Construction of **Sewage Network and Waste Water Treatment Plant (WWTP) in the Municipality of Berane**

Volume 3-1 Employer’s Requirements

Section 4 General Specifications for Electrical Works and SCADA

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# Introduction

These Electrical and SCADA Specifications are part of the Employer’s Requirements (Volume 3-1) which are divided into 5 sections as follows:

* Section 1 General Requirements for Execution of Works
* Section 2 Particular Design and Process Requirements
* Section 2 General Specifications for Mechanical Works
* Section 3 General Specifications for Electrical Works and SCADA
* Section 4 General Specifications for Civil Works

The Contractor shall offer the whole works including civil, mechanical and electrical parts, so that the aim of the project is completely fulfilled, as specified. It is the responsibility of the Contractor to include in his offer all electrical deliveries and services required for the complete Works, and to state the exact quantity and dimensions as necessary to suit his design of the Works.

The quality and kind of the electrical components and systems shall be as specified in the Tender Documents. Additional components shall be selected by the Contractor and shall be described in detail in his offer. Any such component shall fulfill the uniform high quality standard that is required for the whole Electrical Works.

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 whole of the Works, machinery and apparatus shall be new and of first class manufacture and in every way suitable for wastewater works purposes and shall be supplied generally in accordance with the intent of the requirements and the detailed design created by the Contractor (which should be based on the conceptual process design proposed Section 2 of these Employer’s Requirements wherever appropriate standard equipment of proven proprietary design shall be supplied.

If specialized tools are required for maintaining the offered equipment, the Contractor shall include them in his offer. Tools, spare parts and accessories provided by the original manufacturer shall be delivered to the Employer. It shall be guaranteed, that the manufacturer will provide a repair and maintenance service at the place of operation. Spare parts shall be available for at least 10 years. Ordinary spare parts shall be of a locally available type.

Only new equipment of highest quality may be installed. For similar tasks, uniform appli­ances by the same manufacturer shall be used. The number of different brands shall be kept to a minimum. For extensions, only such appliances shall be tendered, which are identical to those that are already in use.

If the Contractor has experiences with the materials and services to be tendered, which are important for a correct, smooth and continuous functioning and knows about influences that could have damaging effects if neglected, he shall inform the Engineer immediately in writing.

The Contractor shall inform the Engineer in writing, if he knows that a change in the offered or ordered goods due to a change in production, standards or regulations is to be expected.

The design and installation of the work including all measuring-, safety- and signalling equipment shall meet the applicable regulations. All devices shall be approved by the proper standardization system and shall show the standard approval sign. The safety of the operating and maintenance personnel shall be guaranteed.

Apparatus and devices shall be arranged in a way that they can easily be operated, regulated, repaired and replaced from the front. All parts of the plant shall be able to be installed or dismantled without any modification of the building. Devices shall be assigned at the location and on the device itself. Key lock-switches and locks shall fit in with the plant's lock system. If installed outdoor, key lock-switches shall be protected against dirt and moisture by a protective casing, made of high-grade steel (W 1.4301/ANSI 304) to prevent defects due to weather or dust. The doors or shutters for the protection of operational devices shall close automatically.

The Particular Requirements for Electrical Works are based on the existing Preliminary design for the new WWTP. It shall be developed by the Contractor’s process technology and shall be adopted as the basis for his Design Proposal and subsequent Works.

The Contractor shall specify his Electrical works in accordance with the Section 2 and Section 4 of these Employer’s Requirements.

The Waste Water Treatment Plant shall be mainly provided with the following electrical systems:

* MV Power supplies cable from grid connecting point to Transformer Station (if and where needed).
* MV and LV Energy Supply system with appropriate switchgears within Transformer Station as well as complete Transformer Station as described in Section 2 and Section 4 of these Employer’s Requirements, and in Volume 5. Drawings.
* Emergency power generation. Stand by power generator.
* Low Voltage Energy supply system for all parts of the plant according to the actual design of the process and the machinery, incl. emergency supply
* Decentralised automation systems and instrumentation for each and every individual part of the plant according to the actual design of the process and the machinery
* Central control system with control computers and appropriate visualisation system
* Telephone system comprising all buildings, incl. connection to the public telephone system
* Electrical installations, earthing, lightning protection for buildings, outdoor and street areas
* Centralised fire alarms and building intrusion system
* Asses control system

The Contractor shall design and install power distribution, auxiliary supplies and control system as required to satisfactorily operating the new plant and equipment being supplied under this Contract.

**The Contractor shall check the necessary rated power.**

The scope of works that is covered by this Tender includes the delivery, installation and commissioning of electrical supplies, instrumentation & control system, as well as all internal cabling and wiring of the WWTP.

Automatic fire detection system shall be provided, designed to enable continuous supervision of the fire threats.

In compliance with the project of explosive gas protection, for all (eventually) determined outdoor hazardous gases dangerous zones 1 and for other indoor space determined in the referred project the proper dangerous gas detection / control system should be designed and provided.

After receiving the technical conditions from Public Utility Electrical Distribution Company, it was drafted the basic design of power supply system.

Location of the transformer station is presented on the General Layout drawing, in Volume 5. Specific conditions for connection to public supply is presented in Section 2 of these Employer’s Requirements, based on preliminary technical conditions issued by the Electricity supply company, Elektroprivreda Crne Gore.

## MV Cabling

Generally MV cabling (outside of the plot) is not subject of this Tender. However, where neccessary to provide connection of the new Transformer station with the public distribution network, the Employer’s Requirements (Section 2) may include construction of MV cable line feeders (if needed, connection between future WWTP Transformer Station and public distribution network). In this cause Contractor can assume MV public grid cabling have sufficient capacities to cover the complete WWTP power demands.

## Suitability of design and equipment

During the selection and/or design of equipment and installations, particular attention shall be paid to the following:

* Safety of operation and easy maintenance
* Well-proven and reliable components
* Ability to withstand the service conditions
* Inaccessibility for vermin, dust and humidity
* Precautions to minimize corrosion
* Service available in Montenegro
* Minimization of noise

Alterations of design and make of the offered equipment after the contract has been signed can only take place with the consent of the Engineer.

The Works shall consist of newly manufactured materials only. Materials which differ from electrical standards, roles or positive practice shall not be used in close proximity.

Top finish colour coats shall be determined in agreement with the Employer. Colour samples shall be submitted if so required.

The Contractor shall be liable for the first fill of oil and grease for all mechanical Works and equipment.

Lifting equipment shall be provided for all Works items over 50 kg (where not under the lift area of overhead cranes specified elsewhere).

The Contractor shall be responsible for the protection of Works up until the date of handover. Suitable measures such as temporary timber covers or plastic sheeting shall be used.

Each item of Works shall bear, in an easily readable position, an identification plate with text in Montenegro and the language of the country of origin stating the name of the manufacturer, year of manufacture and type and serial numbers.

Where the Contractor includes bought-in manufactured items, then full details shall be submitted to the Beneficiary for approval prior to incorporation in the works.

## Environment

All equipment shall be rated for the ambient temperatures relative humidity and altitude at the Site. Necessary frost protection by means of insulation and, if so required, also electric heat tracing shall be considered in the design.

The Contractor shall in his design and selection of equipment take into consideration under which conditions each item shall be in operation. Equipment placed in the open space shall be designed for solar radiation induced temperatures or in some way protected from direct sunlight.

Equipment placed in or near wastewater shall be efficiently protected against the intrusion of humidity and water.

Equipment placed where the risk of condensation prevails shall be provided with drainage holes placed in the lower part of the equipment

Equipment shall moreover be designed for preventing intrusion of insects and smaller reptiles.

## Program of works for equipment

The programme of works for equipment to be supplied and installed shall be divided into the following parts:

* Part I Procurement and/or Manufacturing period:

Design and manufacture of all equipment to be supplied under the contract including inspection and works testing

* Part II Shipping period:

Delivery of all equipment from factory to the Contractor's on site storage including all freight loading, off-loading, customs duties and clearance.

* Part III Erection period:

Removal of the materials and equipment from off or on-site storage, delivery to erection site and installation

* Part IV Site testing:

All electrical equipment and machinery shall be tested in the presence of the Engineer before being put into operation.

* Part V Running-in and Tests on Completion:

All installed electrical equipment and machinery shall be adjusted so as to comply with the operation requirements and actual conditions. Manuals and other documentation shall be provided by the Contractor.

Tests on Completion (Taking Over) shall not take place before the Contractor has finalized all the works including testing and running in, despite the fact that some machinery will, at the time for Tests on Completion, have been in operation for some time.

## Coordination

It is the responsibility of the Contractor to ensure full coherence between the equipment delivered according to the present electrical specifications and the specifications for mechanical and civil works.

The Contractor shall also be responsible for all sub-contractors and suppliers of equipment and materials.

No direct formal communication between the Employer and the sub-contractors will be permitted.

It is the responsibility of the Contractor to secure that sub-contractor and suppliers get all the relevant information of the present specifications.

The Contractor shall appoint and provide an experienced electrical and mechanical engineer to monitor and co-ordinate all aspects of the electrical and mechanical work.

## On-site manufacturing

It is the obligation of the Contractor to provide all installations within the working area as he considers necessary for on-site manufacturing and shaping of materials and equipment. The working site may be used as intermediate storage for equipment at the Contractor's own risk and at his own cost.

It shall be noted, that the Contractor's obligations on taking the necessary safety precautions shall apply for the working camp area as well.

## On-site storage and safekeeping

The Engineer shall be informed by the Contractor about machinery delivery dates well in advance of the anticipated time of arrival of the items.

In general all equipment shall be stored according to the manufacturer's requirements. If equipment and/or machinery are to be stored on site the Contractor shall either:

* Adequately package all items to enable the equipment and materials to be stored in the open without any deterioration whatsoever, or
* Provide an approved store, complying with the following minimum requirements:
* All MV or LV equipment or machinery
* Generator
* MCC, Distributors, cables, accessories
* Instrumentation equipment, hangers, holders etc.
* Luminaries, poles etc.
* Rotating mechanical equipment: Covered, ventilated, dust and vermin proof area.
* Pipes, valves, steelwork etc.: Sheeted on open hard standing area.

The storage site as defined above shall be arranged by the Contractor at his own expense within the contract price.

The Contractor shall be responsible for the operation, safe keeping and maintenance of all equipment on site during storage and after erection up to the issue of the taking-over certificate.

Operation and maintenance of the equipment after the taking-over period and during the Contractor's operation and maintenance period shall be the responsibility of the Contractor.

## Erection

The Contractor shall make his own arrangements for unloading of equipment and materials supplied and shall be responsible for any damage occurred. The Contractor shall at his own expense provide all tools, meters, gauges, temporary provisions as well as skilled and unskilled labour for the erection of the electrical installations so that it can be installed complete and in good working order.

If required by the Engineer, for the proper installation of all electrical equipment under this Contract an authorised representative of the manufacturer and its service organisation shall approve the installation and sign together with the contractor a statement with such approval. A form of such statement will be provided by the Engineer.

## Standards

The list of standards is given in Section 1 of these Employer’s Requirements.

## Equipment and manufacture

The Contractor shall guarantee all electrical equipment against faulty or inadequate design, improper assembly or erection, defective materials or workmanship, as well as leakage, breakage or other failure. Materials used shall be suitable for operation conditions.

All equipment shall be designed, manufactured and assembled in accordance with recognized and acceptable engineering and shop practice and selected for long life and minimum maintenance. Individual parts shall be manufactured to standard sizes to the extent possible, so that repair parts furnished at any time can be installed on site.

Electrical equipment shall be new and shall not have been in operation at any time prior to delivery, except as required by tests.

Electrical equipment manufacturers, will be proposed as wonders, shall have ISO 9000:2000 quality system certificate.

It is the Contractor's responsibility to ensure that the components of the systems are compatible as to dimensions, ratings and operational characteristics and integrated to form a fully efficient system complying with the specifications.

All equipment and materials, which will be provided to be used in pertinent works, shall be submitted to the Engineer's approval together with operating capacity, certified test reports and other necessary information.

Engineer may not accept any equipment or material which is not as per specification.

Warranty period of all offered electrical equipment shall be 2 (two) years after delivery date of the plant to the Employer, following installation and proper operation. The Contractor shall be responsible for draw up of warranty certificates of these equipment in the name of The Employer and hand over the original copies to the Employer.

Any defects or failure within warranty scope and period shall be fixed up in the liability of the Contractor. In such cases; the Contractor shall be involved in not later than 10 days after written communication from the Employer considering the urgency of the case. The Contractor shall be responsible for fix-up of damages in the equipment and paying costs due to the lateness in and evasion of his obligations stipulated in the Contract.

## Machinery guards and labelling

Machinery shall be guarded to prevent injury to persons, and meet international and local safety regulations.

Adequate guards shall be supplied and installed throughout the installation to cover all drive mechanisms.

All rotating and reciprocating part, drive belts etc. shall be securely covered to the satisfaction of the Engineer to ensure the complete safety for both maintenance and operating personnel. However, whilst all such guards shall be of adequate and substantial construction, they shall also be readily removable for gaining access to the equipment.

The Contractor shall arrange for the supply and fitting of warning labels for all machinery operated under automatic control.

All identification information and warning labels shall be in English and Montenegro language.

# General Requirements

If not stated otherwise in the tender documents all electrical equipment shall be offered, supplied, installed, commissioned and put into operation according to all following minimum requirements.

## Certificates

All manufacturers shall be certified in accordance to ISO 9001.

The electro-/mechanical equipment (MEICA[[1]](#footnote-1)) ***shall be provided with the certification “CE”*** in accordance to Machinery Directive ***98/37/EEC***, in particular the following directives shall be considered:

* Machinery Directive 98/37/EEC
* Low Voltage Directive 73/23/EEC
* EMC Directive 2004/108/EC
* And others as required by Directive 98/37/EEC

In addition the following documentation shall be included for each individual machines and/or apparatus:

* Certificate of Conformity in acc. to EN 10204/2.1
* Manufacturers Test Certificate in acc. to EN 10204/2.2[[2]](#footnote-2)
* Manufacturers Work’s Test Certificate in acc. to EN 10204/2.3[[3]](#footnote-3)

All certificates are subject to approval from the Engineer. Expenditures for certification of equipment shall be included in the Contractors prices.

## Abbreviations and terms

Following abbreviations and terms are used in the text with equal meaning:

Contractor = Contractor = Bidder = Tenderer

Engineer = Consultant = Site Supervision

Tender = Quotation = Offer

P.S. = Provisional Sum

L.S. = To be measured as Lump Sum

No. = To be measured by Number

m = To be measured by Running Meter

sq.mm = To be measured by Square Millimetre (mm²)

sq.m = To be measured by Square Meter (m²)

cu.m = To be measured by Cubic Meter (m³)

HV (MV) = High (medium) Voltage (more than 1 kV)

LV = Low Voltage (0.4 kV)

V = Volt

VDE = Verband Deutcher Electotechniker (VDE Association for Electrical, Electronic and Information Technologies e.V)

DIN = Deutsches Institut fur Normung (German Institute for Standardization)

ISO = International Organisation for Standardization

IEC = International Electrotechnical Commission

CEN =Committee European de Normalisation (European Committee for Standardization

CENELEC = Commite European de Normalisation (Electronique European Committee for Electrotechnical Standardization)

A = Ampere

mA = Milli-Ampere

W = Watt

var = Reactive Power

kWh = Kilowatt-hour

f = Frequency

T = Temperature

AC = Alternating Current

DC = Direct Current

IP = International Protection Class

PTC = Positive Temperature Coefficient

RMS = Root-Mean-Square value

UPS = Uninterruptible Power Supply

MCC = Motor Control Centre

PLC = Programmable Logic Controller

SCADA = Supervisory Control and Data Acquisition System

ICA = Instrumentation, Control and Automation

## Standards, Regulations and Engineer’s approval

The conditions specified in these general specifications are minimum requirements for all deliveries and performances. If special requirements are given for particular items they apply only to these particular items.

EU-Standards, IEC Standards or harmonised National Standards in their latest Edition shall be used throughout this Contract, generally. Authoritative shall be all standards that are valid at the location of the Plant during the time of implementation.

