of the test coupons of the individual welders have to be submitted to the employer or its authorized representative for approval on request.

The welding engineer of the contractor or his authorized representative supervise the performance of the welding work.

All welding residues are abraded.

The slag is removed and the weld has to be cleaned for a coating suitable for the construction site.

Bolt connections

Square washers with an appropriate inclination are to be used under the bolt heads or nuts resting on an inclined flange of a steel construction profile.

When using calibrated torque wrenches for pre-tensioning high-strength bolts, the calibration must be checked at least twice per shift.

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When using non-slip bolt connections, the friction surfaces in the area of the connection must be prepared in the workshop in accordance. The prepared surfaces must be free of rust, dust, paint and other impurities when viewed from the assembly area.

Adjustment work

Correction of minor faults, e.g. reaming of holes and adjustment work, can be part of the normal installation procedure.

Faults that require considerable adjustment must be notified to the employer in advance with a proposal for execution and agreed.

I.3.2.3 Quality Control

I.3.2.3.1 Quality Management

The quality management program is established in accordance with ISO 9000, ISO 9001 and ISO 9002.

A quality management plan must be drawn up for the order and approved by the employer. Furthermore, all necessary certificates of suitability must be provided.

I.3.2.3.2 Checking the Dimensional Accuracy

During and after production, all construction parts must be checked by the contractor for dimensional accuracy and documented in a protocol.

I.3.2.3.3 Dimensional Tolerances

Permissible dimensional tolerances must comply to EN ISO 13920.

I.3.2.3.4 Inspection of Welding Work

General information

All welding work must be checked in accordance with EN 25817.

The contractor shall plan and perform the inspection at the different points in time of the production stages.

The contractor shall grant the employer's inspector access to the factory and provide adequate assistance in carrying out his tasks.

The contractor shall supply all equipment and materials necessary for the inspection of the welding work and shall carry out the inspection work.

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Inspection reports

For each welding test, the contractor shall prepare a report on the test procedure and its results. This report shall indicate possible repairs of welds and refer to the compliance with the corresponding regulations and norms.

I.4 PIPES

I.4.1 General Description

For the execution of welding work, the contractor must present a valid welding procedure qualification. EN 729 must be referred by the welding supervisor.

Pipe welding work may only be carried out by qualified welders with a recognized welding certificate. Piping is delivered with caps.

The determination of the nominal widths of the piping is based on the maximum load case (110 % load) under consideration of the generally applicable guide values for flow velocities.

All pipes, fittings, headers and unions are to be designed by the manufacturer in accordance to the applicable regulations.

The manufacturer must prepare a documentation of the pipeline components, which must include the following documents:

- welding procedure qualification, welding procedure sheets;
- Welding products;
- Material lists;
- Welding seam list;
- Isometrics;
- Certificate of annealing.

The contractor is responsible for ensuring that material mix-ups are excluded, both at the delivery stage and in the workshop and assembly.

The load cases, operating weight, impeded thermal expansion and externally applied displacements must be verified. The elasticity calculations of the systems are to be carried out using recognized calculation programs.

A list of the piping systems must be drawn up.

I.4.2 Rules and guidelines

The design, choice of materials, planning and installation of the pipes are based on the regulations and guidelines in accordance with the state of the art applicable at the time of placing the order.

In particular, the following listed regulations apply to the design, manufacture and installation of the piping system:

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- Pressure Equipment Directive 2014/68/EU;
- AD-2000 rulebook;
- EN 13445;
- EN 13480;
- EN 10216;
- EN 10217;
- EN 10220;
- EN 10255;
- DIN 2413;
- EN ISO 3183.

I.4.3 Construction

The aim is to achieve the best possible use of space in the buildings. However, the later maintenance possibilities of the buildings and plant components must be taken into account. Good accessibility to the plant components must be ensured for assembly, repair and testing work as well as for inspection during operation.

Fittings and measuring points as well as spring-loaded pipe supports must be arranged in such a way that they can be reached and controlled from platforms.

All pipes must be designed in such a way that unrestricted compensation, filling, emptying, venting and drainage are possible. The pipes have to be designed in a self-compensating manner, so that compensation is achieved by corresponding pipe leg lengths. Compensators are only permissible in special cases, to be agreed with the employer and, unless otherwise agreed, to be delivered in a corrosion-resistant design.

The piping systems have to be designed with a slope. The number of drains is minimized as far as possible by suitable routing.

The pipelines must be installed in such a way that they do not stand out from the supports and that they require as little drainage as possible. Changes in inclination due to thermal expansion of the pipelines must be taken into account.

Insulated pipes have to be designed in such a way that the insulation can be installed continuously without interruption by other pipes or apparatus.

When designing the piping, the operating conditions during continuous and intermittent operation as well as during start-up and shut-down of the plant, pressure tests and, if necessary, blowing out of the piping system must be taken into account.

The low points are provided with drains. Venting systems have to be installed at the high points of the piping systems; it must be possible to operate them from platform and building levels.

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All necessary drains and vents must be provided and led to funnels or in drainage channels. The fittings have to be arranged at a user friendly heights on the funnels.

Drains of the steam traps are only allowed to be laid together via a collecting pipe if no disturbances are expected.

The drainage funnels have to be designed sufficiently large in accordance to the requirements and equipped with heavy hinged covers.

Pipelines that convey suspended solids must be equipped with flushing connections. The flushing connections are fitted straight to the product pipe. The shut-off valve for the rinsing water should be positioned as close as possible to the product pipe.

When installing headers, it must be ensured that each line can be shut off individually and that the header has a sufficient number of spare connections.

Wall and ceiling openings for pipelines must be equipped with jacketed pipes or collars. The requirements of fire protection must be taken into consideration. Galvanized steel pipes should be used as casing pipes. In areas exposed to chemicals, suitable materials should be used. In the case of insulated pipes, the protective pipes must be designed larger according to the thickness of the insulation. The pipes must be able to move freely in the wall penetrations.

If there are no drainage pipes on the pumps, they must be retrofitted.

I.4.4 Pipe Materials

Pipes of corrosion-resistant steel must be selected in accordance with EN ISO 1127.

For other pipes, only dimensions which comply to EN 10220 and EN 10255, row 1, and the tolerance specifications defined in EN 10217 and EN 10255 are selected.

In principle, seamless pipes and pipe bends have to be used for all pipelines up to and including DN 500. Welded pipes and pipe bends have to be used for all pipes above DN 500. The longitudinally welded pipes in the water-steam cycle has to meet the requirements of the weld seam evaluation number $v = 1,0$. In the low-pressure range, the use of spiral or helical-welded pipes is permitted.

I.4.5 Pipe Supports

I.4.5.1 General Description

All steel structures are provided with a primer coat. If necessary, the pipe supports can also be attached to the main steel structures by welding. After the welds on the steel structure, the corrosion protection must be perfectly restored.

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Pipe supports must be maintenance-free. All bearing points must be designed in such a way that corrosion and contamination do not cause any inadmissible load deviations even after long periods of operation.

I.4.5.2 Construction

Special attention must be paid to ensure accessibility to all places that have to be accessible to the installation and operating personnel. The clear passage height in service and escape routes is, without exception, a minimum of 2,10 m.

When dimensioning, all expected stresses and strains must be taken into account, such as pressure tests and flushing processes. No inadmissible forces and moments may be introduced into the anchorages and connection components. Impermissible displacements must be prevented by suitable designs.

The support of pipes and valves with thermal insulation must be designed in such a way that the thermal insulation is not flattened.

It must be taken into account that no additional supports are required when installing or removing components (pumps, fittings, etc.) installed in the pipeline.

The spacing of the pipe supports must be planned in such a manner that the pipe sections in between do not sag.

For the transfer of forces into the structure (concrete supports and walls), welded-on plates are always provided by the employer for forces > 40 kN. For forces < 40 kN, the force can be transferred via fixing anchors (dowels) with a certificate of approval.

I.4.5.3 Materials

The contractor shall select the materials adapted to the respective design temperatures of the pipelines, the ambient conditions and the material of the pipelines.

When welding different materials, it has to be ensured that the material pairing is suitable for welding.

The use of galvanized steel for pipe supports is not permitted.

I.4.5.4 Labelling

All pipe supports must be marked with support item no.

Spring hangers and spring supports receive permanently attached type plates with serial no., type / size and nominal load.

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I.4.5.5 Corrosion Protection

For all pipe supports, corrosion protection in accordance to Section I.6 must be used.

The paint must be finished before the pipe support is mounted to the building and the pipe.

I.4.6 Audits

I.4.6.1 General

This section applies to pipes, vessels and all equipment covered by the Pressure Equipment Directive.

All tests and acceptances are always carried out in accordance with the Pressure Equipment Directive. All equipment covered by the directive requires a CE marking.

The contractor shall draw up a list of all pipelines, vessels, equipment and systems for which CE marking is required.

The TIG procedure is prescribed for welding the root. The filling layers can be produced using the TIG or electric arc welding process. DIN 8563, EN ISO 3834, EN ISO 5817 apply to the safety and quality of the welded joints, while EN ISO 9692 applies to the weld joint shape.

After completion of the welded joints, the welder must stamp his welder number next to the weld. The contractor is obliged to keep a welding seam book.

Radiation tests must be carried out in such a way that the assembly work is not hindered. Each welder is protocolled during the weld seam tests.

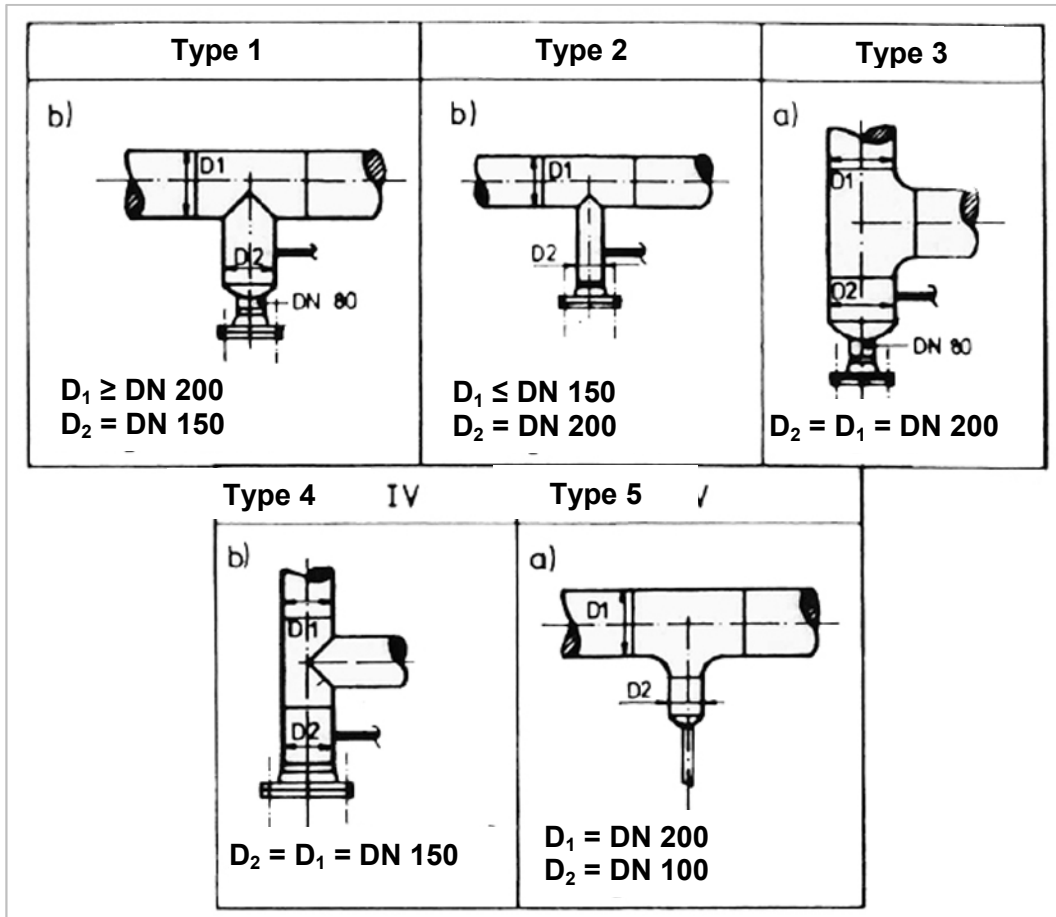
If defects are found during external inspection or by non-destructive testing, these must, in any case, be reported to the authorized inspector and the employer and documented in a suitable manner.

The repair of defects may only be carried out after agreement and joint findings with the authorized inspector and the employer. The repair is performed in compliance with all appropriate measures. No repairs are performed without the approval of the authorized inspector.

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I.4.7 Pipes – Standard Elements

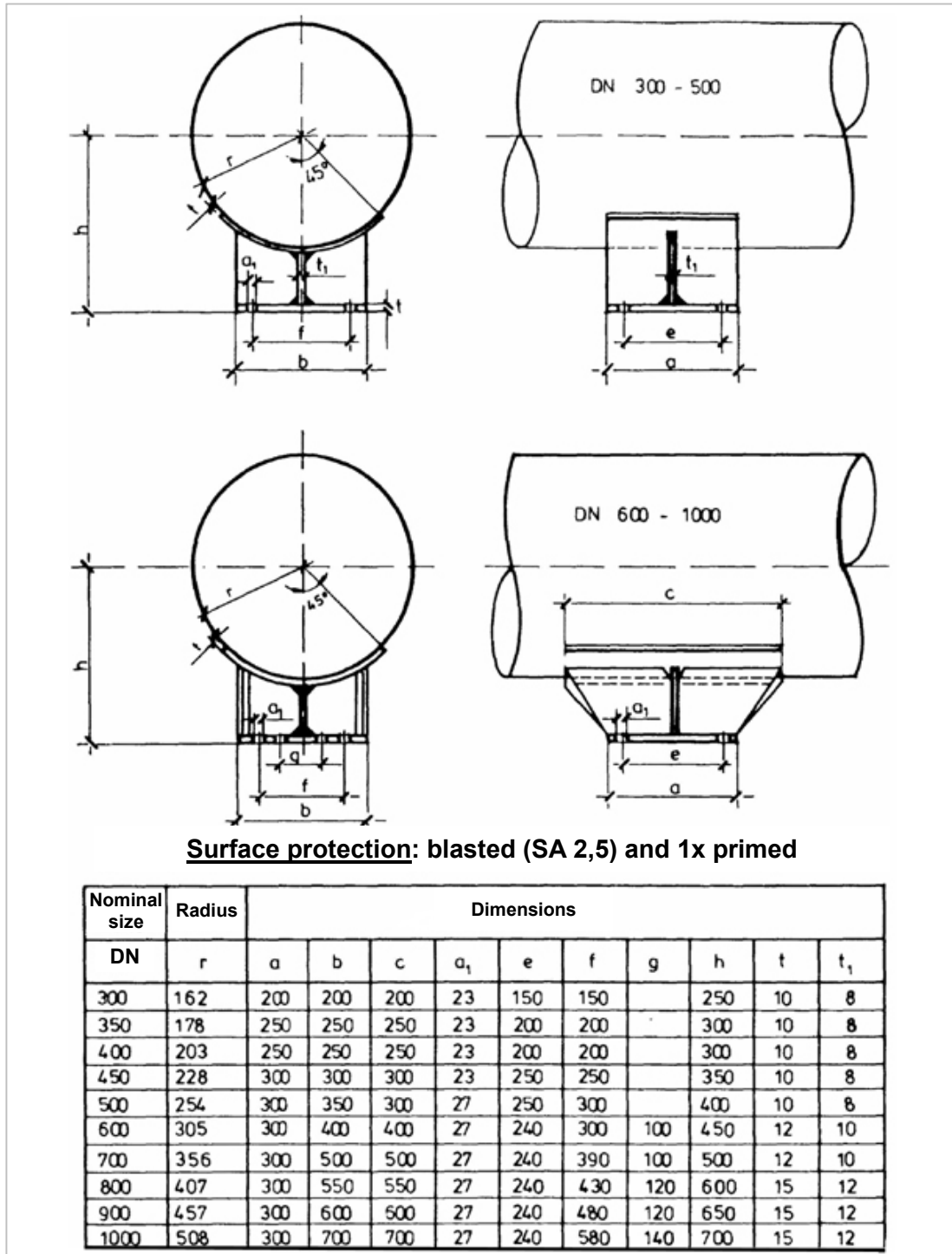
I.4.7.1 Standard Element Condensate Drainage



- a) High pressure steam
- b) Medium pressure steam

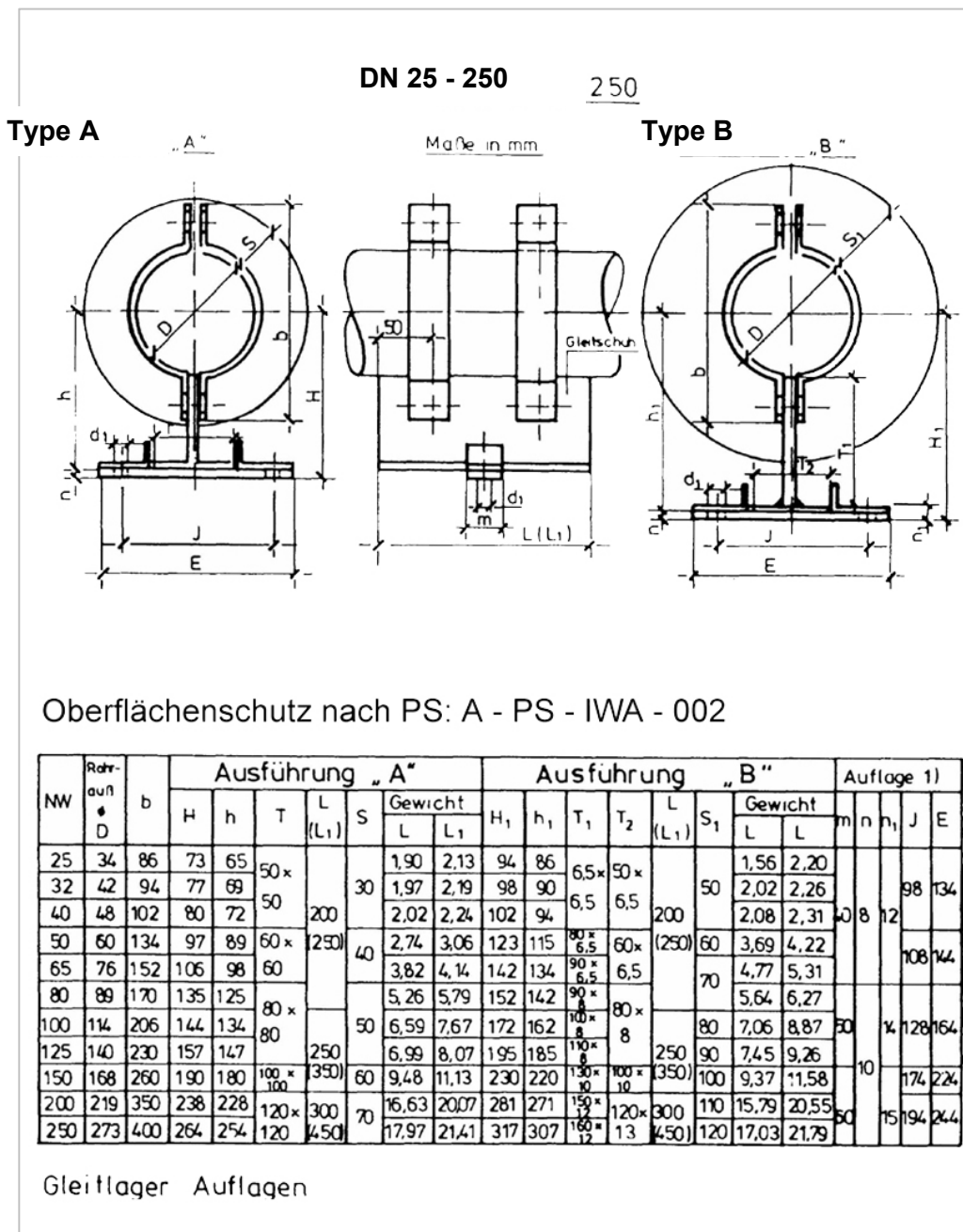
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I.4.7.2 Standard Element Pipe Saddles for Water Pipes



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I.4.7.3 Standard Element Plain Bearing with Guide

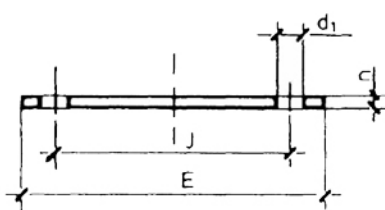


Dimensions in
mm

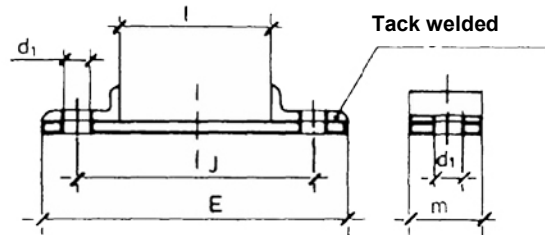
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I.4.7.4 Standard Element Plain Bearing Support

Support without guidance



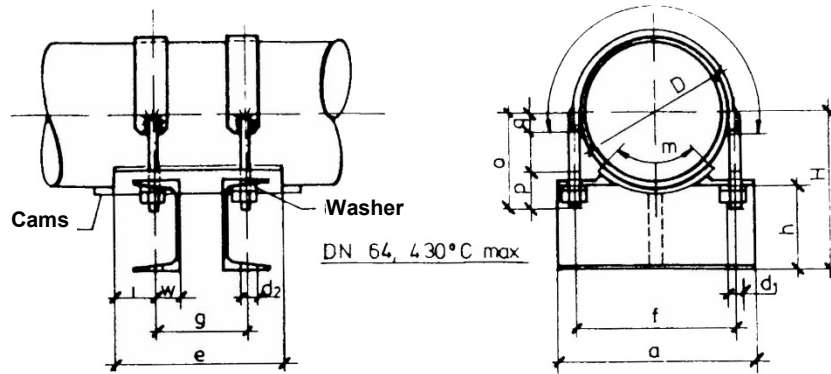
Support with guidance



DN	NW	J	E	d ₁	l	m	n		Bolts	Support	Weight in kg			
									cl	agen	icht	kg		
									DIN EN 10 058 DIN EN 10056 DIN EN 4016	IN 601				
	25	98	134	14	54	40	8	40,8	20-40 4	- M 12	0,34	0,48		
	32													
	40													
	50	64												
	65	108	144		84	50	50-10						0,36	0,50
	80	128	164		104	60	10	60-10			30-60-5	M 16	1,06	1,46
	100	174	224	124										
	125													
	150	194	244	18							1,15	155		
	200													
	250													

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I.4.7.5 Standard Element fixed Point Bearing DN 50-250



Dimensions in mm

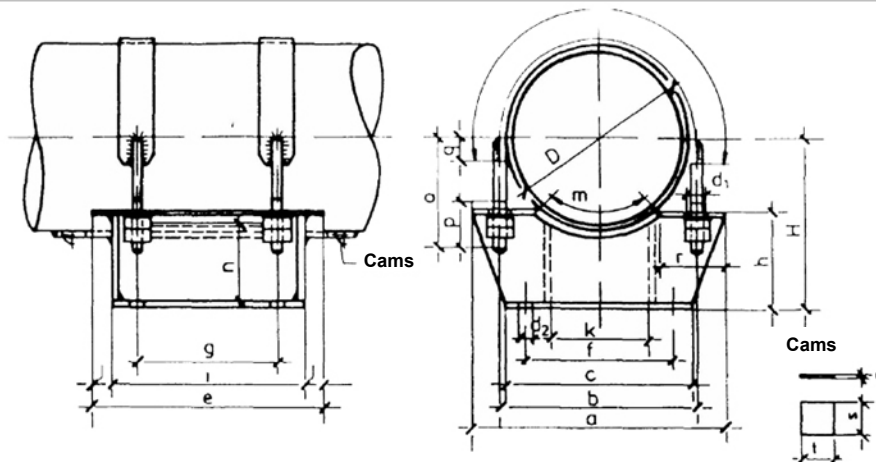
Pipe		Fixed point bearing dimensions															
Nominal size	Outer- ø																
DN	D...	D	a	d ₁	d ₂	e	f	g	h	i	l	m	o	p	q	w	H
	50	60	160	14	14	190	75	140	68,5	25	124	60	50	30	15	25	97
	65	76	160	14	14	190	90	140	68	25	149	70	55	40	15	25	106
	80	89	160	14	14	200	105	140	90	30	169	85	65	45	15	30	135
	100	114	180	18	18	200	130	140	90	30	239	110	80	45	20	30	144
	125	139	200	18	18	200	155	140	90,5	30	248	130	90	45	25	30	157
	150	168	230	18	18	220	180	160	110	30	294	150	110	45	30	30	190
	200	219	300	23	23	250	240	190	130	30	374	200	140	50	30	35	238
	250	273	365	23	23	300	287	240	130,5	30	458	200	160	50	40	35	264

	Pipe		Flat-Steel	U-steel	Metal sheet	Round steel	Hexagon nut	Washer	Bolts	Max Fixed point forces	Weight
	Nominal size	Outer- ø	DIN EN 10 058	DIN EN 10279	DIN EN 10029	DIN EN 10048	DIN EN ISO 4034	DIN 434	DIN EN 4016		
DN	NW	D		 Metal sheet	 tech	 o				N	Kg
	50	60	40 × 5	80	6	12	M 12	14	M 12	2 250	4,1
	65	76	40 × 5	80	6	12	M 12	14	M 12	2250	4,5
	80	89	50 × 6	100	8	12	M 12	14	M 12	2250	6,5
	100	114	50 × 8	100	8	16	M 16	18	M 16	3750	8,0
	125	139	50 × 8	100	8	16	M 16	18	M 16	3750	8,5
	150	168	50 × 10	120	8	16	M 16	18	M 16	3750	13
	200	219	50 × 10	140	10	20	M 20	23	M 20	5500	19,6
	250	273	50 × 10	140	10	20	M 20	23	M 20	5500	23,5

Materials: Flat Steel St37, metal Sheet St00, round steel St37

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I.4.7.6 Standard Element fixed Point Bearing DN 300-500



Dimensions in mm

Pipe		Fixed point bearing dimensions															
Nominal size	Outer- ø																
DN	D	a	b	c	d ₁	d ₂	e	f	g	h	i	j	k	l	m	n	
300	324	445	338	340	27	23	400	260	240	170	320	40	170	589	220	136	
350	355	490	388	400	27	23	400	320	240	191	320	40	200	637	288	143	
400	406	550	439	400	27	23	400	330	240	221	320	50	210	737	322	168	
500	508	564	544	550	33	27	500	450	280	245	400	50	290	917	426	180	

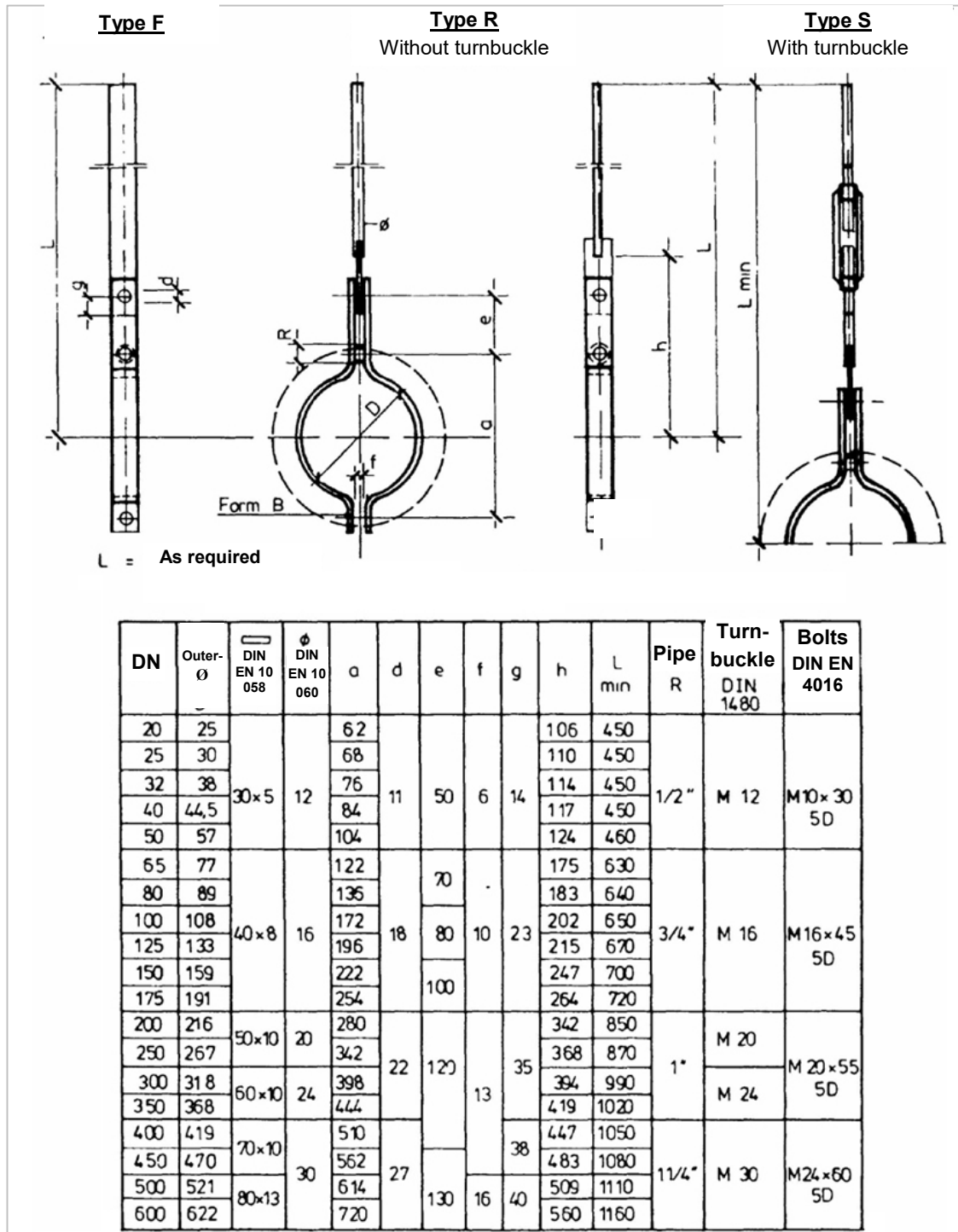
Pipe		Fixed point bearing dimensions															
Nominal size	Outer- ø																
DN	D	o	p	q	r	s	t	u									H
300	324	180	80	40	117	60	60	10									293
350	355	185	85	40	111	60	60	10									319
400	406	210	90	50	125	70	70	10									371
500	508	245	100	60	135	100	100	13									423

Pipe		Flat steel	Round steel	Metal sheet	Hexagon nut	Bolts	Max fixed point forces		Weight
Nominal size	Outer- ø	DIN EN 10 058	DIN EN 10048	DIN EN 10029	DIN EN ISO 4034		With cams	Without cams	
DN	D	φ	o	Sheet			N	N	kg
300	324	60 × 10	24	10	M 24	M 20	7500	39000	45,3
350	355	60 × 10	24	10	M 24	M 20	7500	36000	52,1
400	406	70 × 10	24	10	M 24	M 20	10000	31000	60
500	508	80 × 13	30	12	M 30	M 24	13000	28000	109

Materials: Flat Steel St37, metal Sheet St00, round steel St37

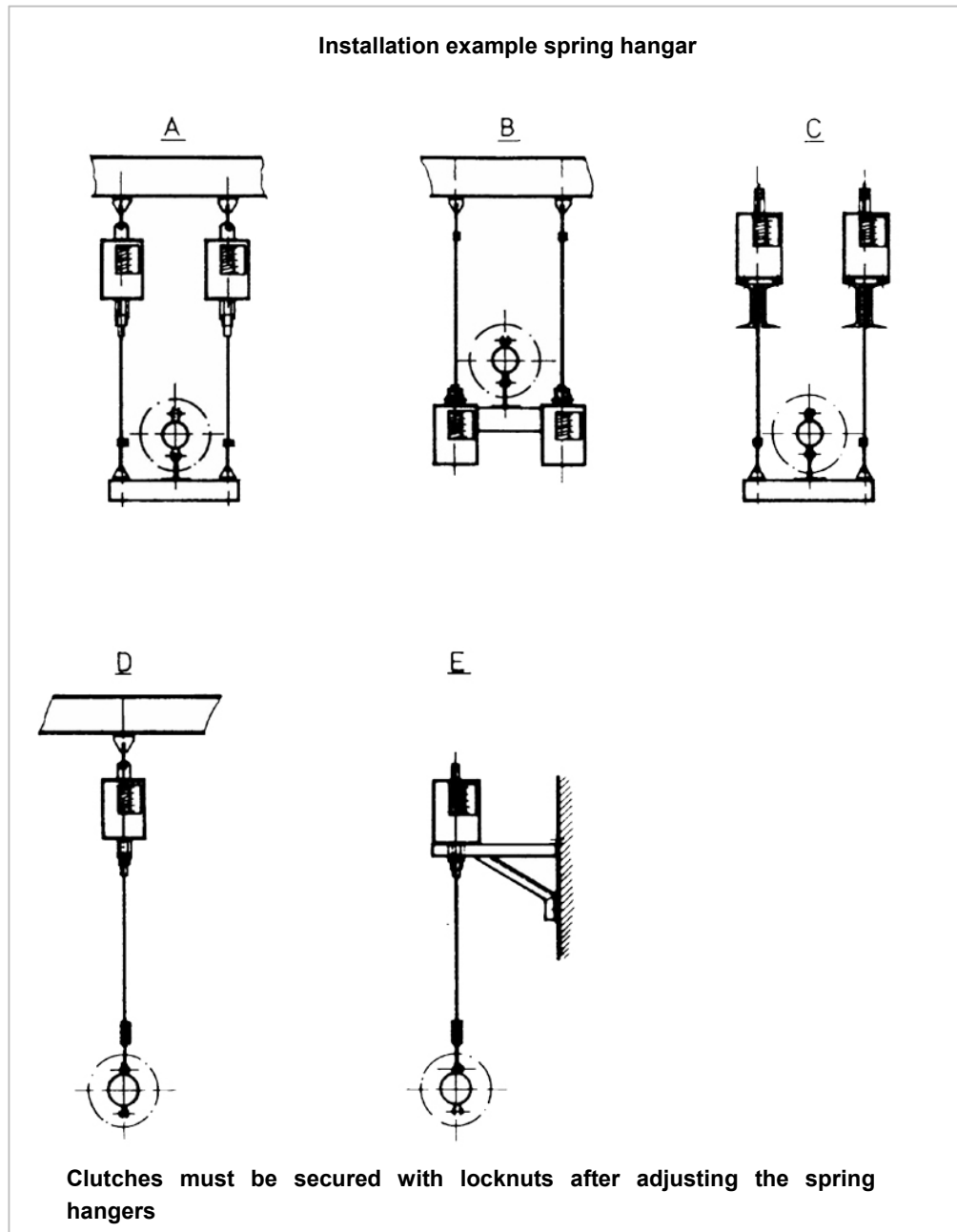
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I.4.7.7 Standard Element Pipes with Insulation Hanging Clamps DN 20-600



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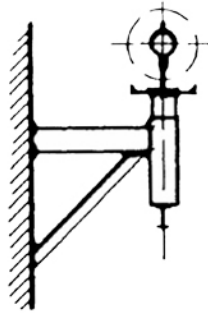
I.4.7.8 Standard Element Spring Hanger



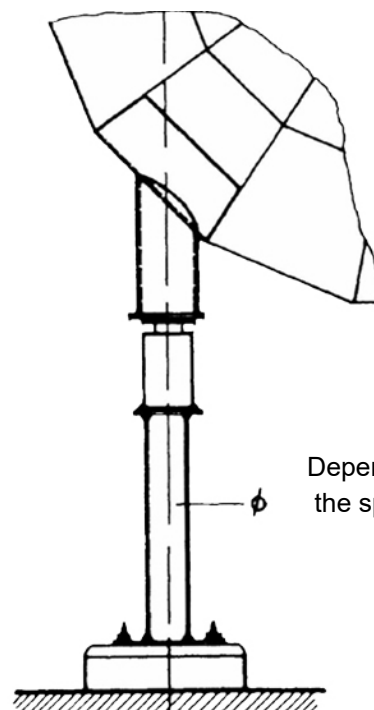
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I.4.7.9 Standard Element Spring Bearing