*This Contract consider apply of national harmonized standards, EU-harmonized German DIN-Standards or other previous named standards if not stated otherwise. Where Montenegro standards are more stringent than other applicable European standards then the Montenegro standards shall prevail.*

The conditions specified in these general specifications are minimum requirements for all deliveries and performances. If special requirements are given for particular items they apply only to these particular items. The Contractor shall propose Standards for the execution of the Works, which shall be approved by the Supervisor.

The regulations concerning the permitted level of noise emissions shall be applied.

Furthermore, the regulations of the Local Electricity Supply Company and the public guidelines, decrees and regulations for the protection of the environment shall be observed.

Materials and methods shall also comply in all aspects with following standards:

DIN (Deutsche Industrie Norm)

Beuth Verlag GmbH

Burggrafenstrasse 6

D-10787 Berlin (Germany)

[www.din.de](http://www.din.de)

VDE (Verband Deutscher Elektrotechniker)

VDE Verlag GmbH

Bismarckstrasse 33

D-10625 Berlin (Germany)

[www.vde.com](http://www.vde.com)

DVGW (Deutscher Verein des Gas- und Wasserfaches e.V.)

Josef-Wirmer-Str. 1-3

D-53123 Bonn

[www.dvgw.de](http://www.dvgw.de)

DWA(German Water Association) / ATV

Theodor-Heuss-Allee 17

D-53758 Hennef (Germany)

www.dwa.de

IEC (International Electro technical Commission)

Central Office of the IEC:

3 Rue de Varembè

PO Box 131 CH-1211 Geneva (Switzerland)

[www.iec.ch](http://www.iec.ch)

VDE Verlag GmbH

Bismarckstrasse 33

D-10625 Berlin (Germany)

www.vde-verlag.de

Authoritative are all regulations and guidelines that are valid at the location of the plant three months before submission of tenders.

The Contractor shall supply one original copy of each standard or regulation, which applies to any materials or methods, used during his performance to the Engineer on his request. The standards and regulations shall be submitted prior to submitting documents for the Engineer's approval. The costs for this service shall be included in the offered prices.

All units of measurements shall follow the SI metric system. All equipment and tools shall be designed with metric standard dimensions.

## Mixture of Standards

The Contractor shall note that the Engineer will not approve of any complete system incorporating component parts and design standards different to National Standards unless the entire system has been designed to function as a whole within the standards and design codes laid down by only one of the approved authorities.

## Electrical Rooms, Ventilation, Heating, Air Conditioning, Fire Extinguisher, Keys

In order to guarantee safe and long last of electrical equipment separate room will be design for MCCs, distributors and/or marshalling cabinet installation. An inner air-temperature between + 15°C and + 30°C, the switchgear cabinets and the rooms of the switching stations shall be supplied with ventilation-, heating-, and air-conditioning devices.

The penetration of aggressive gases, moisture, dust and insects or animals through ventilation openings into the switchgear cabinets shall be prevented. Electrical rooms shall be kept dry under any operating conditions. They may not be located below the surrounding ground level. Air conditioning units or other piping systems shall not be installed overhead of any electrical gear. The components of air conditioners (e.g. cryogenic fluid, insulation) shall not contain any CFHC (Chloro - Fluorinated Hydro - Carbons).

In rooms with gas - insulated switchgear, such as SF6-insulated MV-cubicles, a technical ventilation system, that prevents dangerous levels and concentrations shall be provided. In all rooms with electrical switchboards the Contractor shall provide a sufficient number of CO2 - fire extinguishers.

There shall be a key system for the plant and all doors of electrical rooms that guarantees that the equipment is quickly accessible for operation, maintenance and fault removal.

## Cables and Lines

In general cables of the NYY-J type according to DIN VDE 0250 with the suitable cross section shall be used for cabling. For the supply of drives controlled by frequency converters, shielding cables of the NYCY or NYCWY type with concentric conductor shall be used.

Cables shall be installed without cuttings. To identify all cables a cable identification system shall be proposed to the Engineer and utilized after his approval throughout the whole Works. This system shall indicate the voltage, purpose and running number. All cables shall be marked with long-lasting labels at the connecting points.

Cables in the ground shall be laid in stepped cable-trenches with a layer of stone less sand (approx. 10 cm) at the bottom. High voltage (HV) cables, if applicable, shall be laid at a depth of 1.2 m; LV cables, control and signaling lines 0.8 m in depth, above that a further layer of stone less sand (approx. 10 cm) and the equipotent bonding shall be laid. All shall be covered with plastic cover plates or with concrete tiles. A warning tape, with markings to identify the kind of service in Montenegro and English language throughout the entire length, shall be laid 50 cm above the cables; above optical fiber cables (if applicable) this shall show the writing "Caution! Optical fiber cable" and make the cable's location possible by a steel-wire inlet. Within cable trenches the cables shall be laid out in a "snaked" manner, so that movements of the ground may not create extra forces. Before the excavation of trenches is allowed to begin, the cable route shall be marked and in­spected together with the Engineer.

Surfaces that shall be restored afterwards shall be re­corded by means of reports and photos. Excavation works shall follow DIN 18300. Streets and roads shall be closed, before they are opened up. The safety of the traffic shall be guaranteed.

Blasting may only be carried out with permission of the Engineer. The permission of the Engineer is also needed before trenches are refilled. Afterwards the cable route shall be marked with marking stones at characteristic points.

For installation of LV-units within buildings, cables of the NYM-J type according to DIN VDE 0250 with the suitable cross section shall be used. In this case, cables shall be installed either concealed, in insulating conduit, cable duct or with wiring-cleats, where the distance between two cleats may not be more than 25 cm. Galvanized or high-grade-steel cable trays shall be used where larger amounts of cables are installed.

Cable junctions shall be carried out in insulating junction boxes according to the cables cross-section; the degree of protection shall be IP 54. Terminal boxes with IP 54 indoor respectively IP 65 outdoor shall be used, where the line changes from solid to flexible wiring. In Ex-Zones the junction boxes shall be of the approved type for explosion areas.

If cables are crossing walls or ceilings between fire-protection sections, there shall be fire-proof bushings according to DIN 4102 that can easily be opened for future extensions. At bushings into sections that are endangered by water or gas, sealed and elastic gas- and watertight bushing-systems shall be installed.

Only stainless material shall be used for fixing cleats, terminals, cables, trays, ducts, lamps, switches, outlets, etc.

The fixation to walls and ceilings shall be carried out in a suitable manner using plugs from plastic.

The voltage-drop shall be limited to 5% in all circuits at full load except lighting circuits where limits shall be 3%.

For indoor-transmission of measuring signals, screened paired measuring- and control-installation-cables of the PYCYM type, 230 V, and for installation in the ground, cables of the A-2YF(L)2Y type according to DIN VDE 0250 shall be used.

Specialized cables for data-transmission, safety devices, high-frequency signals, short-circuit-proof installation, optical transmission, shall be used if applicable or special mounting shall be apply for the specific purpose.

Intrinsically safe circuits shall be carried out with cables of the EBCY 2x2x0.75 type, blue, according to DIN VDE 0165; fire-signal cables shall have respective markings.

Underwater cables shall be suitable for the intended purpose and shall be selected so that they withstand their installation at the required location without loss of performance. All cables shall be laid by Sub-Contractors who are especially certified for this service and who own all required equipment. Documents to proof the qualification shall be submitted with the offer. The Sub-Contractor may be appointed only after approval of the Engineer.

Together with telecommunications cables an additional conductor (steel strip 30 × 3.5 mm zinc plated) shall be laid in the same trench to be connected to the potential bonding system at both ends by disconnecting points.

The connections shall be visible and protected against corrosion.

## Electromagnetic Compatibility (EMC)

According to DIN VDE 0843, EN 61326, DIN VDE 0839, IEC 61000, IEC 77/231/CDV:2000,

IEC/CIS/H/189/CDV: 2009 all installations shall regard the EMC. All switching cabinets shall be closed metal casings. All metal parts shall be connected to each other with low resistance. Mechanical connections of varnished casing-parts shall also be electrical conductive, e.g. by using contact- or scratching disks. The cabinet-door shall be connected to the frame by earthing strips as short as possible. In order to reduce electromagnetic interferences and increase EMC, all components shall be protected against damaging influences and radiations by adequate means of earthing and shielding, filters and inductors, regarding possible mains pollution as well as radio interferences.

Signal- and power-lines shall be laid spatially separated. To avoid coupling, a safety distance of 20 cm in switchgear cabinets and 40 cm in switching stations shall be kept. Unscreened wires shall be twisted.

Contactors, relays, magnetic valves, operating hours counters and electrical operated breaks shall always be connected to quenching circuits at the source of interference.

Shielding of signal- and power-cables shall be connected low-resistive to the casing by a screening clamp.

Screens of analogue-signal lines shall be connected to casings on one end.

The earthing system shall be designed in a star-network, and connected to the earthing elec­trodes at the central point. Metal cable trays, pipes, ducts, etc. shall be electrically connected to form an equipotential structure. Both ends shall be connected to the earthing electrodes.

## Protection against Corrosion

If not otherwise specified in the Specifications, the means for protection against corrosion shall be based on the actual DWA M 263 "Recommendations for protections against corrosions of steel-parts on waste-water-treatment-plants".

All parts made of pipes and structural steel shall be sand-blasted with the standardized grade of cleanness SA 2.5 according to DIN 55928 part 4. Afterwards they go through the following steps for protection against corrosion:

Galvanized parts according to DIN 50976, minimum zinc coating 50 - 85 µm, including preparing the surface for painting. Primer paint with two-components-epoxy-resin-paint will be used. Top coating with polyurethane-paint is foreseen.

Colour as required by the Engineer. Edges of cuts from galvanized element shall be protected by adequate primer.

Not galvanized parts shall be painted with a two-components-zinc-dust-color of a high pigment-density before getting the primary and the top coating.

If possible the whole surface-protection process shall be carried out at the factory respectively at the original location of production. Faults due to transport or mounting shall be restored immediately at the site after consultation with the Engineer.

## Engineering for Instrumentation and Control

The Engineering shall be coordinated with the Engineer, the site supervision and all involved Contractors. This means especially a thorough clarification of the services of all suppliers and a detailed definition of the required control system.

The Contractor and the Engineer shall agree completely concerning the requirements and the extent of performances.

## Identification System

The Contractor shall design and propose to the Engineer a unique identification system to identify all parts of the plant, like buildings, process structures, machinery, motors, valves, switchboards, instruments, cables, signals and after approval of the Engineer the Contractor shall put labels and signs to all such structures and shall utilize the same system within the drawings.

## Documentation

For each plant the following information shall be submitted in detail:

List of documents; block diagram, list of components, mechanical installation diagram, drawings and description of installed machinery, function diagram, terminal diagram, cable-list, measuring reports, cable routes diagram, installation data, special characteristics, indication-, control- and automatic control devices, device's function, safety devices, instructions for operational devices, inspection- and mainte­nance table, required tools, functional scheme drawing of the whole plant, start-up-report with information about sequence and effect of external interlocking, inspection drawings, fittings- and devices list, spare parts list, list of electrical consumers, list of electrical instruments, list of identification numbers, protocol of earthing resistances, circuit diagrams, software descriptions, operating manuals, fault identification and troubleshooting instructions, etc..

Drawings, diagrams, programs and texts shall also be submitted as electronic-files for data processing systems as required by the Engineer.

The programs of PLC or other programmable units shall be submitted with a written documentation, if required by the Engineer in a machine-readable and process way.

## Start-up Checklist

After completion of the electrical works, the Contractor shall perform the start-up procedure together with the mechanical-, civil- and process-equipment and structures. Start-up shall be performed according to checklists, which shall be submitted beforehand by the Contractor to the Engineer.

Together with the start-up checklists also list with all adjustable values and their set values and the possible ranges shall be submitted.

Frequency converters with constant voltage intermediate circuitry shall be preferred. The noise level shall be limited according to the location of installation.

* In accordance with Local Location Study in adjacent of future WWTP plot there is, overhead line. Location Study foreseen

# Electrical Power Supply

Purpose : Feeding of electrical power from the public electricity network to the WWTP

Location : MV Power supply from the existing 10 kV overhead distribution line Zaostro. In accordance with the terms and recommendation of Division for Energy Distribution “Elektroprivrede Crne Gore” a.d. Nikšić power supply of the future WWTP Transformer Station is foreseen with underground MV cable

All works shall be supplied with electricity on a very high level of reliability.

For all works on the power supply system, which includes works on connection to MV public electricity network, Transformer Station and WWTP LV power system, the Contractor shall provide technical support to the Employer and documentation required for obtaining corresponding permits.

## Requirements for Power Supply System

### Transformer Station

Waste Water Treatment Plant Power supply system include as follows:

10kV switchgear, power transformers, 0,4 kV switchgear and distribution boards and cables. WWTP power system will be connected to 10 kV network. Therefore connection of plant ′s transformer station 10/0.4 kV with the distribution network will be performed by 10 kV cables.

Typical Single line diagram of the power supply system built on WWTP site and the situation of the object which accommodates MV equipment, transformer(s), LV switchgear are given elsewhere in this document. As shown, this object, Energy Block Object, will accommodate diesel generator unit, as well.

### 10 kV Switchgear

Generally configuration of the 10 kV switchgear will consist of 5 (five) free-standing, beside the wall mounted, metal clad cubicles, each of maximum dimensions 750x1020x1600 mm (WxDxH) – for metering cubicle, other cubicles 375x940x1600 mm (WxDxH). 10 kV switchgear will consist of the following cubicles:

- 2 feeder cubicles for 10 kV transmission lines;

- 1 metering cubicle;

- 2 transformer cubicle for 10/0.4 kV, 630 kVA transformer.

**Note:** Particular Process and Design Requirements are given in Volume 3-1 - Section 2.

10 kV switchgear and cubicle with metering equipment are located in the same room with (envisaged) LV

switchgears.

Equipment in the cubicles is in accordance with the single line diagram shown in Volume 5.

Connection of the switchgear with the cable line and with the power transformer 630 kVA (if different not stated in Particular Requirements is given in Volume 3-1 Section 2) shall be performed with cables which enter the cubicles from the bottom.

### Metering Group

One metering group on 10 kV side is foreseen for measuring consumed active and reactive energy.

Metering group is placed in a separate cubicle and comprises:

- active energy impulse meter with a maxi graph;

- reactive energy impulse meter;

- contact clock for two tariffs;

- terminals, wiring, etc.

- The metering cubicle will take place in the same room with the 10 kV switchgear.

- The Transformer Station shall be designed and installed for use in power distribution networks within the Plant area.

- The transformer shall comply with the requirements of BS171 for outdoor, naturally cooled types utilizing mineral or silicon oil (ONAN) as specified in the General Specification.

- The transformers shall operate satisfactorily when connected to a supply with the following parameters;

- Voltage variation ± 5% of nominal applied voltage.

- Frequency variation ± 2.5% of nominal system frequency

- Simultaneous variations of voltage and frequency shall not be in opposite directions.

### Power Transformer

* The continuous full load rating of the transformer shall be based on the rating of the connected load whilst operating at maximum continuous output plus a margin of 20% for load growth.
* The transformers shall be of the manufacturer's standard range and be capable of delivering the full rated output under the prevailing atmospheric conditions.

Tapings

* An externally operated, manual, off load tapping switch shall be provided. The switch shall provide tapings at ± 2.5% and ± 5% of the nominal voltage on the high voltage winding.
* The switch shall operate on all three phases and only come to rest when the switch is in full contact. The mechanism shall be of robust construction, designed against risk of damage from short circuits, and having all contact surfaces of ample area for satisfactory operation during overloads. The switch shall indicate the ratio that has been selected and it shall be possible to padlock the switch in any position selected.

Connection Arrangement

* Unless stated otherwise in the Particular Specification the transformer connection arrangement shall be Dyn5. The centre point of the LV star windings of the transformer shall be connected to an external earth.

Construction Arrangements

* The transformer tanks shall be constructed of sheet steel and shall incorporate facilities for lifting and rolling the transformer into position. When located in position the rollers shall be removed and the transformer allowed sitting on its base.
* The transformer shall, after removal of grease, weld slag and rust, be painted inside and out such that all surface areas are covered to a total dry film thickness of 100 microns.
* The transformer interior finish shall be anti corrosive and suitable for continuous contact with the transformer coolant. The outside shall be finish colored dark grey to BS4800, colour code 18 B.

Protection

The following protection arrangements shall be provided:-

#### Restricted earth fault protection - The star point of the secondary windings shall be earthed via an air insulated removable link to allow fitting a current transformer. The link and current transformer shall be housed in a suitable enclosure fitted with an access cover and removable gland plate. Restricted earth fault protection shall be provides for all transformers above 1MVA.

#### Pressure relief device - Sealed type transformers shall be fitted with a spring loaded, self resetting pressure relief device actuated by excess pressure within the transformer tank. Operation of the device shall cause a manually resettable switch to operate which shall in turn signal the supply to the transformer to be tripped and initiate an alarm.

#### Winding over temperature protection - Shall be provided by means of a scaled dial winding temperature indicating thermometer fitted with two adjustable contacts arranged to initiate a remote alarm and trip the associated HV circuit breaker respectively. Indication of alarm and trip shall be provided by a hand reset flag relay mounted on the associated HV circuit breaker panel.

Ancillary Requirements

The power transformer shall be complete with the following:-

#### Diagram and rating plate;

#### Earth terminal, minimum 12mm diameter fitted with brass nuts and washers;

#### Oil filler hole and plug;

#### Oil level sight glass;

#### Drain valve, fitted with blanking plate and suitably labelled;

#### Oil temperature indication and switch;

#### HV and LV terminal boxes, suitably sized for the cables to be used. Non magnetic gland plates shall be provided for single core cables. Bolted links shall be provided either within the terminal boxes or in separate enclosures to allow cables to be tested without disconnection.

Installation

* Transformers shall be installed in separate indoor enclosures, suitably ventilated for continuous full load operation of the transformer at maximum ambient. The enclosure shall be provided with an oil containment pit to trap spilled or leaked oil. The pit shall contain graded pebbles of minimum 50mm diameter having 30% voids. The containment volume of the pit shall be at least 110% of the transformer oil capacity below the level of the pebbles. Cable ducts and other entries into the pit shall be a minimum of 300mm above the pebble grade level.

### HV Switchgear

General

* This section covers the standard requirements for indoor HV switchgear operating at voltages up to and including 20kV. It includes distribution switchgear, motor starters and auxiliary systems. Particular switchboards shall consist of standard cubicles as described in this section, selected to provide the functions and ratings required for the particular application.

Standards

* The switchgear and starters detailed in the scope of this Specification shall be manufactured and tested in accordance with the IEC 62271-200, IEC 62271-1, IEC 62271-103, IEC 62271-105, current editions of the BS 5227 and BS 5856 and other relevant local, or British Standards (BS) and/or other International Electro Technical Commission (IEC) standards.

System

* Unless stated otherwise in the Particular Specification switchgear and starters provided under this section shall be suitable for connection to electrical systems with the following characteristics.

| Characteristic | System Operating Voltage | |
| --- | --- | --- |
| 6kV | 20kV |
| Design fault level (3 seconds) | 25kA | 25kA |
| Voltage withstand level | 28kV | 38kV |
| Impulse withstand voltage | 75kV | 125kV |
| Neutral earthing | Resistance | Resistance |

After designing process line and defining ultimate power demands, the Contractor will consider the existing power supply system design and, if necessary, coordinate necessary upgrading (if envisaged technical solution is not sufficient / appropriate for WWTP power supply).

Provision of the reliable LV power supply in the terms of necessary reliability is under Contractor responsibilities.

Contractor should respect the following requirements in regard to redundant power supply design:

1. 0.4 kV consumers within the plant are, as far as priority is concerned, divided in two groups:
   1. General consumers which normally should be fed by power transformer of the proper voltage & wattage and in case of its failure (or distribution network failure) mast not powered during failure, and
   2. Special consumers which, in case of distribution network failure are fed by proper power rated standby diesel generator. Contractor would justify which consumers will be powered by this emergency diesel generator, which must include lifting pumping station and sufficient oxygen to maintain the biological process.
2. Consumers are directly fed from 0.4 kV main distribution switchgear in transformer substation or from 0.4 kV distribution boards, located around the plant in the vicinity of consumer groups, each group forming one functional entity.
3. For WWTP power supply two transformer units should be envisaged (one being stand-by). Parallel operation of these transformers is not foreseen.
4. Status of WWTP power supply, including registration of the power energy consumption (i.e. production in the case of the power supply provision by diesel /future (if) biogas generator when it is installed) has to be transferred to the Plant SCADA Station and included into system visualization system.

# Standby Generator

Purpose : Emergency power supply to inlet pumping station and for maintaining biological treatment during interruption of public electricity supply

Location : Energy Block and Main LV Distribution

## Generator

The standby generator shall be a diesel engine generator set. The generator shall be sized based on power rate and site conditions to allow full operation of all special consumers in cause of transformers or network failure. Output generator voltage is 400 Volts AC, three phase, four-wire, 50 hertz. The generator shall be sized for maximum voltage drops on motor starts. Voltage regulation shall be +/- 1.0 percent for any constant load between no load and rated load.

Frequency regulation shall be ISO-synchronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25 %.

The engine-generator set shall be mounted on a heavy duty steel base to maintain alignment between components with bonded rubber anti-vibration units positioned between the engine and alternator support feet and the base plate or between the base plate and the floor. The base plate shall incorporate an integral bund tray sized to take the full lubricant and coolant volume of the generator plus 10 %. The bund tray shall have two float switches, one to shut down the generator and the other to close the solenoid valves on the fuel tank outlet should a high level in the bund be detected.

If a sub-base fuel tank is applied the bund tray shall be sized to hold the volume of fuel in the sub-base tank in addition to the lubricant and coolant. The base shall incorporate a battery tray with holding down clamps.

## Engine

The engine shall be a multi-cylinder water-cooled industrial 4-cycle diesel engine. Running speed shall not exceed 1,500 rpm. The rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all its accessories.

The engine shall have the ability to cold start, without any preheat, when ambient temperatures are 0°C.

* The engine shall be chiefly supplied with:
* Close control electronic governor;
* An engine driven, mechanical, positive displacement fuel pump;
* Fuel filter with replaceable spin-on canister element;
* Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator;
* Replaceable dry element air cleaner with restriction indicator;
* Fuel solenoid, energized to run;
* Skid-mounted radiator and cooling system rated for full load operation in 40 °C ambient as measured at the generator air inlet. The radiator shall be provided with a duct adapter flange. The equipment supplier shall fill the cooling system with a non-alcohol based antifreeze mixture, containing corrosion inhibitors;
* Rotating parts shall be guarded against accidental contact in accordance with CE requirements;
* Thermostatically controlled water jacket heater, which is automatically turned off when the engine is running;
* An electric starter capable of three complete cranking cycles without overheating;
* Positive displacement, mechanical, full pressure, lubrication oil pump;
* Flexible and fixed supply and return fuel lines to and from the fuel and day tank;
* Engine mounted battery charging alternator, 37 ampere minimum, and solid-state voltage regulator. The alternator/regulator shall be charge rate sensitive.
* The engine, in conjunction with the control gear shall provide automatic shutdown in the event of:
* High cooling water temperature;
* Low lubricating oil pressure;
* Generator overload/earth fault/phase failure;
* Engine failure;
* Engine failed to start (initiated after 3 attempts);
* Engine over speed;
* Frequency change (low to high);
* Fire valve operation.

It shall also be fitted with oil pressure and coolant temperature gauges.

In the event of a shutdown occurring as a result of any of the items listed in the preceding paragraph, a fault lamp relevant to the fault shall be illuminated. The lamp shall remain illuminated and restarting shall be inhibited until remedial works have been implemented and the control system reset. Text displays are also acceptable.

The engine shall be supplied with the correct quantity and grade of lubricating oils and antifreeze solution, with corrosion inhibitors, for protection at temperatures down to minus 50 °C. The thermostatically controlled water jacket heater shall operate on 220 volts, 1 Phase, 50 Hz. The Contractor shall include all costs for connection to the mains supply.

The engine starting system shall be 12 or 24 volts. Heavy-duty low maintenance batteries shall be supplied with the engine. The batteries shall be complete with fully shrouded terminals. The starting system provided shall be capable of permitting a minimum of 3 x 20 second cranking periods to the engine after the batteries and engine have stood for a 24 hour period at a temperature of 0 °C, with the engine heating system inoperative.

All drain points for lubricant and coolant shall be extended for easy access and positioned so that drainage may be carried out easily into a container with a minimum height of 200 mm.

## Alternator

The alternator shall be synchronous; four pole, revolving field, brushless, self exciting, self regulated. The voltage shall be 400 volt, 3 phase, 4 wire, 50 Hz, star connected. The alternator shall have a minimum protection index of IP 23. It shall be air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with a flexible drive disc. Radio interference suppression shall be provided. The system shall comply with the Electromagnetic Compatibility Directive 89/336/EEC.

The stator windings shall be two thirds pitches to reduce the production of harmonics and shall be adequately braced and supported to prevent distortion or movement by short circuit faults, motor starting, load acceptance etc.

All insulation system components shall meet the temperature limits for class H temperature rise. The alternator shall be chosen so that the temperature rise is no greater than class F limits under continuous maximum site loads.

A solid-state automatic voltage regulator shall maintain the terminal voltage. Alternator voltage output shall be within the limits specified.

The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

The terminal box shall be easily accessed. Adequate clearance shall be allowed for the installation and removal of phase and neutral conductors. The requirement to remove other equipment to gain access to the terminal box will not be accepted.

The Generator Set Main Circuit Breaker shall be supplied with a 3 pole main circuit breaker: set-mounted and wired, module case type with electronic trip unit for over current and earth fault protection.

## Control Panel

An enclosed control panel shall be mounted on the generator set with vibration isolators. The generator set mounted control panel shall include the following features and functions:

Three-position control switch labeled RUN / OFF / AUTO.

In the RUN position the generator set shall manually start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. This position is also used to clear a fault and allow restarting the generator set after it has shut down for any fault condition. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

### Generator Set AC Output Metering

The generator set shall be provided with a metering set with the following features and functions:

* Analogue AC Voltmeter, dual range, 90-degree scale, 1.5% accuracy.
* Three No. Analogue AC Ammeter, dual range, 90 degree scale, 1.5% accuracy;
* Analogue frequency/RPM meter, *45-65* Hz, 1350-1950 RPM, 90-degree scale, *+/-* 6% accuracy.
* Seven position phase selector switch, with OFF position, to allow meter display of voltage in each generator phase.
* Digital meters are acceptable in place of analogue.

### Generator Set Alarm and Status Display

* The generator set shall be provided with alarm and status indicating lamps to indicate existing alarm and shutdown conditions. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on the display panel:
* Low oil pressure (shutdown);
* High coolant temperature (shutdown);
* Low coolant level (shutdown);
* Emergency stop operated (shutdown);
* Over speed / over frequency (shutdown);
* Battery charge alternator failed (alarm);
* Under speed / under frequency (shutdown);
* Set failed to start (shutdown);
* Low fuel level (shutdown).

### Engine Status Monitoring:

* The following devices shall be provided on the generator set control panel:
* Engine oil pressure gauge;
* Engine coolant temperature gauge;
* Number of hours of operation (hours);
* Battery voltage (DC volts).

### Control Functions:

* The control system provided shall include a cycle cranking system, which shall be for 3 cranking periods of 20 seconds each, with 10 second rest period between cranking periods. Fail to start shall be indicated by operation of the appropriate alarm indication lamp.
* The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification.

### Alternator Control Functions:

* The generator set shall include an automatic voltage regulation system, which is matched and tested with the governing system provided.
* Voltage adjusting potentiometer, to adjust voltage +1- 5% from rated value;
* Control system including an earth fault-monitoring relay;
* Control Interfaces for Remote Monitoring;
* Common alarm contact set to indicate existence of any alarm or shutdown condition on the generator set.
* One set of changeover contacts to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90 % of rated condition.

## Battery Charger

A two-rate 230 Volt, 1 phase, 50 Hz battery charging system shall be provided with the generator. The following criteria shall apply:

* Constant potential trickle charge output to maintain the battery in a fully charged condition.
* A boost charge facility.
* The Charger shall be able to recharge a fully discharged battery in 24 hours.
* The Charger shall be charge rate sensitive and suitable for permanent connection to the battery.
* The charger may be wall mounted or incorporated into the generator control panel.

## Earthing

The star point of the alternator shall be connected, via an accessible bolted test link, to the chassis and all other exposed conductive parts of the standby generator. All exposed conductive parts of the standby generator shall be connected to the main earthing terminal using a main equipotent bond. The standby generator shall be additionally connected to a separate earth electrode system, if applied.

## Telemetry

The following volt free telemetry signals shall be made available:

DESCRIPTION SIGNAL  
 Generator Running  
 Generator Start Failure  
 Generator Engine Low oil pressure  
 Generator Engine Over speed

Generator Engine Common Fault Alarm  
 Generator Engine High temperature  
 Battery Charger Faulty  
 Battery Low Voltage  
 Generator Auto Selected  
 Generator Manual Selected  
 Fire Valve Operated

## Fuel Supply

A generator sub-base tank shall not be provided unless specifically requested.

If a sub-base tank is provided it shall be capable of taking the full pressure from the bulk tank and the overflow shall be higher than the bulk tank.

The tank shall either incorporate an integral bund or be double skinned and incorporate an integral bund.

The bund shall be covered but allow access for inspection. No drain shall be provided from the bund. The bund shall be sized for a minimum of 110% of the tank contents. The tank must be pressure tested before installation.

## Fire Protection

A dead-weight fire valve shall be installed in the fuel line where it enters the generator building/enclosure. The fire valve shall be operated by fusible links over the alternator and engine. All necessary pulleys and tensioning springs to interface with the fire valve shall be supplied and installed. In the event of a fusible link melting the fuel supply to the generator shall be isolated, the engine shall shut down and a signal shall be generated providing volt-free contacts to the telemetry system.

## Exhaust System

The selection, sizing and fixing on site of all sections comprising the exhaust system, including the silencers, shall be suitable for the installation and duty specified. A flexible connection shall be provided where the exhaust system interconnects with the engine.

Bend radii in an exhaust pipe should be a minimum of 1.5 times the inside diameter. The exhaust pipe should be routed in a path offering the least amount of turns or bends to keep back pressure to a minimum.

All pipes shall be well supported and springs or other dampers are to be used at points of high vibration. Due to heat radiation from the exhaust pipes, all pipes should be located a minimum of 250 mm from combustible material. At points where the piping passes through a wall or roof a metal thimble guard larger in diameter than the exhaust must be installed.

The outlet of the exhaust shall be cut off at a 30-45 degree angle and provided with an open mesh grill to prevent birds or vermin entering. An exhaust pressure actuated rain flap shall be used on vertical outlet pipes.

The level or height at which the outlet is situated should be sufficient to prevent fumes and odors from becoming an annoyance or potential hazard.

Long sections of piping shall include water legs and drain traps at their lowest points so that water does not reach either the silencer or engine. A slight slope downward from the silencer to the water leg or drain trap shall be added to ensure the proper removal of water.

Long piping runs shall be divided into sections separated by additional flexible connections. Any insulation material used for a flexible connection shall allow for the expansion and contraction of the connections due to temperature changes.

The exhaust system shall be designed to reduce noise levels to less than that specified in the tender documents.

Where the system is within the confines of the building 50 mm thickness mineral wool thermal insulation with aluminum cladding shall be applied to the pipe work and silencers

Where any part of the exhaust system can be touched during normal operational conditions adequate

lagging/insulation shall be supplied and installed to prevent bums.