Installation examples spring bearings



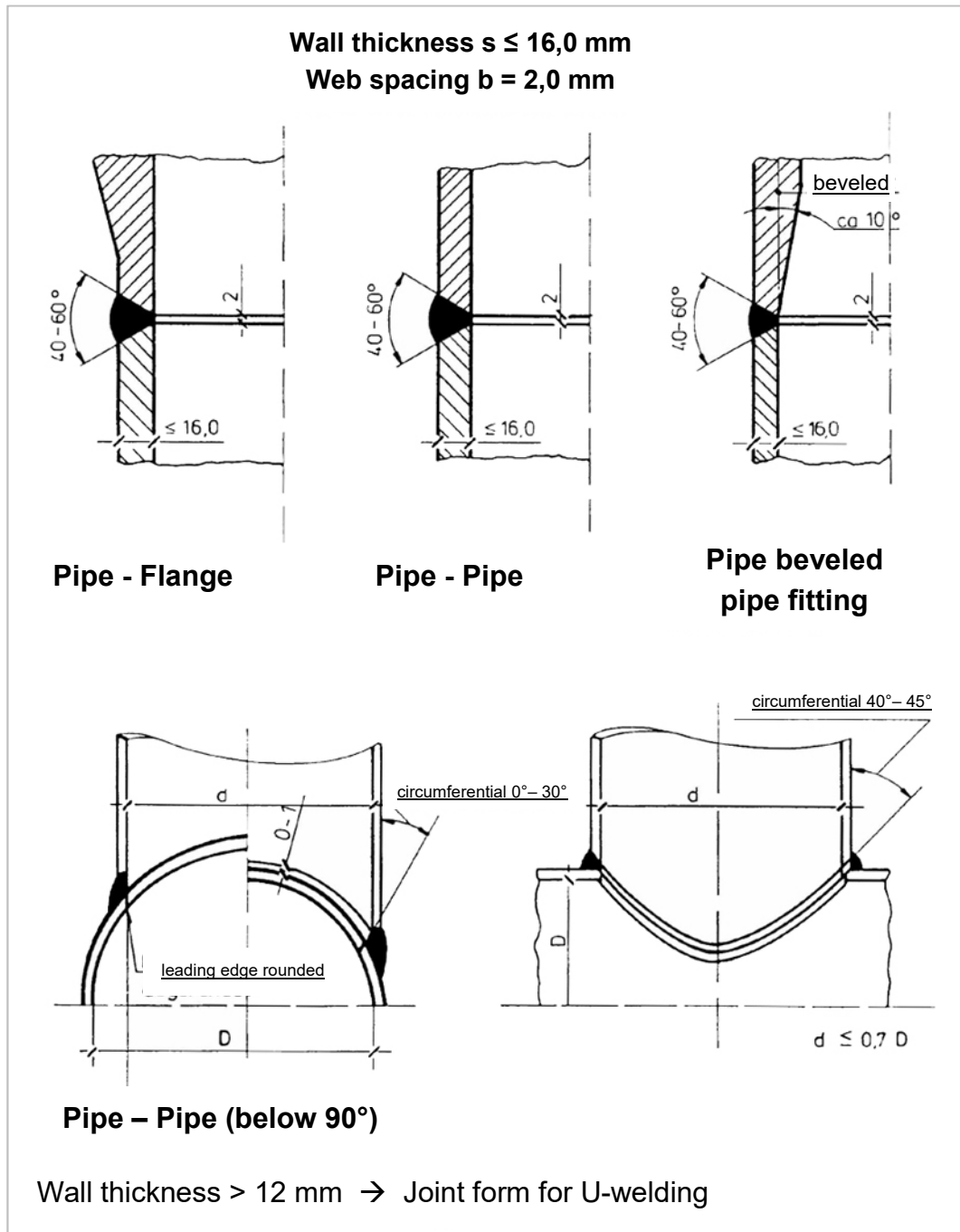
Installation examples spring bearings



Depending on the size of
the spring support

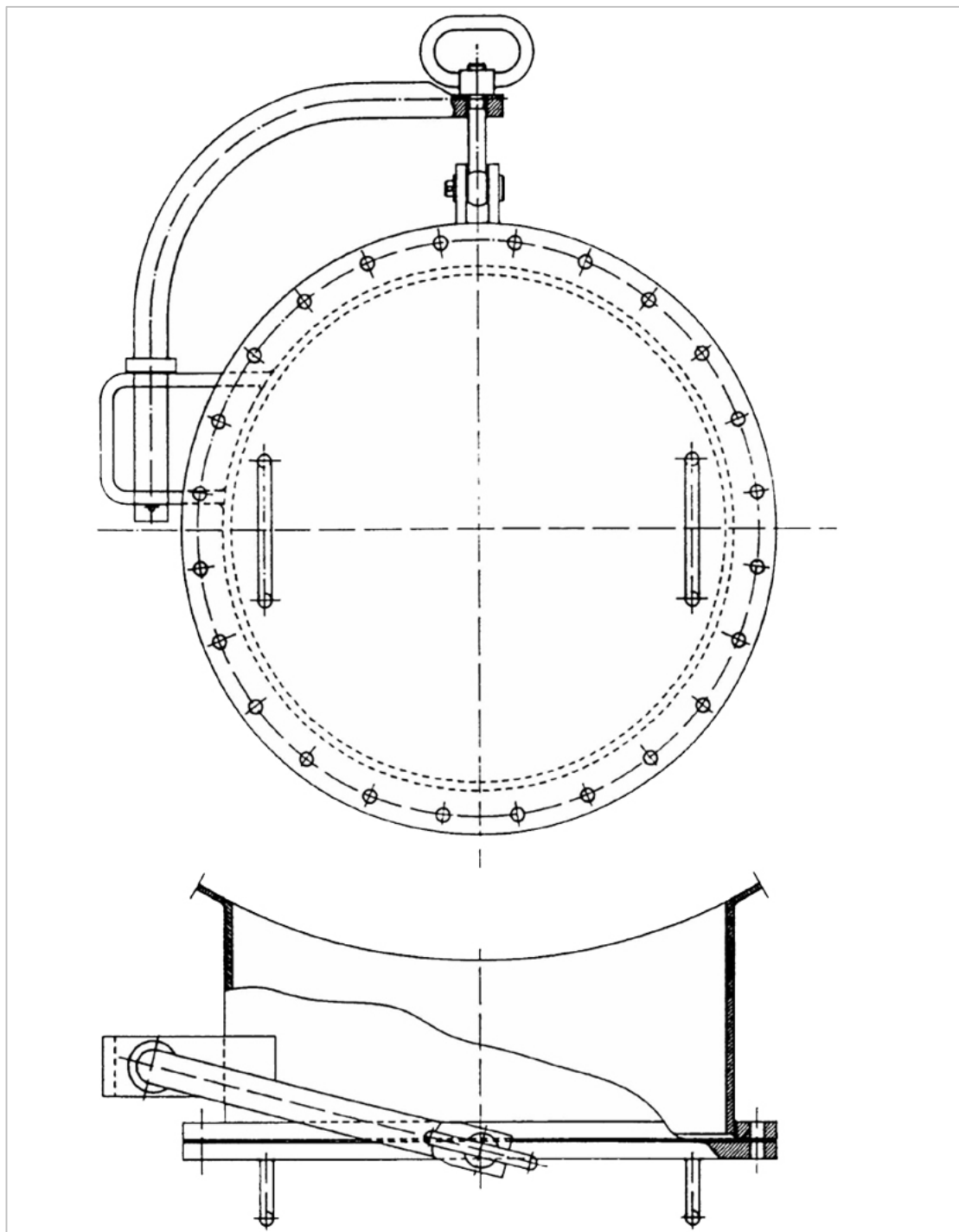
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I.4.7.10 Standard Element shaped Joints for Welds



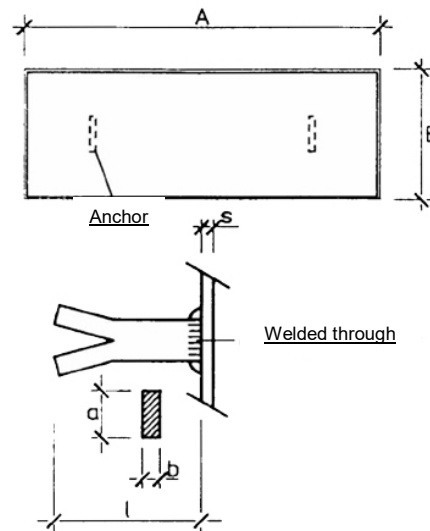
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I.4.7.11 Standard Element Manhole DN 600



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I.4.7.12 Standard Element Weld-on Plates in Concrete Columns and Walls



Material: St37-2

Weld-on plate	Dimensions						Weight kp
	A	B	s	a	b	l	
Type 1	250	100	10	30	5	120	2,28
Type 2	350	150	15	40	8	150	7,05
Type 3	500	200	20	60	10	170	16,08

I.5 VALVES

I.5.1 Nominal Sizes

Nominal sizes and wall thicknesses have to be standardized. The nominal diameters according to EN ISO 6708 have to be used. However, the nominal widths DN 40, 65, 125 and 175 are excluded, unless they are necessary for process engineering reasons.

For valves applies:

- up to DN 50 shut-off valves or check valves;
- for DN 80 and above, gate valves or non-return valves must be used.

In steam and water systems $PN \leq 40$, $> 70^\circ\text{C}$ and from a nominal diameter $DN \geq 350$, butterfly valves with metallic sealing can be used instead of gate valves. The butterfly valves must be leak-proof on both sides according to EN 1266-2.

In cold water systems $PN \leq 40$ and $< 70^\circ\text{C}$ butterfly valves from nominal size DN 100 can be used.

Control valves must generally be coordinated with the employer.

In oil, air, water and gas systems the use of ball valves is permitted regardless of the nominal size.

I.5.2 Corrosion Protection

Valves in buildings can be finished with the standard external corrosion protection coating.

For outdoor valves, **Annex 2** must also be referred.

I.5.3 Maintenance Requirements

It should be possible to maintain the valves with commercially available tools. If special tools are required in exceptional cases, the supplier must specify these in advance.

I.5.4 Design Requirements

I.5.4.1 General Requirements

- Valves are always provided with a straight, not retracted passage, i.e. the seat diameter of gate valves must correspond to the nominal size designation;
- The valves must be closed by turning the handwheel clockwise. This also applies when using primary reduction gear, corridor columns or electric actuators;

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- The circumferential force on the handwheel must not exceed 400 N. If necessary, intermediate reduction gearing must be used;
- The blow-off opening of the pressure relief valve must be arranged in such a way that no personnel can be endangered when the valve responds. If necessary, a blow-off pipe must be provided;
- All valves are equipped with a position pointer indicating the degree of opening or the open/closed position;
- Condensing units must be equipped with a manual shut-off valve upstream and downstream of the condensing unit.

Seals

Only asbestos-free gasket materials may be used.

I.5.4.2 Shut-off Valves

- Shut-off valves $DN \leq 50$ and bypass valves must be equipped with a fixed throttling plug;
- Drainage and venting valves, which are required for start-up and shut-down, are equipped with actuators.

I.5.4.3 Gate Valve

- Gate valves must be designed with external stem and non-rising handwheel;
- Gate valves must be designed with a back seal;
- Gate valves in the nominal pressure stage $PN \leq 40$ must be equipped with a cover flange connection or self-sealing cover connection;
- Gate valves in the nominal pressure stage $PN \geq 64$ must be equipped with a self-sealing cover connection.

I.5.4.4 Non-return Valves

- Swing check valves must be equipped with an internal valve shaft;
- Swing check valves in the nominal pressure rating $PN \leq 40$ must be equipped with a cover-flange connection or self-sealing cover connection;
- Swing check valves in the nominal pressure class $PN \geq 64$ must be equipped with a self-sealing cover connection.

I.5.4.5 Butterfly Valves

- Hand levers on butterfly valves are only permitted up to DN 50. Gearboxes are to be used for valves with DN greater than DN 50;
- The valve body of metal-seated butterfly valves must be provided with cast-on or welded-on stops for the valve disc to prevent the disc from over-revving.

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I.5.4.6 Ball Valves

- Hand levers on ball valves are only permitted up to DN 150. Gearboxes must be used for diameters larger than DN 150.

I.5.4.7 Safety Valves

Safety valves must be coordinated with the Employer.

- Only type-tested safety valves may be used;
- When responding, a sound power level of 120 dB(A) must not be exceeded. A mathematical proof of the sound power occurring must be provided;
- The final inspection of safety valves is carried out in accordance with EN ISO 4126.

I.5.5 Actuators

Pneumatic actuators and control actuators are preferred. Basic equipment:

- Shut-off valve on pressure side;
- Supply air controller/water separator with pressure gauge display and condensate drip tray and manual drain, if required;
- For open-close valves: with contactless limit position switches;
- For control valves: Positioner 4-20 mA input, 4-20 mA signal from positioner, limit switches.

The mounting parts are located near the valve, preferably on the lantern piece. The fittings are to be delivered and installed completely and ready for operation, including hoses and accessories such as vents, check valves, silencers.

The following actuators must be used:

I.5.5.1 Actuator with Diaphragm

Pneumatic actuator must be used for automatic operation for control valves. It must have a robust construction with internal springs for opening and closing. The actuator allows the attachment of positioners or limit switches, with travel indicator. Spring to open and close is required.

I.5.5.2 Rotary Actuator

Single or double acting rotary actuator with robust construction has to be employed. Internal springs, as required are to be installed. The actuator allows the attachment of positioners or limit switches.

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I.5.5.3 Piston Actuator, Linear Actuator

Double acting or single acting (FO, FC) piston or linear actuator, as required, should be used. The actuator allows the attachment of positioners or limit switches. Internal springs, as required, should be provided.

I.5.6 Materials

Permissible materials for fittings:

- Cast iron fittings are not permitted;
- Only tough materials are permitted for handwheels and hand levers.

I.5.7 Inspections and Approvals

I.5.7.1 Leakage Test

The permissible leakage rates are according to EN 1266-2. The final inspection must be documented with a EN 10204-3.1 certificate.

I.6 CORROSION PROTECTION

I.6.1 General

In addition to the normal environmental conditions, the sewage sludge sector has several special requirements regarding corrosion protection.

- A corrosive environment can be caused in particular by the following substances:
 - Dissolved chlorides, especially at higher temperatures ($> 40^{\circ}\text{C}$) and in the water-air regime;
 - Hydrogen sulfide H_2S ;
 - Acidic condensates with very low pH values (< 1);
- Corrosion protection can be achieved by the application of coatings as well as through the selection of corrosion-resistant materials;
- In addition, care must be taken to ensure that plant components are designed and processed in accordance to the corrosion protection requirements. Basic rules on design are laid down in EN ISO 12944-3;
- Plants and plant components must always be designed in such a way that no water remains on surfaces, corners, etc.;
- Types of surfaces and surface preparation are regulated in EN ISO 12944-4;
- Very good experience has been gained with the DB Iron Mica coating system in the sewage sludge sector;
- EN ISO 12944 applies to the coating work in principle, unless higher quality versions are specified for the individual case.

I.6.2 Equipment in contact with Sewage Sludge

For the above mentioned aspects any equipment in direct contact with sludge must be made of stainless steel 1.4541 or better.

This affects in particular the following components:

- Conveyors;
- Dryer;
- Crane components.

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I.6.3 Scope of Application

The present specification applies to the preparation, execution, monitoring and acceptance of coating work on corrosion-endangered plant components made of unalloyed and low-alloy steel.

Parts made of high-alloy steel are not coated.

I.6.4 Applicable rules and standards

- EN ISO 12944-1 to 8 Corrosion protection of steel structures by coating;
- EN ISO 1461 Corrosion protection by hot dip galvanizing.

I.6.5 General Regulations

Weld seam preparation:

in the workshop:

- Mask the weld seam area on both sides of the weld seam edge over a width of approx. 5 cm;
- Apply the primer coating in the nominal layer thickness up to the masking edge (leave the cover in the weld seam area);
- Apply the first top coat only up to approx. 20 cm on both sides of the weld seam edge. each further coat should be set off by approx. 5 cm from the edge of the previous one.

on the construction site:

- remove masking completely before welding;
- remove weld spatter and scale after welding;
- in the area of the welding seams, including the combustion zones on both sides, the surface condition is to be brought to the agreed standard degree of purity and the coating is to be applied according to the system structure.

Sealing surfaces must be covered in a suitable manner before coating.

The required layer thicknesses are defined as nominal layer thicknesses according to EN ISO 12944-5.

The **coating build-up** is to be indicated by clearly distinguishable colour shades of the individual layers.

Painting and airless spraying are suitable as **application methods**; in addition, rollers are also permitted for the 1st and 2nd top coats.

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Repair and completion work on damaged coatings at the construction site has to be carried out with the coating materials specified in **Annex I.8.2** and **Annex 3**.

Connections between metals with different electro-chemical potentials should be avoided, especially between connections of small-surface parts made of less noble materials and large-surface parts made of more noble materials. If these connections cannot be avoided, insulating intermediate layers must be provided (coatings, intermediate layers of UV-resistant plastic).

I.6.6 Surface Treatment

Rust removal according to the condition of the substrate:

- Degree of preparation Sa 2, according to EN ISO 12944-4 the photographic reference samples in the "Informative supplement to ISO 8501-1" serve as comparison
- Degree of preparation Sa 3, if required by the manufacturer's instructions, e.g. heavy corrosion protection
- Degree of preparation PMA, for small-scale repairs by machine processing
- Required peak-to-valley height according to ISO 8303 "medium" or, in the case of heavy corrosion protection, according to the manufacturer's processing instructions.

Free blasting after installation must be avoided with regard to the environment and already existing plant components. Unavoidable blasting work on the object must be carried out dust-free (Vacublast method, suction, other protective measures, suitable low-dust blasting agents).

I.6.7 Coating of Equipment

I.6.7.1 Pipes

Pipelines are supplied with a primer coating in accordance with **Annex** or **Annex ..** On the construction site they are cleaned and provided with a complete coating according to **Annex** and **Annex** . If the pressure test is carried out after coating, the welds must be masked and recoated afterwards

I.6.7.2 Valves

Valves are delivered to the construction site with a primer coating according to the manufacturer's standards, which is compatible with top coats according to Annex or compatible. The coating is completed on site according to **Annex** and **Annex** The Contractor is obliged to deliver the manufacturer's standard or the data sheets of the coating material from the manufacturer with the shipping documents to the construction site.

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I.6.7.3 Pipe supports

Pipe supports must be supplied with a primer coating according to with **Annex 2** and **Annex 3**. On site, the pipe supports are completed according to **Annex 2** and **Annex 3**, in the same colour as the associated piping, as required.

I.6.7.4 Appliances

Appliances are delivered with a primer coating according to **Annex 2** and **Annex 3**. After installation on site, the damage is repaired and, where necessary, the coating is completed.

I.6.7.5 Coldbox, Appliance Steel Construction, Technological Steel Construction

The coldbox (insulation coating), the appliance steel construction as well as the technological steel construction made of structural steels EN 10025 have to be produced in the workshop with a primer coating according to **Annex 2** and **Annex 3**. The complete top coat, according to **Annex 2** and **Annex 3**., is applied on the construction site after completion of the installation.

I.6.7.6 Hot-dip Galvanized Steel Components

Hot-dip galvanized steel components such as gratings and stair treads must be delivered to the construction site in accordance with ISO 1461 with a Zn layer thickness of approx. 70 µm, depending on the thickness of the steel components. They remain without additional coating.

Galvanized bolts and nuts M 6 to M 33 with a zinc layer thickness of at least 40 µm are to be used as connecting elements.

At the construction site, the drill holes, cut edges, assembly welding seams etc. are coated with ethyl silicate zinc dust. The layer thickness of the dried coating is at least 80 µm.

I.6.7.7 Coating for Machinery including Agitator Drives, Pumps, Motors and Fans

Machinery including agitator drives, pumps, motors and blowers are supplied with the manufacturer's standard coating. The coating is applied with a total coating thickness according to **Annex 2** and **Annex 3**.

The data sheets of the coating material manufacturer have to be attached to the acceptance reports.

I.6.7.7.1 Electrical and Instrumentation Equipment

Electrical and instrumentation equipment has to be supplied with the manufacturer's standard coating. This standard coating must be suitable for the climatic conditions during transport and the stress of the installation site.

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Steel components for instrumentation and electrical equipment, such as cable trays, fastening parts and cable protection pipes (above ground), are supplied as hot-dip galvanized components in accordance with EN ISO 1461.

The thickness of the zinc layer is

- for an outdoor load: 70 – 80 µm
- at a load in the interior: 40 µm

These parts remain without any additional coating.

I.6.7.8 Equipment with high Surface Temperatures

The coating of plant components with high surface temperatures is carried out in accordance with **Annex 2** and **Annex 3**.

I.6.8 Coating systems

The coating materials and systems are selected in accordance with EN ISO 12944-2 for a load in the corrosively category C3 (indoor installation) or C 5-I (outdoor installation) depending on the place of application in the factory.

Annex 2 and **Annex 3** contain coating systems for indoor and outdoor installations respectively.

I.6.9 Transport, temporary Storage, Repairs on Site

During transport, the coatings must be protected from damage by suitable slings. Damage to the coating during interim storage must be avoided by placing wood or other suitable materials underneath or between the coatings.

Damage caused by transport and installation must be repaired on the construction site according to the data sheets of the coating material manufacturers.

Before repairing the mechanical damage and any rust spots on the primer coating at the construction site, the surface must be treated by manual rust removal up to purity level PSt 3 according to EN ISO 12944-4. Dirt and deposits must be removed before applying the next coat.

The galvanised surfaces are repaired with 1-component ethyl silicate-zinc dust primer 80 µm.

I.6.10 Quality Assurance and Corrosion Protection

I.6.10.1 Quality Assurance

The contractor shall carry out all necessary quality controls for quality assurance of the surface treatment and coating by qualified personnel using suitable testing equipment. The quality

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controls are carried out by qualified personnel certified by a recognized body, the requirements of EN ISO 12944-7 shall apply. The tests described below are carried out by the contractor during the work processes of surface treatment and coating.

I.6.10.2 Audits

Tools

The following calibrated tools are used for audits.

Table 2: Audit Tools

Audit type	Tools
Roughness grade	Roughness comparison samples, roughness depth measuring device (ISO 8503-4), or visual inspection (magnifying glass)
Degree of purity of the blasted object	ISO 8501-1 and 2 or ISO 12944-4 (photo comparison)
Measurement of ambient conditions (air temperature, object temperature, relative air humidity)	Thermometer, hygrometer, dew point calculator
Wet film thickness measurement	Wet film thickness gauge
Visual inspection of the coated object (completeness, uniformity, colour, covering power)	
Dry bed thickness measurement	ISO 2808, magnetic induction or eddy current dry bed measuring instruments

Coating Thickness Control

Only magnetic-inductive or eddy-current instruments are permitted for measurements of the coating thickness (dry coating thickness).

The required nominal layer thicknesses are achieved if individual values of the dry layer thicknesses do not fall below 80% of the nominal layer thickness and the mean value of the measurement results at least reaches the specified nominal layer thickness. The maximum layer thickness shall not exceed three times the specified value.

It must be assured that the thickness of zinc dust coatings of 140 µm (or the maximum thickness specified by the coating manufacturer) is not exceeded due to the risk of cracking.

I.6.10.3 Control surfaces

Creating Control Surfaces

In order to determine any possible causes of damage to the coatings, the contractor shall create so-called control surfaces before starting the actual coating work. These control surfaces are

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used to assess the functionality of the coating under normal stress. The control surfaces are to be marked according to EN ISO 12944-7 (frame and inscription - K-) and their position has to be recorded in the "as-built" drawings of the corresponding equipment.

Number of Control Surfaces

The number of control surfaces depends on the size of the object and the number of coating systems used.

For objects > 100 to 500 m² one control surface is required, for objects > 500 to 2.000 m² two to three control surfaces are required. The number of control surfaces for other object sizes has to be determined according to Annex A of EN ISO 12944-7.

For each coating system, control surfaces are created according to EN ISO 12944-7 Table 2.

I.6.10.4 Acceptance

Acceptance by the contractor

The contractor has to inform the employer 10 days before the planned acceptance and the decision of participation is up to the employer.

Acceptance on the construction site

Components which are delivered to the construction site with a manufacturer's coating must be checked immediately after their arrival at the construction site. If the manufacturer's coating does not provide a workable surface for the subsequent top coats, it must be completely removed and replaced with a suitable primer coating.

The results of all acceptance tests are recorded in acceptance reports.

The control surface protocols according to EN ISO 12944 is handed over to the employer as originals.

I.7 INSULATION

I.7.1 Design and Layout of the Insulation

I.7.1.1 Design of the Thermal Insulation

In general, external insulation must be designed for an outside temperature of -15 °C.

Thermal insulation must be provided for media with an operating temperature above 60 °C and/or when cooling is not desired for process-related reasons.

The maximum surface temperature of the thermal insulation in the building must not exceed 60 °C at an ambient temperature of 40 °C, measured at a distance of 1 meter (excess temperature = 20 K) and 0 m/s wind speeds.

Thermal bridges must be avoided.

The insulation thicknesses must be determined by the contractor on the basis of the operating temperatures specified for the systems, the external pipe diameter, the ambient temperature, the wind speed and the thermal conductivity of the insulation material, taking into account the permissible average heat flow density of 120 W/m².

If no specifications for the ambient temperature are specified, an ambient temperature of 20 °C is assumed when designing the insulation. For cold insulation, the relative air humidity must be taken into account.

The calculation proofs become part of the quality documentation. At the request of the employer, tested structural statics for the insulation is handed in for specified plant components. Any possible site-specific requirements are taken into account. All thermal insulation has to be provided with coatings.

I.7.1.2 Insulating Materials, Requirements

The insulation materials must be structurally strong, low in alkali, rot- and vermin-proof as well as dimensionally stable under the influence of heat, aging and temporary moisture penetration. They must be completely free of impurities, especially iron parts, and not chemically corrode the material of the insulated parts in any way. Insulation materials must be chemically neutral, non-corrosive in combination with metal, non-combustible according to EN 13501-1, highly elastic, non-hygroscopic, dust-free and vibration-damping, resistant to water vapor and alkalis and comply with building material class A1 (EN 13501-1).

Only mineral fibres which have a carcinogenicity index of KI 40 according to TRGS 905 and TRGS 906 or a fibre half-life of 5565 days in the bio-solubility test according to the German

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Ordinance on Dangerous Substances, Annex V, is to be used. The insulating material must be marked with ("KI value > 40" or "sufficient bio-solubility").

The use of materials containing asbestos is strictly prohibited.

Mineral fibre mats with a gross density of approx. 80 kg/m³ and an admissible temperature of at least 620 °C (DIN 52271) must be used.

For austenitic plant components, mineral fibre mats quilted on stainless steel wire mesh are to be used. The chloride ion concentration must not exceed the value according to AGI-Q 135. The marking on the label should follow AGI-Q 135.

It must be ensured that the thermal conduction coefficients of the insulating material on the insulated part are not exceeded with a tolerance of +5 % at the specified bulk density.

Table 3: Conduction coefficient values

Average Temp.	50°C	100°C	150°C	200°C	250°C	300°C
Laboratory Values (W/mk)	0,041	0,047	0,054	0,064	0,075	0,088
Operating values without bars (W/mk)	0,040	0,045	0,055	0,065	0,075	0,090
Operating values with bars (W/mk)	0,043	0,049	0,059	0,070	0,081	0,097

I.7.1.3 Covering - Sheet Metal Coatings

Galvanized bolts must be used for hot-dip galvanized sheet steel. For aluminium sheets, aluminium-zinc sheets and austenitic sheets, stainless steel bolts must be used.

For outdoor sheet metal coatings, rust-proof stainless steel bolts with rust-proof stainless steel sealing gaskets (neoprene sealing gaskets) must be used.

If gaskets are required for sheet metal coatings, they must be permanently elastic. These seals are necessary in outdoor areas and in areas where wet cleaning is done.

Due to their better resistance against corrosion, jackets made of aluminium or aluminium-zinc sheet metal have to be used for pipelines that are installed outdoors.

Unless corrosion protection reasons speak against it, jackets made of galvanized sheet steel have to be used for pipes installed indoor to minimize the insulation thickness.

I.7.1.4 Protection against accidental Contact

The employer shall provide protection against accidental contact where the surface temperature on the object is > 60 °C at normal working temperature or where a surface temperature of > 60 °C can occur on temporarily operated objects (e.g. blow-out pipes on safety valves) and

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the objects are accessible from surfaces intended for access (platforms, catwalks, stairways, etc.) or fixed ladders. Objects are considered accessible if their distance from the mentioned traffic areas or fixed ladders is less than 2.500 mm vertically and/or 1.000 mm horizontally.

The contact protection is usually designed as thermal insulation. In individual cases, the employer can decide to use a perforated sheet metal casing (without insulation material) instead of thermal insulation, e.g. on blow-out pipes, drainage, ventilation or as large-area contact protection on apparatus, steam generator components, etc. in the area of accessibility.

I.7.1.5 Cold insulation, Insulation to prevent Condensation

The insulation is designed according to the criteria for preventing condensation. The special ambient conditions in the respective plant must be taken into account.

I.7.1.6 Start of the thermal Insulation Works

No object is isolated before a successfully completed pressure test. The approval to install the thermal insulation is given by the employer or his site management.

I.7.1.7 Storage and Moisture Protection

All materials required for thermal insulation must be stored absolutely dry. The reuse of insulation materials that have become damp is not permitted.

The materials must be protected from dirt and damage. Material fibre bundles must be stacked vertically to prevent them from being compressed.

If the thermal insulation is applied to outdoor system parts and the surface protection cannot be installed immediately, the insulation must be protected against moisture by suitable materials (foils).

I.7.1.8 Plant Protection

Electrical cables and motors are not located inside the thermal insulation.

A reduction of the insulation thickness to electrical lines and other temperature sensitive plant components is only permitted with the express consent of the employer or the construction management.

I.7.1.9 Contact Corrosion

To prevent electrolytic contact corrosion, a separating layer of stainless steel must be provided at all points of contact between, for example, the aluminium sheathing and the supporting or load-bearing structure made of steel.

I.7.1.10 Thermal Expansion of the Plant Components

If the thermal insulation touches other parts of the plant, platforms, beams or similar, it must be recessed or flattened to prevent damage to the thermal insulation, due to thermal expansion.

I.7.2 Assembly of the different Insulation Materials

I.7.2.1 Insulating Materials

The assembly is executed according to DIN 4140 and EN 14303.

For horizontal pipelines and horizontal components, the edges of the insulation mats should be at the lower half of the perimeter.

The applied insulation mats must be secured in their position against slipping. For horizontal objects this is done by clamping with galvanized hooks (6 pieces per meter). Vertical objects have to be wrapped with a galvanized 20 x 1;0 mm tension band (4 bands per metre) in addition to the clamping, for diameters > 1000 mm.

Long-fibre mineral fibre mats, stitched to galvanised wire mesh on one side, in thicknesses from 30 to 120 mm are to be used. Large insulation thicknesses are to be applied in several layers.

Table 4: Execution of the insulation layers

Insulation Thickness	Number of Layers
<120 mm	One layer
>120mm – 240mm	Two layers

In the case of the multi-layer design, the insulation mats must be installed with staggered joints on all sides at the joint seams.

In the case of multi-layer insulation, they must be fixed by stapling each layer of insulation. For vertical objects, the last layer must always be wrapped with additional tensioning straps.

The wire mesh of the mineral fibre mats and the mat hooks for the attachment have to be made of galvanised, temperature-resistant material (EN 10223-2); in case of austenitic supports, wire mesh and mat hooks made of austenitic material have to be used.

I.7.2.2 Stuffed Insulation

Stuffed insulation, with the same quality of the subsequent mat insulation, may only be used where the installation of mats is not possible, e.g. hollow spaces. The insulation material must be brought to a density that prevents it from settling afterwards.

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I.7.2.3 Shaped Shells

Pipe shells with an AS quality in accordance with AGI Q 135, e.g. G+H Isover IS -1, Rockwool 880, Paroc PTR or equivalent, can be used.

I.7.2.4 Supporting and Bearing Structures

The use of uninterrupted bars of stainless steel is only permitted after consultation with the employer. In the case of austenitic pipelines, the webs must be made of stainless steel.

Suitable braces which completely fulfil their function are used as supporting structures. Steel strip with dimensions of at least 30 x 3 has to be used for webs and support rings. Ceramic stays are not permitted.

Vertical tanks and pipelines must be provided with a supporting structure of supporting rings at intervals of max. 3,5 m to prevent the insulation from collapsing. The thermal insulation can also be installed from the pipe support; the sheet metal jackets are then placed on S-hooks and provided with sufficient sliding seams at appropriate distances.

For pipes installed outdoors, the support ring must be interrupted by approx. 100 mm at its lowest summit in order to drain off the precipitation or condensation water. The ends must be bent inwards.

Welding of any kind on the components to be insulated is prohibited.

Horizontal Pipes

Supporting structures must be provided for pipes < DN 80 and an insulation layer thickness > 60 mm, for DN 100 and an insulation layer thickness > 50 mm and from DN 125 with an insulation layer thickness > 40 mm.

Vertical Pipes

Supporting structures and brackets on vertical pipes should only be provided if the pipes to be insulated are longer than 5,0 m. In this case the rings are spaced 3,5 m apart. They are to be attached to the pipes using pipe clamps.

I.7.2.5 Thermal Insulation on Straight Pipes

For straight pipe sections > DN 25, the thermal insulation is always provided with mats (shaped shells only after consultation with the employer).

I.7.2.6 Coatings

The insulating mats in the building are provided with heat insulation coatings made of aluminium sheet AlMgMn (seawater resistant) material 3.3528 with a firmness of 23 kp/mm², medium-hard, EN 573-3, material documented by certificate.

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The outdoor insulation mats are provided with a seawater-resistant aluminium coating made of AlMg2Mn0.8 F22 (EN AW 5049) according to DIN 4140 on all sides.

The bolts must be made of stainless steel according to DIN 4140, such as 1.4305 according to EN 10088-3 (design with stainless steel washers).

The design of step-resistant coating areas must be coordinated with the employer in each individual case.

I.7.2.7 Removable Insulation Caps

Design according to DIN 4140, point 8.2. All valves, steam-converting valves, strainers, flanges, inspection openings, manholes and compensators are provided with removable insulation caps. The insulation caps must be designed for transport in handy pieces (max. 25 kg).

I.7.2.8 Removable Insulation for repetitive Inspections

On welds where repetitive inspections are required and on expansion measuring points, easily removable insulation must be provided and marked accordingly.

A permanent, clearly visible marking with clear assignment to the list provided by the contractor is made for the removable parts.

I.7.2.9 Cut-outs for Type Labels, Nozzles and Lugs

Type labels and other markings must remain visible. They must be prepared and designed with inserts.

I.7.2.10 Drainage and Venting Pipes

The pipes are insulated until and including the first shut-off valve. If necessary, a contact protection insulation is applied afterwards.

Drain and vent valves must be insulated in such a way that the blind cover remains free and the bolts can be replaced. Venting bolts remain free.

I.7.2.11 Expansion Joints

Compensators are equipped with a removable insulation cap. They have to be insulated in a way that the distance between the insulation and the compensator does not exceed 60 mm. An internal austenitic sheet metal must be added to protect the joints (joint expansion joints). The protective sheet metal may not touch the compensator shafts. The expansion of the compensator should not be blocked by the use of stuffed insulation material.

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I.7.2.12 Instruments and Vessels

Hand and manholes have to be equipped with an easily removable and reusable cover.

The thermal insulation of the vessels shall generally be provided by mats which are firmly wrapped around the vessel shell and fastened with galvanized steel straps. The butt joints have to be sewn with wire.

I.7.3 Contact Protection, Condensation Water Insulation

I.7.3.1 Touch Protection

Ventilation, drainage and blow-out pipes etc. are only equipped with thermal insulation in the area of stages, stairs, service corridors etc. to protect the operating personnel. The minimum insulation thickness is 30 mm. The distance between railing and piping must be at least 100 mm.

I.7.3.2 Condensate Water Insulation

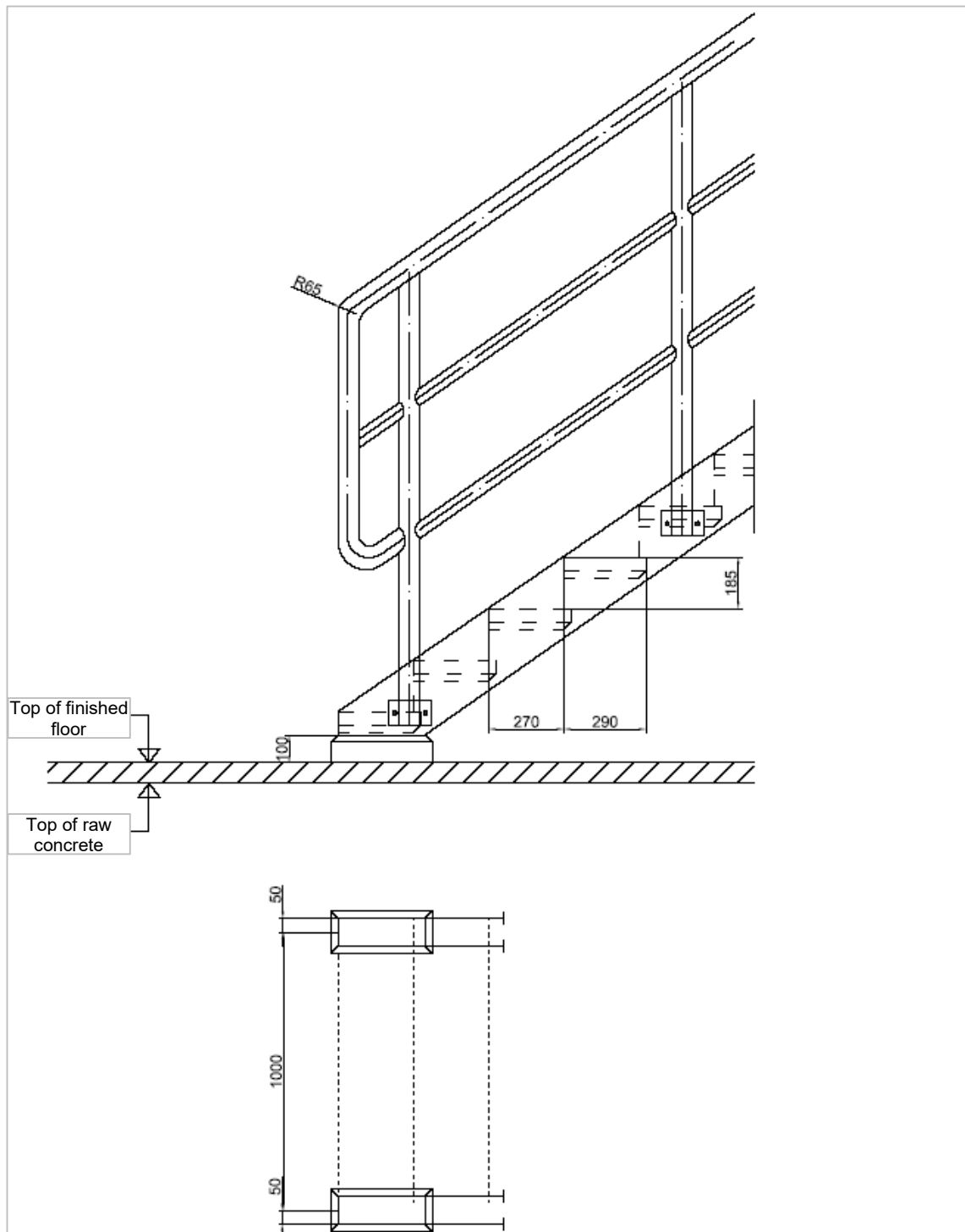
Service water, raw water, dirty water, fire-fighting water pipes and similar systems have to be coated with a condensate water insulation. The condensate water insulation is realised using PU half-shells which have to be attached with a special adhesive. A vapour barrier in the form of an aluminium foil must be applied over the half-shells. To protect the steam brake, a felt with galvanised binding wires must be tied on. The sheet metal casing must then be mounted. The pipes must be primed before insulation (see **Annex 2** and **Annex 3**.)