## Diesel Unit Housing

### Diesel Generator Room

Emergency diesel generator and its engine will be placed in the power block building. The indicative position of the power block building is shown on the WWTP Layout Drawing – Volume 5. Design requirements are given in Volume 3-1, Section 2. The building elements shall be suitably reinforced to prevent mechanical damage and shall be of rigid construction, comprising thermally insulated, fire retardant walls.

All panels used in the construction shall be joined using stainless steel bolts and the joints sealed with a non-biodegradable mastic sealer.

Doors shall open outwards and be provided with panic bars and door stays. Door fittings shall be stainless steel.

Door locks will be free issued to the Contractor.

The generator room shall be sufficiently large to provide 1 meter of clear space around the generator and in front of any control panel door.

The generator room shall be adequately ventilated. All necessary louvers shall be supplied for the ventilation and airflow through the radiator. The louvers shall incorporate mesh to prevent the access of animals or birds. The louvers shall be weatherproof and if specified on the Technical Schedule include a system that will automatically open the louvers when the generator starts and close after generator shuts down, otherwise louvers shall be permanently open. Radiator air should not be depended on to move the louver vanes. Louver free area shall not be less than 65% of the total area of the opening and the overall size shall be matched to the airflow requirements of the engine when operating at full load condition.

Where required to meet the external noise levels specified, air inlet and discharge acoustic attenuators shall be provided suitable for mounting to the weather louvers. The attenuators shall be designed to meet the airflow requirements of the generating set at the ambient conditions specified.

A fire retardant flexible connection shall be installed between the engine radiator and the discharge attenuator/louver as required to prevent the recirculation of cooling air within the plant room.

The Contractor shall supply and install the following equipment in the generator room:

* Fluorescent lighting to provide illumination to a minimum level of 300 Lux.
* One wall mounted 3 kW fan assisted heater complete with a tamperproof electronic thermostat, temperature range 0~25 C. A tamperproof electronic timer with adjustable time ranges to provide heat for a pre-set period. The timer to be manually initiated. The timer shall incorporate “ON” and “OFF” push buttons together with a status indicator. A frost override is not required.
* 2 no. 13 Amp 2 gang switched socket outlets each protected with 30 mA RCCD.
* Emergency battery backed lighting shall be provided for safe egress only.
* Electrical services within the generator room shall be enclosed in heavy duty high impact plastic conduit or cable trunking. All fittings shall be metal clad pattern. The final position of all equipment to be approved before manufacture.
* The generator room shall be designed so that the generator can be removed with the room in position

## Testing and Commissioning

### Factory Acceptance Testing

Factory Acceptance Testing will be required, include the following minimum requirements:

a) Load testing for 20 minutes each at 25% fill design load, 50% full design load, 75% fill design load and 100% full design load. Test at 100% fill design load shall be conducted for a period of 1 hour. All tests shall be conducted using static load banks. During load testing an exhaust emission test shall also be undertaken. This shall consist of CO2 and exhaust temperature measurements to provide information on fuel burn efficiency and provide a benchmark for future maintenance. A frill summary shall be provided.

b) Functional testing of the Control Panel, to include simulated fault conditions of all shut down equipment. A fill summary of trial settings shall be provided.

c) Fuel consumption test over the range of loading shall also be undertaken and a full summary be issued.

Factory Acceptance Testing will be witnessed by the Engineer.

### Site Testing

Site testing shall include the following:

a) Functional testing of the control panel operating in conjunction with the Distribution Panel;

b) Automatic mains to generator and generator to mains changeover sequence by simulation of mains supply failure;

c) Measurement of the generator earthing system;

d) Testing of safety and fire protection equipment;

e) Testing of the battery charger;

f) Testing of the fuel tank switches/alarms;

g) Testing of the installed electrical installation;

h) Load testing the generator using installed equipment in conjunction with load banks shall be conducted at 30 % full design load, 75 % full design load, 100 % full design load. Each test shall run for a minimum period of 30 minutes. Load testing at 100 % full design load shall run for a minimum period of 1 hour;

i) The following test should be undertaken prior to hand over to the purchaser;

2 No 12 hour on site load test using the installed equipment;

14 days functional test where the generator shall be run in automatic mode. Power failure shall be simulated by switching off the power supply to the Distribution Panel. A record of all meter and gauge readings shall be taken at each activity. The tests will be undertaken by the Engineer's site representative. The Contractor shall provide record sheets for all tests.

j) Failure of any of the above tests shall require that the complete site testing program be repeated.

k) The Contractor shall provide all fuel and consumable items for the implementation of these tests.

### Test Results

The Contractor shall compile and list all test results for the approval of the Engineer. Approved test results shall be incorporated within the Operating and Maintenance Manuals for the works.

### Testing Liaison

The Contractor shall inform the Engineer when testing and commissioning is to be implemented. The Engineer shall witness, without exception, all commissioning and testing procedures.

The Contractor shall submit with his tender preliminary details of his commissioning and testing procedures.

The testing and commissioning requirements of this Clause are in addition to those specified in the general testing and commissioning requirements.

## Control

The automatic changeover shall be initiated using a 3 phase - phase failure relay in the following sequence:

|  |  |
| --- | --- |
| Any phase of the electricity board supply off for a set time (variable 0-15 min).  Plant on automatic control restarts automatically. | Supply changeover.  Generator start and run for a minimum of 30 min. |
| Electricity supply restored for a set time (variable 0-30 min). | Generator shut down, automatic supply changeover.  Plant on automatic control restarts automatically. |

A key operable test switch shall be included which will simulate the full control as detailed above.

### Automatic Power Factor Compensation

Purpose : For automatic power factor compensation, for each transformer

Location : LV-Room of the Transformer Station

Services and Deliveries:

The power factor shall be limited according to the requirements of the local electricity supply company but at least to cos ϕ not less than 0.95 by automatic three-phase reactive current compensation units.

The necessary compensation units shall be located one for each power transformer. Each compensation unit shall be divided into approx. 10 steps. Several capacitors each shall be provided. If harmonic distortions created by large frequency converters and soft starters can be envisaged, each capacitor shall be connected in series with a suitable reactive coil such forming individual resonant circuits. The resonance frequencies of these draining circuits shall be adjusted to the 5th, 7th, 11th, and 13th harmonic (250 Hz, 350 Hz, 550 Hz, 650 Hz) in order to achieve a sinusoidal mains voltage. The power factor compensation capacity of the plants shall be divided approximately as follows:

1. 50 % at the 5th harmonic
2. 25 % at the 7th harmonic
3. 25 % at the 11th and 13th harmonic

The power factor compensation plants shall be carefully designed and shall be adjusted with and approved by the electricity supply company, the manufacturer of the frequency converters and the Employer.

Each unit agrees with VDE 0560, DIN IEC 60143, IEC 60871, IEC 33, DIN IEC 60358, VDE 0660-500 and IEC 439 and provides the following characteristics:

1. Rated voltage: 400 V
2. Rated frequency: 50 Hz
3. Control voltage: 230 V, 50 Hz
4. Degree of protection: IP 20

It shall be mounted in cabinets according to the design criteria for low voltage distributions.

The service includes suitable power capacitors according to VDE 0560 part 4, IEC 70 and VDE 560 part 41, IEC 439 with the following characteristics:

1. Low losses, dielectric loss < 0.2 W/kVAr
2. Self-sealing capacitor elements
3. Constructed in a way, that guarantees automatic disconnecting of capacitor elements in case of over temperature or faults
4. Compressible granulated filling in a steel casing

Dry insulation, free of PCB (Poly-Chlorinated-Biphenyls)

1. Compact and stable design
2. Mounting possible in any position

The compensation units shall be tested according to VDE 660 part 500, IEC 439, i.e. for the temperatures according to the local requirements.

Each var-controller shall be mounted to the respective cabinet door including cos ϕ-indicator. Miniature circuit breakers, switches, discharge device, under voltage tripping and remote control input shall be included in the service.

All wiring, mounting materials and complete installation ready for operation shall be also included.

### Battery-System

Purpose : To provide power to motor driven circuit-breakers (if used)

Location : Battery-Room / LV-Room of Transformer Station

Services and Deliveries:

To supply operating power to the high and low voltage circuit-breakers also in case of a mains failure, a Battery-System for stationary plants may be required at each Transformer Station, if the design concept of the power system design requires. The life span shall be at least 10 years. It shall be suitable for permanent charging / parallel operation with the charging set and supply power to the consumers at the same time.

The poles and the cell-connections shall be electrolyte-tight. The inter cell-connectors shall be located below the block cover; they shall be short circuit-proof.

The vessel and the cover shall be welded to each other to be electrolyte-tight. After being mounted the batteries' surface shall be completely insulated.

The technical specifications of the battery shall be:

* Rated direct voltage: as per designed V
* Rated capacity: according to the requirements, for at least 3 hours at full load

Each Battery-System shall be mounted in an acid-proof steel cabinet; all installation and mounting material shall be included.

For permanent charging of the Battery-Systems, a rectifier assembly with a controlled constant volt­age/constant current curve shall be installed each. It shall also be suitable for power supply to the con­nected consumers, including a distribution equipped with miniature circuit-breakers with signalling contact for each motor driven circuit-breaker, 1 suitable circuit breaker for disconnecting the distribution and 6 miniature circuit-breakers with signaling contact, single pole, 16 A.

The technical specifications shall be:

* Power supply: 230 V, 50 Hz
* Constant current: According to the requirements
* Load change tolerance: 0 - 100%
* Radio suppression rating: "G" acc. to VDE 0875
* Smoothing: 5% effective without battery
* Degree of protection: IP 21
* Ambient temperature: According to the local requirements
* Control: With thyristors as actuating elements

On the front panel following instruments shall be installed:

* 1 voltmeter AC
* 1 voltmeter DC
* 1 ammeter DC for the load
* 1 ammeter DC for the charging current

Each battery rectifier assembly as well as the distributions shall be installed in cabinets fitting to the switchgear cabinets of the respective station. They shall be delivered to the site, installed and started up. The service includes all cabling and wiring inside the cabinets, to the battery, to the main distribution and to the consumers, furthermore all mounting materials and complete installation ready for operation. The provisions of DIN VDE shall be regarded.

### Labeling for LV-Rooms

Purpose : In order to operate the LV equipment appropriately

Location : In all LV-Rooms

Services and Deliveries:

1 Set labeling in English and Montenegro language, consisting of:

* 1 Sign with regulations and rules for the operation of power systems (VDE 0105)
* 1 Sign with the instructions for fire fighting in electrical plants (VDE 0132)
* 1 Sign with the instructions for first aid at accidents caused by electric current
* 1 Sign with the five safety rules
* 2 Signs with magnetic clamp and inscription "Do not switch"

The items shall be fixed neatly on the walls of the LV-Rooms. The service includes the complete installation ready for operation, all mounting and installation material, inclusive accessories.

# Electrical Installation

Devices installed in rooms & open space that are potentially endangered by explosive materials and therefore assigned to an "Ex-Zone" shall be approved for use in such locations. Devices for Ex-zone 1, like the channels for wastewater, shall be dimensioned according to DIN VDE standard 0170 part EEx d IIB T3 respectively part EEx i IIB T3, if not otherwise required. International and Montenegro applicable standards are: EN 50014, SRPS EN 60079.

Light-switches shall be installed at a height of 105 cm, socket-outlets at 35 cm above the finished floor, if not otherwise stated. In general at the entrances a socket-outlet with earthing contact shall always be installed right below the light-switch. All waterproof switches and outlets shall be sealed thoroughly against moisture.

All fixed devices shall be connected to the power supply via cable-connection-boxes or junction-boxes.

An adequate number of socket-outlets shall be installed in each room.

The minimum clearance headroom in passages shall at any case not be less than 2,300 mm. All dangerous points at passages, stairs, etc. shall be marked with a yellow/black hatching.

Outdoor lighting shall follow DIN 5044, indoor lighting shall follow the regulation for workplaces and DIN 5035.

To save energy, the outdoor lighting at buildings and streets can be switched from half-night (full) to whole-night (reduced) power by a photo-electric lighting controller and a time switch. The outdoor-lighting control shall be centralized.

# Low Voltage Main Distributions

Purpose : In order to receive electrical power from the transformers and to distribute this power to the LV Process Distributions

Location : WWTP Transformer Station

In the Transformer Station there shall be a LV Main Cubicle to receive electrical power from the transformers.

It is envisaged LV Main Distribution will be housed in the Transformer Station building, as shown on the Typical WWTP Layout Drawing, next to the diesel engine driven emergency generator.

LV Main Distribution is to be segmented into sections according to the number of connected transformers (minimum = 2). Each incoming feeder shall be equipped with a suitable motor or electromagnetic latch driven circuit-breaker as specified and with an Electronic Line Monitor. All sections shall be connected via motor or electromagnetic latch driven circuit-breakers. During normal operation all sections of a LV Main Distribution shall be switched together.

During faults or maintenance each section can be isolated.

The LV Process Distributions shall either be integrated into a radial shaped LV network or shall be supplied by double incoming feeders. In case of a failure of one incoming line, the remaining line shall be sufficient to supply all connected process distributions. The outgoing feeders at the LV Main Distributions shall be equipped with suitable circuit-breakers. Furthermore they shall be assigned to the bus bar sections in a way, that all consumers of each process distribution can be supplied from just one section of the corresponding LV Main Distribution. After defining the ultimate electrical power demand the Contractor will coordinate with City Representatives and its Power Supply System Contractor to provide Power Supply Systems (specifically Power Transformation Station) to satisfy the following requirement: if one unit from standardized transformer units range can cover the whole load, the whole system can be realized with two MV/LV transformer units, one serving as a backup power supply for working one.

The feeder lines (cables), bus bars and all affected circuit-breakers for all LV Process Distributions shall be sufficient for the final power requirements of the second implementation Phase as per Volume 3-1, Section 2.

The front of each LV Main Distribution shall be equipped with all control switches, indicators, meters, instruments, etc. required to control the unit.

Each LV Main Distribution shall be equipped according to the criteria and with components as specified hereinafter.

Each LV Main Distribution shall also be equipped with one automatic reactive current compensation unit for each Bus bars section and with raised floor, labeling, etc. The drives of important circuit-breakers (if motor driven), shall be supplied by the battery of the respectively MV station.

The offered price shall include the complete service, including technical supervising, clarification, delivery,

transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

The Contractor shall produce the final design of his equipment after his own technical clarification and obtain written approval of the design from the Engineer.

# Low Voltage Process Distributions and Electrical Process Installations

Purpose : In order to receive power from the respective LV Main Distribution and distribute this power via circuit breakers to all electrical consumers

Location : Each section of the plant's process

The Contractor shall deliver a complete and functioning Low Voltage (LV) System for the WWTP, including all Supervising and all accessories that are necessary to get a very reliable energy supply system which meets the present state of the art.

For each section of the plants' process, a separate LV Process Distribution Panel (if used as a motor drives, also) called MCC shall be realized (e.g. Mechanical Treatment, Biological Treatment, Sludge Treatment & Dewatering).

The LV Process Distributions receive power from the respective LV Main Distribution and distribute this power via distribution panels or motor control units (switchgear assemblies, soft starters, frequency converters, etc...) to all electrical consumers. The front of the LV Process Distribution Panel or MCC shall be equipped with all control switches, indicators, meters, instruments, operator panels, etc. required to control all consumers additionally to the central control. All electrical consumers shall be supplied with electrical power on a very reliable level. For each electrical consumer an appropriate switchgear assembly with current transformer, ammeter, measuring transmitter, operation hour meter, etc. shall be provided as specified hereinafter.

The operating levels (control levels) for each drive shall be realized according to the specifications.

If the number of certain process units is intended to be increased for the future extensions, the respective MCC shall provide sufficient power within the cabinets for the future extensions.

The service shall include a field control unit for each drive, raised floor or other adequate cable tracing system for each LV-Room, complete labeling, internal wiring, etc.

The offered prices shall include the complete service, including technical Supervising, clarification, delivery, transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

## Design Criteria for Low Voltage Distributions

Regulations: VDE 0660 part 500 air- and creeping paths, VDE 0110, DIN IEC 60664, SRPS EN 60664, IEC 109, VDE 0106, IEC 60990.

For electrical plants within hazardous locations, the regulations of VDE 0165, IEC 61241, IEC 60079, DIN EN 60079, shall be regarded.

LV panel rooms shall be kept dry under any operating conditions. They may not be located below the surrounding ground level.

The distributions shall be designed as partially type-tested low voltage switchgear assemblies. Test reports about the short-circuit strength and heating up shall be submitted to the Engineer.

All cabinets shall be supplied with internal light, socket outlet with earthing contact, anti-condensation heater and a metal-pocket for circuit diagrams fixed to the inner side of the door.

Cables shall be fitted from below; cable clamps and auxiliary fittings shall be included. Cables shall be connected to terminal strips or partially directly to the devices. Cables for light and outlet socket circuits shall be partially fitted from above to internal connected terminal strips. Terminal strips shall be marked with snap-on marking tags beginning with „1“. Parallel cables shall be connected to auxiliary bus bars. All insulation shall be of class C, tropically insulation.

Normalized cabinets made of galvanized sheet steel shall be installed, equipped with internal heating, lighting, socket outlets, miniature-circuit-breakers in suitable number and a metal-pocket for circuit diagrams. Lighting devices shall be protected against falling down. Cabinets with frequency converters or high heat production shall provide suitable ventilation devices.

The panels shall be divided into compartments by metal partition walls.

The degree of protection shall be IP 42 according SRPS IEC 529 (equivalent to IEC 529) and DIN40050 for installation in electrical operating rooms and at least IP 54 at installation within the plant or in humid rooms. Outdoors it shall be IP 65.

The cabinets shall be installed side-to-side against the walls and shall provide the following dimensions, to guarantee an arrangement for easy mounting and operation, regarding the local conditions:

* Height: 2,000 or 2,200 mm (without pedestal)
* Width: 600, 800 or 1,200 mm
* Depth: 600 or 800 mm

Cabinets shall be installed upon a pedestal. The pedestals' height shall be 100 mm at installation upon a raised floor and upon concrete base otherwise it shall be 200 mm.

Doors, covers and sides shall be made from galvanized sheet metal of at least 2mm, double primed with two different colors and with top-color according to the Engineer's instructions or approvals for prefabricated items. To avoid earthing problems, internal parts may not be varnished.

Panel-doors shall close in the direction of escape routes and shall be fitted with locks for double-bit-keys or an approved equivalent and central locking system.

Test reports on the short-circuit strength and temperature rise of the switching stations shall be submitted to the Engineer, the proof of the short-circuit strength by calculation shall meet DIN VDE0103, IEC 60865-1, SRPS IEC 865-1 and SRPS IEC 60865-2. Switchgear cabinets shall be protected against accidental touching, in accordance with DIN VDE 0106 and IEC 60990.

Bus bar systems (material copper) provide 3 phases + neutral + earth. All bus bar systems shall be of the tin-coated type. Type testing reports about the installed bus bar system shall be submitted to the site supervision.

All parts of the bus bar system and the feeders that are under voltage shall be covered and shall be safe against accidental touching. In each switchgear cabinet a potential equalization conductor shall be installed and connected as prescribed.

The electrical specifications shall be:

* Operational voltage: 400 / 230 V, 50 Hz
* Control voltage: 230 V, 50 Hz
* Scanning voltage 60 V, DC (as required by Contractor’s design)
* PLC & light indicators: 24 V, DC

The following material shall be included in the respective distributions' prices:

* Cable ducts
* Mounting material
* Connecting material
* Installation material
* Connecting terminals
* Automatic fuses with signalling contact for 24 VDC, 60 VDC (as required by Contractor’s design) and 230 VAC in adequate number for each panel

Furthermore following control voltage supply units shall be installed individually in each switchgear cabinet, complete with primary (motor-if applicable) circuit breakers in suitable number and size, and included in the price of the respective distributions:

* Transformers according to DIN VDE 0113 part 1 for generating the control voltage 400/230 VAC
* Transformer with rectifier for generating the operational voltage 400 VAC/ 24 VDC for light indicators, isolating amplifiers, etc.
* Transformer with rectifier for generating the scanning voltage 400 VAC/ 60 VDC (if applicable)

All positions shall be tendered as complete and functional units, including delivery, mounting, wiring connecting, etc.

Furthermore each distribution shall be equipped with a suitable number of momentary-contact twist switches and devices for lamp testing, failure indication and failure acknowledgement.

Indicator lights shall be LED-indicators for 24 VDC of high light intensity and long life-span. They shall be controlled independently from the PLC, to provide full manual operation from the panel even in case of a PLC failure.

All devices shall be labeled with lasting signs, white with black plate, fixed with screws. Each cubicle, cell or panel section shall carry a designation plate (title) on its outside surface, identifying the description of the section and the number. All inscriptions shall be in Montenegro and English language. Switch-position indicators for all switches, indicating instruments, switches, pushbuttons, indicating lights, operating hour meters, potentiometers, etc. shall be fixed in a height, where they can be operated and read by a standing person without any difficulties.

Instruments shall be delivered with moving-iron measuring element for alternating current and voltage and with moving-coil for direct current and voltage or digital. All instruments have a black frame according to DIN 43718 and a non-reflecting front glass. The degree of protection shall be IP 54, the accuracy class shall be at least 1.5. All instruments provide the dimensions 96 × 96 mm. Their normal position of use shall be applicable for the location where they are to be installed. They shall provide a replaceable quadrant scale according to their measuring purpose. The safety from touch with the back of the hand and with fingers shall be guaranteed.

All distributions equipped with double feeder cables shall be marked with signs "Caution! Reverse voltage" at the respective places.

A clear and suitable arrangement of the panels shall be realized according to the process. Before execution the plant shall be documented by drawing and submitted to the Engineer. A space reserve of 30% shall be regarded.

Each motor control system shall be supplied with protective devices against over current and short-circuit (fuses, bimetal relays with phase-failure protection, respectively motor circuit-breakers). Electronic switching devices (frequency-converters, soft starters, etc.) shall be protected by additional semiconductor fuses. In general, fuse less technology shall be applied, if necessary with current-limiters shall be used.

Each tripping of a protective device shall be indicated at the switchgear panel respectively at the central control systems by flashing signaling lights and acoustic centralized alarm. After an accept switch has been operated, the flashing light turns to steady light. The optical signaling devices shall have lamp-testing buttons.

Fuses in control-circuits shall be spatially separated miniature circuit breakers with signaling contacts.

Clock timers shall be supplied with automatic change from winter- to summer-time, reserve power, program memory and with manual and automatic control selector. The actual state shall be indicated on the timer.

All low-voltage switching devices shall always agree with DIN VDE 0660 and IEC 60439. Power contactors shall be designed for utilization category AC3, at a power reserve of at least 10%.

## Voltage Levels and Color-Codes

The Low Voltage (LV) system shall be designed as TN-S or TN-C-S system for 400/230 V three - phase alternating current. The energy shall be to be distributed from the LV-distributions preferably through a 5-wire-system to the Sub-Distributions and consumers.

Control-power-supplies shall be provided according to DIN VDE 0113, IEC 62061 and DIN VDE 0550 and shall primary and secondary be protected by circuit breakers with signaling contacts. Tripping of any circuit breaker shall cause a central indication. At a single point the control voltage shall be connected single-pole to the protective-conductor-system by an isolating terminal. The control-voltage shall be 230 V / 50 Hz in power circuits and 24 VDC at in- and output-units of the PLC and the supervisory control system. 60 VDC is optional and shall be used if control signals shall be transmitted over long distances to field units and in all cases where 24 VDC would not be suitable for reliable signaling or when that voltage is envisaged for motor driven / tripping devices of the circuit breaker. In power transformer station, direct current supply can be supplied from the central rectifying unit, while, for each major consumer there shall be an individual control voltage power-supply (e.g. for each pump of an important pumping station there shall be one individual set of power-supply-units, including 230 VAC, 24 VDC and 60 VDC (optional)).

The wires used in switchboards shall be marked by a suitable identification system and a color-code, for example:

* Phases L1, L2, L3: black, and/or brown marked with phase-colours
* Neutral conductor N: light blue
* Potential Equalisation PE: green / yellow
* DC main circuits : black
* AC control circuits: red
* Measuring-transformer lines: white
* DC control circuits – 24V: violet
* DC control circuits – 60V: orange, if applicable
* Signal lines 20 mA: grey (screened)

## Switchgear-Assemblies and Components

Switchgear assemblies shall be complete combinations of electrical components to supply and control electrical motors and electrical consumers (i.e. Motor Control Centers / MCC).

LV switching devices shall always fulfill VDE 0660. Power contactors shall be suitable for utilization category AC 3. All switchgear assemblies shall be at least type tested according to VDE 0660, part 500. DIN VDE 0110 and IEC 60664-1shall be observed concerning insulation and creeping paths.

Each tripping of protective units shall cause an optical and acoustic alarm given at the panel and at the Central Control Room. The alarm shall be accepted by operating an alarm switch that shall be mounted at the switchgear panel. Unaccepted alarms shall be indicated by flashing indicator lights and an alarm horn, accepted alarms shall be indicated by steady lights without alarm horn.

Circuits for lighting and socket outlets shall be equipped with automatic fuses. Socket outlets shall be connected to surge-proof, peak-current-sensitive and universal-current-sensitive current operated earth-leakage circuit breakers, providing a tripping current of 30 mA.

Circuits for heating units with an poor accessibility shall be equipped with current operated earth-leakage circuit-breakers with a tripping current of 300 mA.

All switchgear assemblies shall be installed into switchgear cabinets and shall also include the following devices:

* Connection to the bus bar
* Protective devices against over current and short circuit (fuses, bimetal relay with phase failure protection, motor circuit breaker)
* Protective relays for build in motor temperature thermistors (if applicable)
* Frequency converters and electronic soft starters (if applicable)
* Star-delta starting or soft starters for all drives of more than 15 kW (mech.)
* If a drive is started with a time delay, the activation of the delay period shall be indicated at the cabinet front door
* Contactors for main- and auxiliary circuits
* Clock timers (if required) with automatic change from winter- to summer-time, reserve power, program memory, selector for automatic and manual operation
* Time delay relay for all screw pump feeders, adjustable from 0 - 5 min; screw pumps shall be locked for the adjusted time before they are started
* Contactors for the heating of the switching mechanism box of valve drives
* Coupling relays for all voltage levels (24 VDC/60 VDC, 24 VDC/230 VAC, 60 VDC/24 VDC, 60 VDC/230 VAC, 230 VAC/24 VDC, 230 VAC/60 VDC) – 60VDC as required by Contractor’s design
* Automatic fuses with signalling contact for 24 VDC, 60 VDC (as required by Contractor’s design) and 230 VAC in adequate number
* Steady-contact twist switch as operation mode selector "manual" - "locked" - "automatic" - "central control"
* Momentary-contact switches "start", "stop", "open", "stop", "close" or as required by the drives purpose
* LED indicators "on", "fault", "open", "closed", "local control", etc. as required by the drives purpose, identification colours according to DINVDE 0113 and EN 60204-1.
* Mechanical operation hour meter
* Wiring, cable ducts, terminals, etc. and all required mounting material

Protection devices of the drives shall be in control during any operating mode. The control systems shall assure, that large drives are started in a sequence.

At the switchgear cabinets the unit control level shall be located. By means of operating and indicating devices mounted to the front door of the cabinets, it shall be possible to operate separately each drive in automatic and manual mode. The main purpose of the unit control level shall be an emergency operation in case of failures of the PLC or the communication bus-system. It shall work with circuitry without PLC on the 230 VAC-level, using conventional hardware.

If consumers are equipped with additional protection devices (e.g. leakage or excess temperature monitoring), the respective relays and units supplied by the manufacturer shall be integrated. Submerged drives shall be always equipped with leakage and excess temperature monitoring. Signals shall be connected potential free via coupling relays to the terminals.

Each drive shall be equipped with a field control unit. Each switchgear assembly includes all required devices for the connection of a field control unit and of an emergency-stop momentary-contact switch.

If the local control is selected at the field control unit, all other control levels shall be disabled.

Thermistor motor protection relays shall be included in the service and connected to the temperature sensor of the respectively motor. If the relay is energized, the motor control voltage shall be interrupted immediately. This state shall be indicated by a signal light on the relay. The relay shall provide a push-button for manual resetting of the device. It shall be equipped with a reversing type auxiliary contact. The design shall meet VDE 0113 and 0660.

Especially regarding the devices equipped with semiconductors and the function of data acquisition and processing, he regulations of DIN V ENV 61024-1, DVGW, DWA, DIN VDE 0845 and IEC 61643 as well as the local power supply company shall be followed thoroughly.

The internal lightning- and overvoltage protection shall be realized by a consequent lightning-protective potential bonding, according to separation into protection zones 0-2. This is important especially at devices of the measuring and data-system. The cable routes to these devices shall provide a minimum of loops causing voltage induction. All data- and measuring signals shall be supplied with overvoltage- respectively lightning-protective devices according to DIN VDE 0675 part 6, if they enter a higher lightning-protection zone, to include them in the lightning-protective potential bonding. The LV-auxiliary-power-supply of electronically units shall be protected against remote strikes, induced overvoltage and switching overvoltage by surge arresters. The recommendations of DWA concerning overvoltage-protection in waste-water-treatment plants and BS DD ENV 61024-1 shall be followed.

### Circuit-breakers

Each circuit-breaker shall provide the following characteristics:

* Triple pole
* Withdraw able
* Able for synchronise switching
* Solid-state over current release
* Magnetic short-circuit trip and thermal over current trip adjustable and equipped with tripping delay
* Motor type stored energy operating mechanism or electromagnetic latch
* Integrated control panel for and with ON and OFF pushbuttons
* Release and blocking devices for 60 VDC
* Adequate number of signalling contacts
* Rated short-circuit capacity according to the necessary requirements but at least 60 kA

### Automatic fuses (miniature circuit-breakers)

For AC circuits, in single and three-pole configuration, for mounting on supporting rails with spring catch fastening:

* Current rating 0.5 - 50 Ampere
* Nominal breaking capacity 10,000 Ampere or greater if necessary for short current power withstanding

Each miniature circuit-breaker shall be equipped with 1 reversing auxiliary contact.

In the case of overload tripping, the automatic fuse shall break automatically all poles, also if tripping occurs on one pole only or if the actuator is retained in the closed position.

Design features according to VDE 0113.

### Fault current guard switches (earth-leakage circuit breaker)

A fault current guard shall be provided for various circuits, protecting them from indirect contact. The fault current guard switches to be provided shall break the circuit within 0.2 seconds upon occurrence of dangerous contact voltages that may be due to insulation faults. Earth leakage currents achieving the nominal amperage of the fault current shall be provided to check the guard switches for their efficiency.

The fault current guard switches shall be provided for spring catch mounting on a supporting rail. The following construction sizes shall be taken into account:

1. Size 1 a) power rating 25 Ampere

b) nominal fault current 30 mA

1. Size 2 a) power rating 40 Ampere

b) nominal fault current 30 mA

1. Size 3 a) power rating 40 Ampere

b) nominal fault current 300 mA

1. Size 4 a) power rating 63 Ampere

b) nominal fault current 300 mA

1. Size 5 a) power rating 125 Ampere

b) nominal fault current 300 mA

Each fault current guard switch shall be equipped with 1 normally open and 1 normally closed auxiliary contact.

Design features according to VDE 0664 and DIN IEC 61009 (identical to SRPS EN 61009)

### Motor circuit breakers

The motor circuit breakers where used shall be inherently safe, i.e. they shall be able to be installable at any random location without any fuse provided before.

Making and breaking shall be performed by two push-buttons provided for this purpose, which simultaneously indicate the switch position.

The motor circuits breakers shall be provided with adjustable overload tripping and high-speed short-circuit tripping.

Auxiliary contacts shall be provided for control and signalling purposes, at least 1 normally open and 1 normally closed contact.

Design features according to VDE 0113 and 0660.

### Three-phase AC air-type power contactors

Three-phase AC air-type power contactors for switching of three-phase AC consumer stations shall be designed with a 25 percent spare performance.