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I.8 ANNEXES

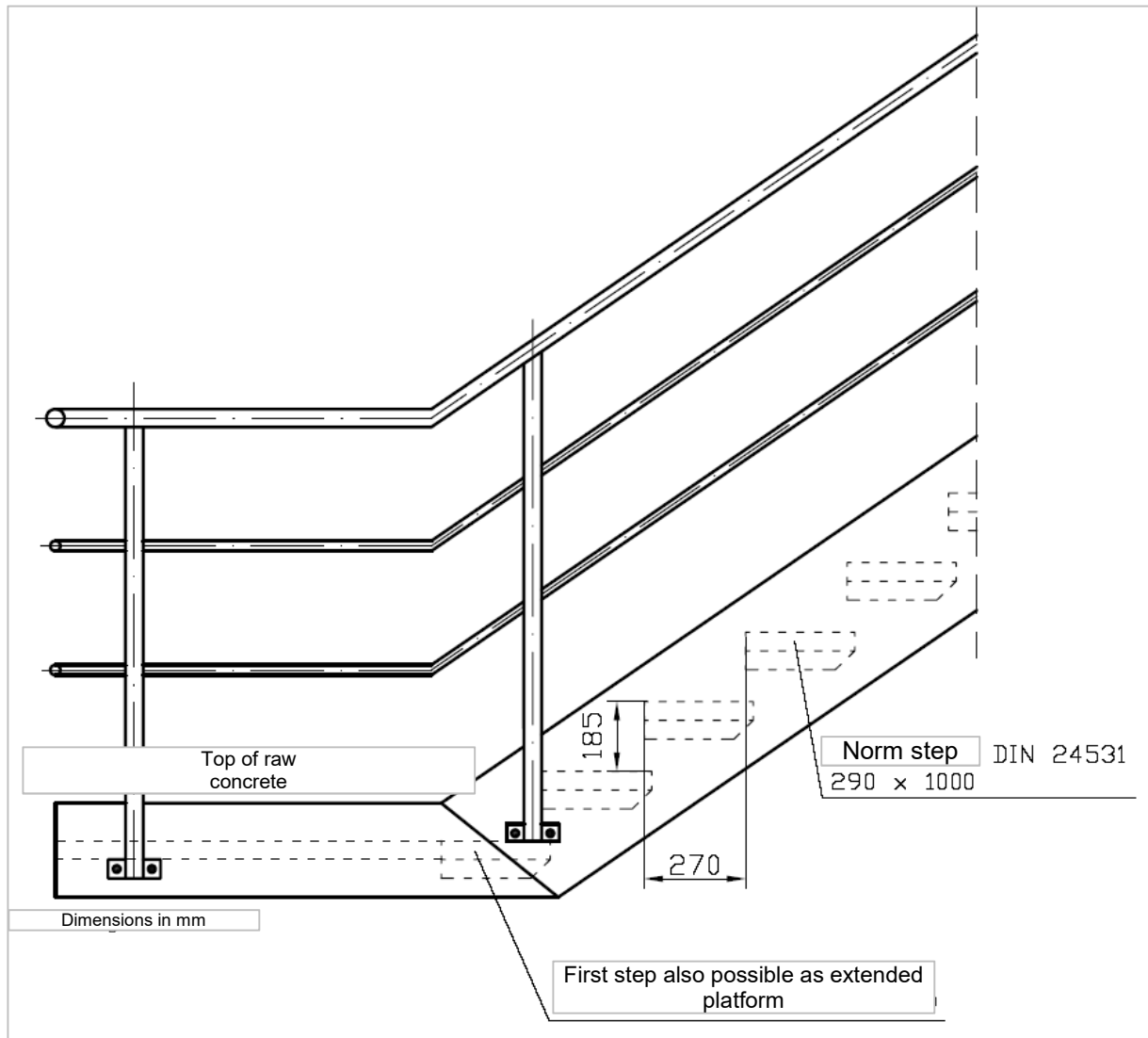
I.8.1 Annex 1 – Steel Construction Standards

Staircase Standard Assembly – Starting from a concrete base



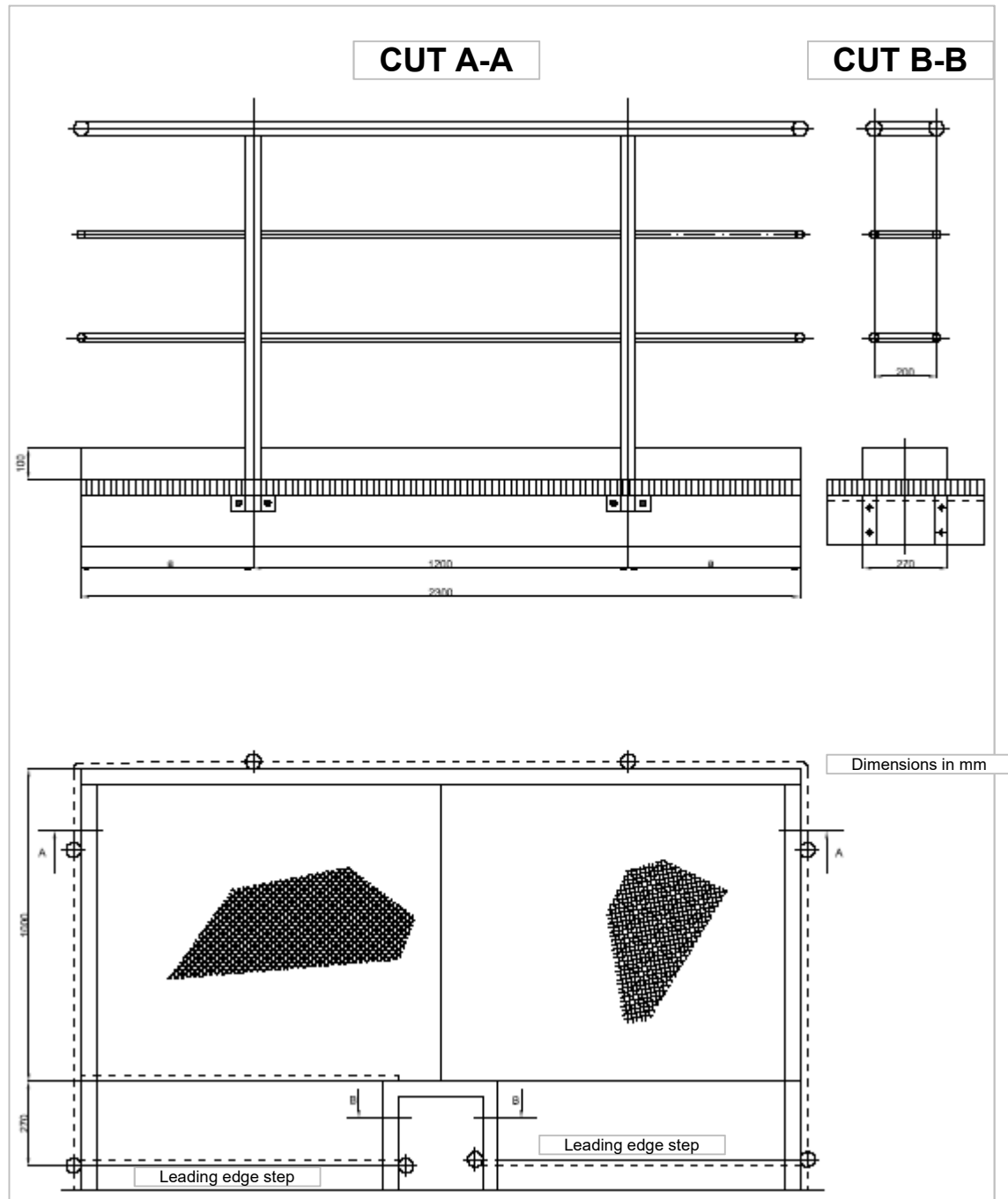
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Staircase Standard Assembly – Starting from an interim platform



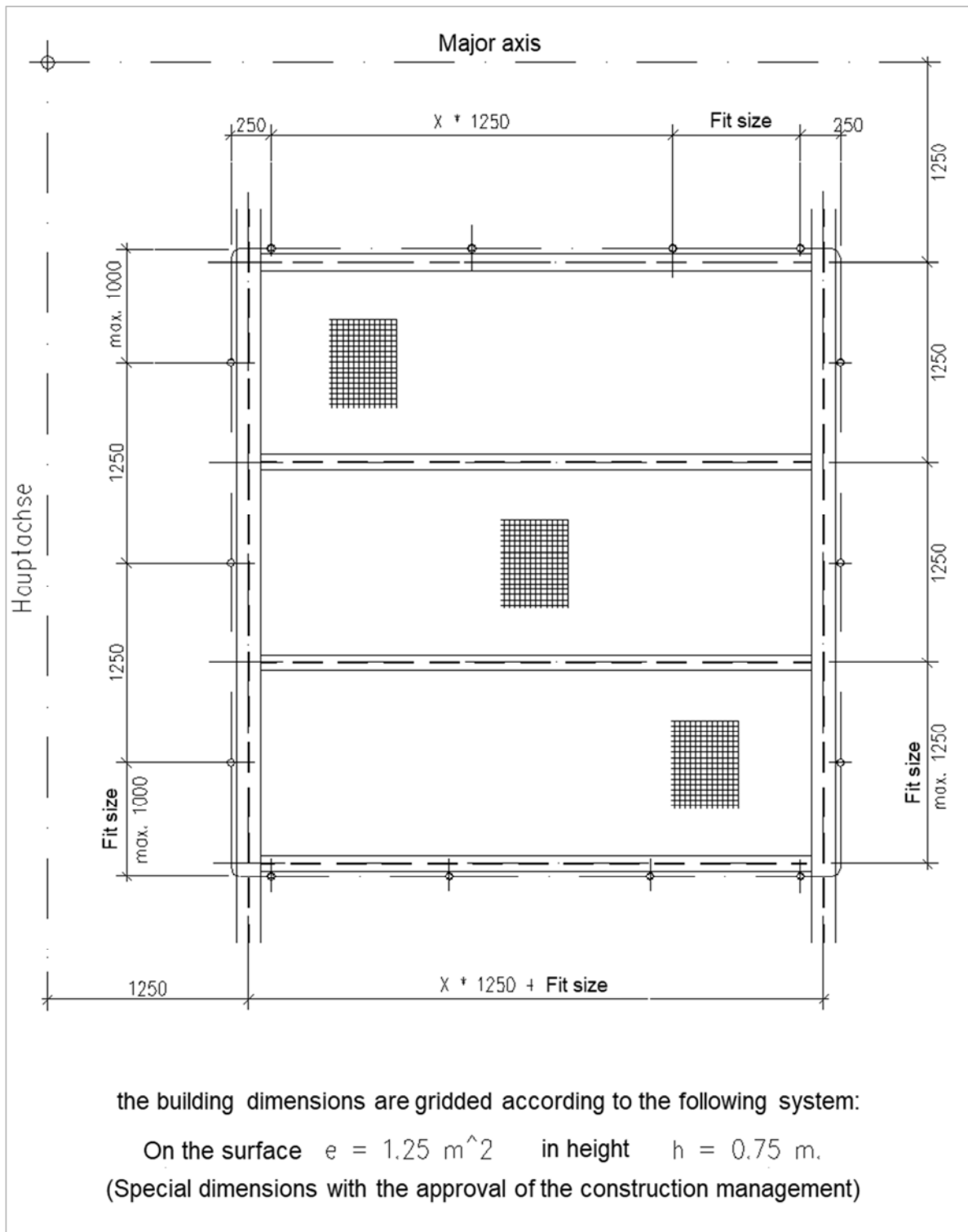
Section VII – Employer's Requirements – General Technical Specifications
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Staircase Standard Assembly – Interim platform



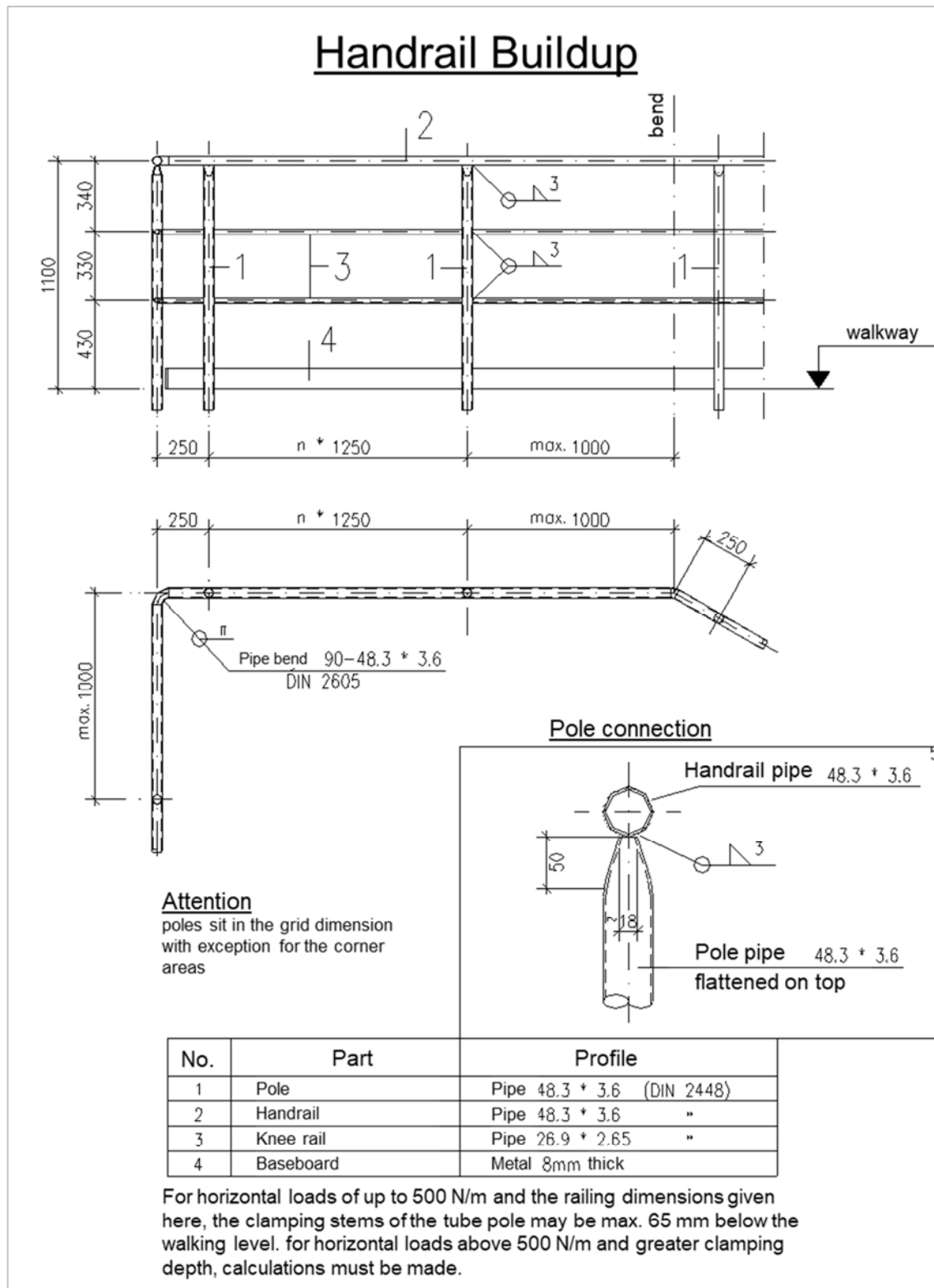
Section VII – Employer's Requirements – General Technical Specifications
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SWB S-K 0-1 Grid dimensions for platform and railing division



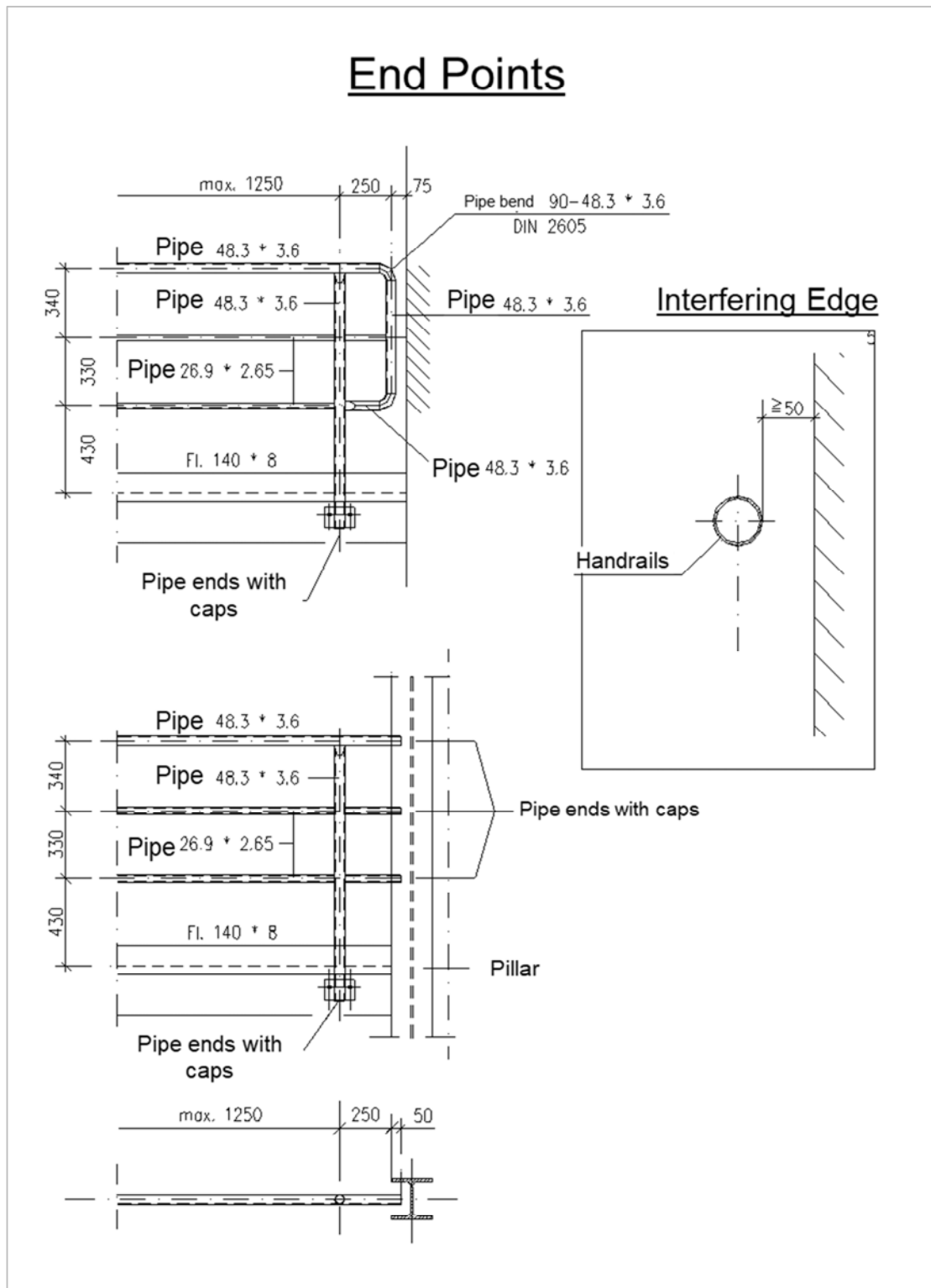
Section VII – Employer's Requirements – General Technical Specifications
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SWB S-K 1-1 Tubular railing – general information



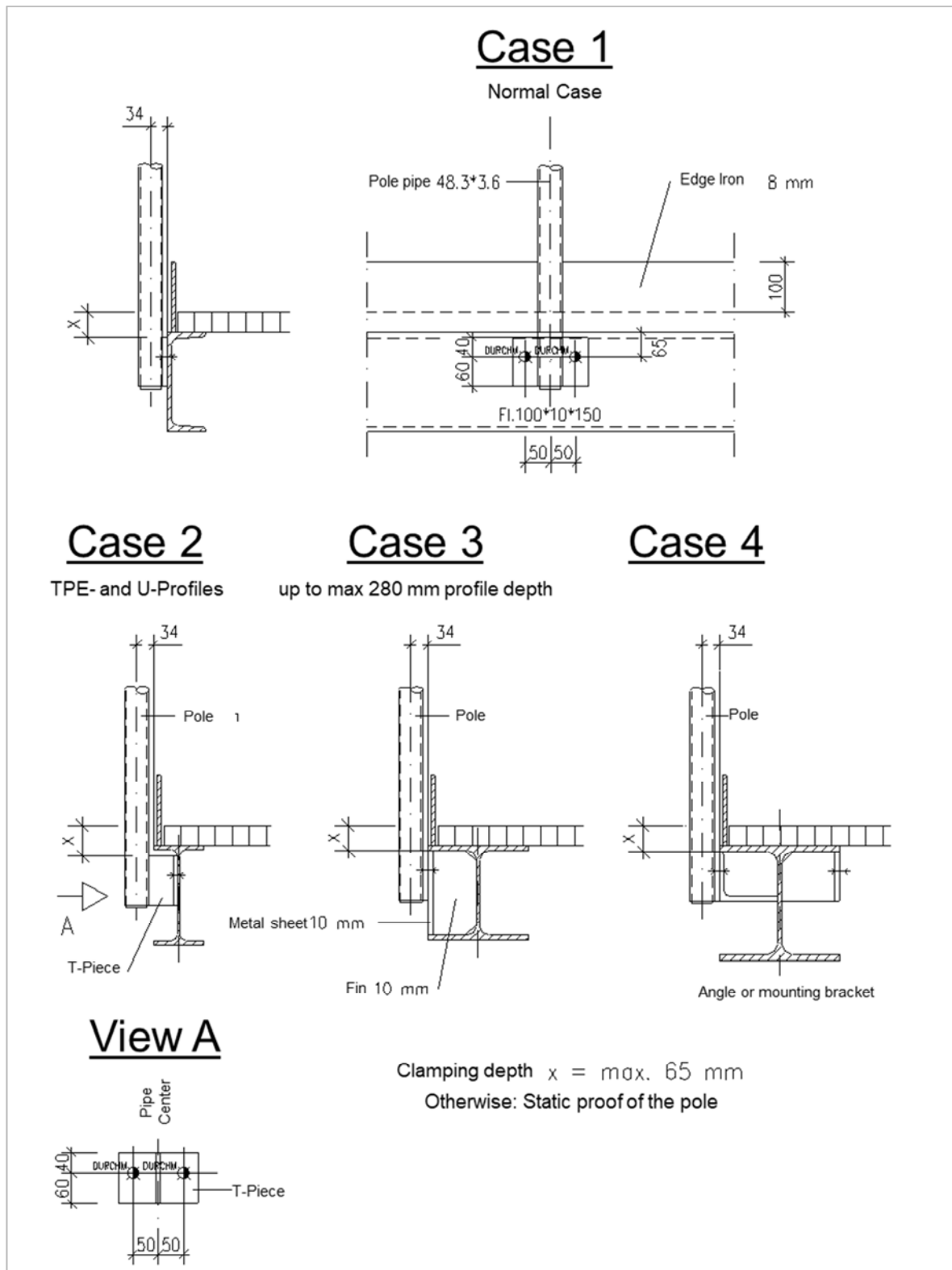
Section VII – Employer's Requirements – General Technical Specifications
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SWB S-K 1-2 tubular railing – various pole connections



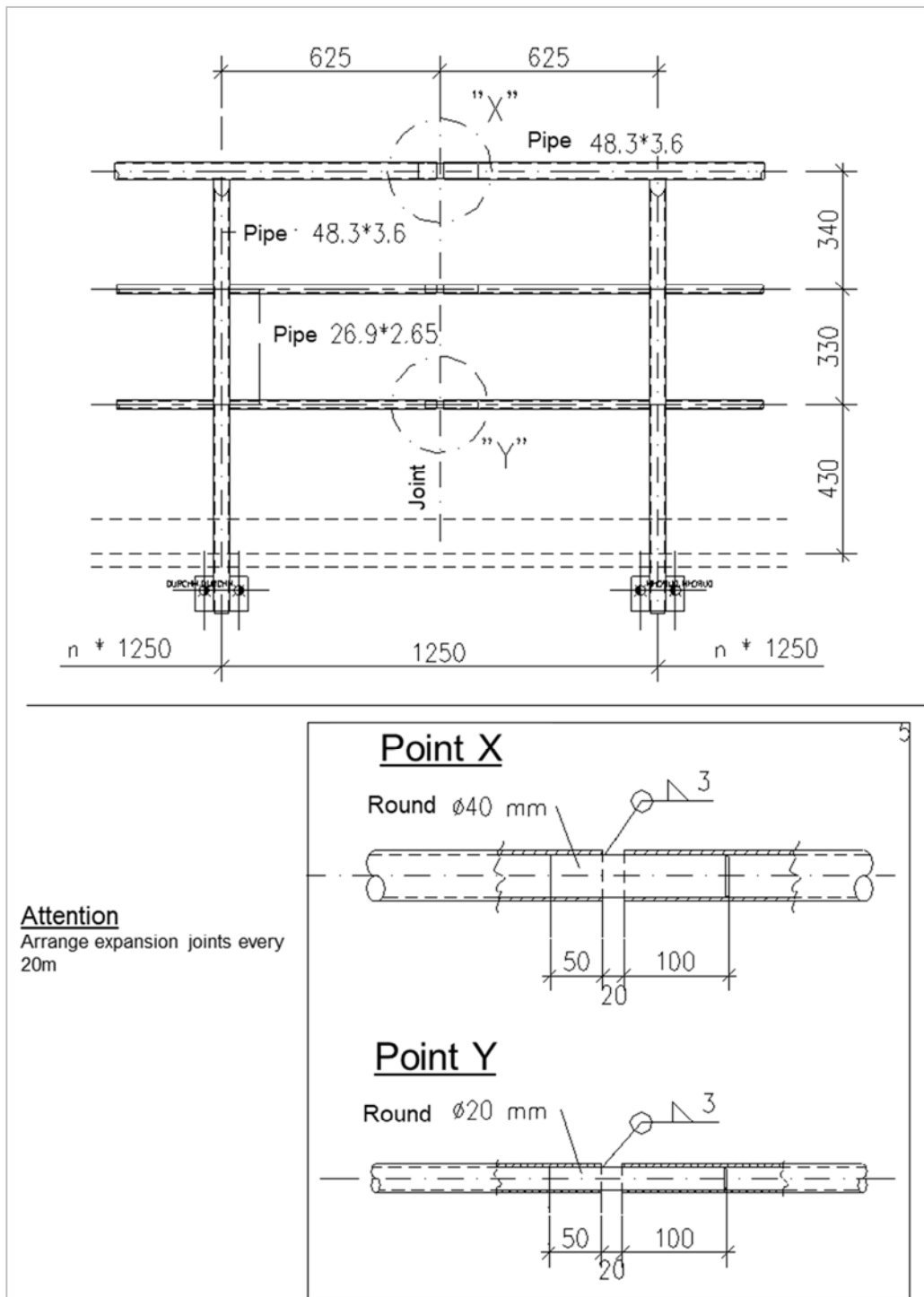
Section VII – Employer's Requirements – General Technical Specifications
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SWB S-K 1-3 Pipe railing Expansion joint



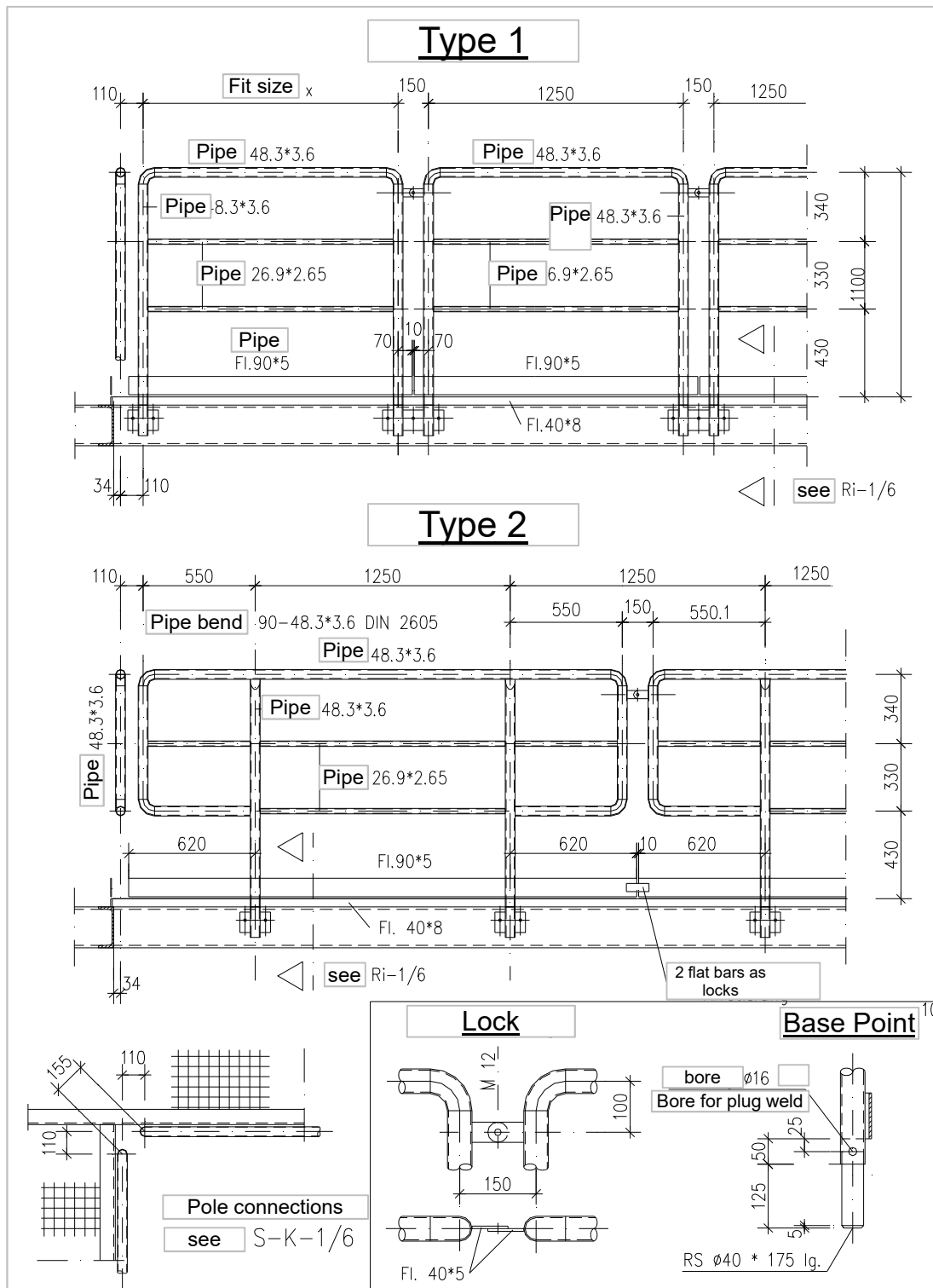
Section VII – Employer's Requirements – General Technical Specifications
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SWB S-K 1-4 tubular railing on steel platforms



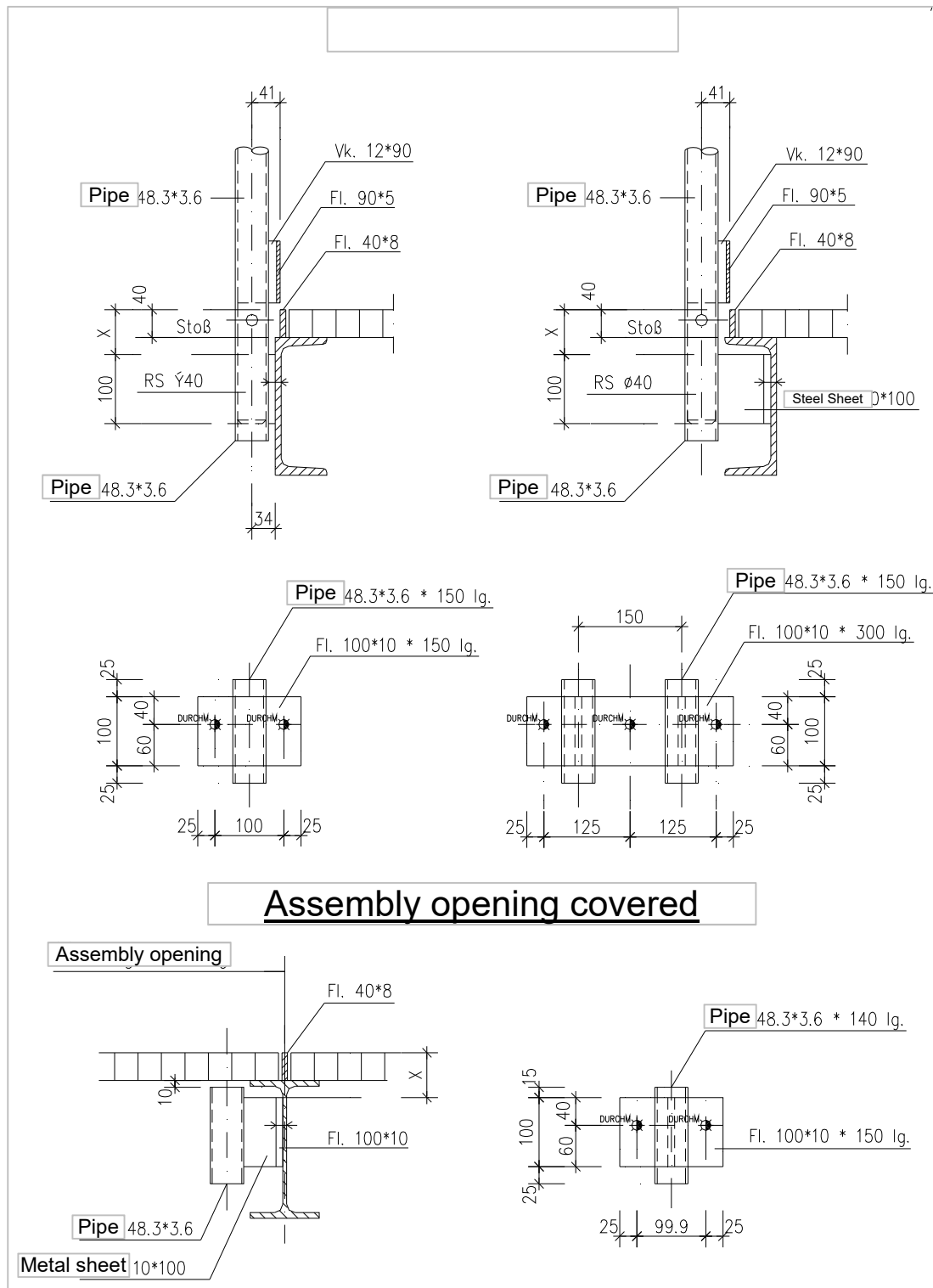
Section VII – Employer's Requirements – General Technical Specifications
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SWB S-K 1-5 Plug-in railing on steel platforms



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SWB S-K 1-6 Pole connections Plug-in railing

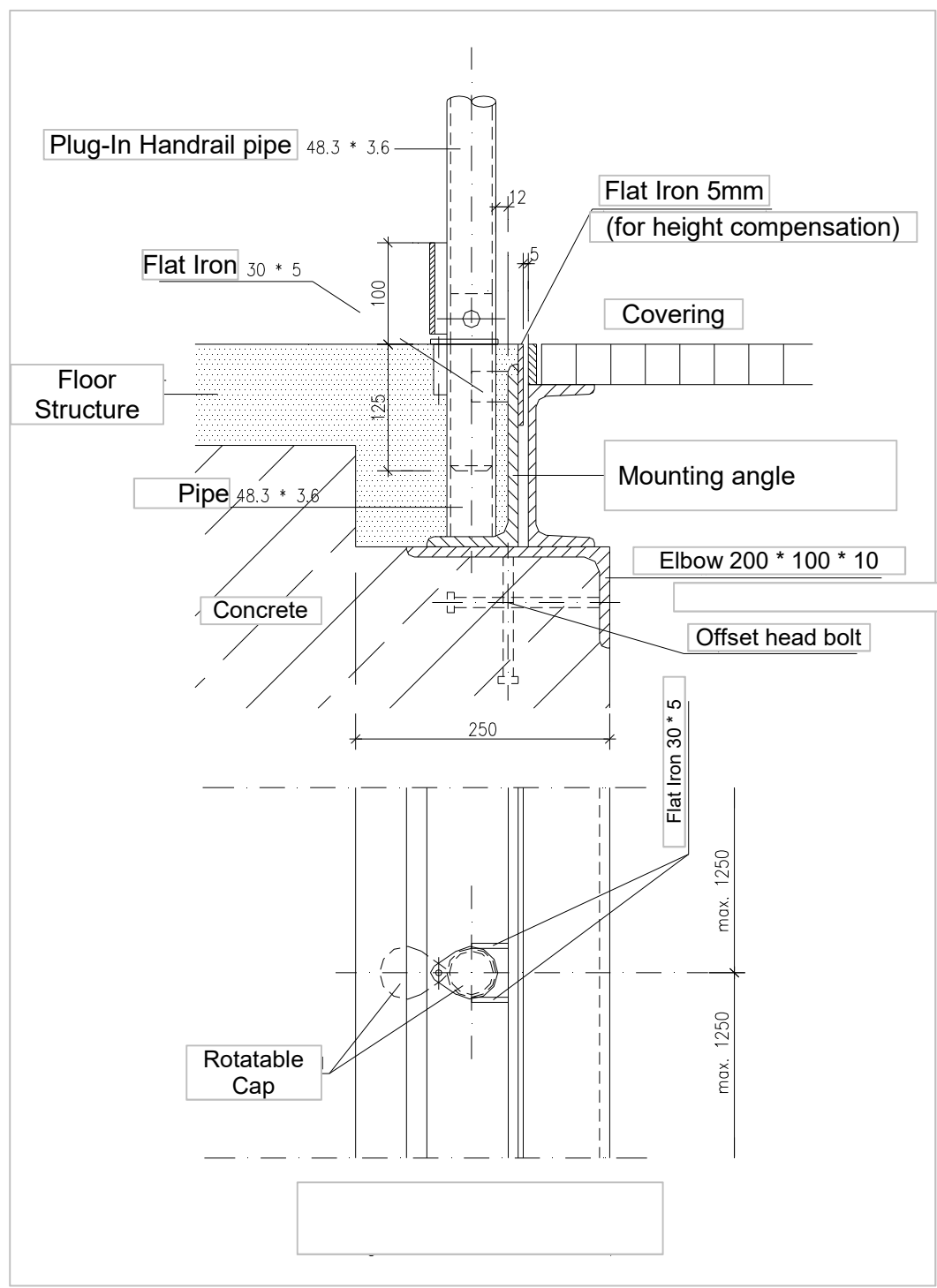


SWB S-K 1-7 Tubular railing plug-in railing on concrete platforms



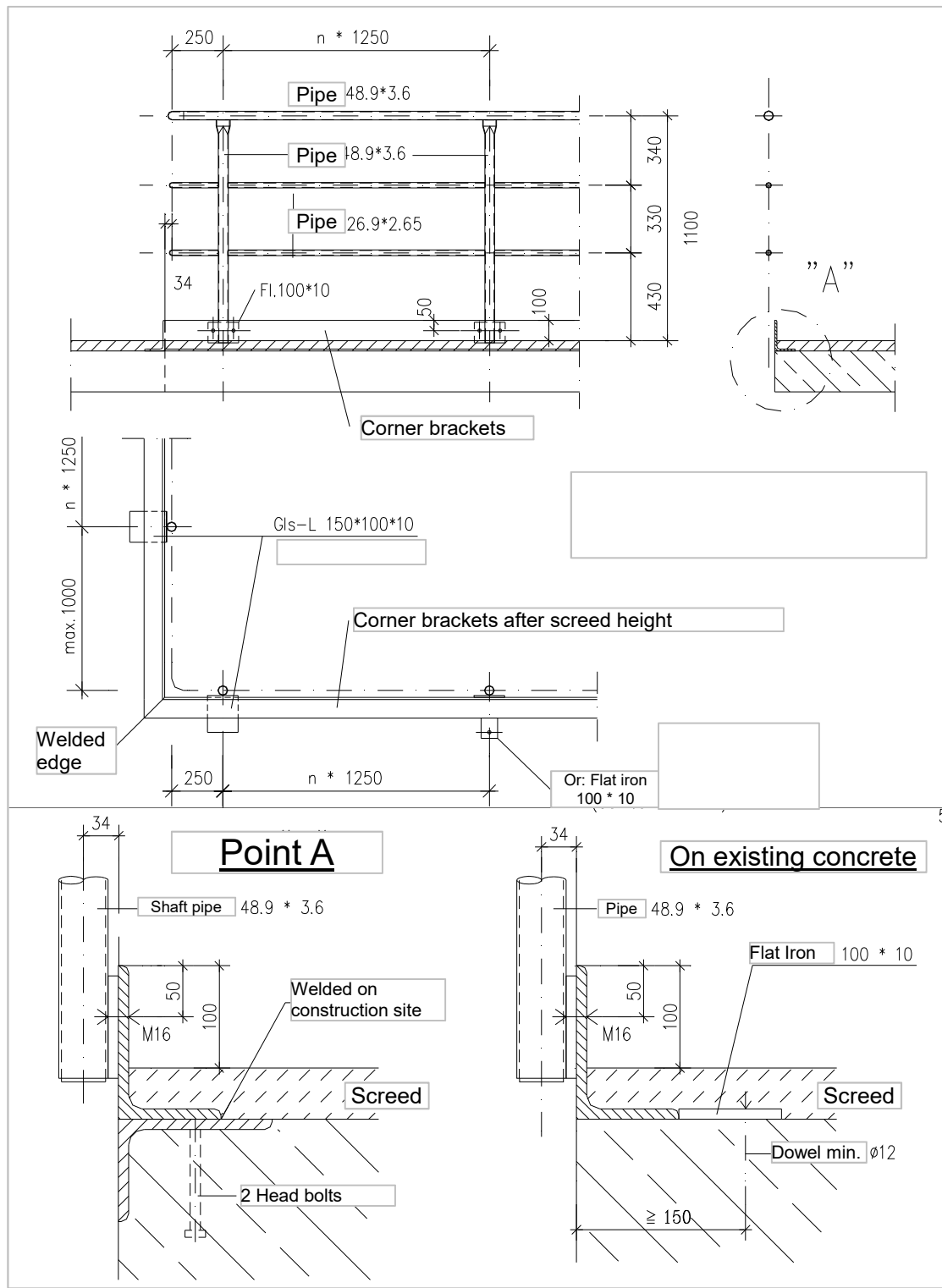
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SWB S-K 1-8 Plug-in railing assembly covers