The air-type contactors shall have a high service life without exchanging the actuator element and without any maintenance needed.

Depending on their use and installation, the air-type contactors shall be designed for at least 3 million actuations.

Each air-type contactor shall be provided with auxiliary contacts, 2 normally open and 2 normally closed.

Design features according to VDE 0660.

### Auxiliary contactors

The auxiliary contactors needed for control shall be of a quickly mountable type provided with spring catch fasteners on a supporting rail. The possibility of screw fastening shall also be provided.

The mechanical service life of the auxiliary contactors shall be designed for at least 30 million actuation cycles.

The actuation voltage of the auxiliary contactors shall be either 230 VAC, 60 VDC or 24 VDC, depending on the place of installation.

In general, auxiliary contactors shall be provided with 4 normally open and 4 normally closed contacts.

The load bearing capacity of the auxiliary contacts at 230 VAC shall be at least 10 Amps.

Design features according to VDE 0110, 0113, 0660.

### Motor protection by thermistor

These devices shall be connected to the temperature sensor integrated in each motor.

If the motor is heated by a clogged cooling system or by sun radiation, this relay shall be energized, immediately interrupting the control of the motor drive.

A signal lamp on the relay shall indicate this condition.

Acknowledgement or resetting of the relay shall be effected by a push-button installed on the relay.

The auxiliary contact shall be of the reversing type.

Design features according to VDE 0113, 0660

### Coupling relays

The power section of the system shall be controlled via miniature relays of the spring catch type to be snapped on the terminal bars.

These relays shall be of the same mechanical configuration as the terminals, to permit incoming leads being connected directly (terminal-type relays).

The contact shall be normally open a light-emitting diode (LED) indicating the status of the relay shall be integrated within the housing.

Design features according to VDE 0660.

### Electronic digital timers

The actuation times or delay shall be adjusted digitally, indicating the time set. The operational readiness shall be indicated by light-emitting diodes (LED’s). The timers shall be designed for 6,000 actuation cycles per hour minimum.

Depending on their function, timers shall be of a make or break time-delayed type. The timers shall be provided with at least one delayed and one non delayed contact of the reversing type.

Depending on the purpose of installation, the following adjustment ranges and actuation voltages shall be

considered.

Operation voltage 230 VAC or 24 VDC

Adjustment range 1 - 9,999 seconds

0.1 - 99.9 hours

Design features according to VDE 0660.

### Clock Timers

Clock timers shall be of the electronic type for an actuation voltage of 230 VAC. including a working range of 7 days minimum.

Each clock timer shall provide the following characteristics:

1. Two independent contact systems
2. Setting of the starting and stopping times by means of buttons and LCD-display
3. Daylight saving time automatic
4. Two switching contacts of the reversing type shall be allocated to each daytime dial.
5. Design features according to VDE 0660

### Current transformers

Current transformers with a secondary connection of 5 A shall be provided for current measurements of various consumer stations.

In general, current transformers shall be designed as plug-on transformers through which both bus bars and wires can be routed.

Fastening shall be effect either directly on the bus bar or by means of fastening legs on the mounting plate.

The individual transformers shall be selected in their transformation ratio so as to minimize the number of different construction sizes and transformation ratios.

The power rating shall be established in accordance with the instruments and devices to be connected, the minimum power rating being 10 VA.

The precision class shall be determined to be 1.

Summation current transformers shall be provided wherever various nominal currents shall be summarized.

The summation current transformers shall be of the leg mounting type.

Each of the inputs and the totalling output shall be for 5 Amps.

The precision of the summation current transformers shall be classified by 1.

The power rating shall be established in accordance with the consumer stations and the measuring circuit connected.

Design features according to VDE 0414, DIN IEC 61869, IEC 38/357, DIN EN 60044 and SRPS EN 60044.

### Transmitter

Measuring transmitters shall be provided for the transmission of electrical values to the PLC, having a signal output between 0/4 mA and 20 mA, depending on the electrical values transmitted. Alternatively, in the case of intelligent meters, the transmission can be provided through process control bus.

The following measurements shall be taken into account:

1. Amperages
2. Voltages
3. Frequencies
4. Effective power
5. Power factor

The transmitters shall be installed in housings to be incorporated in the cubicles of each distribution system. The input amperages shall be designed for 5 A.

The effective power transmitters shall be provided for a four-conductor measurement of random load.

### Transistorised switching relays for intrinsically safe circuits

Wherever signals and control commands shall be received from rooms subject to explosion hazard, including instruments and devices that do not provide an explosion-proof protection system, these signals and control commands shall be received by transistorized switching relays with intrinsically safe inputs.

These switching relays shall meet the relevant specifications and standards, the test and safety adequacy of which shall be proved.

Auxiliary voltages 230 VAC

The contact shall be of the reversing type.

### AC voltage control relay

The mains voltage shall be supervised by a microprocessor-based protection relay with a two-step independent three-phase over- and under voltage characteristic with completely separate time and voltage settings. The phase voltages shall be continuously compared with the pre-set thresholds. For the overvoltage supervision the highest voltage of each phase shall be decisive for energizing and for under voltage supervision the lowest.

The characteristics shall be:

1. Rated voltage: 400 VAC
2. Rated frequency: 50 Hz
3. Power consumption in voltage circuit: < 1 VA
4. Setting ranges for U</U<< and U>/U>>: 2...460 V, tolerance ± 1% or <0.3V
5. Setting ranges for delay time: 0.04...50 s, tolerance ± 1% or ± 15 ms
6. Dropout time: 30 ms
7. Auxiliary voltage: 230 VAC, respectively 60 VDC

Deviations of the auxiliary voltage in the range of 80 to 120% shall not have any influence on the voltage measuring.

The function of the device may not be affected if the auxiliary power is interrupted for less than 50 ms.

For the output the relay provides 4 trip relays and 1 alarm relay with change-over contacts.

### Frequency relay

The mains frequency shall be supervised by a microprocessor-based protection relay with a two-step independent over- and under frequency characteristic with separate time and frequency settings. Additionally the rate of change of frequency shall be supervised. The measuring principle shall be based on the time measuring of complete cycles which minimizes the influence of harmonics. To avoid tripping due to voltage or phase transients, the measuring system uses the average frequency value of an adjustable number of periods. The rate of change of frequency df/dt shall be also averaged over the period of time /f.

The characteristics shall be:

* Rated voltage: 400 VAC
* Rated frequency: 50 Hz
* Setting ranges for f</f<< and f>/f>>: 40...70 Hz, tolerance 0.005 Hz
* Setting ranges for delay time: 0.1...50 s, tolerance ± 1% or ± 15 ms
* Blocking of measuring in case of under voltage: Adjustable from 6 to 100% UN
* Dropout time: 30 ms
* Auxiliary voltage: 230 VAC, respectively 24 VDC

Deviations of the auxiliary voltage in the range of 80 to 120% shall not have any influence on the frequency measuring. The function of the device may not be affected if the auxiliary power is interrupted for less than 50 ms.

For the output the relay provides 4 trip relays and 1 alarm relay with change-over contacts.

### Electronic Limit Controller

In order to automatically control pumps or other electrical consumers according to the signal of a monitoring instrument or to trigger an alarm signal, for instance according to a water level, adjustable electronic limit controllers shall be installed, if required. These control units shall be installed in the front doors of the respective switchgear cabinets in instrument housing of 144 x 144 mm front panel size. At the front panels there shall be following easy and clearly readable LCD displays:

* Digital display, -1,000...+1,999, 10 mm high
* Analogue semi circular indicator with 40 LCD segments
* 4 indicators for the limit and control relays

Normally the actual measured value shall be indicated at the digital display in its correct physical unit. At the same time, the actual measured value and the values of the set limits shall be indicated qualitatively (0...100%) at the analogue display.

There shall be two independently selectable limit relays and two selectable control relays. If the measured value supersedes a set limit, the corresponding limit relay shall actuate its reversing contact and keep this position with an hysteresis of 1% until the measured value drops below the limit. The control relays work similar to the limit relays, but instead of a fixed hysteresis they have adjustable hysteresis in the form, that there are two separate selectable limits

for each control relay. While a limit relay or a control relay is actuated, the respective status indicator shall be on. For each limit or control relay it can be individually programmed if the relay is on or off during the activated condition.

To make smooth signal, there shall be a dampening circuitry built in, that allows selecting 4 grades of dampening.

In order to set a limit, the protective front door of the electronic limit controller can be opened. The display can then be switched over to indicate the various set limits and each limit can be easily and simply set by use of an ordinary screw driver.

* Input: 0/4...20 mA (measured value), 50 Ohms
* Power: 230 VAC +10...-15%, 48...62 Hz, 8 VA
* Outputs: 4 reversing contacts, 250 VAC, 500 VA

The service includes the complete technical clarification, delivery, installation, calibration, adjustment, etc. including all wiring auxiliary relays and auxiliary contactors etc. necessary to control 2 consumers and two limit values/alarms according to the requirements of the specific application.

### Wiring Blocks

The main- and control-circuits 230 VAC shall be connected to the switching stations on terminal strips. Signalling lines and measuring signals shall be put on terminal blocks to guarantee a clearly arranged connection to the PLC.

According to the amount of signals the terminals shall be designed as terminal strips or e.g. as wire-wrap-technology.

Overvoltage-protection devices, coupling relays and optical couplers shall be included in the terminal level.

### Frequency Converter

For pumps, blowers, etc. suitable switchgear assemblies including frequency converters shall be installed.

These switchgear assemblies shall be arranged in a way that provides following operating capabilities:

* Start of the drive with initial higher start-up (break loose) torque
* Manual operation of each drive including setting of variable speed
* Software for automatic operation via the separately specified PLC (e.g. in order to keep a constant level in the tank, fully automatic operation of the necessary number of drives, automatic changeover between the drives to keep equal running hours for all pumps, etc.)
* Soft stop of the drives to prevent pressure peaks in the pipes
* Automatic restart of the drives after power failure in the same mode as before power loss
* Sequential start in all modes
* Save emergency stop with complete isolation of the mains

Each of the switchgear combinations shall be additionally equipped with:

* Central emergency Stop-Button, switches and controls for manual operation and fault reset, LED status indicators (Manual - Auto - Fault - Excess temperature - Leak - Control Voltage Fault), main contactor, semiconductor fuses, complete set of spare fuses, mains filter, motor filter, individual voltage power supply for control voltage, isolation amplifiers 0/4...20 mA, thermostat, cooling fan, etc.
* Integrated relays and circuitry to protect the pumps against dry running and leakage, protection relays and circuitry for motor-excess temperature and overload/excess temperature of the frequency converter, including warning and alarm signals
* Frequency Converter, fully digital, low-loss, constant link voltage, sinusoidal pulse width modulation, for standard 3-Phase motors, modular and easy serviceable, with:
* Comprehensive self-diagnosis
* Non-volatile memory for settings, status and fault signals incl. timestamp
* LED-display and status indicators
* Automatic and manual programming at built in, removable control panel
* Interface to connect to a computer complete with all required access for serial communication
* Computer software for programming and diagnosis of the frequency converter
* Outputs 0/4...20 mA for mains current and motor speed
* Digital outputs for status signals
* Control inputs

The frequency converter shall be resistant respectively against: mains overvoltage; mains undervoltage; phase failure; short circuit; earth fault; idling; overload

Technical data of the frequency converter:

* For motor: According to the requirements
* Mains voltage: 0.4 kV, 50 Hz, 3 phase, +/- 10 %
* Cooling: Forced air cooling
* Overload capacity: 1.5 x Nominal Current for 60 Seconds
* Protection class: IP 20

Motor filters and line filters shall be provided as protective measures. Measuring devices and displays for current and rotational speed shall be installed for controlling frequency converters. To prevent overheating, motors driven by frequency converters shall be equipped with forced ventilation and 3 PTC thermistors, 2-steps, for high-temperature warning and release, and with the relevant protective relays.

The frequency converters shall be completely delivered, installed, carefully programmed according to the connected machines, tested etc. The contactors, fuses, circuit breakers required to complete the circuitry of the switchgear assembly shall be included in the service.

### Capacitors

Capacitors shall not contain PCB (Poly-Chlorinated Biphenyls). They shall be equipped with filters, respectively inductors to follow the actual electricity supply company-regulations concerning harmonic-wave contents, especially regarding the damping of ripple-control signals. The power factor according to the regulations of the electricity supply company shall be maintained.

### Electronic Motor Soft Starter

These units perform the soft starting, reduction of starting current, soft stopping, breaking, energy saving and motor protection functions. By use of thyristors the built-in microprocessor unit of a soft starter controls the voltage of the connected motor in a way that during the starting phase the voltage is continuously increased while the motor current and the motor torque is monitored and limited to a preset value. To make sure that motors start in a reliable manner, the units can be programmed to send an initial pulse of a higher voltage to the motors. For soft stopping, the soft starters reduce the voltage so that the torque of the motor reduces gradually without sudden steps. Included shall be among others the power supplies for the electronic units, mains filter, motor filter, high power fuses suitable for semiconductor-equipped sets, circuit breakers with signalling contact for the control voltages, a set of spare control fuses, etc..

Included in the soft starter shall be also a temperature limit switch to protect the unit in case of excess temperature, a number of control inputs and outputs to control the associated motor starter circuitry, five LED indicators to display the operating condition and a covered control panel with following elements: adjusters for ramp time (0..180 sec), start voltage (20..100%), current limit (0.5...6x nominal motor current) and stop time. DIP switches to program the operating modes.

If not specified differently, the soft starters shall be connected in series with a main Contactor to enable emergency shut off. In parallel to the soft starter there shall be another contactor to bypass the soft starter after starting is complete to reduce power losses. The latter shall also allow running the connected motor directly in case the soft starter is malfunctioning. The soft starters shall be completely delivered, installed, carefully programmed according to the connected machines, tested etc... The contactors, fuses, circuit breakers required to complete the circuitry of the motor starter shall be in­cluded in the service.

### Rechargeable Batteries

Throughout the whole works there shall be only rechargeable batteries of the same operation principle utilized. The offered price shall include the charging-units including regeneration and trickle charging. The voltage of the charging-units shall be controlled so that the permissible voltage may not exceed the maximum voltage for the connected equipment even when there is no battery connected. All batteries should comply with EN 50272 and adopted standards under SRPS EN 50272 series.

### Electronic Line Monitor

All Low Voltage Distribution Switchboards need to have Electronic Line Monitors. These devices shall constantly monitor the three phase voltages and currents at the feeding point. The ratios of the connected current and potential transformers shall be field adjustable at the monitor unit. The units shall be mounted in the doors of the switchgear cabinets. All programmed and recorded data shall be kept in non-volatile memory. No batteries required. Data and limit values can be easily selected and keyed in by the user at buttons at the front panel.

The measured values shall be processed by a built in microprocessor and at least the following data shall be indicated at a digital display at the front panel and shall be updated every 1.5 seconds:

* AC Amperes (three phases, 1% accuracy)
* AC Voltage (three phases-phase, three phases-neutral, 1% accuracy)
* Watts, VArs, Watt demand, Watt-Hours (2% accuracy)
* Power Factor (4% accuracy), Frequency (0.5% accuracy)
* Alarm Condition, Trip Condition, Unit Factor (Kilo, Mega)

At least following protection functions shall be implemented:

* Phase loss (depending on voltage or current)
* Phase unbalance
* Phase reversal
* Overvoltage
* Under voltage

Additional Features:

* Pulse generation for watt-hour measurement
* Suitable for 3-wire or 4-wire systems
* Self protected from fault, Self diagnosis
* Energy management

Outputs:

* Output contacts for Trip and Alarm conditions and Watt-Hour pulses
* Analogue outputs for Current, Voltage, Power, etc.
* If intelligent device is going to be used, it can be connected to the process communication bus and / or interface to the process slave (or master) PLC

The line monitors shall be completely delivered, installed and programmed, tested, etc., including a set of spare fuses and the circuit breaker with signalling contact for the supply of the control voltage.