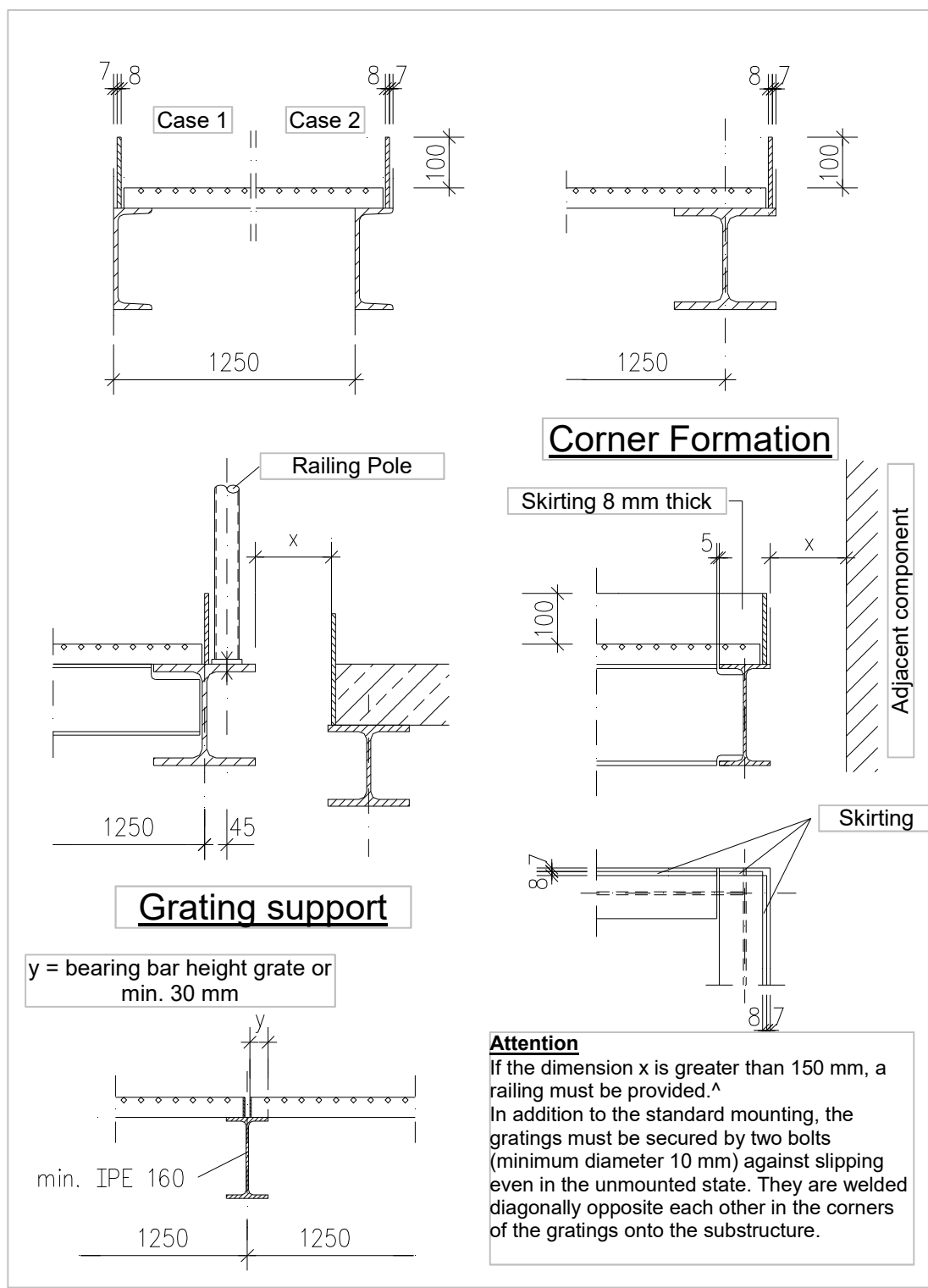
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SWB S-K 1-9 Tubular railings on concrete platforms with corner brackets



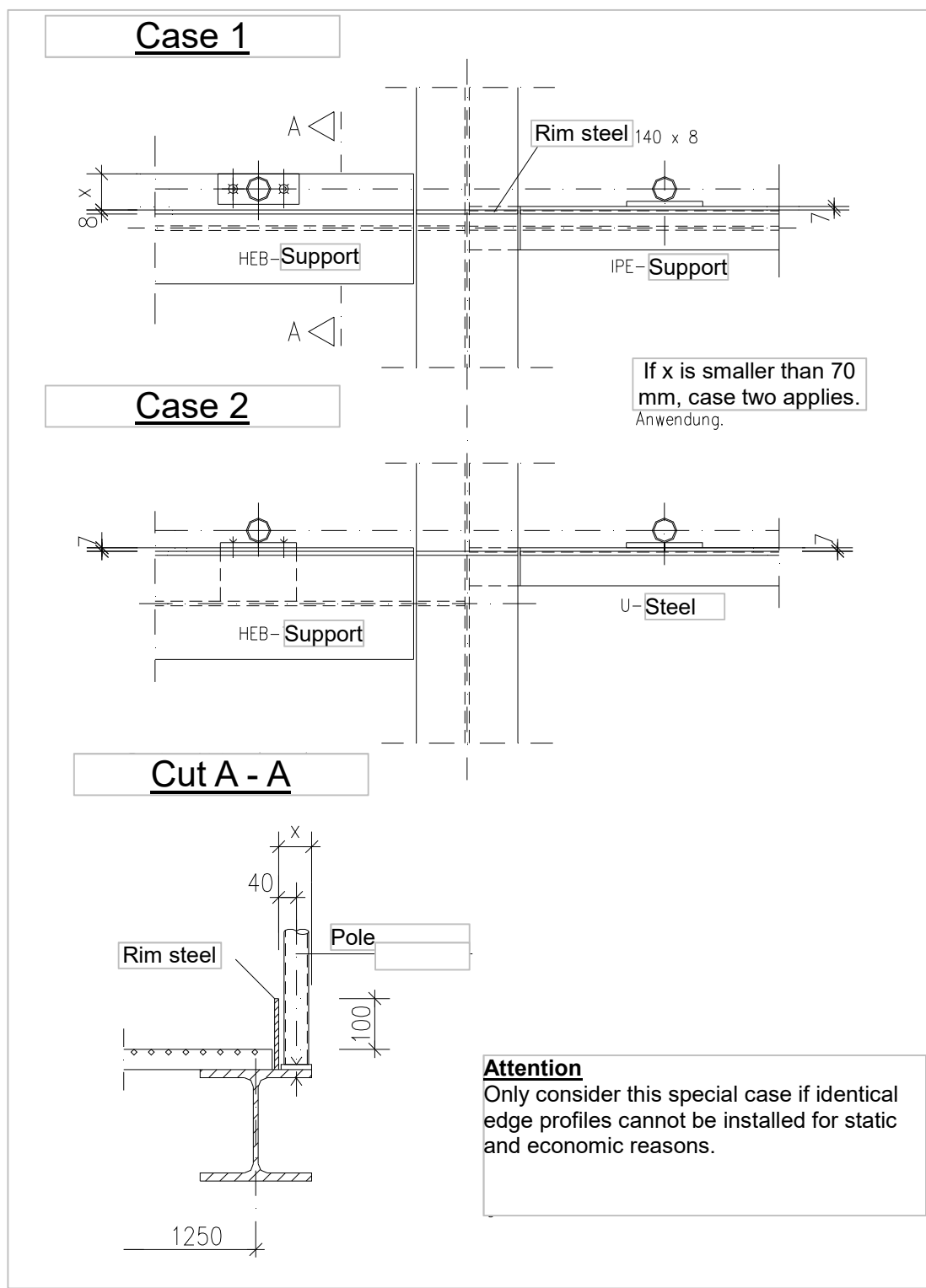
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SWB S-K 3-7 Stages and Walkways Edge formation



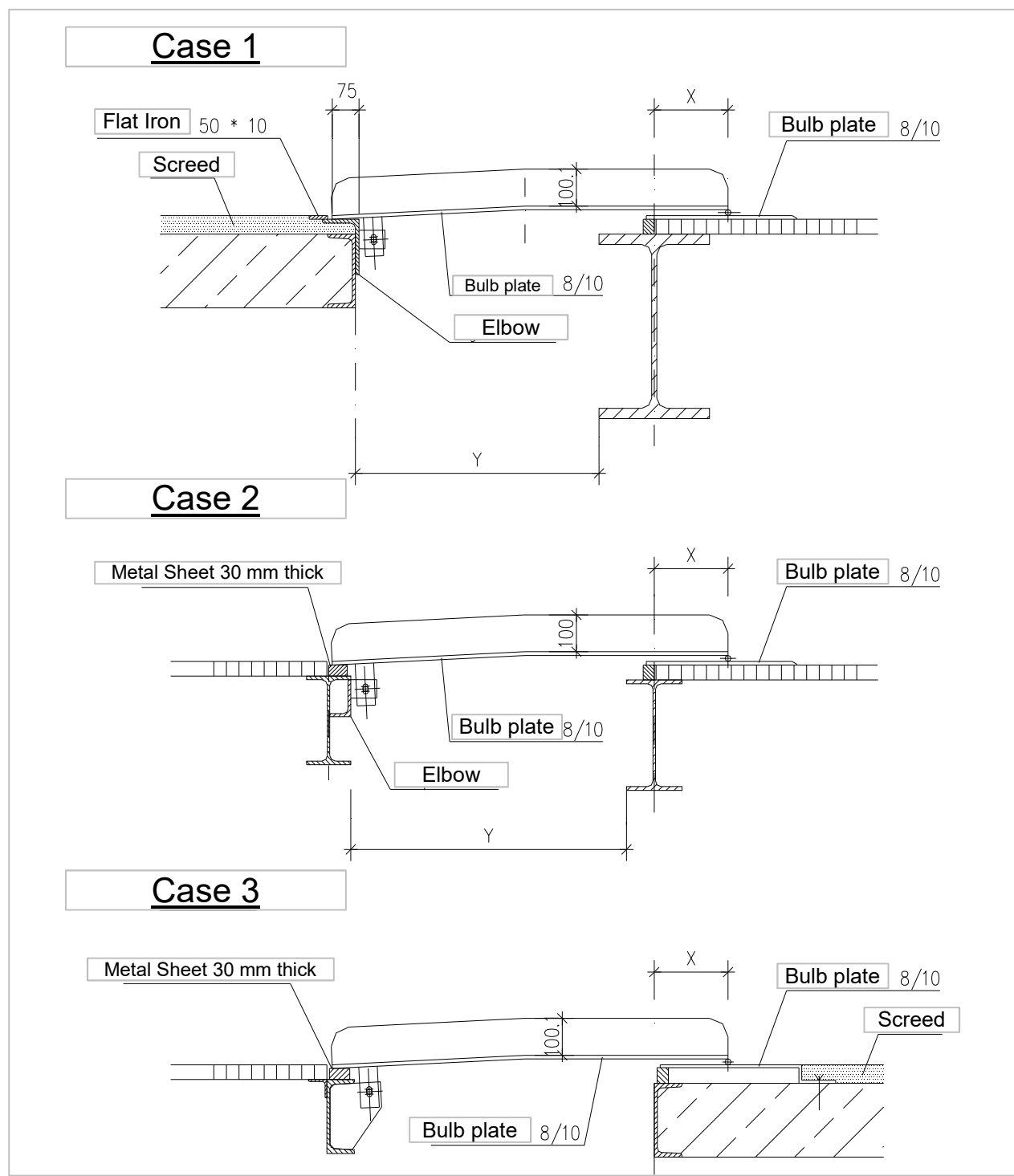
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SWB S-K 4-1 platforms and walkways edge formation (special case)



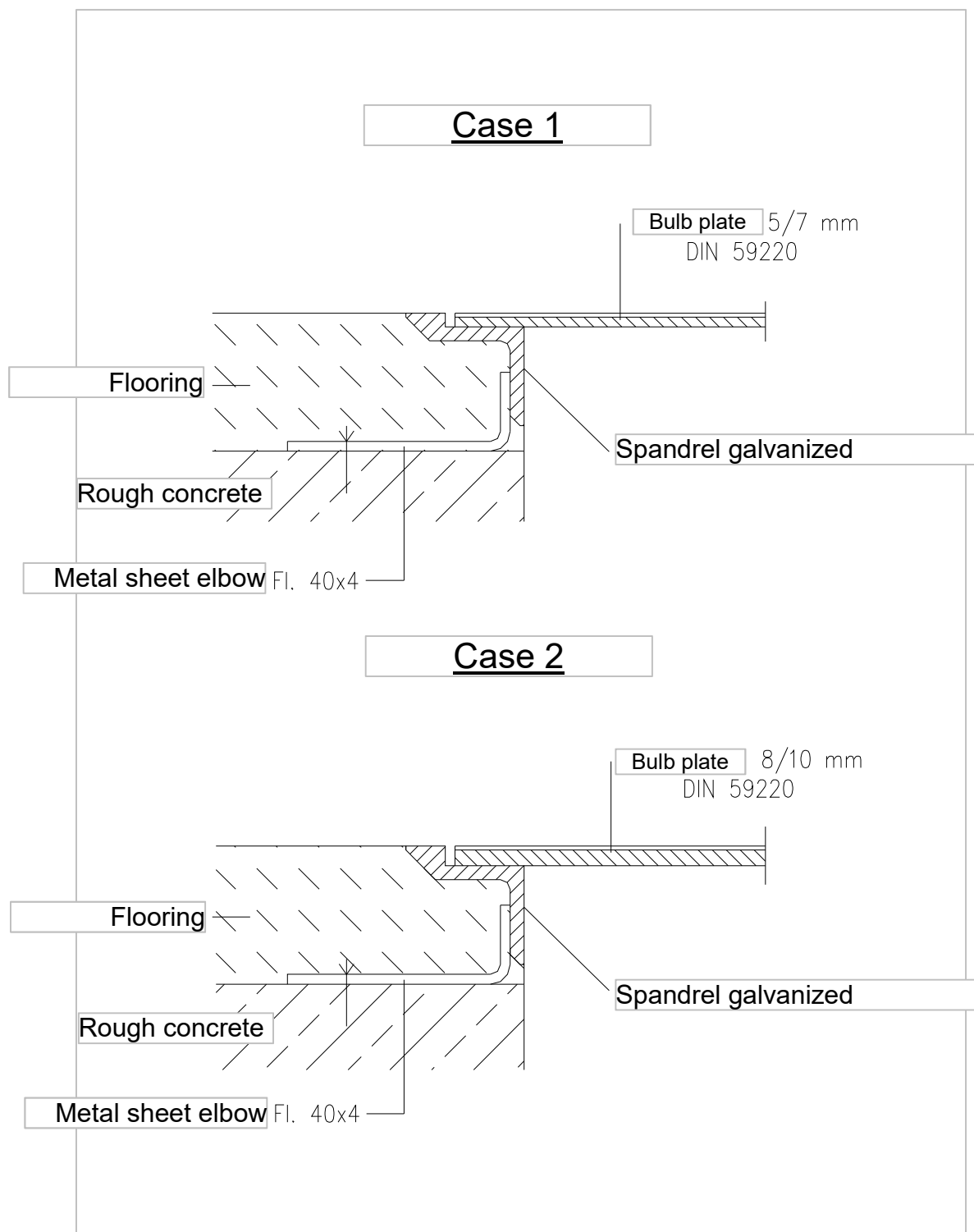
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SWB S-K 4-2 Platforms and walkways bulb plate



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SWB S-K 4-3 Stages detail bulb plate support



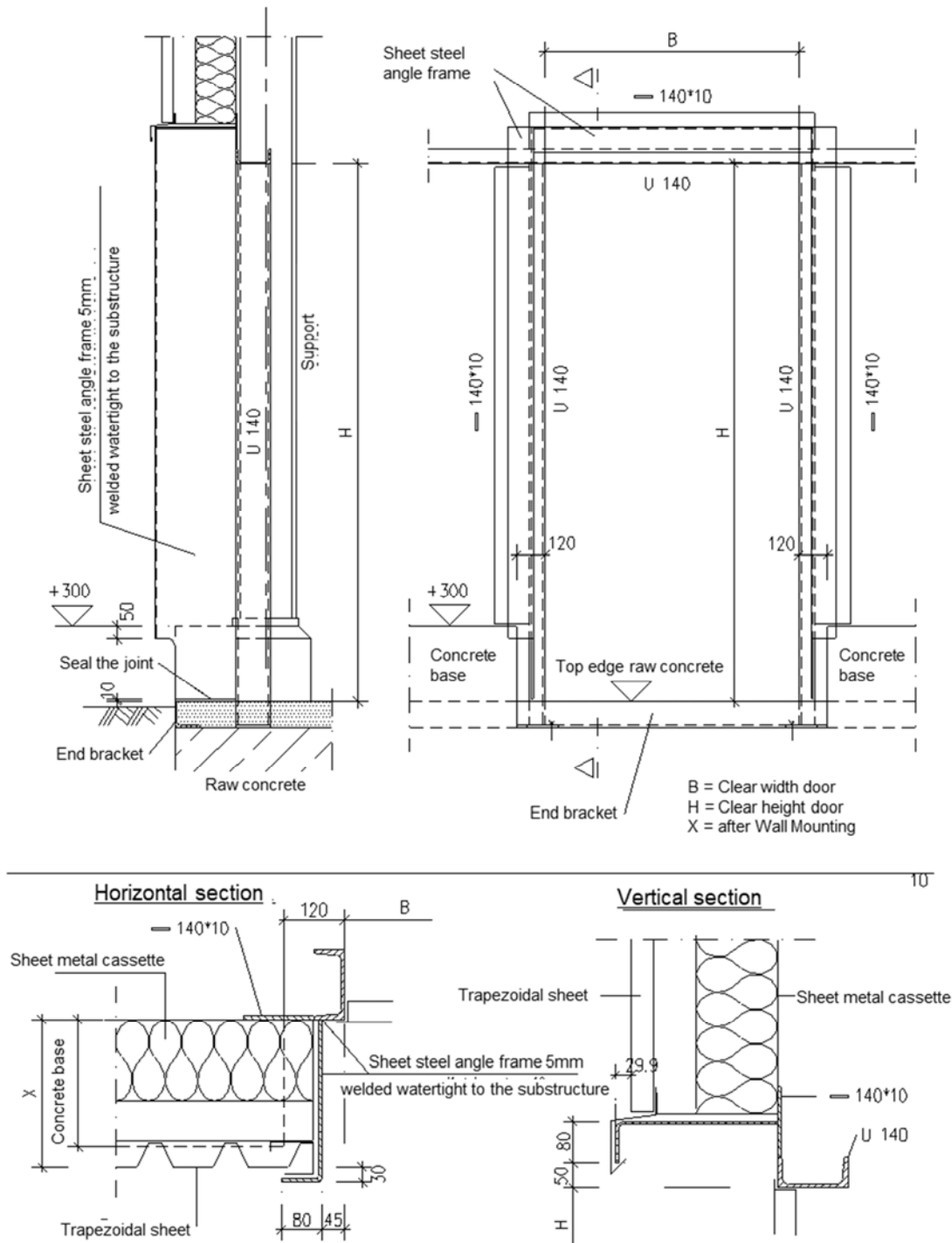
SWB S-K 6-1 Anchor locker hammer head screw with square M24 - M100





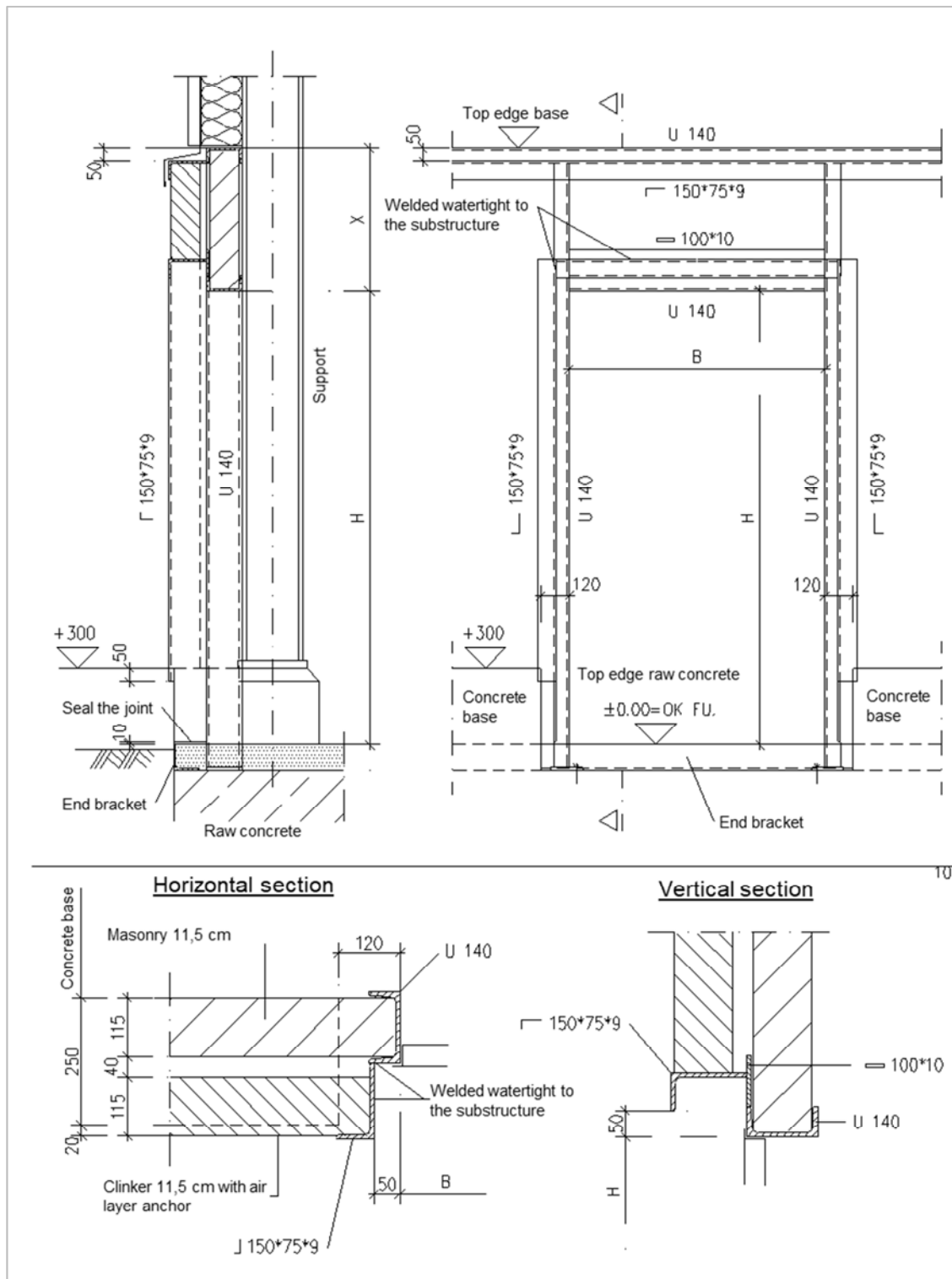
Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

SWB S-K 4-4 U-iron door frame in sheet steel cassette



Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

SWB S-K 5-1 walkway with door through sheet steel cassette wall

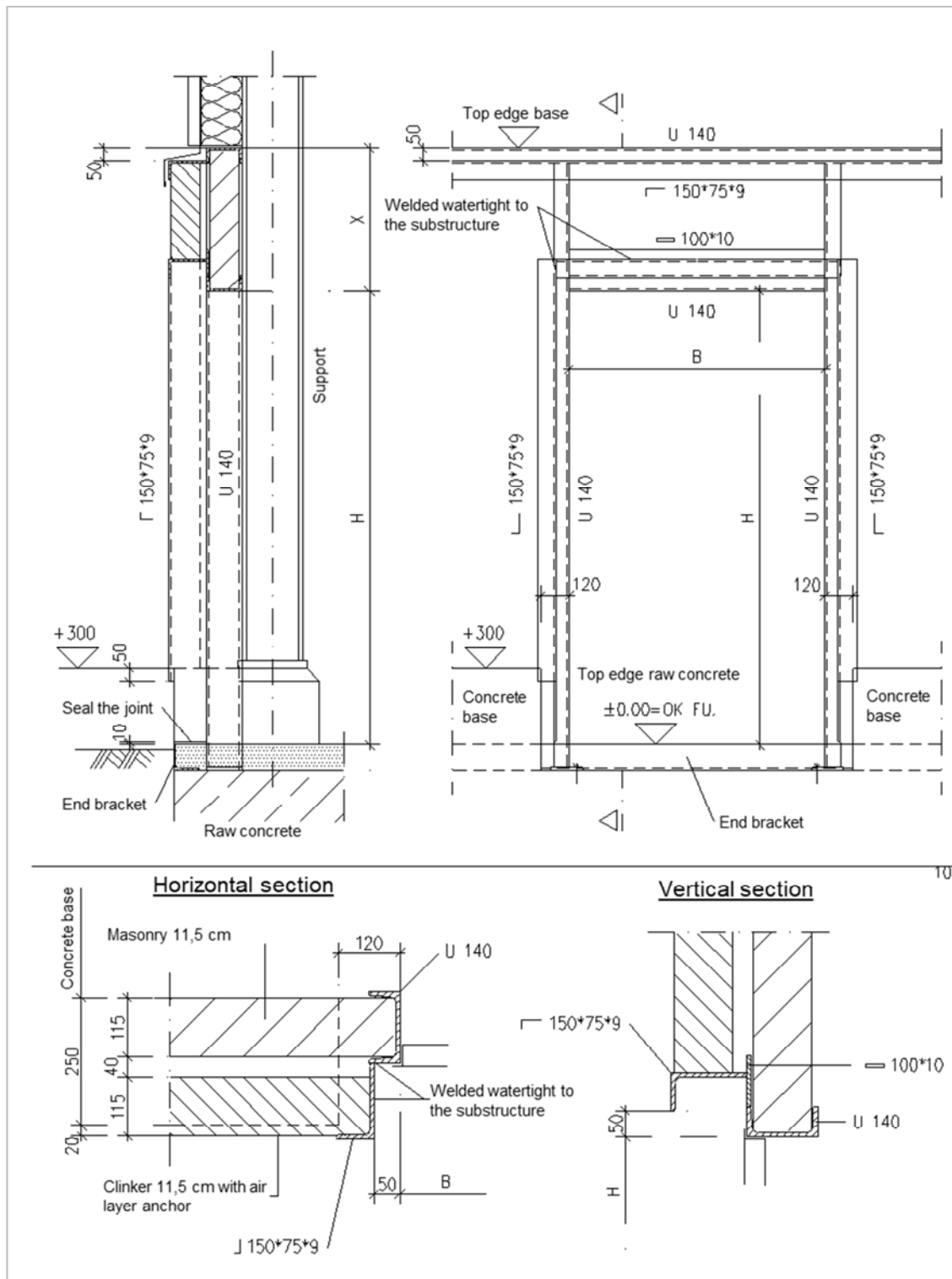


SWB S-K 5-2 U-iron door frame in clinker base



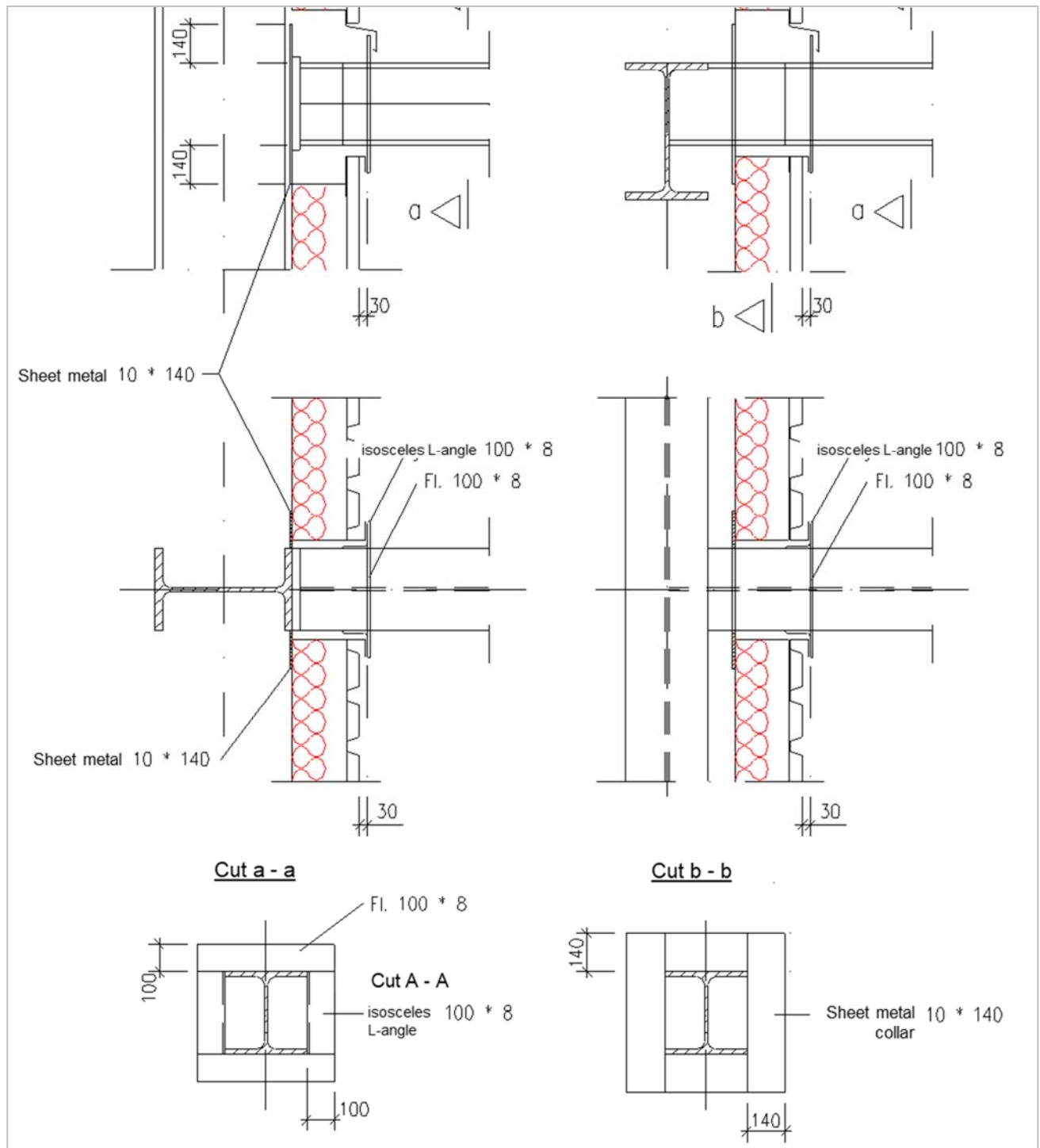
Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

SWB S-K 5-3 U-iron door frame in sheet steel cassette



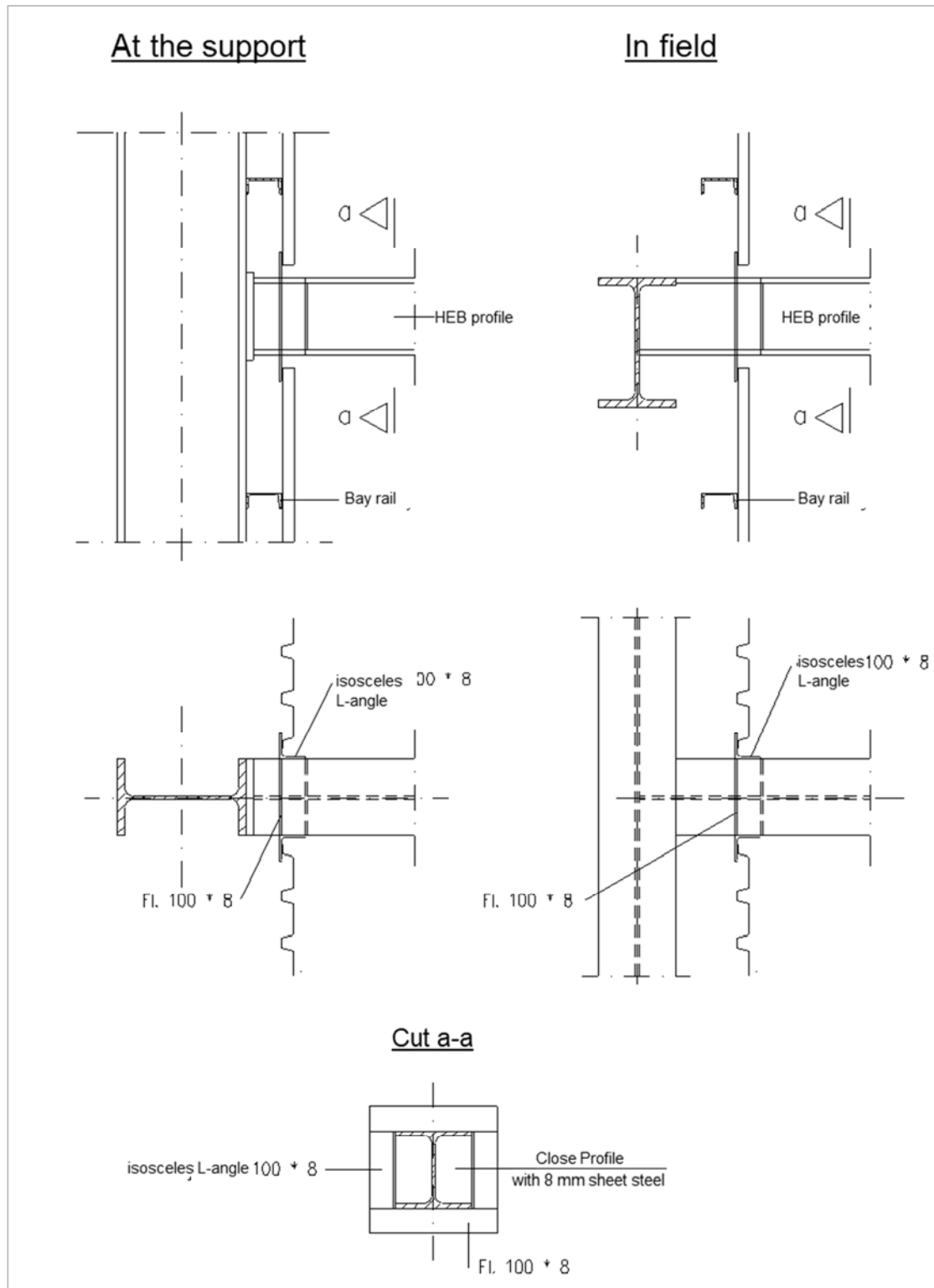
Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

SWB S-K 5-4 U-iron goal frame in clinker base



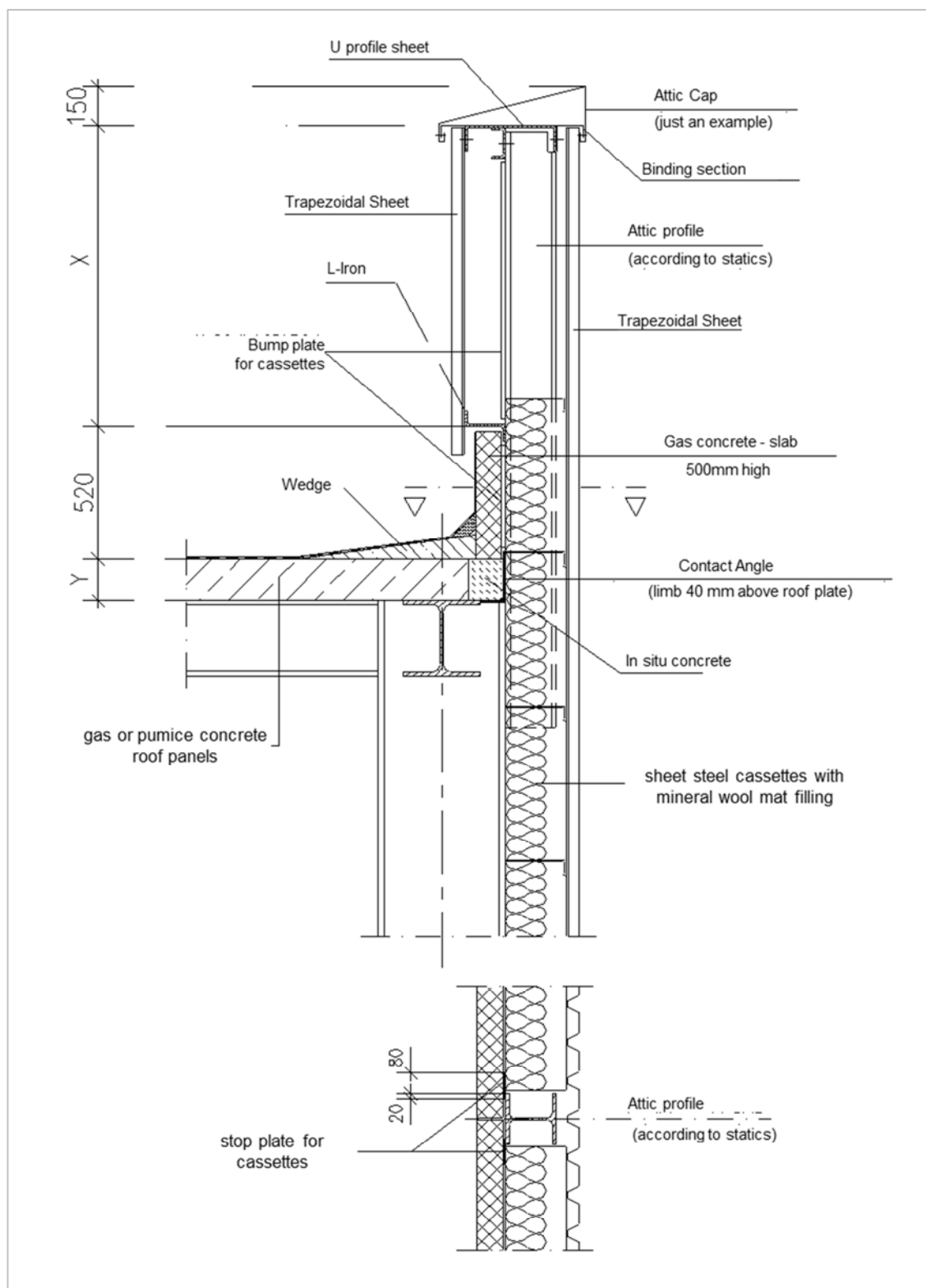
Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

SWB S-K 5-5 Wall opening in sheet steel cassette



Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

SWB S-K 5-6 Wall opening in steel trapezoidal profile or similar







Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

I.8.2 Annex 2 – Coating systems for outdoor installations

Nr.	Min./max. Operating Temp. (C°)	Equipment	Priming coat (µm)	1. Finishing coat (µm)	2. Finishing coat (µm)	Total coating thickness
1	-50 to 150	apparatus, steel construction, pipelines, fittings without insulation	2-component epoxy resin - zinc dust ¹⁾ or Ethyl silicate Zinc dust ¹⁾ 70	2C epoxy resin Micaceous iron ore Top coat (RAL 7035) 80	2K-PUR Top coat 70	220
2	-90 to 300	apparatus, pipelines, fittings with insulation	Ethyl silicate Zinc dust ^{1) 2)} 70	-	-	70
3	-50 to 120	galvanised stairs and gratings	-	-	-	70 - 80

1) Maximum Layer Thickness 140 µm

2) Nozzles and connections sticking out of the insulation must be completed with the 1st and 2nd top coat of Coating No. 1

Section VII – Employer's Requirements – General Technical Specifications
Part I – Requirements Sewage Sludge Incineration Plant (SSIP)

I.8.3 Annex 3 – Coating systems for indoor installations

Nr.	Min./max. Operating Temp. (C°)	Equipment	Priming coat (µm)	1. Finishing coat (µm)	2. Finishing coat (µm)	Total coating thickness
4	-50 to 150	apparatus, steel construction, pipelines, fittings without insulation	2-component epoxy resin - zinc dust ¹⁾ or Ethyl silicate Zinc dust ¹⁾ 70	2-component epoxy resin Micaceous iron ore Top coat (RAL 7035) 40	2K-PUR Top coat 40	150
5	-90 to 300	apparatus, pipelines, fittings with insulation	Ethyl silicate Zinc dust ^{1) 2)} 70	-	-	70
6	-50 to 120	galvanised stairs and gratings	-	-	-	70 - 80

1) Maximum Layer Thickness 140 µm

2) Nozzles and connections sticking out of the insulation must be completed with the 1st and 2nd top coat of Coating No. 4

Bidding Documents for the Construction of the Wastewater Treatment Plant, Sewage Sludge Treatment Plant and Sewage Sludge Incineration Plant for the City of Podgorica

Volume 3: Employer's Requirements

Section VII: Employer's Requirements

1. Specifications

b) Technical Specifications

Part J: Training and Technical Operation Management

Content of Volume 3:

Section VII: Employer's Requirements

1. Specifications

- a) Scope of Supply of Plant and Installation Services by the Contractor
- b) Technical Specifications
 - Particular Technical Specifications
 - General Technical Specifications
- c) Specifications for Project Area Environmental, Social, Health and Safety Management (ESHS)
- d) Personnel Requirements
- e) Equipment Requirements

2. Drawings

3. Supplementary Information

- a) Urban-Technical Conditions (Urbanisticko-Tehnicki Uslovi)
- b) Conceptual Design Report;
- c) Environmental and Social Impact Assessment Report (ESIA) and Environmental and Social Management Plan (ESMP);
- d) Geotechnical Survey Report;
- e) Reports on Soil Contamination;
- f) KAP Well Water Analyses Data.

Section VII – Employer's Requirements

1. Specifications

b) Technical Specifications

Particular Technical Specifications

Part A: General Project Requirements

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List of Acronyms

BOD ₅	Biochemical Oxygen Demand after 5 days	FS	Faecal Streptococci
C	Carbon	HVAC	Heating, Ventilation, and Air Conditioning
CFU	Colony Forming Unit	KfW	KfW Entwicklungsbank
CHP	Combined Heat and Power	MLSS	Mixed Liquor Suspended Solids
COD	Chemical Oxygen Demand	MNE	Montenegro or Montenegrin
CPM	Critical Path Method	N	Nitrogen
CV	Curriculum Vitae	NTK	Total Kjeldahl Nitrogen
DNP	Defects Notification Period	P	Phosphorus
DO	Dissolved Oxygen	PLC	Programmable Logic Controller
DR	Dry Residue	RAS	Return Activated Sludge
DS	Dry Solids	SAS	Surplus Activated Sludge
mDS	Mineral Dry Solids	SCADA	Supervisory Control and Data Acquisition
oDS	Organic Dry Solids	SHPP	Small Hydro-Power Plant
d.o.o.	Drustvo sa ogranicenom odgovornoscu (private limited liability company)	SS	Suspended Solids
EC	European Commission	SSIP	Sewage Sludge Incineration Plant
EN	European Norm	SSTP	Sewage Sludge Treatment Plant
ENG	English	SVI	Sludge Volume Index
ESIA	Environmental and Social Impact Assessment	TC	Total Coliforms
ESHS	Environmental, Social Health and Safety	TKN	Total Kjeldahl Nitrogen
ESMP	Environmental and Social Management Plan	TN	Total Nitrogen
EU	European Union	TP	Total Phosphorus
FC	Faecal Coliforms	TSS	Total Suspended Solids
FIDIC	Federation Internationale des Ingenieur-Conseils (International Federation of Consulting Engineers)	VDS	Volatile Dry Solids
FGT	Flue Gas Treatment	VIK	Vodovod i Kanalizacija (Water and Sewerage Company)
		VSS	Volatile Suspended Solids
		WWTP	Wastewater Treatment Plant

Format of Numbers

Throughout this report, as well as in the annexes, appendices and drawings, the **decimal comma** is used and the dot is used as **thousand separator**.

J.1. TRAINING

J.1.1. General

The Contractor's scope of works and services include the provision of comprehensive training for the Employer's staff in charge of the operation and maintenance of the plant. The operations and maintenance training shall be carried out on site.

The Contractor shall carry out theoretical and on-the-job practical training for the designated Employer's staff. The training programme shall consist in a combination of further education in the relevant respective fields, skills training and continuous on-the-job-training, the latter to be carried out during the technical Operation Management period under the responsibility of the Contractor (Section J.2).

The main objective of the training sessions is to enable the Employer's managerial and operation staff to autonomously operate and maintain the plant and to take any necessary appropriate decisions and measures for the protection and preservation of the facilities, the protection of the workers and the general public and the protection of the environment, including in case of emergency.

The training shall provide the Employer's staff with the necessary knowledge of technology and of the operation and maintenance of all equipment, installation and works included in the Contract, to ensure that at the end of the respective Operation Management period under the responsibility of the Contractor, the staff will be considered by the Employer to be capable of managing, operating and maintaining the Works to the highest international standard without additional external support and supervision.

The training shall be based on the actual Plant and the implementation of operation and maintenance schedules outlined in the operation and maintenance manuals provided by the Contractor.

The core training components shall be carried in the period starting three (3) months before commissioning of the plant until 6 months after the taking over and shall be completed with follow-up and complementary training measures in the remaining Operation Management period under the responsibility of the Contractor based on regular assessment of the capacities of the staff and identified possible deficits.

The training to be provided in advance of commissioning is aimed at enabling the Employer's staff to participate in the full process of commissioning of the system.

The Contractor shall allow for training the number of personnel deemed to be necessary by the Employer.

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Part J: Training and Technical Operation Management

The liability for the entire Works during training remains with the Contractor, irrespective of who may be responsible for any fault or damage.

All expenses in connection with the implementation of the training services, excepted Employer's staff costs, are deemed to be included in the Contract price. This shall include travelling (airplanes, taxis, buses, etc.), accommodation and living allowances of the Contractor's staff.

J.1.2. Training Programme

The Contractor shall specify in his offer the proposed training courses in line with his technical offer. The Contractor shall specify in his offer the minimum educational level and minimum levels of experience and qualification required for participants to the training sessions. The Contractor shall outline his own training proposals but he shall allow for the following levels of tuition:

- managerial level;
- operating staff; and
- maintenance staff.

Training shall be applicable to all mechanical, electrical, instrumentation and control equipment including SCADA if applicable provided under this Contract and shall be tailored to satisfy the particular requirements of the trainees e.g. training in maintenance - either electrical or control and instrumentation.

The Contractor shall carry out the training on the basis of a structured programme, which shall be submitted not less than five (5) months before the start of the Commissioning for review and approval by the Engineer.

The Contractor shall provide the Engineer with a synopsis of his proposed training course content at least two (2) months prior to the commencement of training for in principle approval. Prior to the commencement of each specific training course the Contractor shall provide the Engineer with copies of the lecturers notes, the trainee handouts and details of the audio / visual / practical materials to ensure compliance with the approved synopsis. The Contractor shall supply O & M documentation prior to training.

As a minimum the training programme shall include, but shall not be limited to the following:

- General training: covering the principle of the WWTP regarding its mechanical, electrical and treatment processes;
- Operational training: Practice in operation of all mechanical and electrical equipment and its effect on the treatment processes and results. Plant optimisation, troubleshooting and emergency cases;
- Automation training: Covering programming, application design, and debugging principles and practice;

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- Preventive maintenance, covering all mechanical and electrical equipment;
- Health and safety procedures and training;
- Monitoring and data recording, including sampling and laboratory analyses.

Training to be provided in advance of commissioning

This course shall be designed to familiarize the assigned Employer's staff with the general running of the standard operating system including but not limited to:

- Loading and starting up the Plant;
- System Operators interface;
- Operator control of programme / task execution;
- Operator control of disc files;
- Operator response to system failure, online / offline diagnostics, transfer of control between the computers synchronization of the system database;
- PLC system interrogation facilities – alarm lists, log printouts select mimic and trend display etc.;
- Alarm acknowledge accept / delete;
- Control actions e.g. start pump, close valve etc.;
- All functions associated with each access level of the PLC system.

J.1.3. Execution of Training

All training - practical training and classroom seminars - shall be designed and executed by the Contractor. Training shall base on and be in line with the Operation and Maintenance Manual.

To ensure that adequate training is provided, the training personnel from the Contractor shall carry out each and every Operation and Maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the Employer's personnel to carry out these activities, even if they are not required during the actual operation of the Works.

The Contractor shall pay particular attention to safety training for all assigned personnel. Safety training shall not be limited to personal safety, but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall provide all training materials and equipment needed, e.g. trainee handouts, notebooks, pens and pencils, photocopying facilities and materials, lecturers, training aids, training videos, safety appliances, protective clothing, etc., all as required to cover the complete training course(s) as defined in the Employer's Requirements.

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The Contractor shall provide all necessary facilities for training including didactic equipment, simulators video, slide and overhead projection equipment. The necessary specialist buildings or rooms for training shall be provided as part of the Permanent Works. All training equipment shall become the property of the Employer at the end of the Training Period.

Training shall be carried out in the Montenegrin or English language. In the second case, the Contractor shall provide a sufficient number of interpreters to overcome any difficulties arising due to the Employer's personnel not being fluent in the English language.

J.1.4. Training Documentation

Training Documentation shall be submitted in Montenegrin language, in sufficient quantity to allow one complete set per each trainee.

J.1.5. Employer's Personnel – Trainee

The Employer will designate staff to the Contractor to participate to training. The Contractor shall have the right to request each candidate to pass an examination to determine his/her basic knowledge in reading writing, calculating and understanding of technical issues and to reject those candidates that have not passed the examination.

The learning progress of the trainees shall be checked and evaluated by the Contractor before, during and after completion of training.

The Contractor shall report to the Engineer and the Employer in writing every week, detailing the activities, attendance, performance and ability of each of the trainees. The Contractor must ensure that at the end of the training programme, prior to Taking-Over, designated staff is fully qualified and capable of maintenance and operation of the system by their own.

J.1.6. Contractor's Personnel

The Contractor shall provide training personnel for each of the positions required for management, Operation and Maintenance as identified in the training programme. The duties of each of the training personnel shall be to manage, operate and maintain that element or those elements of the Works appropriate to his position, and to train the Employer's assigned staff members for that particular position. The emphasis shall be on "hands-on" training.

In addition to his normal training personnel, the Contractor shall also provide specialist trainers who shall be responsible for formal classroom, laboratory or workshop training.

J.1.7. Training of Operating Staff

The Employer will designate operating staff to the Contractor prior to start of installation of plant and equipment. Training shall start at the latest with Tests on Completion. During all

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times of Tests on Completion, the Contractor shall associate the trainees to his staff on site. Training shall be completed together with Tests on Completion.

If reasonably applicable the theoretical courses should be held / completed before the start of Tests on Completion, so that trainees can attend these tests with better understanding. Theoretical courses shall enable them to understand the function of the equipment and to know operational and maintenance issues. Practical training should be conducted as training on-the-job during Tests on Completion as mentioned above. The Contractor shall consider training activities in his Programme for Tests on Completion.

Training shall enable Employer's staff to sustainably and continuously operate the plant and to undertake regular and preventive maintenance of the equipment installed under the Contract.

Training shall be held for the number of trainees as specified in the Particular Technical Specifications with different technical background and knowledge.

J.1.8. Training of Maintenance Staff

The Employer designates maintenance staff to the Contractor prior to start of installation of plant and equipment. The Contractor shall associate such staff to his team.

For installation of mains, training of maintenance staff shall start when 20 % of the mains have been laid and tested and shall end at the pressure test for the last portion of mains to be executed.

J.1.9. Training of System Operators, Supervisors and Developers

The training shall be organised such that the Employer shall be able to operate and maintain the SCADA systems and components following completion of all training courses.

J.1.9.1. System Operators

This purpose-designed course is to be held at the Works Control Centre. Training must be provided in advance of commissioning to enable the Employer's staff to participate in the full process commissioning of the system and safely operate the plant and maintain the SCADA system. System take-over shall not take place until satisfactory training has been provided.

This course shall be designed to familiarise the participants with the general running of the standard operating system and the SCADA package to include but not limited to:

- Loading and starting up the Operating System;
- System Operators interface;
- Operator control of programme / task execution;
- Operator control of disc files;

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- File transfer tasks - archiving, retrieval;
- Operator response to system failure, on-line / off-line diagnostics, transfer of control between the computers synchronisation of the system database;
- SCADA system interrogation facilities - alarm lists, log printouts select mimic and trend displays etc.;
- Alarm acknowledge accept / delete;
- Control actions, e.g. start pump, close valve;
- All functions associated with each access level of the SCADA system.

J.1.9.2. System Supervisors

The Contractor shall provide training at the Works Control Centre prior to the systems handover. The training shall consist, in addition to the above described components, in the following:

- Basic systems design overview;
- The use of computers to perform diagnostics and to tune other parts of the system;
- System Administration; e.g. changing passwords and access control;
- Sequence verification;
- Preventive maintenance.

J.1.9.3. Systems Developers / Programmers / Engineers

The training shall be designed to cover all configuration and advanced facilities of the SCADA package. It shall include, but not be limited to the following:

- The system database structure;
- System database building / configuration;
- Mimic building;
- Applications program interface to the system database;
- Management information system interface;
- Downtime loading of control programs / sequences to PLCs;
- Advanced operating features.

J.1.10. Training Test Period

The last thirty (30) days of the Training Period shall be considered as the Training Test Period. During this period, the Works are to be entirely managed, operated and maintained by the Employer's assigned personnel. The Contractor shall remain, nevertheless, fully responsible for the successful Operation and Maintenance and his training personnel shall remain on site to act in an advisory capacity if needed.

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If, during the Training Test Period, any section of the Works fails to achieve the required performance standards or any fault cannot be located or rectified, the training personnel will be required to assume "hands-on" operational activities.

If the Employer considers that the Works are not being properly managed, operated or maintained, the Contractor shall immediately provide additional training as necessary. Once this additional training has been successfully completed, the Contractor shall seek the Employer's approval for a repeat of the Training Test Period of 30 days for that section of the Works. Training Test Periods shall be repeated until the Employer is satisfied that the assigned personnel are successfully managing, operating and maintaining the Works.

No additional payment will be made to the Contractor for the repetition of a Training Test Period as described above, nor will the Contractor have the right to claim any payment in connection with Operation and Maintenance for the repetition of any Training Test Period.

J.2. OPERATION MANAGEMENT

J.2.1. General

The Contractor's scope of works and services include the provision of Section C – Technical Operation Management services to the Employer during following periods after issuance of the respective Taking-over certificates:

- Two (2) years for the Section A Works (Wastewater Treatment Plant (WWTP) and Sewage Sludge Treatment Plant (SSTP), Small Hydro-Power Plant (SHPP) and common facilities);
- Three (3) years for the Section B Works (Sewage Sludge Incineration Plant - SSIP).

The above indicated Technical Operation Management period extends one year after expiry of the related Defects Notification Periods (1 year for the WWTP, SSTP, SHPP and Common Facilities and 2 years for the SSIP).

Purpose and main objectives of the Technical Operation Management period are:

- To operate the plant in the optimum way in order to warrant that the guaranteed performances and consumption values are achieved and maintained at all times;
- To train the Employer's technical (operation and maintenance) staff at all levels and in all fields in order to guarantee that it will have the capabilities to adequately operate the plant autonomously at the end of the Technical Operation Management without assistance from the Contractor.

The operation period shall include appropriate training of the Employer's staff in the fields of process control, laboratory analyses and mechanical, electrical, instrumentation and control equipment including SCADA to both operation and maintenance staff.

Training services shall be carried out in accordance to Section J.1 of the Employer's Requirements.

The Contractor has to price the Section C Services (Technical Operation Management) in the Price Schedule.

J.2.2. Responsibility of the Contractor

The Contractor will assume the full responsibility for the technical operation of the wastewater treatment plant. He will be accordingly empowered to take any decision regarding the operation and maintenance of the plant and to give instructions to the Employer's staff assigned to the operation and maintenance of the plant.

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The Contractor is responsible for failures, breakdown and irregularities in the plant performance as well as for any damage to the Works which result either from mal-functioning of equipment during the Defects Notification Period period or from operation errors which result from wrong advice of the Contractor, provided the damage was not caused by malpractice of Employer's staff.

The Contractor shall make good such damage without undue delay and, in case applicable, without additional cost to the Employer.

The Contractor shall provide the Technical Operation Management Services in compliance with the requirements of the Operation, Maintenance and Safety Manuals.

If the Contractor wishes to modify a document which has previously been submitted and approved, the Contractor shall notify the Employer's Representative, and shall subsequently submit revised document(s) to the Representative appointed by the Employer for review, accompanied by a written explanation of the need for such modification.

The Contractor shall not implement any proposed modification until such modification has been reviewed by the Employer's Representative, and consent to proceed has been given in writing. However, any such approval or consent, or any review / under this Section or otherwise), shall not relieve the Contractor from any obligation or responsibility.

J.2.3. Excluded services

For the avoidance of doubt, the following services shall be excluded from the scope of the Section C Services (Technical Operation Management):

- Commercial and overall management of the WWTP;
- Representation of the Employer against external parties;
- Liaison with external parties;
- Pay role function related to Employer's staff;
- Invoicing of external parties;
- Purchasing any goods or services on account of the Employer.

J.2.4. Responsibility of the Employer

The Employer will be responsible for recruiting, employing (pay role function) and assigning the operation and management staff in the conditions described in Section J.2.5 below.

The Employer will be responsible for the provision of following material and services at his expenses, in the limits, where applicable, of maximum consumption values guaranteed by the Contractor:

- Drinking water supply;

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- Electrical energy;
- Telecommunications (telephone, internet, ...);
- Chemicals for chemical phosphorous precipitation, sludge treatment and flue gas treatment;
- Lubricants and consumables (in the limits indicated in Clause A.2.2.9.
- Spare parts, after expiry of the Defects Notification Period.

The employer will be responsible for the adequate disposal, including the payment of the corresponding fees, of any residues and by-products including but not limited to:

- Ashes from the sludge incineration;
- Flue Gas Treatment residues;
- Screenings;
- Grit.

The Employer will be responsible for the payment of any fee resulting from the operation of the plant in accordance to the applicable regulations, including but not limited to:

- Water abstraction fee (process water produced by the plant's own well);
- Wastewater discharge;
- Emission of air pollutants.

The Employer will determine the operating needs and inputs with assistance of the Contractor and be responsible for their timely provision in order to meet the targets for wastewater treatment designated in these tender documents.

J.2.5. Employer's Staff

J.2.5.1. General

The plant will be operated by the water supply and sewerage company Vodovod i kanalizacija (ViK) Podgorica d.o.o., who will assign the available operation staff in charge of the operation of the existing WWTP and additional staff, as required, for the operation and maintenance of the new WWTP.

During the Technical Operation Management period, the Contractor will be responsible for the adequate technical management, operation and maintenance of the plant and will supervise and instruct the Employer's staff.

Recruitment and assignment of the Employer's staff will be regulated as described in the following.

Nine (9) months prior to the pre-commissioning tests, the Contractor shall submit to the Engineer and to the Employer, for approval, a fully detailed work programme for Operation and

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Maintenance of the Works. This shall include an organisation chart with number of job descriptions for each grade of staff including the Plant Manager.

The above Programme for Operation and Maintenance of the Works shall include a list of required staff for the operation and management of the plant with a job description indicating for each staff the minimum requirements with regard to:

- level of education;
- qualification and experience;
- special skills;
- necessary licenses and certificates (e.g. high / medium voltage license for electrician).

Future staff and labour of the Employer shall include, but not be limited to the following categories:

- Plant manager;
- Qualified engineers and experts;
- Qualified technicians;
- Semi-skilled labour;
- Unskilled labour;
- Security personnel.

More than one job categories can be performed by one person if he/she possesses the requested proven experience records for those positions, and if this allows for a continuous efficient performance of Operation and Maintenance.

In a first step, the Employer and the Contractor will assess the adequacy of the profile and qualification of available staff with the above requirements and, where deficits are identified, prepare a programme of recruitment of the necessary additional staff.

The Employer will engage, with support from the Contractor, the necessary steps for the engagement of the required staff. The Contractor will be consulted and shall assist the Employer during the recruitment procedure as the Employer may require.

J.2.5.2. Contractor's Right to Request Removal

The Operator shall be entitled to request the Employer to remove a member of the Employer's personnel from the WWTP Site for Cause. Any such request shall, where appropriate, be made in writing. Upon receipt of such request, the Employer shall comply with such request as soon as practicable.

For the purposes of the present section, "Cause" shall mean the (i) failure by a Person to substantially perform his or her employment duties, (ii) the wilful engaging by a Person in

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conduct which is injurious to the interests of the Contractor, or (iii) the breach by a Person of any Legal Requirements applicable to the Employer, the Contractor or the WWTP.

J.2.6. Contractor's Staff Requirement

J.2.6.1. General

The work programme, organisation chart, number of manpower and job descriptions of all staff necessary for assistance in Operation and Maintenance as submitted by the Contractor with his Tender will form the basis for the organisation of the services. It may, however, be amended by the Contractor at his expense to meet the requirements of these services to the approval of the Employer's Representative.

The Contractor shall entrust adequately experienced key staff with the responsibility of assistance in Technical Operation and Maintenance of the wastewater treatment plant. The key staff shall plan, establish and administer the organisation of the technical operation and maintenance of the plant in close cooperation with the Employer and subject to the approval of the Engineer.

The personnel of the Contractor shall have the appropriate experience and qualifications to perform the assistance in Operation and Maintenance. Minimum Requirements for the personnel are given in Section VII Employer's Requirements, Part 1, d) Personnel Requirements.

The proposed personnel for the Operation management Phase (Item 2) shall be submitted to the Engineers and Employer's approval minimum 3 months before the start of the commissioning and testing of the respective parts of the plant.

For this purpose, the contractor shall submit, for the personnel proposed under Item 2. "Technical Operation and Management Phase" in the Table in Volume 3, Section VII "Employer's Requirements" Part 1. d), in accordance with Volume 1, Section IV "Personnel":

- Form PER-1 : Proposed Personnel, and
- Form PER-2: Resume of proposed Personnel for each of the proposed personnel. A full CV giving details of professional qualifications and experience of the key personnel should be submitted

The Engineer and the Employer reserve the right to request additional information from the Contractor to substantiate that the proposed personnel possess the necessary qualification and experience.

Any staff not having the requisite qualification shall be substituted, at the cost of the Contractor, within one month after request by the Employer's representative or the Employer.

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Each Technical Operation Management staff of the Contractor shall at a minimum be fluent in the English language. Fluency in the Montenegrin language would be an advantage.

In any case the Contractor is responsible for comprehensive communication e.g. by providing sufficient number of eligible English-Montenegrin-English translators / interpreters at his expense. Costs for the translator / interpreter shall be included in the unit rates of the respective Operation Management staff.

The contractor shall provide and maintain all necessary protective and safety equipment and clothing for his staff.

J.2.6.2. Minimum Requirement for WWTP and SSTP Management Staff

The key staff assigned by the Contractor to provide Operation Management and Training services to the Employer for the WWTP and SSTP shall include at a minimum, but not be limited to the following:

- Plant Operation Manager: Full-time
- Expert for Electromechanical Maintenance: 18 Man-Months
- Wastewater and sludge treatment Process Engineer: 4 Man-months
- Wastewater and sludge analysis Expert (Chemist): 4 Man-months
- Control and Supervision (SCADA) Expert: 2 Man-Months
- Occupational Health & Safety and Security Specialist 2 Man-months

J.2.6.3. Minimum Requirement for SSIP Management Staff

The key staff assigned by the Contractor to provide Operation Management and Training services to the Employer for the SSIP shall include at a minimum, but not be limited to the following:

Table 1: Minimum Requirement for SSIP Management Staff

Position	1 st year	2 nd year	3 rd year
SSIP Operation Manager (Engineer)	2 staff members [1x Day-shift, 1x On-call night-shifts]	2 staff members [1x Day-shift, 1x On-call night-shifts]	1 staff members [Day-shift]
Experts for Electromechanical Maintenance (Technician Mechanical / Electrical)	4 Man-Months	2 Man-Months	2 Man-Months

Since the intended operational concept is intermittent operation with periodic standstills over weekend, the SSIP Operation Manager is mainly required during weekdays. Therefore, at least two SSIP Operation Managers could be sufficient in the first and second year of operation (Defects Notification Period). An on-site presence during the day shift, coverage of

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the night shifts by on-call duty and sufficient holiday and illness coverage shall be ensured during the first two years.

The expert for electromechanical maintenance will be required in the first two month of operation and during the annual maintenance period. In addition, the expert shall be available on call in case of major malfunctions with a reaction time of 48 hours.

J.2.6.4. Employer's Right to Request Removal

The Employer shall be entitled to request the Contractor to remove a member of his personnel from the WWTP Site for Cause. Any such request shall, where appropriate, be made in writing. Upon receipt of such request, the Operator shall comply with such request as soon as practicable.

For the purposes of the present section, "Cause" shall mean the (i) failure by a Person to substantially perform his or her employment duties, (ii) the wilful engaging by a Person in conduct which is injurious to the interests of the Contractor, or (iii) the breach by a Person of any Legal Requirements applicable to the Employer, the Contractor or the WWTP.

J.2.7. Delays and Interruptions during the Section C Services.Phase

Delays and interruptions during the Technical Operation and Maintenance Service will be regulated as follows:

(a) Delays or interruptions caused by the Contractor

If there are any delays or interruptions during the Operation phase which are caused by the Contractor or by a cause for which the Contractor is responsible, the Operation phase will be extended accordingly without any extra payment to the Contractor. The Employer shall be entitled to recover the amount due by making a corresponding deduction from the next payment to the Contractor.

(b) Delays or interruptions caused by the Employer

If there are any delays or interruptions during the Operation phase which are caused by the Employer or by a cause for which the Employer is responsible, the Operation phase will not be extended or will be extended on request and at the expense of the Employer.

(c) Suspension by the Employer

The Employer's Representative may at any time during the Operation phase, instruct the Contractor to suspend his assistance in Operation and Maintenance. During such suspension, the Contractor shall give advice to protect, store, secure and maintain the Plant against any deterioration, loss, or damage.

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If the need to suspend the Contractor's services during the Operation phase by the Employer is due to any failure to the Contractor or circumstances for which the Contractor is responsible under the Contract, the provisions of paragraph (a) of this Sub-Clause shall apply.

If the need to suspend the Contractor's services during the Operation phase is not as a result of any failure by the Contractor or is due to circumstances for which the Contractor is not responsible under the Contract, the provisions of paragraph (b) of this Sub-Clause shall apply.

If a suspension which is not due to any failure to the Contractor or is due to circumstances for which the Contractor is not responsible under the Contract has continued for more than 28 days, the Contractor may request the Employer's Representative's permission to proceed. If the Employer's Representative does not give permission within 28 days after been requested to do so, the Contractor may give notice of termination of the Contract.

After the permission or instruction to proceed is given, the Contractor and the Employer's Representative shall jointly examine the Works. The Contractor shall make good any deterioration or defect in the Plan, and the Employer's Representative shall make a written record of all making good required to be carried out by the Contractor. If the suspension is not due to any failure by the Contractor or is due to circumstances for which the Contractor is not responsible under the Contract, the Contractor shall be entitled to be paid the Cost plus the Profit or making good the Works prior to re-commencing his services during Operation phase.

J.2.8. Administration

J.2.8.1. Facilities and Equipment

During the Operation period, the Contractor shall make use of the new facilities and equipment of the WWTP in cooperation with the Employer.

The Contractor shall take care that the facilities and equipment are in good condition at the end of the Operation Management period.

J.2.8.2. Legal and Financial Aspects

The Contractor shall verify and consider all legal aspects concerning the engagement of his staff, disputes and claims with regard to local rules and regulations.

It shall be assumed that any activity of the Contractor required for assistance in Operation and Maintenance including comprehensive Training activities etc. is included in the Price Schedules. After the award of the Contract no alteration will be made to the Price Schedules to rectify any "unpriced" activities or items.

The tasks of the Contractor will also include assistance in the general budgeting of Operation and Maintenance, the utilisation of proper audit functions and the administration and payment of assurances.

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J.2.8.3. Safety and Security

The Contractor shall submit to the Engineer's approval a Health and Safety Plan as required by local and European regulations and standards.

Safety

The Contractor shall provide a safety specialist being responsible for the preparation, implementation and maintenance of a comprehensive safety programme, which shall be approved by the Employer's Representative, and which shall be evaluated whenever appropriate and at least at the conclusion of the Operation Service. The specialist shall develop the safety and health policies, standards and procedures.

The responsibility of the safety specialist includes performing safety training and conducting safety inspections, sessions and practice. He will also be responsible for the investigation of accidents.

A safety committee shall be formed and regular safety meetings shall be organised. All safety equipment and tools shall be provided by the Contractor in the frame of the erection of the plant.

Fire Protection

The safety specialist shall prepare, implement and maintain a comprehensive fire protection and prevention programme in accordance to the applicable local regulations, which shall be approved by the Employer's Representative.

The safety specialist will also be responsible for the inspection and maintenance of the fixed and portable fire protection equipment and for the investigation of fire incidents.

Two (2) months prior to the Operation period, the safety specialist shall develop a project emergency action plan and fire hazard inspection procedure which will be subject to the approval of the Employer's Representative. The implementation of these plans including training activities shall be performed prior to the Operation Management period.

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Security

In order to protect property, materials and facilities against unauthorised entry and trespass, pilferage and theft, destruction, damage, sabotage, embezzlement, fraud and other dishonest, illegal or criminal acts during the Operation Service, a security programme shall be prepared by the Contractor in accordance with the local regulations and shall be approved by the Employer's Representative. The Contractor shall assist the implementation and maintenance of the security programme in accordance with the local regulations.

J.2.8.4. Reporting

The Contractor shall submit monthly reports including any important details concerning technical performance, staffing, training and Technical Operation and Maintenance of the Works by the 10th day of the successive month. After approval by the Employer's Representative, the reports shall be used as a guide for regulation, adjustment and modification of the plant facilities, in case applicable.

The reports shall continuously record and demonstrate the performance of staffing, training and operation and maintenance. The reports shall be in both English and Montenegrin language. The number of hardcopies of each monthly report shall be two (2) English and four (4) Montenegrin versions and two (2) digital copies, the number of the final report at the end of the Operation period shall be three (3) English and ten (10) Montenegrin versions and three copies. The layout of the reports and other general requirements shall be discussed with the Employer's Representative and arranged to his satisfaction.

The Contractor shall establish and maintain a daily machine journal. The journal shall be a record of all the readings of flow rates, counter readings, pressure values, temperatures, odours, etc. for all facilities and equipment of the treatment plant. A file shall be maintained on site for storage of hardcopies from supervisory control panel printouts showing the listed parameters. In addition, all characteristic operation data of any major item of the treatment plant and all remarks and comments of the shift leaders concerning abnormal readings, overloads, stoppage, failures and other operation events shall be recorded.

Monthly laboratory reports shall be prepared by the Contractor presenting the results of the records of laboratory tests and continuous quality control measurements.

The monthly reports on daily sample and measurement shall be prepared including, but not be limited to:

- monthly influent flow rate curves and tables showing daily maximum, average and minimum inflow values, including faecal sludge co-treated at the WWTP;
- quantities of sludge and other residuals produced, stored and leaving to the recycling / disposal site;
- laboratory average daily, weekly and monthly results tabulated with maximum and minimum values;

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- diagrams showing the performance of the Works;
- list of monthly penalties charged from local authorities for non-compliance with the guaranteed effluent values;
- daily consumption figures of electricity and chemicals, service hours of main machinery and equipment, times, duration, reason and remedying of emergency operation and failures;
- other data requested or events of significant importance;
- statistics of staff members and labour utilisation;
- information on major equipment repair, overhaul and other maintenance works;
- spare and wear parts used and mobile equipment;
- monthly expenditures.

The annual and final reports shall include, but not be limited to:

- monthly average influent flow rates with maximum and minimum values and total value;
- monthly and total quantities of sludge and other residuals and record of delivery to recycling / disposal site;
- monthly average quality of influent, effluent, sludge and odour emission with maximum and minimum values as well as other data as temperatures, etc.;
- summary of monthly penalties charged from local authorities for non-compliance with the guaranteed effluent values;
- monthly and total electricity and chemical consumption figures;
- service hours of main machinery and equipment;
- monthly and total staff and labour utilisation excluding training;
- monthly and total staff utilisation for training of Employer's personnel;
- times, duration, reason and remedying of emergency operation and failures;
- information on major equipment repair, overhaul and other maintenance works;
- spare and wear parts used and a list of remaining spare and wear parts;
- monthly and total expenditures.

J.2.9. Operation

J.2.9.1. Provision of Electricity, Consumables and Disposal of Sludge and Residuals

During the entire Operation phase the Contractor shall assist the Employer in providing electricity, potable water and the necessary supplies of chemicals, lubricants in the limits indicated in Section A.2.2.9, fuel and others consumables sufficient to continuously operate and maintain the Works.

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Until the Taking Over of the plant, all lubricants recommended and admissible by the manufacturers have to be supplied by the Contractor. After Taking Over, during Defects Notification Period, the lubricants shall be supplied by the Employer in accordance with the recommendations of the various equipment and Plant manufacturers in the limits indicated in Section A.2.2.9 (lubricants for the first year of operation to be supplied by the Contractor prior to the Taking Over).

The Contractor shall limit the various types of lubricants by consolidating these, with the manufacturer's approval, into the least number.

The Contractor shall provide the Employer's Representative with three (3) copies of a list showing the proper lubricants (after consolidation) for each item of equipment and Plant with a schedule giving the estimated frequency and quantity of lubrication required. This will not relieve the Contractor from supplying this information within the Operation and Maintenance Manuals as well.

The Contractor shall assist the Employer to make all necessary arrangements for the disposal of any screenings, grit, sand, other wastes, debris and residuals removed from the wastewater or generated at the treatment plant. Toxic wastes shall be disposed of at a site to be agreed with the concerned local body. On request of the Employer, the Contractor shall assist in the obtaining of all necessary permits for the disposal of residues. The Contractor shall assist the Employer as required in the administration and management of the disposal of all residuals.

J.2.9.2. Penalties for Non-Compliance

The Contractor shall assist the execution of composite and continuous sampling and testing as described in the approved Operation and Maintenance Manuals, and any other tests as necessary to fully control and monitor the performance of the wastewater treatment plant.

Penalties due to non-compliance performance will apply as described in Volume 2, Part A Schedules of Operational Performance and Consumption.

J.2.9.3. Emergency Conditions

The Contractor shall establish requirements for dealing with potential hazardous conditions.

All possible situations of emergency shall be scheduled within an emergency plan by the Contractor. Herein, the required services, additional required structures, equipment, staff and other resources shall be planned and recorded for the possible situations of emergency. The emergency action plan shall be submitted for approval to the Employer's Representative. Every effort shall be made to ensure that any emergency situation at the treatment shall be limited to the shortest possible period to minimise any negative effects on the environment.

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Any necessary shutdown of the plant for operational adjustments shall be restricted to the possibly shortest period with minimum flow at the inlet works and shall be approved by the Employer's Representative.

J.2.10. Maintenance

J.2.10.1. General

Administrative maintenance policies shall be prepared and implemented by the Contractor, based on the developed maintenance programme. The policies shall be approved by the Employer's Representative and shall include, but not be limited to:

- preventive maintenance;
- overhauls and half-overhauls plan;
- failures and unexpected repair works plan.

A basic maintenance management system shall be implemented after approval by the Employer's Representative. It shall include, but not be limited to:

- planning and scheduling;
- maintenance personnel;
- maintenance instructions;
- inventory control of items;
- equipment records;
- forms for costs and budgets.

The Contractor shall assist in carrying out maintenance. All items of equipment shall be inspected and maintained in accordance with the manufacturer's specifications and to the local conditions. The Contractor has to take care that replacements, repairs and painting will be carried out immediately and when necessary. Maintenance records showing all maintenance work carried out on each item of equipment shall be updated daily and shall be made available at any time for examination by the Employer's Representative.