### Electronic Motor Monitor

For electrical motors, upon Designer’s justification electronic protection relays may be installed together with the electric starter circuits of the motors to protect the motors against over current and excess temperature. The motor monitors shall continuously measure the motor currents of the three phases and the temperatures of the windings and determine on the basis of true RMS calculations and on the basis of the user-programmable motor characteristics and limit values if there is normal operation, or if there is a trip or an alarm condition. The programmable motor characteristics shall include: Full Load Amps, Locked Rotor Current, Locked Rotor Time, Ultimate Trip current. All programmed and recorded data shall be kept in non-volatile memory. Batteries would not be required. Protection relays should be for door mounting. Data and limit values can be easily selected and keyed in by the user by buttons at the front panel.

At least all following protection conditions shall be monitored:

* Locked rotor current, Ultimate trip current, Instantaneous over current trip
* Maximum allowable stall time, I2T alarm level
* Ground fault trip, Motor excess temperature trip and alarm
* Jam trip and alarm, Under load trip and alarm, Phase loss and phase unbalance trip and alarm

On the front plates of each motor monitor shall be a digital display to indicate at least:

* Motor currents - 3 phases and ground
* Temperature reading of up to 11 sensors (°C or °F selectable)
* Operation count
* Run time
* Remaining starts
* Highest phase current
* Highest winding temperature
* Number of trips (sorted by reason)
* Conditions stored prior to a trip
* Timer
* Status LED’s

Following inputs shall be available:

* Supply voltage
* Remote trip signal (programmable)
* 11 temperature sensors
* 3 curent transformer connections (programmable ratios 10:5...4000:5)
* Ground fault transformer connection

Following programmable outputs shall be provided:

* Alarm contacts
* Trip contacts
* Auxiliary Trip contacts
* Transition contacts
* 0/4...20 mA output for relative motor current or temperature

The motor monitors shall be completely delivered, installed and programmed, tested, etc., including a set of spare fuses and the circuit breaker with signaling contact for the supply of the control voltage to the motor starter circuit.

## Field Control Units

Purpose : To operate valves, pumps, aerators and other consumers at the location of installation during maintenance or control system failures

Location : At the location of the respective drive

Services and Deliveries:

For each valve, pump, aerator, etc. a field control switch box shall be mounted at a location where the function of the equipment can be observed. For this encapsulated switchgear assemblies according to VDE 0660 with the degree of protection IP 65 are required. They shall be suitable for use in waste water treatment plants and outdoor mounting.

The casings for surface mounting shall be installed vertically, with cables fitted from below to a screwed watertight gland according to the cables. Labels, white with black inscription, shall be fixed with screws.

The switchgear assembly consists of:

* Suitable number of pushbuttons with flat button and a cover plate resistant to abrasion, with inscription (e.g. "Open", "Close", "Stop", "On", "Off", "Slow", "Fast", etc.)
* 1 key lock switch according to plant's locking system, for electrical blocking of the pushbuttons, with abrasion-proof label "Local control - Off - Central control", key removable in all switch positions
* 1 mushroom-head emergency pushbutton (red), latching, including key lock according to plant's locking system and surrounding circular yellow label with black inscription "Emergency Stop".

The emergency-stop-button shall be equipped with three NC contacts. One emergency pushbutton may be sufficient for a group of drives that shall be stopped together in case of an emergency.

Due to heat, dust and rain all field-mounted key locks shall be subject to heavy abrasions and may be blocked by dirt if no special precautions are taken. Therefore the Contractor shall propose various adequate locking systems like safety-lock, square-key, triangular-key, etc... to the Engineer for consideration.

The whole switchgear assembly shall be surface-mounted into a weather-proof casing made of high-grade steel (W 1.4301/ANSI 304) installed on a suitable pole with protective sun and weather roof, made of high-grade steel (W 1.4301/ANSI 304), each key lock provides a protective cap to protect the cylinder from being affected by dirt. The installation ready for operation and all mounting and installation material shall be included. Field control units shall be readily accessible.

## Miscellaneous Services

The price for miscellaneous services shall at least include the training of the operational staff and the complete sets of spare parts and tools. If any other costs arise for the correct and complete execution of the WWTP that are not covered by one of the items of schedules of prices, they shall be calculated within this position and shall be described in the offer.

### Spare Parts for LV Stations, Automation, Instrumentation and Control Systems

Purpose : For replacement of wear-and-tear parts

Services and Deliveries

The Contractor shall supply all spare parts, recommended by the manufacturer of the various equipment, for the period of two years. The Contractor shall submit a list of the offered spare parts together with the offer.

The provision of spare parts shall include but shall be not limited to the following items for the WWTP:

* 30% of the respective number of built-in LV fuses of each size that is required for the plants (at least 6 pieces per size),
* 10% of the respective number of built-in indicator lights of each colour that is required for the plants (at least 20 pieces per colour),
* 10% of the respective number of built-in coupling relays, auxiliary relays and isolating amplifiers of each type that is required for the plants (at least 5 pieces per type),
* 20% of the respective number of built-in overvoltage protection units of each type and size that is required for the plants (at least 6 pieces per type),
* 10% of the respective number of built-in miniature circuit breakers of each type that is required for the plants (at least 5 pieces per type),
* 1 complete set of spare parts for each diesel generating set, including all belts, sealing, hoses, flexible connections, bearings, fuel and lubricant filters, rotary diodes for alternator, etc.,
* For all offered works: 1 piece of each installed PLC module, such as CPU, I/O-modules of each installed type, communication-modules, interface modules, power supply modules, etc.,
* 20% of the respective number of built-in lamps of each size and type that is required for the plants (at least 5 pieces per size),
* 100% of the respective number of built-in non-rechargeable batteries of each type and size that is required for the plants,
* Filter material sufficient for the replacement of all installed filters within switchgear cabinets, air-conditioning units, etc.

All spare parts shall be new parts from the original producers, delivered in undamaged original packing. The package shall guarantee that the parts are not damaged by mechanical, electromagnetic, temperature stress, self-discharging, etc. during storage. They shall be sorted in one set of labeled stable plastic boxes for each WWTP that can be used for storage of the spare parts.

# Automatic Control System

Purpose : To perform the automatic operation of WWTP

Location : WWTP

The control system hierarchy shall conform to a layered client server based model. Three layered configuration is planned:

*On the WWTP area:*

1. Real-time control environment - the CONTROL network segment in which the process controllers operate. This network includes:

* programmable controllers, called for the purpose of this specification RPU (Remote Programmable Units) or Slave Controllers (Slave PLCs) which have to communicate using the same IP based protocol and shall communicate without need for any form of protocol converter (i.e. the protocol shall be supported as a native protocol by the programmable controller). Those RPUs (with Master PLCs specified under 2) represent the basic for the realization of the distributed control system, and
* Intelligent Process Instrumentation - all interconnections between a RPU and analogue devices, including but not limited to instrumentation, may use Ethernet SRTP, Mod bus Ethernet, RS-485 Profybus and/or RS485 Mod bus.

1. Local SCADA network segment – realized as Ethernet IP Network. This network includes:

* programmable controllers, called for the purpose of this specification Master PLCs, which can serve as RPU and accommodate portion of process control on the areas they are mounted, but also serve as the bridge between the real-time control environment (the CONTROL network segment in which the controllers operate), and the Local SCADA network segment. Those PLCs will be used as (and with) operator interfaces. All operator stations (OS) within the SCADA system shall have the technical ability to access all information from all of the controllers through the PLCs. Access control shall be restricted based on user network login and physical location. If a user does something that slows down or locks up an OS, this shall in no way limit or restrict the functionality or performance of any other OS. The Contractor will decide on optimal number / locations / configurations of Master PLC, having in mind the physical units of the technological process, physical locations, functions and system complicity. One possible sets of those master PLCs can be: Inlet Section (Pump Station), Primary Sludge Thickeners with digesters and belt presses, Sludge Recirculation Pumping Stations / Secondary Thickeners and Energy Block (Blowers, Power Supply and Diesel Emergency Generator). Please consider this list as indicative, the final design / choice is under Contractor consideration.
* Process-control computer system (SCADA Workstation), which realized the Plant Central Control / Supervision, Plant Visualization and Process Data Handling.

*The new Central Control System is planned to be incorporated into the network of the entire Waterworks and Sewage Public Utility Company in the future:*

1. Remote SCADA network segment – TCP/IP Network, realized as City Waterworks Wide Area Network (WAN). This WAN is separated into different Virtual Local Area Networks (VLANs) for traffic control, one for administrative purposes and one for SCADA purposes. A separate real-time control segment shall be provided which is physically (i.e. at the hardware level) separated from the City (W&WW PUC) Administrative WAN. The routers will be configured to maintain complete separation between these segments such that the Input / Output Server (IOS), used in City (PUC) WAN is the only data gateways between the two segments.

For the purpose of the realization of the Distributed Control System based on the described Three Layer

Configuration the adequate Interface (Telecontrol, Telemetry) units (modules) shall be used in the future. Those units shall be self-testing and shall continuously test the telecontrol connection. If the connection or the device fails, a failure signal shall be given by a potential-free contact immediately.

If Contractor realizes in his design the usage of line modems, as an the Interface Unit to the future City WAN or for local LAN, an approval certificate by the Telephone Company shall be submitted for all telecontrol installations that are directly or indirectly connected to the public telephone-network.

Transmission paths of a high availability and a fast and undisturbed transmission shall be used. The reachable transmission-rate at a smooth faultless transmission shall be investigated during the test run with different transmission-rates. This shall be certified in a report that shall be submitted to the Engineer.

The Control System Hierarchy is shown on the Diagram 1. It is given only for the purpose of the basic System Control Concepts explanation and defining of the Scope of Delivery. Specific network topology, network realization and control system devices / components selection is under Contractor responsibility. The Designing Solution has to have sufficient capacity or to be easily expandable in two ways:

* 1. to accommodate the control systems on the same concepts for the following phases of WWTP construction, primarily for the second possible phase (sludge line treatment)
  2. to establish communication with the higher Control Systems (primarily the City (PUC) Central Control System as required in Volume 3-1, Section 2, and Section 4 (if applicable) – Plant Description (Particular Technical requirements), the Contractor shall submit a fully developed plant control philosophy for the WWTP together with his offer. It shall be based on the requirements of Volume 3-1, Section 2 and Section 4 of these Tender Documents and shall comprise the detailed description of the individual control circuits for the different process units and electro-/mechanical equipment, including specification of the foreseen SCADA and measuring instruments.

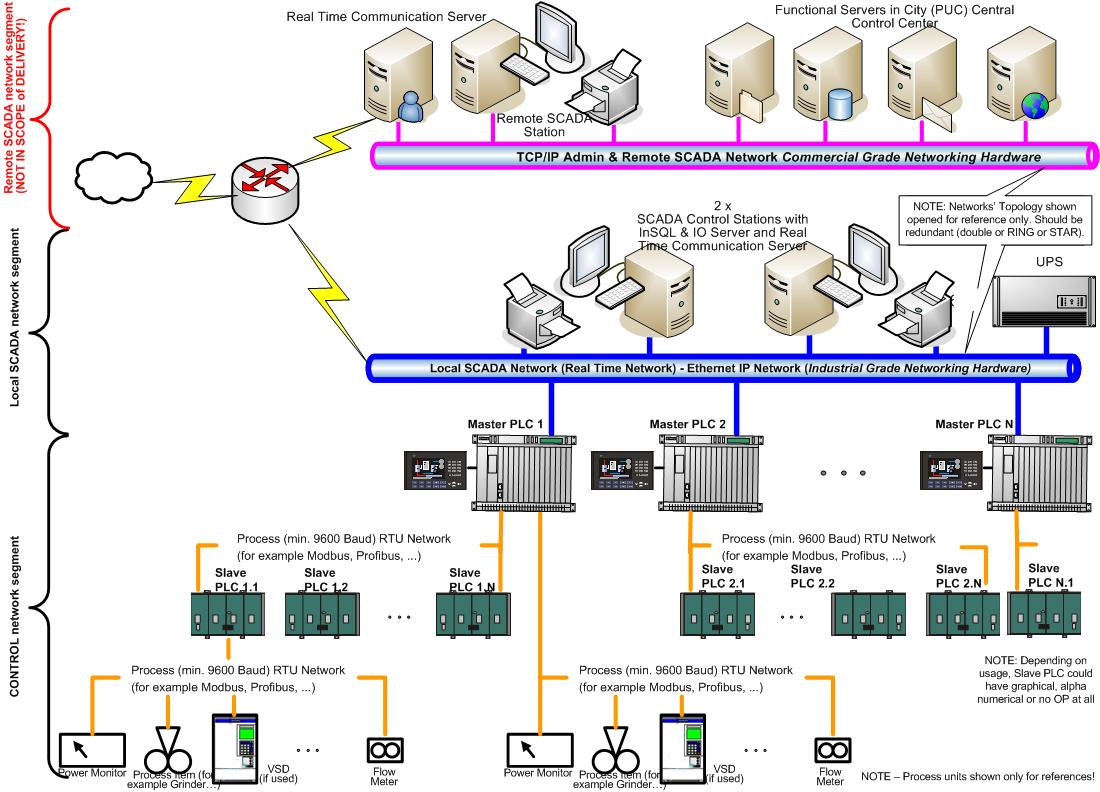
The SCADA system shall be designed with consideration of the following:

1. Standard design principle shall be prepared for use in present design and future extension of the system;
2. Naming convention, symbols and color scheme (status and groups) for graphic screens shall be consistent across the system;
3. Controls should be arranged and grouped in an intuitive and logical manner;
4. Decentralized control system (DCS) shall be adopted;
5. Long term data storage and retrieval shall be provided;
6. Flexible communications topology linking master terminal unit, programmable logic controllers, remote terminal units and intelligent electronic devices shall be provided;
7. All levels (master or slave) shall be provided with sufficient redundancy for future expansion of the system;
8. SCADA protocols (Mod bus, Profibus, Ethernet/IP) shall be open and non-proprietary
9. Standby facility shall be provided;
10. SCADA equipment should be protected from the effects of dust, dirt, water and other contamination by appropriate location within the facility or within appropriate enclosures;
11. Transient voltage suppression shall be provided to protect the SCADA system.

All software errors which might occur during the computers (programmable controllers) operation, must be removed by restarting the computer (programmable controller). Computers (programmable controllers) must have backup save of the necessary parameters of the process, thus enabling regular operation upon restarting.

Software should contain damage procedures to be executed in case of failure of individual parts of equipment, which could result in highly unfavorable consequences to the plant. Besides, there must be a possibility to change the software and add new damage procedures during the plant exploitation.

Diagram 1: Control System Hierarchy



The automatic control of the Waste Water Treatment Plant shall be realized with Programmable Logic Controllers (PLC). The WWTP control function is to be realized through distributed control system architecture. Each LV main- and process distribution shall be equipped with a separate PLC unit; further PLC shall be supplied for MV (HV) stations and other important parts of the plant, which may require a separate control unit. The control and data acquisition at the control centre should be realized with proper SCADA station.

The Contractor shall deliver a complete and functioning Automation System for the Waste Water Treatment Plant, including all Supervising and all accessories that are necessary to get a very reliable system which meets the present state of the art.

All PLC units shall be of the same design and type, whereby the design and type shall be chosen according to the highest requirements of any task within the complete works.

Each PLC unit shall fulfil but shall not be limited to the requirements of Volume 3-1, Section 2 and Section 4, and may be equipped with marshalling cabinets and shall be supplied by an UPS. The service also shall include the required PLC software, a programming unit, etc. The Contractor shall carry out the realization of the automation systems according to the following work program, regarding the whole electrical systems:

* Creation of description of functions, lists of consumers and measurements, circuit diagrams, workshop- and installation drawings for the whole electrical equipment
* Creation of the plant identification system
* Design of control computers
* Creation of the logical diagrams and control algorithms
* Creation of program descriptions for PLC units and the bus system
* Creation, installation and implementation of the software, start-up
* Submittal of draft of the final documentation
* Training of operational staff
* Test-run for 6 months
* Multiple optimisation of the system according to the experience, gained by the operating personnel
* Creation and submittal of the final documentation, firmware and software

Each step includes the respective technical clarification, production of the required documents, and multiple revision of documentation until approval by the Engineer.