The Contractor has to take care that the installed equipment shall be checked and serviced daily during working days. This includes the following:

- The operating conditions of any instrument shall be maintained by function checks and services. Calibration shall be checked and corrected whenever necessary. After submission of the calibration data for approval, the instruments shall be calibrated as required and directed by the Employer's Representative.
- The Contractor has to take care that the buildings, HVAC, electrical and sanitary installations shall be kept clean and continuously maintained in a proper and orderly manner. All interior and exterior structures, structural elements, equipment, installations, infrastructural elements and others shall be maintained, repaired,

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replaced if necessary at the expense of the Contractor during the Defects Notification Period.

The maintenance of site works shall include, but not be limited to the repair, painting and the replacement of defective items for traffic areas, pipes and fittings (including protection), cables, channels, roads, lighting poles and fences and shall also include the maintenance of lawn areas, plants, shrubs, bushes and trees.

J.2.10.2. Management

The Contractor shall assist the management of maintenance which shall include, but not be limited to:

- implementation and operation of a separate maintenance budget system comparing the budget with the general budget of Operation and Maintenance;
- planning and controlling the work of subcontractors, if applicable;
- establishing of requirements for equipment manuals, for each item of equipment;
- setting out procedures for installation and commissioning, instructions for Operation and Maintenance and listings of component parts.

J.2.10.3. Planning and Schedule

The performance of maintenance shall be administered by the Contractor developing, implementing and using a maintenance work package system in which the job priorities, the work assignment and the necessary personnel are listed. The required daily work shall be scheduled in charts by the hour or more detailed.

The maintenance work package system shall consider the manufacturers' maintenance manuals and also conditions like topography, climate and operation of the wastewater treatment plant.

The maintenance work package system shall include a chart for periodic maintenance of any equipment and Plant on Site. The chart of every equipment and Plant shall indicate any necessary step of preventive maintenance.

The maintenance work package system shall be submitted to the Employer's Representative for approval.

Only highly skilled and trained personnel of the Contractor shall be assigned to assist in performance of inspections, repairs and preventive maintenance tasks. Specific skills are required for the maintenance of mechanical, electrical and instrumentation machinery and equipment.

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J.2.10.4. Maintenance Instructions

At an agreed central location, all manufacturers' maintenance manuals and other information shall be filed for each item of equipment by the Contractor.

The recorded data shall be well organised and documented together with the relevant general arrangement drawings in order to enable ready availability. A manual describing the preventive maintenance of the equipment and Plant shall be prepared by the Contractor and approved by the Employer's Representative.

J.2.10.5. Inventory Control of Items

A central storeroom for spare and wear parts, equipment and supplies shall be maintained. The Contractor shall assign all parts with item identification codes, each of them possibly being an extension of the design and construction documents.

A computerised system shall be developed and implemented by the Contractor using the item identification code to record all necessary information of any item, to place the items in the storeroom and to re-order the items when required. This system shall keep a record of the quantity of each item remaining in stock, shall allow a direct comparison with the recommended stock level, as well as indicate the replacement lead-time.

J.2.10.6. Equipment Records

The Contractor has to take care that the performance and the future requirements of maintenance shall be recorded daily and updated in the equipment records. All maintenance of equipment, identification of occurred problems and action taken to avoid failure shall be recorded. The records shall be made available at any time for examination by the Employer's Representative.

J.2.10.7. Work Control and Failure Management Planning

Work control shall be established by preparing and implementing procedures of Corrective and protective maintenance, of tool control and of spare and wear parts issues.

Failures of maintenance shall be bridged or repaired as soon as possible so as to minimise negative effects on the environment. Therefore, the Contractor shall develop, implement and use a standard procedure such as the critical path method (CPM), or equivalent, to sufficiently schedule for maintenance failures.

Resource planning shall be carried out in order to find out the requirements for special materials, special tools and/or special equipment for bridging or repairing any failure as soon as possible.

J.2.11. Technical Services to be assisted and implemented by the Contractor

J.2.11.1. Plant chemistry

The Contractor shall develop and maintain a chemical treatment programme to minimise corrosion, extend system life and maintain efficiency of the wastewater treatment plant.

The project systems shall be reviewed and recommended in relation to the chemical treatment programme. Required improvements of the systems shall be carried out, after approval by the Employer's Representative. The Contractor shall instruct and train the staff necessary for implementation of the chemical treatment programme.

J.2.11.2. WWTP and SSTP Monitoring

The Contractor shall assist the Employer in monitoring as stated in the following instructions.

Wastewater treatment

Flow rate measurements.

All measurement instruments shall be checked and rated at start up and at the end of each year of the Operation Management phase by the Contractor and a rating certificate shall be provided.

The points for continuous discharge measurements, with graphic recordings, shall include but not be limited to:

- At the plant head-works: metering of effluent inflow;
- Metering of treated water prior to discharge;
- By-pass, either directly by using metering instruments or indirectly by operation performance of pumps;
- Supernatant flows;
- RAS and SAS flows;
- The internal recirculation flow (pre-denitrification) must be checked continuously, either directly by using metering instruments or indirectly by operation performance of pumps.

Quality of treatment

The monitoring of the wastewater treatment quality will be carried out by Employer's staff assisted by the Contractor.

The Contractor will be responsible for the implementation of all the tests necessary for the daily operation of the plant. The laboratory of the WWTP will be used to execute all tests and analyses necessary for the daily operation of the plant. The Contractor will guide the laboratory staff and assist in these measurements.

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Additionally analyses will be carried out by an independent laboratory two times in the O&M service period in order to validate the results and methods used. The costs of these independent tests will be borne by the Employer.

The temperature and pH-value of influent entering the treatment plant will be measured continuously. Twenty-four hour flow-proportional composite samples will be collected daily on untreated wastewater at the inlet and on treated effluent after final disinfection. Samples shall be analysed for the following parameters (minimum frequency):

- COD (7 / week);
- BOD₅ (3 / week);
- TKN (7 / week);
- NO₂-N and NO₃-N (3 / week);
- NH₄-N (3 / week);
- Total P (7 / week);
- TSS (7 / week);
- Turbidity (3 / week);
- pH (7 / week);
- Conductivity (7 / week);
- Acid capacity (1 / week);
- Bacteriological quality, at a minimum: Total Coliforms (TC), Faecal Coliforms (FC), Faecal Streptococci (FS) (1 / week).

Checking the operation of certain units

Various measurements and checks will be performed under the guidance and assistance of the Contractor to assess the operation of individual units.

The form of the test protocol shall be proposed by the Contractor and approved by the Employer's Representative. The Contractor shall provide intermediate inspection parameters for assessing the proper operation of the structures, for example localised inflow / outflow samples, sludge characteristics, etc.

The test protocol shall include but not be limited to the following points and measurements:

a. Screenings and grit

Following samples are taken each month:

- Screenings after compaction;
- Grit after washing and classification.

The dry matter and volatile matter (for grit only) content of each sample is analysed.

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The quantities produced are measured each day and expressed in m³ and kg of dry matter.

b. Reagent consumption

The consumption level must be measured daily on any treatment process involving the addition of reagents.

c. Biological reactor

- Daily measurements of MLSS in the aeration basin;
- Continuous dissolved oxygen measurement;
- Sludge volume index (SVI) once a day;
- Microscope observations to determine micro-fauna once a month;
- Internal recirculation flow rate, continuously;
- Return sludge flow, continuously;
- MLSS of return sludge three times a week.

Sludge Treatment

The production of primary, biological and tertiary sludge shall be measured continuously (where applicable). The quantities of sludge must be noted at each stage (thickening, dewatering) and if necessary for each type of sludge. The quantities of reagents consumed must be noted.

Sludge analysis shall be carried out every week. The analyses shall be performed on mean samples obtained by mixing six grab samples taken over a 24-hour period, and shall concern the following parameters:

- fresh liquid primary and biological incl. tertiary sludge: TSS, VSS, DS, VDS, pH;
- thickened primary and biological incl. tertiary sludge: DS, VDS, pH;
- digested sludge: DS, VDS, pH;
- dewatered sludge: TSS, VSS, pH;
- for supernatant: TSS, COD, BOD₅, NH₄-N.

Checking of general operation

Active and reactive energy consumption shall be measured each day for the plant as a whole and for each of the sub-components.

The total volume of supernatant shall be recorded each day. The corresponding pollutant loads must be measured each week.

Other Points to be noted

- Consumption of all reagents;

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- Working time of the main items of equipment: pumping, aeration, mixing, thickening dewatering, drying etc;
- Measurements of power consumption by equipment: compressor, stirrers, facilities for thickening, dewatering and drying, etc.

Noise

Noise levels shall be measured after three months of operation. Noise measurements shall be carried out during a period when all the installations, in particular those involved in sludge treatment and sludge incineration, are in operation.

At the edge of the property

During the tests, an overall measurement of the noise emitted by the installation shall be carried out at the edge of the property. The measurement shall be made by an organisation approved by the Employer's Representative and in accordance with internationally recognised standards. The measurement point shall be chosen in agreement with the Employer's Representative.

The measurement shall be carried out for a period of 24 hours, during which the installation shall be in normal operation, in conditions that are as close as possible to nominal working conditions.

Within the premises (at the plant)

The appropriate measurements shall be performed to ensure that the arrangements made by the Contractor comply with local rules and regulations concerning the safety of staff and with the guarantees provided by the Contractor.

Data filing and processing

Employer's staff shall be trained sufficiently by the Contractor to ensure that the following data filing and processing operations will be performed efficiently:

- all kind of process control measures;
- inventory control concerning supply and removal items;
- all kind of management;
- preparation of reports in the Montenegrin and English language;
- record keeping and operation;
- maintenance of equipment and laboratory data;
- additional programmes as directed by the Employer's Representative.

In order to achieve a proper functioning control of process performance, an interdisciplinary reporting and data filing system shall be implemented by the Contractor, combining the fields

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of Operation and Maintenance like expenditure, personnel, operations performance, maintenance performance and laboratory activities.

Changes in the computer systems shall be documented. Proposed computer system modifications shall be developed or reviewed. The realisation of modifications and repairs shall be co-ordinated by the Contractor.

J.2.11.3. SSIP Monitoring

All measured and operating values transmitted to the control system are archived in the long-term archive of the SCADA with a frequency of at least 5 seconds. No data is deleted or modified during or after the end of the operation management service period.

The following sampling shall be carried out according to the operating and maintenance instructions, but at least monthly:

- Thermal oil;
- Ash;
- FGT residues.

All installed measuring equipment is tested and calibrated according to the manufacturer's specifications. The tests and calibrations shall be documented.

J.2.11.4. SHPP Monitoring

Following data shall be monitored for the Small Hydro-Power Plant at a daily frequency:

- Average water level in the Moraca River;
- Volume of water transferred through the turbine (m³/d);
- Energy produced (kWh/d);
- Average daily power (kW) produced;
- Peak daily power (kW) produced.

J.2.11.5. Quality control

A quality control management system shall be developed and maintained by the Contractor, based on the prepared quality control manual. All staff from the Employer shall be trained in the application of the quality control management system.

All programmes and systems prepared for Operation and Maintenance as well as for Staff Training shall be integrated in the quality control management system. The quality control management system shall be approved by the Employer's Representative.

1. Specifications

c) Specifications for Environmental, Social, Health and Safety Management (ESHS) of the Works

Throughout the ESHS Specifications, a reference to the Conditions of Contract (CC) means a reference to both the General Conditions of Contract and the Particular Conditions of Contract. Readers should apply due care, when referring to a specific Clause or Sub-Clause, and:

- (a) Read first the Clause or Sub-Clause text from the General Conditions of Contract;
- (b) Then check whether this text has been amended by the Particular Conditions of Contract, and if so, to which extent.

As per CC Sub-Clause 1.5, when interpreting the Contract, the terms of the Particular Conditions of Contract prevail over those found in the General Conditions of Contract.

Any term in these ESHS Specifications which is identical to a term in the Conditions of Contract shall have the same meaning as the one defined in the Conditions of Contract.

Any term in capital letters in these ESHS Specifications is defined in CC Sub-Clause 1.1 – Definitions.

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A. Environmental, Social, Health and Safety Management

1. Responsibilities and liabilities

- 1.1. In conjunction with his obligations defined under the Contract, the Contractor will plan, execute and document construction works pursuant to the present Environment, Social, Health and Safety specifications (ESHS).
- 1.2. The Contractor is liable for all damages to the environment and people caused by the execution of the works or the methods used for execution, unless it is established that the execution or methods were necessary, according to the provisions of the Contract or an Engineer's instruction.
- 1.3. Under the Contract and as introduced by the present ESHS Specifications, the term "Project Area" means:
 - a) The land where work will be carried out; or
 - b) The land necessary for the implantation of construction facilities (work camp, workshops, offices, storage areas, concrete production plants) and including special access roads; or
 - c) Quarries for aggregates, rock material and riprap; or
 - d) Borrow areas for sand and other selected material; or
 - e) Stockpiling areas for backfill material or other demolition rubble; or
 - f) Any other location, specifically designated in the Contract as a Project Area.

The term "Project Area" encompasses any individual Project Area or all Project Areas.

For the sake of clarity, Project Area is a different concept than Site under CC Sub-Clause 1.1.6.7.

Project Area defines an area within which the Contractor is to comply with environmental, social, health and safety obligations defined in the present ESHS Specifications.

Site is the places where the Permanent Works are to be executed and to which Plant and Materials are to be delivered, and where right of access to, and possession of, is to be given by the Employer to the Contractor. The Employer is under no similar obligation for any area located outside the Site, even if within the Project Area, where access is at Contractor's risk.

In term of physical footprint, the CC Sub-Clause 1.1.6.7 Site is included in the Project Area. The Project Area is then of greater geographical extent than the Site.

- 1.4. The ESHS Specifications refer to:
 - a) Protection of the natural environment (water, air, soil, vegetation, biological diversity) in areas within any

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Project Area and its surroundings, i.e. including but not limited to access roads, quarries, borrow areas, stockpiling of backfill material, camps or storage areas;

- b) Health and safety conditions to be maintained for the Contractor's personnel and any other person present on the Project Areas, or along access routes;
- c) Working practices and the protection of people and populations living near the Project Area, but exposed to the general disturbance caused by works.

1.5. Subcontractors

The Contractor shall ensure that all Subcontractors and Suppliers (in particular those for major supply items) are familiar with the ESHS requirements and guidelines valid on Site and Project Area.

1.6. Applicable regulations

The Contractor must identify all applicable laws, permits and regulations in relation to the protection of the environment (water, air, soils, noise, vibration, vegetation, fauna, flora, waste, groundwater) and, pursuant to Clauses 4 and 6 of the CC, the protection of people (labour law, indigenous populations, standards on occupational exposure, other). The Contractor must list all texts, standards and other regulatory limitations in its Project Area Environmental and Social Management Plan (PA-ESMP as specified in ESHS Specifications Sub-Clause 2.1) and specify the means taken for compliance.

2. ESHS Planning Documents

- 2.1. The Contractor prepares and ensures prior validation by the Engineer, implementation and regular update of the Project Area Environmental and Social Management Plan (PA-ESMP), which includes Health and Safety aspects.
- 2.2. The PA-ESMP represents the unique reference document in which the Contractor defines in detail all organisational and technical provisions implemented to satisfy the obligations of the present ESHS Specifications.
- 2.3. The Contractor defines in the PA-ESMP the number, the locations and the type of Project Area as defined in ESHS Specifications Sub-Clause 1.3. For each Project Area, unless otherwise agreed by the Engineer, the Contractor establishes site specific management strategies and implementation and monitoring plans (Site-ESMP) to manage and monitor Environmental, Social, Health and Safety (ESHS) risks, depending on the type, scope and risks of the project and as assessed in the project's Environmental and Social Impact Assessment (ESIA). These sub-plans shall be included in the PA-ESMP and include:

- e.g. Health and Safety Plan

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- e.g. Traffic Management Plan (to ensure safety of local communities from construction traffic)
 - e.g. Water Resource Protection Plan (to prevent contamination of drinking water)
 - e.g. Boundary Marking and Protection Strategy (for mobilization and construction to prevent offsite adverse impacts)
 - e.g. Biodiversity Action Plan
 - e.g. Worksite Management Plan
 - e.g. Site Emergency Plan
 - e.g. Accommodation Plan
 - e.g. Waste Management Plan
 - e.g. Hazardous Materials Management Plan
 - e.g. Specific mitigation plan for endangered species in the wider area
 - e.g. Emergency plan
 - e.g. Community Interaction plan
- 2.4. The PA-ESMP (and the sub-plans) are structured according to the plan specified in Appendix 1 of the present ESHS Specifications.
- 2.5. PA-ESMP covers the entire period from the Contract Agreement signature date to the date of issue of the Performance Certificate by the Engineer.
- 2.6. Unless agreed otherwise by the Engineer, the PA-ESMP is written in the language of communication defined under Sub-Clause 1.4 of the CC.
- 2.7. The first draft version of the PA-ESMP is to be provided by the Contractor to the Engineer within 28 days from the date of execution of the Contract Agreement.
- 2.8. The Contractor shall proceed in accordance with the programme, subject to the Engineer's approval of the PA-ESMP. The Employer's Personnel shall be entitled to rely upon the programme when planning their activities.
- 2.9. No physical work or activity shall commence on any Project Area until such time when the PA-ESMP, and the annexed Site-ESMP corresponding to the Project Area, are approved by the Engineer.
- 2.10. During the execution of the works, whenever instructed by the Engineer, the PA-ESMP will be updated by the Contractor and reissued to the Engineer. The revised version shall highlight the new elements incorporated in the document. Such approval shall only be withheld if the PA-

ESMP shows substantial deficits.

2.11. Related to the PA-ESMP, the Contractor will be responsible for:

- a) communicating the contents of the ESMPs to their Subcontractors and Suppliers (in particular those for major supply items) and workers and training them to ensure that they understand their respective responsibilities
- b) ensuring that adequate resources are mobilised to implement the specific Plans, including input from any specialist resources necessary to ensure effective planning and implementation of measures
- c) ensuring that the procedures established in the PA-ESMPs are complied with by their workers and Suppliers (in particular those for major supply items)
- d) implementing effective monitoring measures listed in the PA-ESMP to ensure that the effectiveness of the activities are assessed and any issues are promptly detected and addressed
- e) ensuring that lessons are learned and corrective actions are taken
- f) keeping the Engineer fully informed of any Project Area ESHS issues.

3. Management of Non-Conformities

3.1. In application of Clause 5, non-conformities detected during inspections carried out by the Engineer are subject to a process adapted to the severity of the situation. The non-conformities will be defined as deviations from the requirements of the applicable regulations, the present ESHS Specifications, the ESMP, and the Worksite - ESMP. Non-conformities are divided into 4 categories as follows:

- a) Notification of observation of minor non-conformities. The non-conformity results in a notification to the Contractor's Representative, followed-up by a signed notification of observation prepared by the Engineer. The multiplication of notifications of observation at the Project Area, or absence of corrective actions by the Contractor, can result in the severity of the non-conformity being raised to that of level 1.
- b) Level 1 non-conformity: Non-conformities that do not represent a serious immediate risk for health, environment, social or safety. The non-conformity is the subject of a report addressed to the Contractor and which shall be resolved within five (5) days. The Contractor addresses to the Engineer a report explaining how the non-conformity has been corrected. Further to an inspection and a favourable evaluation of effectiveness of the corrective action, the Engineer signs a close-out report for the

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non-conformity. In all cases where a non-conformity of level 1 is not resolved within one (1) month, the severity of the non-conformity is raised to level 2.

- c) Level 2 non-conformities: applies to all non-conformities that represent a risk with major consequences to health and/or the environment, social or safety. The same procedure as for level 1 non-conformities is applied. Corrective action shall be taken by the Contractor within three (3) days. The Contractor addresses a report explaining the corrective actions implemented. All level 2 non-conformities, which are not resolved within one (1) month, are raised to level 3.
- d) Level 3 non-conformities: applies to all non-conformities that have resulted in damage to health or the environment, or which represent a high safety hazard or high social risk. The highest levels of the Contractor's and Engineer's hierarchies present in the Employer's country are informed immediately and the Contractor has twenty-four (24) hours to bring the situation under control. Pursuant to Clause 14.6 of the Particular Conditions of Contract (PC), a level 3 non-conformity results in the staged reduction of interim payments until the non-conformity has been resolved. Following the resolution of the Level 3 non-conformity the reduction(s) will be included in the next Interim Payment Certificate for payment. No interest will be paid on any reductions or suspended payment amounts. If the situation requires, and in pursuance to Clause 8.8 of the PC, the Engineer can order the suspension of work until the resolution of the non-conformity.

4. Resources allocated to ESHS management

4.1. ESHS supervisors and managers

- a) Pursuant to Sub-Section Specifications (c) Personnel Requirements, Sub-Clause 4.18 of the CC and in addition to the provisions of Sub-Clause 6.7 of the CC, the Contractor appoints at one or several competent Environment, Social, Health and Safety manager in charge of implementing the present ESHS Specifications.
- b) The appointment of the ESHS Manager shall include specific instruction to enforce regulations and delegated authority to take any action, measure or to issue instructions regarding their enforcement. All staff and labour within the Project Area shall be made aware of the name and authority of the ESHS managers and supervisors.
- c) The ESHS manager holds the power within the Contractor's organisation to suspend the works if considered necessary in the event of severe non-

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conformities, and allocate all resources, personnel and equipment required to take any corrective action considered necessary. The ESHS Manager speaks fluently the language of communication of the Contract, and the official language of the Employer's country, if the language of communication of the Contract is not the official language.

- d) If so required in accordance with Sub-Section Specifications (c) Personnel Requirements, ESHS supervisors represent the ESHS Manager within work teams. Their role is to ensure that the works are carried out pursuant to the present ESHS Specifications and notify the ESHS Manager of any detected non-conformities.

4.2. Personnel in charge of relations with external stakeholders

- a) If so required in accordance with Sub-Section Specifications (c) Personnel Requirements, the Contractor appoints an External Stakeholders Relations Manager responsible for relations local communities, administrative authorities, and representatives of economic activities located within one hour travel from the Project Area. In smaller projects, the person responsible for relations with external stakeholders can also be the ESHS Manager appointed under Sub-Clause 4.1.a) of the ESHS Specifications, providing that the latter speaks the local population language fluently.
- b) If so required in accordance with Sub-Section Specifications (c) Personnel Requirements, the Contractor shall appoint several subject specific Community Liaison Officers.
- c) Personnel in charge of relations with external stakeholders will be based on or near the Project Area on a permanent basis.
- d) Administrations and local authorities will be informed of the existence of this person as of the start of works and will be provided with telephone contact details so as to be able to contact this person if a problem arises during the execution of works, or concerning the behaviour of the Contractor's Personnel, inside or outside the Project Area.

4.3. The team, including the ESHS supervisors and manager, and the person in charge of relations with external stakeholders, will be equipped with the necessary resources to operate independently and get to all location of the Project Area without delay. Commensurate with the size and location of the project, this may include:

- a) A 4WD vehicle (unless otherwise instructed by the Engineer) and the necessary operating budget;

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- b) A complete IT workstation: computer, printer, Internet access;
- c) Field equipment: GPS, digital camera;
- d) One communication equipment per person adapted to the context (mobile phone, satellite phone, or, should coverage not be adequate, a long-range two-way radio).
- e) Lists of equipment will be maintained on site for inspection by Employer.

5. Inspections

- 5.1. The ESHS Manager will carry out an ESHS inspection of the facilities and Project Area on a weekly basis. A written report of reasonable length will be drafted for each weekly inspection, in a format approved by the Engineer, addressing non-conformities detected on the Project Area as specified in the present ESHS Specifications.
- 5.2. Any non-conformity shall be immediately addressed by corrective actions, which will be mentioned in the reports to the Engineer.
- 5.3. Each non-conformity will be documented by a digital photograph with captions to provide a visual illustration, explicitly indicating the location, date of inspection and the non-conformity in question.

6. Reporting

- 6.1. The Contractor includes a summary of ESHS activities implemented in relation to the execution of the works during the reporting period in the monthly Progress Report (as specified in Sub-Clause 4.21 of the CC) to the Engineer. The Contractor shall report on compliance with applicable laws, permits and regulations and the project related ESHS requirements. E.G. key issues shall include: monitoring results, covering amongst other issues, safety issues, incidents/accidents, need for corrective measures, conflicts amongst construction workforce or with local residents, grievances of workforce or stakeholders, any other details related to the social and environmental management and performance. Issues related to Subcontractors and Suppliers (in particular those for major supply items) shall also be included.
- 6.2. The ESHS progress report is written exclusively in the language of communication defined under Sub-Clause 1.4 of the CC.
- 6.3. Specific reporting requirements related to Health and Safety are detailed in the respective section (e.g. Health and Safety, accident reporting)

7. Code of Conduct

- 7.1. A Code of Conduct is established by the Contractor for the Project Areas, addressing the following: safety rules, zero tolerance for substance abuse (as defined in Clause 41 of these ESHS specifications), environmental sensitivity of

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areas around the Project Areas, the dangers of STDs and HIV/AIDS, gender issues (in particular sexual harassment) and respect for the beliefs and customs of the populations and community relations in general (drawing special attention to the risks of prostitution and human trafficking).

- 7.2. The rules are clearly displayed at the different Project Areas and posted in the Contractor's vehicles and machinery driving cabs.
- 7.3. The rules confirm the Contractor's commitment to implementing the ESHS provisions provided for in the Contract.
- 7.4. New Contractor's Personnel and existing Contractor's Personnel are made aware and acknowledge their understanding of the rules of procedure and the associated provisions. Rules of procedure document are initialed by all Contractors' Personnel prior to the start of any physical work at any Project Area.
- 7.5. Pursuant to Sub-Clauses 6.9 and 6.11 of the CC, the rules of procedure include a list of acts considered as serious misconduct and which must result in dismissal from any Project Area by the Contractor, or by the Engineer if the Contractor is not acting in due course, should a Contractor's Personnel repeatedly commit an offence of serious misconduct despite awareness of the rules of procedure, and this is without prejudice to any legal action by any public authority for non-compliance with applicable regulations:
 - a) Drunkenness during working hours, leading to risks for the safety of local inhabitants, customers, users and personnel;
 - b) Punishable statements or attitudes, and sexual harassment in particular;
 - c) Violent behavior;
 - d) Intentional damage to the assets and interests of others, or the environment;
 - e) Repeated negligence or imprudence leading to damage or prejudice to the environment, the population or properties, particularly breaching provisions intended to prevent the spreading of STD and AIDS;
 - f) Drug use;
 - g) Possession and/or consumption of meat or any other part of an endangered animal or plant as defined in the Washington convention (CITES) and national regulations.
 - h) Entering property of neighboring people without

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permission of the landowners or those cultivating/renting the land.

- 7.6. Serious misconduct, such as organization of sex trade (pimping), committing pedophilia, physical aggression, drug trafficking, deliberate and severe pollution, trading and/or trafficking in all or part of protected species, shall lead to immediate dismissal as of the first report of misconduct is detected, in application of the rules of procedure and labour laws.
- 7.7. The Contractor establishes a record for each case of serious misconduct, and a copy will be provided to the Contractor's Personnel in question, indicating all action taken to terminate the misconduct by the Contractor's Personnel in question and to bring the attention of other Contractor's Personnel to the type of incident detected. This record will be provided to the Engineer as an attachment to the ESHS progress report (see ESHS Specifications Sub-Clause 6.1.).
- 7.8. The Contractor shall without delay inform the Engineer who in case of serious misconduct shall immediately inform the Employer.

8. ESHS Training

- 8.1. The Contractor prepares a training programme adequate for the works to be performed within the Project Areas and the personnel engaged in the works.
- 8.2. The Contractor ensures that Employees with direct responsibility for activities relevant to the Project's ESHS performance are adequately qualified and trained so that they have the knowledge and skills necessary to perform their work.
- 8.3. Training sessions are two-fold: introductory sessions for starting work at the Project Area, and technical training as required in relation to the execution of the works.
 - 8.3.1. Starting work sessions are organised for each Contractor's Personnel and shall cover as a minimum:
 - a) Rules of procedure;
 - b) Safety rules on Project Areas;
 - c) Protection of areas adjacent to Project Area;
 - d) Risks relating to sexually transmitted diseases (Sub-Clause 6.7 of the CC), prostitution, human trafficking, and sexual harassment;
 - e) Basic health: combating malaria (if prevalent) and waterborne diseases, improving hygiene;
 - f) HIV/AIDS sensitization training,
 - g) Gender sensitization;

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- h) Emergency response procedures or evacuation;
 - i) Community relations training for workers interacting with local communities;
 - j) Communication of the contents of the Employment, Training and Worksite Management Plans to workers and all Subcontractors and Suppliers (in particular those for major supply items) and training them to ensure they understand their responsibilities with respect to employment, training and worksite management, incident reporting and response.
 - k) Health and Safety awareness training
 - l) The Contractor shall be responsible for informing all workers of the Worker Grievance Mechanism at the time of hiring
- 8.4. The Contractor shall ensure that adequate resources are mobilised for these trainings, including input from any specialist resources necessary to ensure effective planning and implementation of measures and that trainings are delivered in a timely manner.
- 8.5. Technical training:
- a) Training in the skills needed for tasks requiring a work permit (see ESHS Specifications Clause 27)
 - b) Training in first aid and transporting the injured
 - c) If applicable: appropriate driving skills
 - d) If applicable: the Contractor establishes and implements a transparent and binding Local Workforce and Supplier Training plan to enhance the capabilities of local people and companies, with a view to increasing local content
 - e) a matrix of training requirements showing the training frequency and interval between refresher courses and covering:
- 8.6. The Contractor details in the training programme the actions and ESHS training for all Subcontractors and Suppliers (in particular those for major supply items) or personnel of a joint venture when applicable.
- 8.7. The Contractor prepares an awareness program for local communities on the risks of prostitution, human trafficking and other forms of illegal trafficking.
- 8.8. The Contractor shall develop means of confirming that the training system is effective.

9. Standards

- 9.1. The Contractor complies with all applicable norms, standards and discharge limit values defined in the national regulations of the Employer's country regulations and pursuant to Sub-Clause 1.6 of the present ESHS Specifications.
- 9.2. The Contractor complies with norms, standards and discharge limit values recommended by the specialised international organisations affiliated to the United Nations, as described in ESHS Specifications 9.3 below. In the event of discrepancies in between international standards and national regulations, the Contractor shall comply with the most stringent requirements.
- 9.3. The specialised international organisations affiliated to the United Nations referred to in ESHS Specifications Sub-Clause 9.2 include:
- a) World Bank, including the IFC and its Environmental, Health and Safety guidelines available from <http://www.ifc.org/ehsguidelines>;

For matters not addressed in the above mentioned IFC document, the most stringent of the norms, standards and discharge limit values of the following institutions shall apply:

- a) World Health Organization (WHO);
- b) International Labour Organization (ILO) in particular in pursuance to Clauses 6.20, 6.21, 6.23 and 6.24 of the PC (Part B);
- c) International Maritime Organization (IMO).

B. Protection of the Environment and People

10. Protection of adjacent areas

- 10.1. The Contractor shall be responsible for any foreseeable adverse environmental and social impacts arising from its activities and operations and for putting in place any necessary measures to avoid or if not possible mitigate them.
- 10.2. Pursuant to Sub-Clause 4.18 of the CC, and unless instructed otherwise by the Engineer, the Contractor uses construction methods and means of protection in order to avoid or minimize adverse effects that are incurred on vegetation, soils, groundwater and surface water, biodiversity, natural drainage and the water quality in areas within any Project Area and its surroundings for the entire duration of the works.
- 10.3. Prior to the start of Project activities, the Contractor will stake out the alignments, boundaries and limits of Project sites in accordance with plan(s) agreed upon in advance

with the Engineer. Contractor will establish the working strip to restrict the area of impacts to within the working corridor and limit personnel and vehicle movements to only within working areas.

- 10.4. All Project work activities will stay within the staked out alignments and boundaries, and outside the designated ecologically and archaeologically sensitive areas unless specifically authorised by the Employer as part of the Project.
- 10.5. Prior to construction, the Contractor shall place signs with environmental protection information in areas identified as environmentally sensitive, and other areas where sensitive flora and fauna species are situated immediately adjacent to construction areas and that may be inadvertently disturbed or damaged during construction. Sensitive areas may include, but are not limited to, nest sites, plant and wildlife species of high conservation value, site-specific habitat features to be protected.
- 10.6. Wetland areas include marshes, fens, mires or natural or artificial bodies of water, whether permanent or temporary, where water is stagnant or flowing, fresh, saline or briny, including seawater with a low-tide depth of six metres or less. Filling of all or part of a wetland area is not permitted, unless the works are necessary according to the provisions of the Contract or the instructions of the Engineer.
- 10.7. With the exception of access roads, or unless instructed otherwise by the Engineer, the entire perimeter of land sites with a surface area of less than 2 hectares is physically demarcated with a fence or tape. For Project Area with a surface area of more than 2 hectares, the perimeter will be physically demarcated by a perimeter track, road, signs or any other means leaving no possible ambiguity as to the location of the Project Area perimeter.
- 10.8. Unless otherwise specified, the perimeter of the Project Area is at a distance of at least:
 - a) 50 m from any permanent water course and outside of floodable areas;
 - b) 300 m from sensitive urban services and buildings (health centre, school, water supply for populations);
 - c) 200 m from any housing; and
 - d) 300 m from housing in the specific case of work requiring the use of explosives.
- 10.9. If the footprint of the works are located in the situations a) to d) of the ESHS Specifications Sub-Clause 10.8 above, and unless agreed upon otherwise by the Engineer, the Contractor will contract a bailiff to make a sworn statement regarding the existence and conditions of residential buildings situated around the site with a distance specified

in Sub-Clause 10.8 above.

10.10. The Contractor shall perform a topographic survey of all additional areas and facilities, including ground elevations in order to reinstate the land after termination of the works; this includes recording all perimeter GPS coordinates; and ensuring that the entire area proposed for land take or temporary usage is included in the survey and recorded via photographs. Access roads shall be identified as new, upgraded or existing. All data, including GPS coordinates, shall be provided electronically to the Engineer.

10.11. The bailiff's sworn statement is prepared and provided to the Engineer with the Site-ESMP.

11. Selection of borrow areas, backfill material stockpile sites and access road

11.1. The Contractor will submit to the Engineer for prior approval, including but not limited to (i) the location of proposed borrow areas or areas to be excavated, or (ii) proposed backfill material stockpile locations or zones designated for the rubble from demolition works; maintenance facilities, storage areas, batch plants, etc.

11.2. This requirement also applies to the side casting during the construction of linear infrastructure (roads, pipelines, transport routes) and which are included in the category of stockpiling of waste material.

11.3. The opening or rehabilitation of all access routes between Project Areas will be shown on a map and approved by the Engineer prior to the start of the corresponding works.

12. Pollution prevention

12.1. The Contractor shall take the necessary measures to ensure that pollution to air, water or land is prevented or, where this is not possible, reduced and mitigated as far as practicable during the construction phase. If required in the PA-ESMP the Contractor will develop a pollution prevention Plan for managing e.g. atmospheric emissions and dust, e.g. noise and vibrations, e.g. waste (specified in ESHS Specifications 13, 14 and 15 below):

- a) liquid effluents (see Clause 15 of these ESHS specifications)
- b) air emissions
- c) noise and vibration management
- d) vehicle and equipment maintenance and selection
- e) fuel, oil and chemical storage and handling.

12.2. Environmental and/or occupational health and safety regulators will be notified and informed as required by applicable laws about any Environmental pollution. The Contractor shall ensure that all appropriate environmental protection measures are adopted during the clean-up process after termination of works and that clean-up activities are appropriately documented

13. Effluents

- 13.1. Effluents consist of liquid discharges, including infiltration, from Project Area, transporting a pollutant (dissolved, colloidal or particles).
- 13.2. A pollutant is a given chemical compound that is at a concentration greater than the limit value established for that compound according to the Clause 9 of the present ESHS Specifications.
- 13.3. If no recognized threshold exists for a chemical compound pursuant to ESHS Specifications Sub-Clause 12.2, the Contractor provides proof that the concentrations of the chemical in effluents released (discharged) to the environment are harmless to it and human beings.
- 13.4. No effluent is discharged by the Contractor neither into water courses or bodies including marine environment nor to ground surface or infiltrated into subsoils, without prior treatment and without monitoring quality of the treatment's performance to guarantee the absence of pollution in the effluent. Effluent discharge and flow rates into natural water bodies will be managed to control erosion/sediment freight.
- 13.5. The Contractor is responsible for carrying out or contracting the monitoring of the effluent quality pursuant to Sub-Clause 12.4 of the present ESHS Specifications by in situ measurements, and sampling and laboratory analysis. In the first case, the Contractor provides the ESHS manager with the resources, equipment and skills to carry out in-situ monitoring and laboratory analysis of the performance indicators. In the second case, the Contractor establishes a contract with a specialised laboratory, accredited with the Employer's country authorities for this activity.
- 13.6. The physical and chemical parameters of an effluent that require quantity and quality monitoring are those listed in the Employer's country environmental regulations or in additional international standards or guidelines, or if these do not exist, the parameters are based on the recommendations of specialised international organisations pursuant to Clause 9 of the present ESHS Specifications. The list of monitoring parameters requires approval from the Engineer.
- 13.7. The Contractor will list, locate, and characterise (flow, expected quality, discharge frequency) all sources of effluents and outlets to the natural environment in the Site Environment Management Plan(s).
- 13.8. The Contractor will submit to the Engineer an Effluent Quality Monitoring Report on a monthly basis, including documentation for the following for each effluent discharge point: (i) average flow rates of discharged effluents, (ii) discharge frequencies and durations over the month, and (iii) the physical and chemical quality of the effluent discharged, for the conformity with parameters listed in

ESHS Specifications Sub-Clause 12.1above.

13.9. Wastewater run-off

13.9.1. The Contractor will take appropriate measures to ensure that discharges of process wastewater, sanitary wastewater, wastewater from utility operations or stormwater to surface water will not result in contaminant concentrations in excess of local ambient water quality criteria or, in the absence of local criteria, other sources of ambient water quality.

13.10. Rainwater run-off

13.10.1. Run-off consists of the rainwater flow on the surface or the soil and other technical surfaces at Project Areas.

13.10.2. In the context of the Contract, surface run-off is considered as an effluent unless demonstrated otherwise, as documented and substantiated by the Contractor, and approved by the Engineer.

13.10.3. All platforms where generators, hydrocarbon storage tanks and refueling stations are installed have impervious and chemical resistant surfaces are drained separately and equipped with an oil removal treatment (oil-water-separator) to prevent pollution pursuant to ESHS Specifications Sub-Clause 12.4 above. For concrete batching plants, run-off will be drained to settling basin, where the pH will be buffered.

13.11. Contractors shall prohibit its workers and its subcontractors from bathing or washing clothes and vehicles/equipment in rivers or watercourses.

14. Atmospheric emissions and dust

14.1. Emissions refer to any discharge into the air of solid substances, aerosols, gases, radiation, or energy, whether point sources (e.g. incineration stack) or diffuse (e.g. fugitive dust emissions from road use by trucks).

14.2. The Contractor will use equipment and adopt construction and transport methods with atmospheric emissions, which are not in excess of the threshold emission values recommended by the Employer's country standards, or the organisations mentioned in Clause 9.

14.3. Once having received the agreement from the Engineer, the Contractor will document the maintenance records for its fleet of vehicles, machinery and equipment. The records will be in the language of communication defined under CC Sub-Clause 1.4, or any other language approved by the Engineer, and will be at the disposal of the Engineer.

14.4. The fleet of vehicles or equipment emitting combustion

gases will be maintained at the intervals and according to the methods specified by the manufacturer.

- 14.5. The Contractor shall exercise care to minimize emissions of dust from its activities, including traffic, at work sites, in residential areas and on access roads. Where it is deemed that dust is impacting or may have an impact on human, plant or animal receptors or where dust may cause sedimentation of watercourses/water bodies or unacceptable levels of soil loss, the Contractor shall apply water to the area creating the dust and consider implementing other dust control measures such as using windbreaks, netting screens or semi-permeable fences; controlling vehicle speeds to reduce traffic-induced dust dispersion and resuspension by setting and enforcing speed limits (Contractor vehicle speed limits are specified in ESHS Specifications Sub-Clause 50.10).
- 14.6. This shall include: posting speed limit signs in sensitive areas; ensuring trucks hauling sand, dirt or other loose materials are covered (sheeting trucks); suspending topsoil stripping and replacement during strong winds; using a dust collection system for bulk materials unloading; wet suppression (as needed, depending on the soil type) in the dry season, where unpaved roads and/or the working strip is located <200 m from settlements taking appropriate abatement measures.
- 14.7. The Contractor describes in the PA-ESMP the road sections designated for the application of dust suppression agents and the methods and frequencies programmed. The Contractor will implement the measures approved by the Engineer.
 - 14.7.1. Where applicable, visual inspections of atmospheric emissions shall be conducted, especially dust and emissions from vehicles and machinery as agreed with the Engineer. The inspections shall identify areas where the implementation of dust reduction measures is required,
 - 14.7.2. When storage, transport and handling of bulk materials is made in the open air and exposed to the wind, the Contractor implements the necessary dust abatement measures.

15. Noise and vibration

- 15.1. The Contractor uses equipment and adopts construction and transport methods so not to generate noise levels in excess of values recommended by the Employer's country regulations and organisations mentioned in Clause 9.
- 15.2. The Contractor will plan high noise generating works (e.g. pile driving, blasting, rock clearing, drilling, percussion drilling) in line with national regulations and respect maximum ambient noise-levels and night time rest hours at

the nearest receptor area. A receptor is defined as an area used for nocturnal socioeconomic activities (e.g. accommodation camps, residential areas, hotels, health centres).

- 15.3. The Contractor shall locate stationary equipment (such as power generators and compressors) as far as possible from nearby receptors (e.g. worker resting areas, populated areas and environmentally sensitive areas). Equipment known to emit noise strongly in one direction, whenever possible, will be orientated so that the noise is directed away from sensitive receptors
- 15.4. The use of heavy vehicles at night is specified in ESHS Specifications Sub-Clause 50.9.
- 15.5. Standard noise abatement equipment shall be fitted to equipment by the Contractor, used and maintained in accordance with manufacturers' instructions.

16. Waste

- 16.1. The Contractor is responsible for identifying, collecting, transporting and treating all waste produced on the Project Areas.
- 16.2. The Contractor shall minimize the generation of waste and reuse, recycle and recover waste in a manner that is safe for human health and the environment.
- 16.3. The Contractor shall establish a Waste Management Plan which details a concept to manage non-hazardous and hazardous waste in line with the local legislations and adapted to the level of danger for human health or the natural environment. In absence of adequate legislation, waste shall be managed according to the guidance provided in the respective sections of the General World Bank Group EHS Guidelines with the objective of protecting soil and water resources. The Waste Management Plan shall include provisions for the training of workers.
- 16.4. Waste register and categorization:
 - 16.4.1. The Contractor establishes and maintains a waste register, which is at the disposal of the Engineer. This register will record all waste management operations: production, collection, transport, treatment. It will be available as of the Contractors mobilisation to any Project Area. Waste shall be categorized according to the following definitions:
 - a) Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals, and small concrete spills. Other non-hazardous solid wastes include office, kitchen, and dormitory wastes when these types of operations are part of construction project activities.

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- b) Hazardous solid waste includes contaminated soils, which could potentially be encountered on-site due to previous land use activities, or small amounts of machinery maintenance materials, such as oily rags, used oil filters, and used oil, as well as spill cleanup materials from oil and fuel spills.
- c) Hazardous liquid waste includes effluents and waste material containing "free liquids" (e.g. used cutting oil or wastewater mixed with oil after cleaning machinery).

16.5. The following aspects are documented in this register:

- a) Type of waste, using the nomenclature specified in Sub-Clause 16.3.1 above;
- b) Waste quantities;
- c) Name and address of the third party waste management facilities receiving waste or parties taking possession of the substances no longer considered as waste;
- d) Name and address of waste transport Contractors;
- e) Planned waste treatment.

16.6. In accordance with national regulations, the Contractor files and maintains at the disposition of the Engineer the waste manifests for the collection, transport, treatment and/or elimination of waste.

16.7. The Contractor assesses, document and effectively implements any local recycling or re-use options for its waste.

16.8. Waste is stored separately prior to removal from the Project Areas, depending on the level of danger, phase (liquid, solid or gas), the waste management solution to be applied and its potential in terms of recycling or reuse.

16.9. Waste is collected from each Project Area at the same rate that it is produced and is placed in temporary locations meeting the following criteria:

It shall be located at a distance of over 100 m from any natural sensitive area and over 500 m from any socioeconomic sensitive area (school, market, healthcare centre, water well or catchment area), with the exception of waste storage area in camps; and on a flat impervious surface to prevent infiltrations.

16.10. Unless otherwise specified in the Contract or instructed by the Engineer, waste incineration is prohibited on Project Areas. Two exceptions are medical waste and green waste, which unless instructed to the contrary by the Engineer, are

managed pursuant to Clause 16.3 of the present ESHS Specifications.

16.11. The use of third party waste management services is subject to a documented prior audit of the treatment, storage and recycling facilities by the Contractor, to guarantee the conformity with the provisions of the present ESHS Specifications on waste.

16.12. Pursuant to Sub-Clause 1.5 of the present ESHS Specifications, the provisions applicable to the Contractor regarding waste management also apply to any third party waste management Subcontractor. The Engineer reserves its right to inspect third party waste management facilities and prohibit the Contractor from using the facilities if considered unacceptable.

16.13. Non-hazardous waste management

16.13.1. The management of non-hazardous waste shall comply with the following conditions:

- i. The Employer will communicate information to the Contractor about the location of and distance to the nearest landfill area and the disposal conditions.
- ii. If no landfill area exists nearby, the Employer will communicate to the Contractor where the Contractor shall establish a temporary landfill area. The Employer is responsible for obtaining the respective permits.

16.14. Hazardous waste management

16.14.1. The Contractor shall develop a Hazardous Materials Management Plan for those hazardous materials the Contractor is directly responsible for, and detailed procedures for working with chemical products and hazardous materials and handling hazardous waste.

16.14.2. Hazardous materials are those that pose a potential risk to human health or the environment and include cleaning chemicals, solvents and fuels.

16.14.3. Fuel and hazardous chemicals/materials shall be stored in designated areas, pursuant to Sub-Clause 26.8 of the present ESHS Specifications, except for quantities generated or required for the daily construction activities. Fuel, oil or hazardous materials required to be temporarily stored onsite shall be stored within secondary containment located greater than 100m from a watercourse or water body.

16.14.4. Fuel and hazardous chemical storage areas shall

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not be allowed within 30m of a minor watercourse, within 100m of a major watercourse, within a floodplain or where there is the potential for spilled fuel to enter groundwater.

- 16.14.5. All fuel and hazardous chemical storage facilities shall be located on flat or gently sloping ground and shall be contained within a bund designed to contain at least 110% of the total capacity of the storage containers plus 10% of the aggregate tank volume within the containment area or as otherwise specified by regulatory requirements. The bund walls and floor shall be constructed of concrete or other suitably impermeable material. The filling connection must be within the bund. No drain valves or other connections through the bund walls shall be permitted. Tanks shall be fitted with a gauge to allow the fill level to be monitored during refilling and preferably with a high-level alarm.
- 16.14.6. When the Contractor's hazardous waste management is conducted by third parties, they must be reputable and accredited in the Employer's country for this activity.
- 16.15. If applicable and in the absence of an existing waste management solution for hazardous waste, the Contractor takes the following action:
 - 16.15.1. Medical waste is incinerated in a specific facility constructed and accredited for this purpose. The Contractor will submit the technical specifications of the facility to the Engineer before importing or procuring the equipment.
 - 16.15.2. Hydrocarbons, lubricants, paints, solvents and batteries are transported in drums to suitable waste management facilities available, if available.
 - 16.15.3. If not otherwise instructed by the Engineer, contaminated soils from construction/demolition and drilling muds shall be treated, stabilized and disposed of to landfill. Prior approval is required from the Engineer regarding the method and site location. The Employer obtains authorization from the competent local authorities prior to any disposal to landfill.
 - 16.15.4. Prior approval from the Engineer is required before implementing waste management solutions on any other hazardous waste.
 - 16.15.5. Prior to the issue of the Taking Over Certificate for the Works, the Contractor provides documentation on hazardous waste, produced by

the Contractor's works, landfilled at other sites than accredited third party waste management facilities. The documentation includes a plan showing the location of landfill sites. The document is provided to the competent local authorities whose jurisdiction covers the landfill sites.

- 17. Vegetation clearing**
- 17.1. The works, including the opening up of the right of way and other worksites (e.g. camps, access roads, storage yards) may require vegetation clearance in work areas. Vegetation includes crops, trees, shrubs, bushes, grasses and other minor vegetation. Supervisors shall be trained in the controlled felling of trees to prevent impacts beyond worksites. They shall also be trained on the importance of identification and preservation of wild fauna encountered and disturbed during the stripping operation.
- 17.2. The Contractor describes in the PA-ESMP the planned methods and schedule for vegetation clearing. Specific agreement from the Engineer is obtained prior to any clearing works.
- 17.3. Vegetation clearing using chemicals is not permitted. Vegetation clearing using bulldozer is not permitted in zones less than 30 m from areas designated as sensitive by the Engineer, where only manual clearing is authorised.
- 17.3.2. Where it is not possible to restrict the timing of construction practices, vegetation shall be removed outside the breeding period so that works can carry on into this period unhindered.
- 17.3.3. The felling of trees shall be avoided where possible. Felled trees may be used for building gabions if required for land stabilization. Vegetative material (slash) is not to be used for construction purposes and shall be stockpiled at the edge of worksites. Areas of gathered plant material shall be separated to prevent flames spreading in the event of a fire.
- 17.3.4. Unless otherwise specified in the Contract or if otherwise instructed by the Engineer, burning vegetation is not permitted. Green waste can be burnt with prior approval from the Engineer regarding the location, method and schedule.
- 17.3.5. The collection of wild plants is prohibited.
- 17.3.6. Lighting fires in work areas is prohibited unless specifically authorised by the Employer.
- 17.3.7. It is prohibited to introduce foreign/non-adapted vegetation to the worksites.
- 17.3.8. Removed vegetation will be placed far from

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surface water. Large woody debris will be stored along the outside edge of worksites in clear areas. Small twigs, branches and pieces of vegetation shall be used for composting along with biodegradable waste generated in the camp and work areas.

- 17.3.9. Clearing of vegetation shall be limited to that which is strictly necessary.
- 17.3.10. Where possible, cutting of vegetation on steep hillsides will be minimal.
- 17.4. Areas cleared prior to undertaking earthworks are shown on a plan with a minimum scale of 1/10,000. Plans are submitted to the Engineer, for validation prior to starting clearing works.
- 17.5. The Contractor undertakes physical demarcation of zones to be cleared using a method approved by the Engineer.
- 17.6. The characteristics (location, species, diameter at chest height) of trees not to be cut down are defined by the Engineer in coordination with the Employer. Such trees are marked with paint and protected against clearing machinery using a method approved by the Engineer.
- 17.7. Trees and areas to be cleared are to be marked precisely so that clearing is undertaken without damage to adjacent non-cleared areas. Topsoil is stored within the cleared areas at the edge of the cleared zone. Clearing is undertaken working from the edge of the zone inwards.
 - 17.7.1 During clearing, the Contractor stockpiles separately:
 - (i) tree trunks with a diameter at chest height greater than the size defined by the Engineer, and
 - (ii) trunks with a smaller diameter, branches, leaves, stumps and roots.
 - 17.7.2 Unless instructed otherwise by the Engineer the trunks of trees exceeding the diameter defined by the Engineer are the property of the Contractor.

18. Biodiversity

- 18.1. The Contractor shall ensure that all personnel are informed and aware of the importance to protect species, habitats, fauna and flora and are informed about wildlife encounter procedures. Information and awareness training is documented.
- 18.2. If applicable, the Employer will provide to the Contractor a range of ecological surveys prior to the start of construction, conducted by the Employer. These will include but not be limited to the type and location of identified species and habitats of conservation interest within the Project Area, and any resulting measures that are required by Contractor.
- 18.3. The Employer will provide to the Contractor a constraints

map, showing the areas where sensitive, endangered or breeding species are known to occur, including protected areas, sites of importance for nature conservation, wildlife refuges, nature and national parks, important bird areas.

- 18.4. The Employer will inform the Contractor about seasons for the protection of birds and wildlife. If applicable, the Employer will inform the Contractor if, as a result of protecting birds and wildlife, construction is restricted during a certain period and/or the Contractor must take precautionary measures in compliance with respective national laws and/or as stipulated by the respective local authorities.
- 18.5. The Employer may update information on the presence of wildlife or sensitive or endangered species' in the Project Area following any additional wildlife/endangered species' survey. If any are identified, the Employer will notify the Contractor who will ensure that all personnel are informed and aware of the required mitigation procedures as communicated by the Employer.
- 18.6. The Contractor shall apply the Contracting Authority's procedures with regards to fauna and flora management prior to clearing activities.
- 18.7. The Employer will communicate to Contractor his specific responsibilities related to protecting endangered species, biodiversity and wildlife, present within the Project Area. Responsibilities may include but not be limited to the following measures:
 - a) The Contractor's personnel shall not approach, injure, hunt, capture, possess, feed, transport, rear or trade wild animals and/or collect birds' eggs on the Project Areas
 - b) The Contractor's personnel shall avoid where possible breeding, feeding and nesting sites of endangered species, as identified by the Employer's environmental experts and as communicated to the Contractor by the Employer.
 - c) The Contractor personnel shall not collect flora or fauna species on the Project Areas.
 - d) The Contractor shall report any sighting or finding of dead wildlife killed by the works to the Engineer immediately.
 - e) The Contractor shall protect excavations with temporary fencing to prevent injury to animals.
 - f) The Contractor shall release any trapped uninjured animals immediately.
 - g) The Contractor shall report injured endangered and/or larger animals to the Engineer who will inform the

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appropriate Environmental Authority.

- h) The Contractor shall not disturb natural habitats outside the Project Areas.
- i) The Contractor shall only use designated roads or paths and abide by speed limits.
- j) The Contractor shall not start forest fires.
- k) The Contractor shall not introduce Invasive Alien Species (IAS)
- l) All construction machinery imported from overseas shall be inspected to detect IAS and washed before dispatching to the Project Areas.
- m) Where necessary, the Contractor shall develop IAS control procedures (e.g. physical removal, slashing, mulching, herbicides, etc.). Methods used to control or prevent such species shall not cause adverse impacts on the environment or communities.
- n) To limit the risk of introducing marine invasive species, the Contractor shall control the ballast water and anti-fouling systems of vessels arriving from other bioregions in accordance with International Maritime Organization (IMO) conventions and guidelines.

18.8. For impacts to biological resources:

- a) development of a specific mitigation plan for endangered species in the wider area
- b) trenches or holes created during site works must be covered at night

18.9. Regarding habitat loss/degradation and habitat fragmentation Contractor will:

- a) site permanent infrastructure on unused land of no particular ecological value
- b) take no construction materials from the surrounding environment unless otherwise specified in the respective management plan
- c) monitor the impacts on flora and fauna at sensitive locations

18.10. The Contractor will adopt best construction site practices to minimize the risks of adverse effects on neighbouring habitats/species from construction activities (dust, noise, waste disposal etc.). This will include appropriate toilet and litter collection facilities as inspected by the environmental coordinator.

19. Erosion and sediment transport

- 19.1. Erosion and sediment control shall be taken into consideration from the beginning of the construction phase, i.e. from site clearance.

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- 19.2. The Contractor plans earthworks and optimises the management of space to ensure that all cleared surfaces and areas exposed to soil erosion are minimised on all Project Areas and erosion is minimised as far as practical.
- 19.3. The Contractor shall determine the appropriate locations and the type of erosion control measures required, to be agreed with the Engineer.
- 19.4. If not instructed otherwise by the Employer, the Contractor shall install erosion matting to provide an immediate protection for slopes against erosion, prevent the washing-out of seeds and enhance the micro-climatic conditions in the soil for plant growth. Erosion matting is used to provide temporary protection of the soil surface until sufficient natural vegetation cover has been established.
- 19.5. Topsoil
 - 19.5.1. Topsoil is the uppermost and most fertile portion of the soil (unless indicated otherwise, the top 25 centimeters), containing organic matter, seeds and nutrients that promote vegetation growth. Its presence is a key factor in promoting revegetation success. Consequently, preserving topsoil is a key component of revegetating worksites and restoring the soil's ability to protect itself against erosion. Contractor shall observe the following basic principles of good topsoil management:
 - 19.5.2. Topsoil shall be removed from working areas only when absolutely necessary and in accordance with Project guidelines. Areas subject to topsoil stripping will be identified prior to grading activities.
 - 19.5.3. Any plant, turf layer or root mass will be stripped together with the topsoil, except in wetlands where the turf will be stripped separately from the topsoil layer where practical. Topsoil will be removed using backhoes only.
 - 19.5.4. Topsoil is stored according to the provisions approved by the Engineer to enable reuse during Project Area rehabilitation.
- 19.6. Draining rainwater run-off
 - 19.6.1. Run-off from the working corridor will be intercepted. Surface water run-off will not be permitted to enter surface watercourses. Contractor will take appropriate measures.

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- 19.6.2. The gradient of Project Areas allows the collection and drainage of rainwater from the entire surface area to one or several discharge points. No pools of water are created.
- 19.6.3. Suspended solids in rainwater are removed using sediment traps / settling ponds. Rainwater from vehicle parking areas, machinery areas, workshops is subject to treatment with oily water separators.
- 19.6.4. Rainwater pre-treatment units are sized, cleaned, maintained and accessible to ensure compliance with the effluent quality criteria defined in ESHS Specifications Sub-Clause 12.9 and to allow monitoring of performance.
- 19.7. Sediment control
 - 19.7.1. The Contractor installs sediment control barriers to slow the flow of water and control sediment transport at Project Areas with (i) a gradient of more than 20%, and (ii) where land is disturbed by the works or where stockpiled mineral material exposed to sheet or rill erosion.
 - 19.7.2. Sediment control barriers are installed on the slope or at the base of the slope to protect the natural drainage system from sediment accumulation at levels higher than the natural situation. These barriers comply with the following principles:
 - a) Made with geotextiles or straw bales or any other means pre-approved by the Engineer;
 - b) Deployed before the start of works and removal of topsoil. Barriers can be used for the physical demarcation of working areas;
 - c) Installed, cleaned, maintained and replaced according to manufacturer recommendations;
 - d) If applicable, drainage surface area does not exceed 1,000 m² per 30 m of barrier. The length of the slope behind the barrier is less than 30 m, and is not used for flows in excess of 30 l/s.
 - 19.7.3. For the dredging of marine sediments, if applicable and unless specified otherwise in

the Contract, or instructed otherwise by the Engineer, and particularly if the working area is exposed to currents, the Contractor will install a geotextile silt curtain, or any other technique approved by the Engineer to control turbidity clouds.

19.8. Backfilling and stockpiling of backfill materials

19.8.1. In case mineral material stockpiles do exceed a height of 6 m, with a maximum slope of 3:2 (height: volume), the slope has to be crossed at a height of 3 m by a berm with a minimum width of 2 m and with a peripheral drainage trench, to ensure stability and resistance to rainwater runoff erosion.

19.8.2. For permanent backfill material stockpiles, the stockpile is shaped and compacted every 30 cm to ensure long-term stability.

19.8.3. Temporary stockpiles in place for more than 60 days are protected against runoff erosion by (i) revegetation using fast-growing grass species, either by direct seeding or by hydro-seeding, or (ii) using other natural anti-erosion cover with prior approval from the Engineer.

19.9. Side casting during the construction of linear structures (roads, pipelines, transport lines), will be permitted in the following conditions:

19.9.1. For natural gradients with a slope <40%, the side cast materials are piled to create a slope of less than 2H:1V.

19.9.2. For natural gradients with a slope >40%, to ensure stability 3m wide berms will be installed perpendicular to the slope and onto which the side cast material is deposited. Regular earthworks to maintain the form of the side case and long term stability of the side cast is carried out. The slope of the side cast in general does not exceed 3H:2V.

19.9.3. The provisions of Clauses 10 and 19.6 for the protection of water courses exposed to erosion induced by the works apply.

20. Site rehabilitation

20.1. Unless instructed otherwise by the Engineer, the Contractor will rehabilitate all Project Areas and landscapes disturbed by the works, to their original condition where possible upon completion of construction and prior to the provisional acceptance of the works. Close collaboration with all statutory stakeholders will be conducted in cooperation with the

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Employer during the reinstatement.

- 20.2. The Contractor describes in the PA-ESMP the planned revegetation works to ensure sustainable Project Area rehabilitation: methods, plant species to be used and their origins, activity schedule based on a progressive taking over of Project Areas.
- 20.3. As a minimum, the Contractor shall carry out the following reinstatement activities:
 - 20.3.1. If not otherwise instructed by the Engineer, all buildings, campsites and free standing and underground structures (e.g. piping, underground tanks, sumps and basins) are removed pursuant to the provisions of Sub-Clause 4.23 of the CC. All waste and rubble is removed in accordance to the provisions of Clause 16 of the present ESHS Specifications. After removal of buildings structures and rubble, the Contractor returns Project Areas to their original condition, according to the following provisions.
 - 20.3.2. Land is levelled to ensure that run-off water drains without eroding soil or stagnating in pools.
 - 20.3.3. Rehabilitated Project Areas do not represent hazards for people. Areas near steep drops at quarries are fenced off and indicated with permanent concrete warning signs. Holes are refilled. Sharp or unstable items are rendered inoffensive.
 - 20.3.4. Unless specified otherwise in the Contract, or instructed otherwise by the Engineer, the Contractor undertakes revegetation of all Project Areas disturbed by the works and bears the cost of such work.
- 20.4. Fertiliser application shall be limited to areas where it is necessary to establish a rapid vegetative cover for erosion control purposes in areas of high risk. Any fertiliser applications must be formulated and performed so that natural nutrient balances in adjacent ecosystems are not altered, particularly where there are nearby water bodies.
- 20.5. The Contractor shall perform routine maintenance of revegetated areas until such time that occupation of the land is officially handed back to the Employer or third parties.
- 20.6. The Contractor shall control noxious weeds and invasive species within revegetated areas.
- 20.7. Prior approval by the Engineer is required regarding the origin of seeds and plants proposed by the Contractor. The species used for revegetation must be

suitable for the local environmental conditions, and selected according to the rehabilitation programme: stabilisation of backfill, landscaping, drainage, prevention of erosion, etc.

20.8. Revegetation is undertaken throughout the duration of construction works, and is not limited to the rehabilitation of Project Areas at completion of the works.

20.9. The present Clause applies to the side casting of waste mineral materials generated during the construction of linear structures (roads, pipelines, transport lines).

21. Documentation on site conditions

21.1. The Constructor documents changes in condition of all Project Areas from the start of works until the Performance Certificate is issued. Documentation comprises dated and geo-referenced colour photographs taken from a constant angle and viewpoint.

21.2. The Project Area condition is documented as a minimum for the following stages:

- a) Before any Project Area disturbance at the start of works;
- b) On completion of works, but prior to starting rehabilitation;
- c) On completion of rehabilitation and revegetation, if necessary, but prior to the Taking Over Certificate issuing;
- d) After the end of the Defects Notification Period and prior to the Performance Certificate issuing.

21.3. The Contractor specifies in the PA-ESMP (i) the list of viewpoints to be used, (ii) areas to be photographed, and (iii) methods used for taking and archiving photographs, according to industry photographing and archiving standards.

21.4. Adjacent areas (100 m from the perimeter of the Project Area) are included in photographic documentation.

C. Health and Safety

22. Health and Safety Plan

22.1. In application of Clauses 4 and 6 of the CC, the Contractor shall develop a Health and Safety Plan (HS Plan) section of the PA-ESMP, its organization for managing health and safety, pursuant to its Health and Safety Management system (HSMS).

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- 22.2. Pursuant to Clause 6 of the CC, the HS plan identifies and specifies:
- a) That Contractor understands and manages all health and safety risks relating to the execution of the works, including gender-specific risks;
 - b) Prevention and protection measures to control risks related to the execution of the works, by differentiating, where necessary, measures concerning the protection of women and men;
 - c) Human and material resources involved;
 - d) Works requiring a permit (e.g. blasting, butting of trees);
 - e) Emergency plans to be implemented in the case of an accident.
- 22.3. The Contractor implements prevention, protection and monitoring measures, as described in the health and safety plan.
- 22.4. The Contractor shall have in place a Behavioural Safety Based Programme and actively train and encourage Personnel to intervene on unsafe behaviours and situations and report on deviations.

23. Health and Safety Reporting

- 23.1. The Contractor shall document in a structured system (e.g. a Site Accident record sheet) all accidents, dangerous occurrences and investigations, which shall be available at all, times for inspection by the Engineer.
- 23.2. The Contractor shall investigate any incident and record and report systematic follow-up of relevant findings and recommendations. Problem areas related to HS shall be recorded with information about status, responsible person(s) and alternative solutions.
- 23.3. As specified in Sub-Clause 4.21 of the CC, the Contractor includes in the Progress Report to the Engineer a monthly HS Performance Report. The format and content of the HS Performance Report shall be agreed with the Engineer prior to the commencement of the works and report them to the Engineer.
- 23.4. In pursuance to clauses 4 and 6 of the CC, this report shall contain the following data, as related to the works:
- a) Progress against implementation of the Contractor's HS Plan
 - b) A list, including a brief description, of all incidents and dangerous occurrences

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- c) Number of fatalities
- d) Number of serious incident frequency
- e) Total Recordable injury frequency
- f) Number and type of accidents with and without lost-time
- g) Serious illness
- h) Total number of 'near miss events;
- i) Number of theft incidents;
- j) Number of security and number and type of other incidents;

23.5. In the event that the Contractor receives communication from the Engineer on HS under-performance, the Contractor shall prepare and implement an HS Improvement Plan to rectify such.

24. Accident reporting procedure

24.1. The Engineer is informed within one hour day/night of any accident involving serious bodily injury to a member of personnel, a visitor or any other third party, caused by the execution of the works or the behavior of the personnel of the Contractor.

24.2. The Engineer is informed as soon as possible of any near-accident (near misses) relating to the execution of the works which, in slightly different conditions, could have led to bodily injury to people, or damage to private property or the environment.

24.3. The Contractor shall prepare a report on each accident or dangerous occurrence and a copy of the report, together with witness statements and any other relevant information, shall be submitted to the Engineer as soon as possible.

24.4. A reportable accident shall include any accident to any person on Site requiring medical attention or resulting in the loss of working hours or any incident that resulted, or could have resulted in injury, damage or a danger to the Works, persons, property or the environment. Contractors will also notify and report of incidents of Subcontractors and Suppliers (in particular those for major supply items) and their Contractors Sites.

24.5. The Contractor shall report any HS accident, related to Contractor activities or personnel, to national or local authorities as required by relevant legislation. A copy of all such reports shall be provided to the Engineer.

24.6. The Contractor shall not notify or give any information to the media or other units or people without the

employer's consent.

- 24.7. The Contractor shall immediately rectify any situation or condition that could result in injury or a danger to the Works, person, property or the environment. If the situation or condition cannot be corrected immediately, the Contractor shall provide temporary barriers and appropriate warning signs and devices and/or take other appropriate action necessary for the protection of persons, property and the environment.

25. Health and Safety meetings

- 25.1. Contractor shall ensure efficient and effective HS communication and consultation with all Personnel involved in the Work. This includes but is not limited to toolbox meetings prior to the start of the Work, worksite HS meetings on a regular basis with all parties involved (including Subcontractors, the Engineer and third parties). It may also comprise other forms of communication.
- 25.2. Contractor shall ensure that supervision, directly in charge of construction activities, fully brief and discuss with Personnel at HS Tool Box Talks at the start of each work day and prior to commencing new activities. These talks shall be conducted in a language understood by the workforce. A checklist shall be utilised for this purpose. At a minimum it shall include the following;
- a) Nature of the job
 - b) Associated hazards
 - c) Safe working methods to be adopted
 - d) Requirements of the Permit to Work
- 25.3. The Contractor shall convene weekly team talks, extended to Subcontractors if applicable.

26. Security

- 26.1. The Contractor shall evaluate the security strategy and arrangements required for all worksites including transport. This evaluation shall be performed by qualified security experts and shall form the basis for the Worksite Security Strategy and Plan, which shall be submitted and approved by the Engineer as part of the PA-ESMP. The Security Strategy and Plan shall describe:
- Security risks and the identified mitigation / management measures
 - Roles and responsibilities including details of the Contractor and Subcontractors
 - Detection, monitoring and management procedures
 - Escalation plans including resources

27. Equipment and operating standards

27.1. The facilities and equipment used by the Contractor are installed, maintained, revised, inspected and tested pursuant to the manufacturer's recommendations. The recommendations are available in the language of communication defined under CC Sub-Clause 1.4 (or any other language approved by the Engineer).

28. Work permit

28.1. The Contractor puts in place a work permit procedure, prior to the starting of the works. The procedures define the approval process between the person qualified to issue the work permit and the personnel (or Subcontractors) carrying out the work.

28.2. Permits are issued in writing. Unless specified otherwise in the Contract, or instructed otherwise by the Engineer, works which require a work permit are defined in the health and safety plan. All other work permits required by the Engineer will be implemented by the Contractor.

29. Personal protective equipment

29.1. The Contractor ensures that all personnel, visitors or third parties entering a Project Area are equipped with Personal Protection Equipment (PPE) pursuant to the practices and standards specified in Clause 9.

29.2. Where appropriate, PPE must be worn by women as well as by men.

29.3. The Contractor describes in the PA-ESMP the PPE to be used per Project Area and per activity.

29.4. Personnel and visitors to Project Areas are equipped with a safety helmet, safety shoes and a reflective jacket as a minimum.

29.5. Adequate quantities of PPE are available on the Project Areas. Storage conditions must be compatible with usage pursuant to the provisions of ESHS Specifications Clause 30.

29.6. Contractor personnel are trained in how to use and care for PPE and the Engineer has access to training certificates.

29.7. When handling acids, caustics, and chemicals with corrosive or toxic properties, suitable protection shall be worn to prevent accidental contact with the substance.

30. Dangerous substances

30.1. A substance is considered dangerous if one or several of its properties render it dangerous, as defined in Appendix 2 of the present ESHS Specifications. The Contractor identifies and manages dangerous substances planned for use on the Project Area in the manner described in the present Clause.

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- 30.2. The assessment of the impact of the toxicity of dangerous substances on the reproductive functions of women and men must be taken into account.
- 30.3. The transport to the Project Area and use of dangerous substances requires prior authorisation from the Engineer.
- 30.4. Details of risks and related prevention and protection measures are included in the health and safety plan.
- 30.5. The Contractor obtains all necessary authorisations and/or licenses for the storage and use of dangerous substances from local authorities. A copy of the authorisations is provided to the Engineer.
- 30.6. For each dangerous substance used, the Contractor will implement the recommendations described (i) in the Material Safety Data Sheets (MSDS), and (ii) by the Globally Harmonized System of Classification and Labelling of Chemicals established by the United Nations for hazardous chemicals.
- 30.7. Copies of MSDSs are kept on the Project Area, and made available to personnel. The Contractor provides the Engineer with copies of all MSDSs.
- 30.8. Storage of dangerous substances
 - 30.8.1 Storage areas are designed and equipped by the Contractor based on the chemical and physical properties of the substances, on the types of containers stored, the number of people requiring access, the ventilation requirements, the quantities of the substance used and potential chemical reaction with other substances (see ESHS Specifications Sub-Clause 30.8.5 below).
 - 30.8.2 Pursuant to ESHS Specifications in Clause 16.12, the Contractor anticipates and plans for the storage and management of hazardous waste.
 - 30.8.3 Storage areas for dangerous substances are subject to strict rules, which are regularly checked by the ESHS manager. The rules include the following as a minimum:
 - a) Access to the storage area is limited to trained and authorised individuals;
 - b) An inventory is maintained up-to-date;
 - c) MSDSs must be available for all stored dangerous substances, and the substances must be clearly labelled;
 - d) A strict and methodical storage system

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is implemented (storage plan posted, large or heavy packaging may not be stored at heights, equipment and tools may not be stored in the dangerous substance storage room);

- e) Compliance with product expiry dates and implementation of a disposal procedure for substances which are not needed or which have expired;
- f) Entrances, exits and access to emergency equipment are kept clear at all times.

- 30.8.4 Storage areas are clearly identified with warning signs at the entrance. The Contractor displays the storage plan (location of the different products, maximum inventory), a summary of labelling system and information on chemical incompatibilities.
- 30.8.5 Chemicals which could react together (leading to explosions, fire, projections or the emission of dangerous gases) are physically separated.
- 30.8.6 Products that react violently with water are stored so as to prevent contact with water, even in the event of flooding.
- 30.8.7 Inflammable products are stored separately in a dedicated area with adequate ventilation at all times.
- 30.8.8 Buildings used to store large quantities of dangerous substances are isolated from other buildings to avoid the spreading of fire. Such buildings are constructed using solid and non-combustible building materials, and are equipped with evacuation systems and the appropriate firefighting equipment. Access to the buildings is clear, allowing for rapid evacuation in the event of an accident. The electrical systems are reduced to the essential minimum, and access points are equipped with adequate lighting (300 lux).
- 30.8.9 All storage areas are equipped with secondary retentions. Each storage area acts as a general secondary retention. Suitable absorbents (neutralising and non-combustible) are available in the storage area to clean up any spills and leaks.
- 30.8.10 The Contractor maintains the storage area at a suitable temperature for dangerous substances to prevent overpressure and bursting of containers.

31. Planning for emergency

- 31.1. The Contractor shall establish an emergency plan as a section of the PA-ESMP. It covers the following

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situations

emergency situations as a minimum:

- a) e.g. Fire or explosion;
- b) e.g. Collapse of structures, or scaffolding;
- c) e.g. Loss of the containment of dangerous substances;
- d) e.g. Safety incident or malicious act.

31.2. The Contractor shall maintain fit-for-purpose Emergency Response Capability, which shall be clearly documented.

31.3. At a minimum, the Contractor shall make contingency arrangements for calling a Doctor and transporting injured persons to hospital. The telephone numbers of the emergency services and the name, address and telephone number of the Doctor and the nearest hospital shall be prominently displayed in the Contractor's office.

31.4. The Contractor ensures that all personnel are informed and aware of how to react in an emergency situation, and responsibilities are defined. Information and awareness training is documented, and available on all Project Areas.

31.5. The Contractor organises and documents emergency simulation exercises within 3 months of the physical start of the works, and subsequently once every 12 months up to the issue of the Taking-Over Certificate. The Engineer is invited to participate in each of these exercises.

31.6. Fire protection

31.6.1. Based on a fire safety risk assessment, the Contractor will ensure that adequate and appropriate fire safety measures are in place to minimise the risk of injury or loss of life in the event of a fire. Appropriate actions include: Keeping sources of ignition and flammable substances apart; Avoiding accidental fires; Ensuring good housekeeping at all times, e.g. avoiding build-up of rubbish that could burn; Installing smoke alarms and fire alarms or bells; Installing fire warning systems; Having correct fire-fighting equipment; Keeping fire exits and escape routes clearly marked and unobstructed at all times; Ensuring workers receive appropriate training on procedures they need to follow, including fire drills.

31.6.2. Fire will not be used as a method of forest or vegetation clearance.

31.6.3. Fire extinguishers are made available in each building at clearly identified locations, and fires

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are strictly forbidden outside of the cooking area.

- 31.6.4. If applicable, the Contractor makes arrangements with local fire-brigades for emergencies

32. Medical check-ups

- 32.1. The Contractor organises medical check-ups carried out by a doctor or an appropriately qualified nurse for all Contractor's Personnel prior to the initial mobilisation to the Project Area to check aptitude for the work. Medical check-ups are adapted to the anticipated occupied positions and carried out pursuant to the recommendations of the International Labor Organization. Subsequent to the check-up, a written medical certificate is issued declaring the aptitude of the worker for the allocated tasks.
- 32.2. Hearing tests are conducted for the Contractor's personnel exposed to noise levels above 80 dB(A) in order to establish initial audiograms. Annual tests are carried out to monitor any changes and detect any deterioration.
- 32.3. The Engineer can request additional medical examinations for the Contractor's Personnel if considered necessary, all costs to be borne by the Contractor.
- 32.4. A medical examination is carried out on any Contractor's Personnel returning to work after leave caused by a work related accident. A written medical certificate is issued confirming the Contractor's Personnel's aptitude to return to work at the designated workstation.
- 32.5. The Contractor can produce a copy of its Contractor's Personnel's work aptitude certificates at the request of the Engineer or any competent authority.
- 32.6. Specific arrangements for tasks' assignments or workstations shall be made for pregnant Personnel.

33. First-aid

- 33.1. The Contractor ensures a minimum of first-aid provisions on any work site, including: suitably stocked first-aid kits; a person, respectively an adequate number of staff appointed and trained to take charge of first-aid arrangements and ensure that staff and workers are informed about first-aid arrangements. .
- 33.2. The Contractor equips the Project Area with a communication system exclusively for the purposes of communication with the first aid services. Information on how to communicate with the first aid services is clearly indicated near the communications equipment.

34. Medical Services and Personnel

- 34.1. The Employer will inform the Contractor about the presence and number of medical personnel in the Project Area. If not otherwise instructed by the Engineer, in application of Clause CC 6.7, the Contractor shall

- collaborate with local health authorities and make arrangement with an appropriate number of local doctors, and/or nurses, hospitals and ambulance services to ensure that medical staff, first aid facilities, sick bay and ambulance service are available at a minimum within 45 minutes at the Site, and at any accommodation for Contractor's and Employer's Personnel or if appropriate, be based in the Project Area.
- 35. Health care**
- 35.1. The Contractor guarantees access to health care for all personnel in case of accident or illness occurring during the execution of the works.
- 35.2. In absence of a health centre or health post in the vicinity, or within the Project Area, the Contractor shall make contingency arrangement for transporting injured persons to a hospital in application of ESHS specification Clause 36.
- 36. Emergency medical evacuations**
- 36.1. The Contractor allocates rapid emergency transportation for first aid purposes to the first aid station pursuant to standard NF EN 1789:2007.
- 36.2. In cases where there is no first aid emergency vehicle available to evacuate severely ill or injured personnel, the Contractor establishes an agreement with a specialised company for the handling of personnel in the event of a serious accident requiring an emergency medical evacuation and ensures that transport is guaranteed any time and as fast as possible. The Contractor will provide a copy of the agreement to the Engineer within one month of the physical start of works.
- 36.3. The agreement includes a convention with a referring hospital where the member of personnel evacuated in emergency conditions will be treated.
- 36.4. In highly remote areas or in demonstrably life threatening cases, the agreement may cover the use of air transportation (if available) in order to evacuate the injured patient(s) to the referring hospital.
- 36.5. The telephone numbers of the emergency services and the name of the service providers and the doctors shall be prominently displayed in the Contractor's site office
- 37. Access to health care and training**
- 37.1. The Contractor guarantees access to health care as defined in Clause 34 for all personnel in case of accident or illness occurring during the execution of the works, i.e.:
- a) Medical check-ups: initial (recruitment), annual and upon returning to work after sick leave;
 - b) Screening, vaccinations and preventive healthcare;
 - c) General healthcare during the execution of the works;
 - d) Medical assistance in the event of an accident and

assistance for emergency evacuations.

37.2. Subcontractor's personnel, other contractors, the Employer or the Engineer, present at the Project Area, must never be refused medical assistance, under the pretext that they are not directly employed by the Contractor. The Contractor may however define a unit rate cost per medical act for personnel, other than its own Contractor's Personnel, display this rate in the healthcare centre and forward the information to the Engineer.

37.3. In the event of accident or serious illness, medical personnel must be trained, available and equipped with the necessary material, medicines and consumables to provide first aid for the patient, stabilise their condition, until the patient is:

- a) Either treated or discharged; or
- b) Hospitalized at the camp or in a larger hospital; or
- c) Evacuated to a medical centre, which is well equipped for intensive care, if necessary.

38. Health monitoring

38.1. The Contractor cannot recruit workers in poor health.

38.2. The initial pre-recruitment examination must confirm that applicants are physically able to carry out the tasks required for the position.

38.3. The detection of pregnancy during the initial pre-recruitment examination of female applicants shall not constitute grounds for declining recruitment, unless medical risk is proven.

38.4. The Contractor organises annual medical check-ups for its Contractor's Personnel and keeps up to date a medical record for each Contractor's Personnel. The presence of Contractor's Personnel for medical check-ups, treatment and hospitalisation is incorporated into the Contractors planning.

38.5. If applicable and as recommended by a doctor or instructed by the Engineer, the Contractor provides the Contractor's Personnel with prophylaxis and vaccinations against local diseases and vectors. In particular, the Contractor will promote the use of impregnated mosquito nets by its Contractor's Personnel in camps or offsite lodging, and distributes these nets appropriately.

38.6. The health and safety plan includes a Contractor's Personnel health risk assessment based on exposure to dangerous substances and describes the medical monitoring implemented.

39. Sanitary repatriation

39.1. The Contractor is responsible for the sanitary repatriation of Contractor's Personnel in the event of a serious injury or illness, based on a diligent examination and a statement of

the doctor in charge. The Contractor will take out the necessary insurance to cover the cost of the sanitary repatriation of its Contractor's Personnel.

40. Hygiene, accommodation and food

40.1. Drinking water

40.1.1. Pursuant to Sub-Clause 6.14 of the PC (Part B), the Contractor provides personnel with drinking water at all Project Areas. The quantity and quality of this water complies with the standards of the World Health Organization at supply points.

40.1.2. Unless the supply of drinking water is provided by a certified supplier, the quality of the drinking water provided to workers is tested at least at the start of the works and then on a monthly basis. The protocol for taking and analyzing samples is based on the recommendations of the World Health Organization. The results shall be documented and made available on the Project Areas.

40.2. Accommodation conditions

40.2.1. The accommodation provided for non-resident Personnel in a camp or an alternative structure outside of the Project Areas, such as a hotel or rented house, will comply with the conditions of the present ESHS Sub-Clause in pursuance of Sub-Clause 6.6 of the CC.

40.2.2. The person in charge of managing the accommodation has a specific duty to report to the ESHS manager or if existent, the HS manager, the outbreak of any contagious diseases, food poisoning and other important casualties. The ESHS Manager in turn will inform the appropriate health authorities.

40.2.3. Rooms are lit and equipped with power sockets, beds and windows fitted with mosquito nets. Flooring is of a hard and impervious material.

40.2.4. The temperature in rooms and common areas shall be kept at an appropriate level during occupied hours (20 degrees in moderate to cold zones and providing adequate ventilation in hot zones).

40.2.5. The Contractor provides one drinking water tap per 10 Contractor's Personnel, one shower per 10 Contractor's Personnel as a minimum, one individual toilet for 15 Contractor's Personnel as a minimum, and one urinal per 25 Contractor's Personnel at accommodation camps. Separate showers and toilets must be made available for women.

40.3. Hygiene in shared areas

40.3.1. Sanitary areas (showers, sinks, urinals, toilets) are

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cleaned and disinfected by the Contractor's cleaning service at least once every 24 hours. Cleaning operations are documented.

40.3.2. The canteen, kitchen and kitchen utensils are cleaned after each meal service.

40.3.3. The number and location of toilets on Project Areas shall be adapted to the number of employees and the configuration of the Project Areas (distance, isolated area, etc.). For urinals and toilets, usual standards are 1 unit to max 15 persons.

40.3.4. Toilet facilities are conveniently located and easily accessible. In addition, all toilet rooms shall be well-lit, have good ventilation or external windows, have sufficient hand wash basins and be conveniently located.

40.4. Food

40.4.1. In application of Sub-Clause 6.13 of the PC (Part B) and ESHS Specifications Sub-Clause 46.1 of the present ESHS specification, the Contractor provides meals at a reasonable cost or free of charge to its Contractor's Personnel per shift in a canteen area and according to a procurement system which complies with the provisions of this ESHS Specifications Sub-Clause.

40.4.2. The Contractor defines and implements actions in order to guarantee (i) the quality and quantities of food stuffs, (ii) compliance with health rules when preparing meals, (iii) fitting out and servicing premises and equipment, both in the kitchen and food storage areas.

40.4.3. The Contractor inspects the cleanliness of food transport vehicles, temperature control and the cold chain, as well as best-before dates, and takes the necessary corrective actions. The temperatures of chillers are regularly checked.

40.4.4. The Contractor checks that health requirements are met for food storage conditions in the kitchen or other locations, food cooking times and temperatures, and the conditions in which prepared products are left prior to consumption, to ensure no health risks. Prepared food is eaten or thrown away, no food remains are reused.

40.4.5. The Contractor recruits trained canteen personnel and ensures that supervisors monitor compliance with sanitary instructions. The Contractor ensures that canteen personnel have means of ensuring compliance with health rules (changing rooms, linen, hand washers, the condition of flooring and

paint, and the existence of a cleaning plan).

40.5. At the request of the Engineer, the doctor at the health centre specified in Clause 35.2.2. of the present ESHS Specifications, carries out an audit on all Project Areas every 3 months, and documents the results, and includes the conditions of hygiene in which meals are prepared and food conserved. The results of this audit are provided to the Engineer.

40.6. The Contractor, on the basis of the advice of the doctor at the health centre, informs Contractor's Personnel on appropriate behaviour in terms of workplace hygiene. The occasional distribution of information is not sufficient, the Contractor regularly reiterates the importance of hygiene, documents these reminders, and ensures that the information is understood, easy to apply and scrupulously complied with.

41. Substance abuse

41.1. Pursuant to Sub-Clause 6.16 of the PC (Part B), the use, possession, distribution or sale of illegal drugs, controlled substances (as per local regulations) and alcohol is totally prohibited on the Project Areas. The Contractor implements a zero tolerance policy for the consumption of these substances.

41.2. Any person suspected by the Engineer to be under the influence of alcohol or controlled substances on any Project Area is immediately suspended from his position by the Contractor, pending the results of medical tests.

D. Local labour and relations with local communities

42. Labour conditions

42.1. The Contractor shall ensure decent labour conditions for workers and notably compliance with applicable law and regulations in the country of implementation of the contract, and with the fundamental conventions of the International Labour Organisation (ILO). This includes workers' rights related to wages, working hours, rest and leave, overtime, minimum age, regular payment, compensation and benefits, equal opportunities, a non-discriminatory workplace, best practice on human resource management and occupational health and safety. Wages, benefits and conditions of work will be comparable to employers in the relevant region of that country/region and sector concerned.

42.2. The Contractor shall respect and facilitate workers' rights to organize and provide a Worker Grievance Mechanism for all workers, including the workers of subcontractors, shall receive an induction on their rights and on the Worker Grievance Mechanism. The Contractor will display the contact details of the Worker Grievance Mechanism at

well visible places in all camps and work sides.

- 42.3. The Contractor shall issue and implement internal policies and procedures to assure that no employee or job applicant will be subject to discrimination and/or harassment.
- 42.4. The Contractor shall establish for their personnel and those of their main contractors a system to monitor hours worked on the Project and seek to identify and remedy any practices, which lead to long working hours in excess of national legislation.

43. Local recruitment

- 43.1. Local recruitment is defined as the number of positions actually allocated to people residing in the region of the Works (less than two hours by land transport to the Project Area) for more than one year and citizen of the Employer's country.
- 43.2. Pursuant to Sub-Clause 6.1 of the CC, and if requested by the Employer, the Contractor, and/or respectively the Subcontractor hiring local workers, establishes and initiates a local recruitment policy and a procurement plan to ensure that recruitment procurement procedures are transparent and disseminated to the project affected communities for the duration of the Works.
- 43.3. The policy and plan shall be enforced by the Subcontractors and suppliers of major supply items, responsible for hiring local workers.
- 43.4. The Contractor demonstrates the effective implementation of this policy to the Engineer in its monthly activity report as defined in Sub-Clause 6.1 of the present ESHS Specifications.
- 43.5. Pursuant to Clause 8 of the present ESHS Specifications and if requested by the Employer, the Contractor develops a training programme aiming to support the local recruitment policy.
- 43.6. This training programme must be available to women and adjusted to their level of education.
- 43.7. An incentive mechanism to increase the share of women recruited by the Contractor and the Subcontractors may be established.
- 43.8. Local labour needs are estimated prior to the start of works and described in the PA-ESMP with the following information:
 - a) Identification of positions that could be filled by local staff and the level of qualification required;
 - b) Definition of the planned procedure for the effective recruitment of these members of staff;
 - c) Establishment of mechanisms to ensure non-

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- discrimination of women in accessing recruitment procedures;
- d) Deployment schedule for these positions;
 - e) Initial training to be provided by the Contractor for each job description.
- 43.9. In order to prevent outsiders from entering the Project Area, local recruitment at the Project Area, including at the entrance, is prohibited.
- 43.10. Local recruitment office
- 43.10.1. One month prior to the start of Works, the Contractor establishes a local recruitment office in the district where the main Project Area is located, at a location pre-approved by the Engineer.
 - 43.10.2. A representative of the Contractor is present in this office at least two mornings each week, from the start of the works to a date pre-approved by the Engineer.
 - 43.10.3. The representative provides information on job vacancies with the Contractor for the execution of the works (required qualifications, duration, and location) and on the information to be provided in applications.
 - 43.10.4. Lists of local candidates are drafted by the representative allocated to the office and forwarded to the Contractor's Humans Resources manager on a weekly basis.
- 43.11. The Contractor's Human Resources manager selects candidates listed by the local recruitment office based on requirements for the Works and the Contractor's recruitment procedures. A written contract between the Contractor and the local Contractor's Personnel is drafted, signed and archived by the Contractor.
- 43.12. If the Project Areas are located near to several different communities, the Human Resources manager ensures a fair distribution of local recruitment between the different communities.
- 43.13. The Human Resources manager will ensure that recruitment campaigns in local communities have been spread to women and that the latter have not been discriminated in recruitments.
- 43.14. Pursuant to Sub-Clause 6.22 of the PC (Part B), the Contractor maintains one record per local Contractor's Personnel indicating the hours worked per person allocated to the works, the type of tasks carried out, the wages paid and any training provided. Records are

available at the main Project Area at all times, so the Engineer and the authorised representatives of the government can assess the content.

44. Transport

- 44.1. Unless specified otherwise in the Contract, or instructed otherwise by the Engineer, the Contractor provides or enables access to daily transport for Contractor's Personnel not housed in the camps managed by the Contractor and living more than 15 minutes' walk from the Project Area and less than one hour by land transport.
- 44.2. The transport is organised under conditions which comply with local regulations and which ensure the safety of the people transported.
- 43.3. The Contractor organises collective transport: pick-up times and locations are defined and services organised appropriately.
- 43.4. Transport from the living facilities to his wages worksite is safe and free. If the Project Area is moved during the working season and if the Contractor retains the local personnel trained at the start of the works, the accommodation of the Contractor's Personnel is managed by the Contractor:
 - a) Within a mobile camp with the other non-local Contractor's Personnel; or
 - b) In villages located near to the mobile Project Area, in this case, each local Contractor's Personnel will receive a housing allowance in addition areas within each camp and a sports field for use by Personnel.

45. Workers' accommodation

- 45.1. Living facilities are located to avoid flooding and other natural hazards.
- 45.2. Where possible, living facilities are located within a reasonable distance from the worksite.
- 45.3. The living facilities are built with adequate materials, the sites are adequately drained to avoid the accumulation of stagnant water, kept in good repair and kept clean and free from rubbish and other refuse.
- 45.4. Rooms shall not be mixed: separate rooms must be made available for both men and women.
- 45.5. Separate toilets and locker rooms shall be provided for women and men.
- 45.6. The Contractor constructs and maintains a range of recreational facilities and shared leisure
- 45.7. The Contractor ensures that at campsites:
 - a) Workers have access to an adequate and convenient supply of free potable water,

- b) that drinking water meets national/local or WHO drinking water standards,
- c) that all tanks used for the storage of drinking water are constructed and covered as to prevent water stored therein from becoming polluted or contaminated,
- d) that drinking water quality is regularly monitored.

45.8. Dormitories

45.8.1. A separate bed for each worker is provided. The practice of "hot-bedding" shall be avoided. Rooms shall not host more than 8 individuals.

- a) There is a minimum space between beds of 1 metre.
- b) Double deck bunks are not advisable for fire safety and hygiene reasons, and their use is minimised. Where they are used, there must be enough clear space between the lower and upper bunk of the bed. Standards range from 0.7 to 1.10 metres.
- c) Triple deck bunks are prohibited.
- d) Each worker is provided with a comfortable mattress, pillow, cover and clean bedding.
- e) Bed linen is washed frequently and applied with repellents and disinfectants where conditions warrant (malaria).
- f) Facilities for the storage of personal belongings for workers are provided, including 0,5 m³ and 1 meter of shelf unit.

45.9. The Contractor shall mitigate impacts of activities (e.g. those that create noise or light) at worksites in order to avoid any public disturbance or disturbance of camp residents.

46. Meals

- 46.1. Food supplies for the meals of the Contractor personnel will exclude any meat obtained from hunting or poaching, with the exception of fish.
- 46.2. The Contractor provides for at least two meals per shift to local Contractor's Personnel pursuant to the hygiene conditions specified in Clause 40 of the present ESHS Specifications, at reasonable price for the Contractor's Personnel. If no canteen is available, the Contractor at least pays for a minimum of 2 meals per day per shift.
- 46.3. The Contractor shall avoid any local disputes through respecting local culture and values. The Contractor shall ensure that workers are aware of local issues and sensitivities, and respect local culture and values in order to avoid any local disputes and crime.

47. Community Interaction

- 47.1. Commensurate with the size of Construction activities and unsolved potential disturbances of the community and risks to public health and safety, the Contractor shall produce an Implementation Plan related to Community Interaction and submit it to the Engineer for review and acceptance prior the commencement of any works or traffic related to works.
- 47.2. The plan shall include a schedule of planned work activities which may impact a neighboring community and describe (i) the activities per task and phase which may impact the neighboring communities (ii) the approach to engage and communicate with stakeholders related to the works defined in (i); (iii) responsibilities for community interaction per task and phase.
- 47.3. When meeting stakeholders in neighboring communities, minutes of meetings shall be produced and recorded as by Employer's guidelines;
- 47.4. The Contractor shall disclose relevant information related to the involved impacts and risks to communities (e.g. related to Traffic Management or e.g. to entering of private property for surveys) in local language and at a level of complexity that is commensurate with local realities to ensure that stakeholders fully understand the content.
- 47.5. The Contractor shall include information about the Employer's grievance mechanism and the contact details in all community communication materials.

48. Damage to people and property

- 48.1. The Contractor shall implement a worker's Code of Conduct and not disturb or interfere with the inhabitants of local communities close to or in the Project Area, and shall respect their houses, cultures, animals, properties, customs and practices.
- 48.2. The Contractor's personnel shall be trained to understand the requirements about use of unapproved land and the need to stay strictly within site boundaries and within the working areas, using only approved access and service roads.
- 48.3. Pursuant to Clauses 4.14 and 17.1 of the CC, the Contractor is responsible for damages to people and property caused by the execution of the works or the procedures used for execution (e.g. project vehicles demolishing local fences or houses, driving accidentally over crops or causing any other material grievances).
- 48.4. Access to the Project Areas is prohibited to unauthorized persons. The Contractor is responsible for the security and access control of the Project Areas.
- 48.5. The Engineer is informed of any damage caused to people, or the property of individuals, other than the Contractor's personnel, within 6 hours of the event,

regardless of the value of the prejudice.

48.6. The Contractor shall establish procedures to manage and rectify and record incidents related to community disturbances.

48.7. Blasting

48.7.1. Housing existing before the start of the works, located within a minimum radius of 800 m around the perimeter of the quarries and within a minimum radius of 500 m around the other Project Areas that will be subject to blasting, will be examined by a bailiff unless agreed upon otherwise with the Engineer.

48.7.2. The bailiff's sworn statement is prepared and provided to the Engineer with the Site-ESMP.

48.7.3. Should any problems be detected due to the intensity of blasting, the Engineer is entitled to request that the Contractor carry out seismic measurements of the intensity of the vibrations induced by the blasting, at variable distances from the blasting points, under the supervision of the Engineer, and at the cost of the Contractor.

49. Land acquisition and land take

49.1. Pursuant to Sub-Clause 7.8 of the CC, the Contractor will cover (i) occupancy indemnities for the extraction or use of construction materials and (ii) the cost of acquiring the necessary land to stockpile excess backfill material.

49.2. The Contractor provides compensation for any prejudice suffered by the owners of the land mentioned in Sub-Clause 48.1 of the present ESHS Specifications, but also for any prejudice incurred by users of this land, if these users are not the same parties as the owners.

49.3. If not otherwise instructed by the Employer, the Contractor demonstrates to the Engineer (i) who are the owner and the users, if different parties have been identified, and (ii) a written agreement governing the temporary occupancy or acquisition of this land has been negotiated and duly paid up to the two parties, if different.

50. Traffic management

50.1. The Contractor defines the characteristics of its fleet of vehicles and site machinery in the PA-ESMP, in the form of a traffic management plan with the aim to prevent construction site vehicle incidents by the effective management of transport operations throughout the construction process.

50.2. The Contractor defines in the traffic management plan the itineraries used on a map for each route between the different Project Areas and for each phase of the construction works, and obtains the validation of the Engineer. The Contractor requests that the Employer obtain the authorisations of the competent administrative authorities if public roads are used. Any Engineer's

instruction to update the traffic management plan shall be implemented.

- 50.3. To reduce accidents, the Contractor will ensure that:
- a) Pedestrians and vehicles are kept apart (e.g. through providing separate entrances, walkways, signals)
 - b) Vehicle movements are minimized
 - c) Drivers are adequately trained and have the appropriate permits for driving vehicles
 - d) Turning circles for turning vehicles are installed.
- 50.4. Within one month of the physical start of works, the Contractor informs the administrative authorities of areas crossed by the Contractor's vehicles, of the itinerary and characteristics (frequency of passing, size and weight of trucks, materials carried) of the Contractor's fleet of vehicles.
- 50.5. If public roads are used, and unless approved otherwise by the Engineer, the Contractor mandates a bailiff to make a sworn report regarding the state of the road prior to use by the Contractor's vehicles. The report is annexed to the PA-ESMP.
- 50.6. The Contractor describes in the traffic management plan the expected traffic created by its fleet of vehicles (frequency of trips between Project Areas, working hours, convoys).
- 50.7. The Contractor also describes the number and positioning of flagmen.
- 50.8. Unless specified otherwise in the Contract or instructed otherwise by the Engineer, heavy vehicles (i.e. with a GVWR of more than 3.5 tons) may not be used at night between 22:00 and 06:00.
- 50.9. Speed limits
- 50.9.1. The Contractor takes action to limit and check the speed of all vehicles and machinery used to execute the works at an appropriate level.
 - 50.9.2. The maximum speed of all machinery and vehicles of the Contractor comply with the lowest of the following: the speed limit defined according to the Employer's country regulations or the following limits.
 - 50.9.3. 20 km/h within the Project Areas;
 - 50.9.4. 30 km/h in villages or hamlets, in towns, from 100m before the first house;

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- 50.9.5. 80 km/h on unpaved roads outside of towns, villages, hamlets and camps.
- 50.9.6. Pursuant to Sub-Clause 4.15 of the CC, and in coordination with the competent Employer's country authorities, the Contractor provides and installs signs for the fleet of vehicles along public roads, when public signs are inadequate.
- 50.9.7. The Contractor provides each of its drivers with a map at the appropriate scale of the roads authorised for the execution of the works, clearly indicating the maximum speeds authorised, and ensures their understanding.

50.10. It is strictly prohibited to transport people, equipment or products other than those required for the Works and the management of Project Areas, on board any of the Contractor's vehicles. This provision also applies to the transport of live animals and meat obtained from hunting, fishing or poaching.

50.11. The trailers and skips used to carry materials which could be projected (sand, crushed material, aggregates, selected materials) are covered with a tarpaulin for the entire itinerary between two Project Areas.

**51. Fossils/
Archaeological
Chance Finds**

51.1. The Contractor shall establish specific procedures to manage the protection of archaeological and historical sites, chance finds and fossils as stipulated in Sub-Clause 4.24 of CC.

**E. Amendments to the Specifications for
Environmental, Social, Health and Safety
Management (ESHS) of the Works**

Above specifications for Environmental, Social, Health and Safety Management (ESHS) of the Works (Clause 1 to 51) are amended as follows

**10. Protection of
adjacent areas**

10.9 The sworn statement regarding the existence and conditions of residential buildings shall be made for each and all cadastral parcels which are directly adjacent to the construction works site, i.e. on both sides of the road in which the main collectors will be installed and shall include any building and other existing infrastructure (e.g. fences, walls, sheds, ...) in the above cadastral parcels that may be impacted by the construction works.

- 10.10 The topographic survey shall be carried out on the entire area of the construction works site, including each and any area proposed for temporary usage up to a minimum distance of 10 m from the external boundary of the construction works site or area proposed for temporary usage.
- 21. Documentation on site conditions** 21.4 This clause is replaced as follows:
- Areas to be included in the photographic documentation shall include the entire area of the construction works site, including each and any area proposed for temporary usage up to a minimum distance of 20 m from the external boundary of the construction works site or area proposed for temporary usage.
- 32. Medical check-ups** 32.1 Medical check-ups prior to the initial mobilisation to the Project Area can be replaced by issuance of Contractor's Personnel's work aptitude certificates or a pre-recruitment examination certificate based on a medical check in the sense of Clause 38.2 or an annual medical check-up certificate in the sense of Clause 38.4, provided the delivered certificate is not older than one year at the time of the initial mobilisation to the Project Area.
- 50. Traffic management** 50.5 Not applicable

Appendix 1

Example for the Contents of a PA-ESMP

- 1. Environmental policy**
 - Declaration of ESHS policy signed by the Managing director of the Contractor and clearly defining the commitment of the Contractor in terms of (i) ESHS management for its construction sites and (ii) compliance with the ESHS Specifications of the Contract.
- 2. PA-ESMP**
 - Target and content of the Project Area Environmental and Social Management Plan (including Health and Safety)
 - Preparation and updating schedule
 - Quality assurance and validation
- 3. ESHS resources**
 - Human resources:
 - ESHS manager
 - ESHS supervisors
 - Person in charge of relations with stakeholders
 - Medical personnel
 - Logistics & communications:
 - ESHS vehicles
 - IT stations
 - In situ noise, air and water measuring equipment
 - Analysis laboratory used
 - Reporting:
 - Weekly inspections
 - Monthly
 - Accident/ Incident
- 4. ESHS regulations**
 - Definition of standards for the applicable national ESHS regulations and the ESHS recommendations of institutions affiliated to the United Nations (WHO, ILO, IMO, IFC), applicable to the execution of works:
 - Environment.....
 - Noise and Vibration Soil Erosion
 - Air Quality
 - Solid Waste
 - Hazardous Materials
 - Wastewater Discharges
 - Contaminated Land
 - Occupational Health and Safety
 - Community Health and Safety
 - General Site Hazards
 - Disease Prevention
 - Traffic Safety
 - Discharge standards
 - Minimum wage
 - Day and/or night traffic restrictions
 - Other

- Definition of ESHS standards for the industry applied
- 5. ESHS operational inspection resources**
 - Site tracking procedure:
 - Frequency
 - Personnel
 - Assessment criteria
 - Non-conformity handling and detection procedure:
 - Distribution of information
 - Notification depending on the level of importance allocated to non-conformities
 - Tracking of the closing of the non-conformity
 - Management of data on tracking and non-conformities :
 - Archiving
 - Use as a performance indicator
- 6. Project Areas**
 - Description of Project Areas (as per definition in ESHS Specifications Sub-Clause 1.3):
 - Number
 - Location on a topographical map
 - Activities
 - Opening & closing schedule
 - Access
 - Reference to the Appendix: a Site-ESMP for each Project Area.
- 7. Health and safety plan**
 - Identification and characterisation of health and safety risks, including the exposure of personnel to chemicals, biological hazards and radiation.
 - Description of working methods to minimise hazards and control risks.
 - List of the types of work for which a work permit is required
 - Personal protection equipment
 - Presentation of the medical facilities at Project Areas:
 - Healthcare centre, medical equipment and allocation of medical staff
 - Medical treatments that can be carried out on-site
 - Ambulance, communications
 - Referring hospital
 - Evacuation procedure for medical emergencies
 - Description of the internal organisation and action to be taken in the event of an accident or incident
- 8. Training plan**
 - Basic training for non-qualified staff
 - Health and Safety inductions
 - Health & safety training
- 9. Labour Conditions**
 - Description of Human Resource Policy for construction works of direct and indirect workers
- 10. Local**
 - Local labour requirements:

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Recruitment	– Job descriptions and the levels of qualifications required – Recruitment procedure and deployment schedule – Initial training to be provided by the Contractor for each job description
11. Project machinery and vehicle traffic	➤ Location and management of the local recruitment office(s) ➤ Description of the fleet of vehicles/machinery used for the execution of the works and emission levels and safety requirements ➤ Deployment (Project Area & schedule) and maintenance sites for each vehicle and machine ➤ Mapping of itineraries, travel times, and areas where speeds are limited ➤ Dust suppression: – Mapping of road sections where dust reduction initiatives apply – Water points identified or to be created for refueling tanker trucks – Capacity of the tanker trucks used and calculation of the number of trucks required – Width of the track to determine if one watering run or equivalent is adequate (narrow track) or if two runs are required (wide track) – Number of watering or equivalent operations proposed per day depending on the climate
12. Dangerous substances	➤ Inventory of dangerous substances per Project Area and per period ➤ Transport and storage conditions and chemical incompatibility
13. Effluents	➤ Characterisation of effluents discharged to the receiving environment ➤ Facilities for the treatment or pre-treatment of effluents including sufficient run-off ➤ Measures for reducing the sediment content of rainwater runoff ➤ Measures for monitoring the efficiency and performance of facilities for reducing sediment content of rainwater runoff ➤ Resources and methods for monitoring effluent and rainwater runoff quality
14. Noise and vibrations	➤ Estimation of the frequencies, duration, days of the week and noise levels per Project Area
15. Waste	➤ Inventory of waste per Project Area and per period ➤ Collection, intermediate storage, handling and treatment methods for ordinary or inert waste ➤ Storage and handling methods for dangerous waste
16. Clearing and revegetation	➤ Methods & schedule for clearing vegetation and earthwork activities ➤ Methods, species and schedule for the revegetation of Project Areas disturbed by the works
17. Biodiversity	➤ Schedule for adequate fauna and flora management ➤ Measures for minimizing impact on fauna and flora species based on the Contracting Authority procedures

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- Measures for monitoring the efficiency and performance of the plan in place
- Measures for limiting IAS
- Measures for monitoring the efficiency and performance of the plan in place
- 18. Prevention of erosion**
 - Location of zones suffering from erosion
 - Methods and schedule for the implementation of anti-erosive actions, including topsoil storage
- 19. Documentation of site condition**
 - List and cover of viewpoints
 - Imaging method
 - Archiving photographs
- 20. Rehabilitation**
 - Method and schedule for Project Area rehabilitation
- 21. Appendices**
 - Site-ESMPs (number and location specified in Section 6 "Project Areas" above):
 - Marking out of the Project Area perimeter on a map
 - Definition of zones for vegetation clearing, zones for the storage of usable timber, zones for burning of green waste
 - Definition of on-site activities: construction, storage areas, accommodation areas, offices, workshops, concrete making units
 - Layout of activity areas on the Project Area: construction works, production/operation areas, rehabilitation and closure
 - Zones for the storage of topsoil, spoil from earthworks, materials
 - Access routes and checkpoints
 - Project Area occupancy schedule
 - Organisation of Project Area preparation
 - Liquid discharge outlet points
 - Proposed sampling points for monitoring water quality
 - Atmospheric emission outlet points
 - Location of the storage site for dangerous products
 - Location and mapping of waste treatment facilities when handled by an external service provider
 - Any other information relating to the environmental management of the Project Area
 - Emergency plan
 - Description of facilities
 - Characterisation of hazards
 - Emergency situations
 - Organisation structure - roles and responsibilities
 - Emergency procedures
 - Human and material resources
 - Triggering of the plan
 - Reporting

Appendix 2 - Properties rendering a product dangerous

1.	Explosive	substances and preparations which could explode in the presence of a flame or which are more sensitive to impacts and friction than dinitrobenzene.
2.	Combustive	substances and preparations which, when in contact with other substances, particularly inflammable substances, undergo strongly exothermic reactions.
3.	Easily inflammable	substances and preparations (i) in liquid phase (including extremely inflammable liquids), with a flash point below 21°C, or which can heat up to the extent of spontaneous combustion in ambient air; or (ii) in solid phase, which can burst into flames easily in the brief presence of a source of inflammation and which will continue to burn after the removal of the source of inflammation or (iii) in gaseous phase, which are inflammable in air at normal pressure; or (iv) – which, when in contact with moist air or water, produce dangerous quantities of gases which are easily inflammable.
4.	Inflammable	liquid substances and preparations, with a flash point equal to or above 21°C and less than or equal to 55°C.
5.	Irritant	non-corrosive substances and preparations which, when in immediate, extended or repeated contact with the skin and mucosa, can cause inflammation.
6.	Harmful	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to risks of limited severity.
7.	Toxic	substances and preparations (including highly toxic substances and preparations), which, in case of inhaling, swallowing or cutaneous penetration, can lead to serious, acute or chronic risks, and even death.
8.	Carcinogenic	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to or increase the frequency of cancer.
9.	Corrosive	substances and preparations which, in case of contact with living tissues, can destroy the latter.
10.	Infectious	substances containing viable micro-organisms or their toxins, for which it is known or we have good reasons to believe that they cause disease in humans or other living organisms.
11.	Harmful to reproduction function	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can induce or increase the frequency of undesirable non-hereditary effects in offspring or have a negative effect on reproductive functions and abilities.
12.	Mutagenic	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to hereditary genetic disorders or increase the frequency of these disorders.
13.	React with water	substances and preparations which, in case of contact with water, air or an acid, release a toxic or highly toxic gas.
14.	Sensitising	substances and preparations which, in case of inhaling or cutaneous penetration, can lead to a hypersensitisation, so that renewed exposure to the substance or preparation will cause characteristic harmful effects. This property can only be considered if test methods are available.
15.	Ecotoxic	substances and preparations with inherent or potential immediate or deferred risks for one or several environmental components.
16.	Dangerous for the environment	substances and preparations which are likely, after elimination, to lead to another substance, by any means, e.g. a lixiviation product, with one of the above characteristics.

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d) Personnel Requirements

The Bidder must demonstrate that it has the personnel for the key positions that meet the following requirements.

Bidders shall submit Form PER-1 (Proposed Personnel) and Form PER-2 (Resume of proposed Personnel) in accordance to Section IV "Bidding Forms" in Volume 1 of the Bidding Documents for the personnel proposed in the above Table under Item 1.: Design and Construction Phase.

One candidate can be proposed for two key positions if the requirements of the project implementation allow (e.g. assignment for one position during construction and for the other position during the operation period) and if the candidate possesses the required qualification and experience for the two positions. The Bidder is requested in any case to submit separate Forms PER-1 and PER-2 for each position.

The proposed personnel for the Operation management Phase shall be submitted to the Engineers and Employer's approval minimum 3 months before the start of the commissioning and testing of the respective parts of the plant. The proposed personnel shall comply with the minimum requirements indicated in the above table.

The proposed staff shall at a minimum have good written and spoken English skills (B1). Knowledge of the Montenegrin language is an advantage. Knowledge of the Montenegrin language is compulsory for the ESHS Manager.

Work experience in the Balkan Region is an advantage.

Section VII: Employer's Requirements – Personnel Requirements

Minimum Requirement for key Staff

No.	Position	Qualification	Total Work Experience (years)	Experience In Similar Works Experience (years)
1. Design and Construction Phase				
1.1.	WWTP and SSTP Process Engineer	Engineer, M.Sc., M. Eng., or equivalent, in the fields of : Process engineering, civil or mechanical engineering, chemical engineering	Min 15 years of post-graduate professional experience as an engineer	Min 10 years of experience in process design and calculation of wastewater treatment and sewage sludge treatment facilities. Minimum two (2) projects designed at the level of a detailed design for wastewater treatments plants including sewage sludge digestion and reuse of biogas for power production with a minimum capacity of 100.000 pe
1.2.	SSIP Process Engineer	Engineer, M.Sc., M. Eng., or equivalent, in the fields of Mechanical engineering, process engineering or electrical engineering	Min 10 years of post-graduate professional experience as an engineer	Min 5 years of experience in process design and calculation of sewage sludge incineration facilities Minimum two (2) projects designed at the level of a detailed design for sewage sludge incineration plants with a minimum capacity of 1.000 t DS / year
1.3.	Project Manager / Contractor's Representative according to FIDIC conditions of Contracts	Engineer, M.Sc., M. Eng., or equivalent, in the fields of Civil, mechanical or process engineering	Min 15 years of post-graduate professional experience as an engineer	Min 10 years of experience as Project Manager / Contractor's Representative in construction of wastewater infrastructure implemented under FIDIC conditions of Contract Minimum one (1) project supervised as FIDIC Project Manager for a wastewater treatment plant including sewage sludge digestion and biogas reuse for power production of a capacity of 150.000 pe or more

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No.	Position	Qualification	Total Work Experience (years)	Experience In Similar Works Experience (years)
1.4.	Project Manager Construction of the Sewage Sludge Incineration Plant	Engineer, M.Sc., M. Eng., or equivalent, in the fields of Civil, mechanical or process engineering	Min 15 years of post-graduate professional experience as an engineer	Min 10 years of experience as Project Manager in management of construction of incineration plants including testing and commissioning Minimum one (1) project for a sewage sludge incineration plants with a minimum capacity of 1.000 t DS / year supervised, including testing, as FIDIC Project Manager or in an equivalent function
1.5	SSIP Commissioning Manager	Engineer, M.Sc., M. Eng., technician or equivalent, in the fields of Process engineering, civil or mechanical engineering, chemical engineering	Min 15 years of post-graduate professional experience as an engineer or technician	Min 10 years of experience in the commissioning of incineration plants, at least two references for the commissioning of sewage sludge incineration plants and/or fluidized bed incineration systems
1.6.	ESHS Manager ⁽¹⁾	Engineer, M.Sc., M. Eng., technician or equivalent	Min 10 years of post-graduate professional experience as an engineer or technician	Min 5 years of experience as Environmental, Social Health and Safety (ESHS) Manager in civil and mechanical works construction activities. Fluent in the Montenegrin language
1.7	QA/QC Manager	Engineer, M.Sc., M. Eng., technician or equivalent, in the fields of Civil, mechanical or process engineering	Min 10 years of post-graduate professional experience as an engineer or technician	Min 5 years of experience as Quality Assurance / Quality Control Manager in civil and mechanical works construction activities.
2. Technical Operation Management Phase (possibly including commissioning and testing)				
2.1.	Plant Manager	Engineer, M.Sc., M. Eng., technician or equivalent, in the fields of Process engineering, civil or mechanical engineering, chemical engineering	Min 10 years of post-graduate professional experience as an engineer or technician	Min 5 years of experience in commissioning and management of the operation of WWTPs and SSTPs
2.2.	SSIP Plant Manager	Engineer, M.Sc., M. Eng., technician or equivalent, in the fields of Process engineering, civil or mechanical engineering, chemical engineering	Min 15 years of post-graduate professional experience as an engineer or technician	Min 5 years of experience in the operation of incineration plants and/or commissioning of incineration plants

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No.	Position	Qualification	Total Work Experience (years)	Experience In Similar Works Experience (years)
2.3.	WWTP and SSTP Expert for Electro-mechanical Maintenance	Electro-mechanical, Mechanical or Electrical Engineer or Technician	Min 15 years of post-graduate professional experience	Min 10 years of experience in the maintenance of electromechanical equipment and plants for wastewater and sewage sludge treatment
2.4.	SSIP Expert for Electro-mechanical Maintenance	Engineer or Technician	Min 10 years of post-graduate professional experience	Min 5 years of experience in the maintenance of electromechanical equipment and plants for sewage sludge and/or solid waste incineration, especially in implementation of the annual routine maintenance of facilities
2.5.	Laboratory Expert	Chemist, Engineer or Technician	Min 10 years of post-graduate professional experience	Min 5 years of experience in the implementation of water, wastewater and sludge analysis including bacteriological analysis. Key experience in the management of a laboratory.
2.6.	Control and Supervision (SCADA) Expert	Engineer or Technician	Min 10 years of post-graduate professional experience	Min 5 years of experience in the development and maintenance of SCADA based solutions for supervision and control of facilities
2.7.	Occupational Health and Safety Manager	Electro-mechanical, Mechanical or Electrical Engineer or Technician	Min 10 years of post-graduate professional experience	Min 5 years of experience as Occupational Health and Safety (H&S) Manager in the operation of technical plants. Fluent in the Montenegrin language

⁽¹⁾ Two candidates can be proposed for, on the one hand, the function of Environmental and Social Manager and, on the other hand, the function of Health and Safety Manager

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e) Equipment Requirements

Not Applicable