The offered prices shall include the complete service, including technical engineering, clarification, delivery, transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

Following control levels shall be realized:

* Local control = control at the location of the drive
* Group/unit control = control at the switchgear cabinet, respectively MCC
* Central control = control at the supervisory control system

The local control respectively the field control unit has the highest priority. It shall also be designed as an emergency control, i.e. it shall be operational even if the automatic control is out of function. With the local control a drive can be operated under direct visual observation while being maintained and in case of a control-failure. The local control can only be used, after a key-switch is turned on, which at the same time blocks the control of other levels. The degree of protection of local control devices shall be IP 65. For outdoor installation it shall be protected by a protective case made of high-grade steel (W 1.4301/ANSI 304).

The switchgear assembly belonging to the local control shall work with a control voltage of 230 VAC. It shall contain all interlocking devices that are necessary for the drive's protection (e.g. over current-relay, limit switches, dry running and overpressure protection, etc.) and the devices for the safe stop (e.g. emergency-stop). Usually a drive can be switched on respectively off permanently by the local control. If permanent operation is not allowed due to the drive's function in the process, the local control may allow just inching-mode for testing operation.

The unit control level shall be realized at the respective switchgear cabinet in the electrical switchgear room on the 230 VAC level for each drive. For the I/O to the PLC units and for the signal lights 24 VDC shall be utilized.

From unit control level at the switchboard each drive can be controlled manually or can be submitted to the automatic control. If the unit control level is selected, the central control is disabled. The unit control (incl. signal lights) shall remain completely functioning even when the PLC units are out of order.

At Group/Unit control level, for each drive four operating modes can be selected at the switchgear cabinet respectively at the MCC:

The "manual"-mode allows the manual control of a drive by means of operating devices at switchgear cabinet in the respective LV panel room. In this mode the PLC and the Central Control are disabled.

* To turn a drive off for a longer time (e.g. for maintenance or repair) the "locked"-mode shall be used. In this case, the drive shall be disconnected and alarm signals of this particular drive shall be suppressed. While working on the drive, additional safety measures shall be taken (safety switch, remove fuse, etc.).
* In the "auto"-mode, the drive shall be controlled by the local PLC-unit. The operation from the central control room shall be locked.

## PLC System

In order to control the Waste Water Treatment Plant and to gather the data in order to make them available for the central control system, all PLC units shall be interconnected via a bus-system. In addition all signals shall be interchanged through the bus and be indicated at the respective section at the process control computer.

At each PLC a space reserve of 30 % shall be maintained in the mounting racks for future extension of I/O-modules.

Automation devices shall be installed within separate switchgear cabinets in the respective LV-Room. Switchgear cabinets shall be designed according to the specifications concerning the low voltage distributions (observe also Volume 3-1 Section 2) they shall conform to other switchgear cabinets at the location of installation.

The electrical specifications shall be:

* Operational voltage: 400 / 230 V, 50 Hz
* Control voltage: 230 V, 50 Hz
* Scanning voltage (optional): 60 V, DC
* PLC and light indicators: 24 V, DC

Following materials shall be included:

* Cable ducts
* Mounting material
* Connecting material
* Fitting material
* Connecting terminals
* Automatic fuses with signalling contact for 24 VDC, 60 VDC (if applicable) and 230 VAC in adequate number for each panel
* Operator panel with LCD-display in order to show the operational status of the PLC, the controlled plant and to input control variables

All positions shall be tendered as complete and functional units, including delivery, mounting, wiring and connecting.

A clear and suitable arrangement of the panels shall be realized according to the process. Before execution the plant shall be documented by drawing and submitted to the Supervisor. A space reserve of 30 % shall be regarded.

The PLC shall be delivered uniform with front connections respectively front plug connectors, including connection wiring, interface element and build-in hardware-clock.

There shall be self-diagnostic routines within the CPU to check all systems constantly. The program memory and all status registers shall be buffered with a long lasting battery (minimum 3 years).

The service includes the technical project planning, generation and submission of all documen­tations and their careful storage within the switchgear cabinet.

The PLC shall be delivered and mounted completely functional with mounting racks, power supply units, over voltage protection devices, circuit breakers, monitoring devices, interfaces, bus connections, connecting cables with plugs, coupling relays, isolating amplifiers, terminals, fitting material, etc. including the wiring of the switchgear cabinets.

The programs shall be to be stored on an EPROM memory.

The in- and outputs of the PLC provide the following specifications:

* Digital inputs (DI) isolated, 24 VDC
* Digital outputs (DO) potential-free via coupling relays, 24 VDC, 2 A
* Analogue inputs (AI) isolated, 0/4…20 mA, converter resolution 11 bit
* Analogue outputs (AO) isolated, 0/4…20 mA, converter resolution 11 bit
* System interfaces, transmission speed min. 187.5 kbit/s

Each PLC unit shall be supplied by an uninterruptible power supply unit. A switch "UPS / Main" to select the power source shall be installed at the front of each PLC unit cabinet.

### Signals to be processed by the PLC

For important signals and signals for safety purposes the bus system may not be used. These signals, optionally, may be transmitted directly by means of control cable with a transmission voltage of 60 VDC - if necessary for the reason of long distances transmissions / high electromagnetic disturbing environment. Contractor is required to analyse and justify (eventual) necessity for 60VDC control system.

At least the following signals shall be processed and transmitted to the Central Control Room either via communication bus system:

1. For motors, drives and valves:
2. commands (on, off, faster, slower, high speed, low speed, open, closed, right, left, etc.)
3. status signals (fault, on, off, faster, slower, high speed, low speed, open, closed, right, left, active starting delay, etc.)
4. analogue values (motor current, rotation speed, measurements, etc.)
5. further signals as required
6. For measuring devices:
7. status signals (fault, maintenance, limit alarms, etc.)
8. analogue measuring values
9. Electric switchgear:
10. commands (open, close, etc.)
11. status signals (open, close, fault, tripped, etc.)
12. analogue values (curent, etc.)
13. further signals as required
14. Other signals from or to the plant:
15. electricity supply (voltages, frequencies, all signals from the generating sets, etc.)
16. from the process (calculated values, etc.)
17. all signals provided from machinery units with separate control devices
18. All further signals that can be gathered from any device installed at the plant

### Marshalling and Instrumentation Cabinets

Each PLC unit may be equipped with a marshalling and instrumentation cabinet of identical design as the PLC cabinet and of sufficient size, installed as a switchgear cabinet according to the specifications for LV equipment.

The marshalling and instrumentation cabinets shall provide a sufficient number of terminal blocks for the marshalling of all incoming signal cables to the I/O units of the PLC.

All signals and analogue values shall be connected potential-free by means of suitable coupling relays and isolating amplifiers.

According to the design of the instrumentation and overvoltage protection the required devices shall also be installed within the marshalling and instrumentation cabinets. The design shall be carefully adjusted and coordinated to all requirements and components.

## PLC Software

The PLC software consists of the programs for the automatic control of the plants' devices and for the connection to the process control system, including in- and output via communication modules with the necessary communication software. It shall be possible to process all in- and outputs and transfer them respectively to and from the process control system. The service includes the generation and implementation of the software according to the required amount of data. For further software extension a memory reserve of at least 30% shall be provided.

The programs shall be designed in a way that the normal operation will carry on automatically right after a power supply failure. If necessary, a warning shall be given, before a drive is restarted automatically. Drives, which are blocked at under voltage due to safety-reasons, may not be started again automatically. All automated circuits shall provide the option, that drives can be stopped by an external signal from a maximum-demand indicator to limit the plants power demand. In this case a selected drive either shall be stopped until the signal disappears, or it shall be not started.

PLC and automating devices shall be protected against electromagnetic influence and power-supply failures and shall be supplied with extensive diagnosis facilities. The operating personnel shall always be able to change important setting values without going through an extensive programming with the computer, to adjust the control to changing processing conditions. This shall be realized by menu-assisted LCD operator panels with usage instructions on screen. Digital outputs from the PLC shall be supplied with relay contact-assemblies. Wherever possible the PLC programs shall be finally implemented in non-volatile memory (e.g. EPROM), if possible, after all functional tests and adjustments have been successfully completed.

Programmable logic controllers (PLC) programming standards should be in compliance with IEC 61131.

The correct function of the programs shall be tested and optimized in all parts of the process while the machinery is working.

The price and the service includes all clarification necessary to define the exact functional requirements of the various parts of the plant and the necessary flow of manual and automatic control, written description incl. flow-charts of all details and functions of the control system and submittal for approval (4-fold), the complete software, project planning, programming and generation of the complete documentation, start-up, test run and optimization.

The software shall be delivered on and test run on the PLC shall also be included.

## Control Coupling System

The PLC units shall be connected to each other by a local bus at a central location (star coupler) or through ringed bus structure. This is to be equipped with an interface for connection of all PLC, the programming unit and the process control system, with sufficient capacity (ports) for this and final phase of construction. It consists of connecting modules for the PLC units, a module for the programming unit and a module for the process control system. The bus system provides a continuous fault diagnosis that gives alarm signals via potential free contacts in case of faults. Suitable coordinated communication processors at the bus, the PLC, the process control system and the programming unit shall be included in the price. The service also includes the installation of the field bus system in a cabinet according to the design criteria for low voltage distributions at the operation building, configuration, parameterization, programming, as well as all terminals, bus cables and connection of all modules.

All components by the manufacturer that are necessary for this bus system also shall be included in the offered price.

The components of the bus system shall provide a modular design, which allows easy connection of further PLC units, to meet the requirements of the further implementation Phases if any.

The single PLC units shall be connected to the bus system by a point-to-point or star connection consisting of cable laid underground or on cable racks. The service includes all cable laying, connections, plugs, mounting and mounting material.

Before mounting the bus system, the Contractor shall submit a detailed description to the Supervisor for his approval; the first design shall be submitted with the tender. Finally a completely functional communication system shall be delivered.

Physically, as a rule, process control system should be realized with standard copper bus and SCADA communication networks are to be realized with optical fibres. When other designing requirements, such as EMI interferences, significant trace lengths distances, and transmission speed…) do not require other choice, standard copper made bus cabling is preferred for the reason of the easier maintenance/ repairmen. Proper mechanical protection is must in both cases.

## Laptop as Programming Units

For programming the PLC, a programming unit based on a Laptop shall be implemented. The Laptop for programming the PLC shall remain with the Employer.

## Uninterrupted Power Supply (UPS)

Purpose : To provide 230 VAC to all automation equipment, the telephone system, etc.

Location : At each LV Process Distribution, PLC Station and Control Centre

### Services and Deliveries

In order to supply emergency power 230 VAC, 50 Hz, sine wave to the different consumers during mains power failure some UPS-Systems, suitable for permanent power supply to all critical consumers are required. They shall supply all critical consumers for minimum 120 min. with electrical energy. The specifications of all well known computer producers shall be fulfilled. At least the following consumers shall be supplied by UPS:

1. Central Control equipment,
2. All PLC-units and PLC bus-system
3. Computers and printers of office rooms
4. Telephone and Fire Alarm system
5. Further critical consumers as required

Furthermore the unit for data transmission to the Pumping Station shall be supplied by the UPS. The Contractor shall clarify the exact requirements with the Subcontractor, who will deliver this unit. All required equipment for this connection shall be included in the offered price.

Each office room shall be equipped with at least two socket outlets, which are supplied by the UPS. These socket outlets shall be marked as required by the Employer and labelled "UPS" in English and Montenegro language.

Each UPS consists of a rectifier with a constant voltage / constant current curve ac­cording to DIN 41 773, a Battery-System (life-span at least 10 years) and an inverter with electronic power switch (EPS). The batteries shall be in­stalled in separate battery cabinets.

Each UPS system shall be installed in two cabinets according to the switchgear cabinets of the respective station.

The UPS shall provide a mimic diagram with following devices mounted to the front door:

1. LED testing button
2. Current and voltage meters
3. Circuit breaker and disconnect for manual by-pass
4. LED signal "Inverter On"
5. LED signal "Inverter Operation"
6. LED signal "Inverter Failure"
7. LED signal "Mains Operation"
8. LED signal "EPS Blocked"
9. LED signal "Battery Discharge"

Following signals shall be transmitted via potential-free changeover-contacts:

1. Rectifier Failure
2. Rectifier Operation
3. Inverter On
4. Inverter Operation
5. Inverter Failure
6. Mains Operation
7. EPS Blocked
8. Battery Discharge

The inverter operation by remote and the blocking of the frequency control by mains shall be possible. Primary failures shall be indicated and stored by a number. Following signals shall be indicated in detail:

1. Three-Phase AC under voltage
2. DC overvoltage
3. DC undervoltage
4. Time step for high-rate charging
5. Inverter power electronics
6. Over current
7. AC deviation
8. DC deviation
9. Phase comparison

An UPS shall be provided to enable the uninterrupted changeover to the mains in case of an inverter failure and the automatic return when the inverter is operating with its rated voltage again.

The specifications of each UPS shall be:

1. Mains voltage: 3 × 400 V, ± 30%, fluctuation of voltage and frequency as given at the place of installation
2. Rated direct voltage: 220 V
3. Curent ripper content: Acc. to VDE 510, T2
4. Direct voltage: Range of use +20/-15%
5. Limit range of use: ± 20%
6. Stored energy time: Approx. 120 min.
7. Rated alternating voltage: 230 V, ± 1%
8. Voltage wave form: Sine-wave
9. Static behaviour: Max. ± 1% within the whole range of load and power
10. Dynamic behaviour: Max. ± 3% at sudden load change 0% - 100% - 0%
11. Overload behaviour: Permissible overload 125% for 10 min.
12. Short circuit behaviour: The system shall be short-circuit-proof
13. Radio suppression rating: "N" acc. to VDE 0875, EN 55011
14. Sound level: Max. 55 dB(A) acc. to DIN 45630 at a distance of 1 m and half height of the device
15. Ambient temperature: According to the local requirements
16. Cooling: Increased air cooling
17. Degree of protection: IP 20 (if built on separate electrical panel), other wise IP43

Each UPS-System shall be equipped with a distribution including a suitable number of miniature circuit breakers with signaling contact. Furthermore the complete cabling to the consumers, necessary socket-outlets and mounting materials shall be delivered incl. complete installation ready for operation.

The service includes the start-up of the UPS including all necessary tests, instruction of opera­ting personal and submission of operating instructions, diagrams and mounting instructions at a single consultation.

# Central Control System with Control Computer System

Purpose : Allow the central supervision, control and documentation of WWTP

Location : WWTP

The Contractor shall deliver a complete and functioning Central Control System for the Wastewater Treatment Plant, including all Engineering and all accessories that are necessary to get a very reliable system, which meets the present state of the art.

The plant shall be equipped with a central control room, including computer system for automatic control of all drives and plant facilities. Through automatic control system the Operator should be able to set / change process parameters and initiate the automatic control sequences. Manual control from the Central Control System is not envisaged. Display the Graphical Plant Images will be on the high resolution minimum 25’ Monitors. A data bus system shall be installed for data transmission between the PLC units and the central control system. As specified, the control system shall be equipped with extensive alarm processing, e.g. optical and acoustic alarm, registration at the printers, etc. All parts of the central control system shall be supplied by uninterrupted power supply units (UPS) to guarantee full performance in case of a main's failure. Air conditioning systems shall be installed for the control rooms. The noise level within the control rooms may not exceed 40 dB(A).

The central control shall be located in a Central Control Room which needs to be set up newly in the Administration Building (also part of the Contract). From there systems can not been controlled manually, but automatic control can be called or set. The "central (remote) control"-mode allows the complete remote control of a drive from the PLC commutating with the SCADA system in central control room in "auto"-mode. In this mode operation is possible only in “remote automatic mode”, which allow only initialization of the automatic sequences and setting parameters for automatic work.

The central control shall use the PLC bus system for transmission of signals and commands from and to the PLC units. Optionally, if analysis shows it is inevitable, important signals and commands shall be transmitted directly on the 60 VDC level.

The central control room shall provide the control computer system for supervision of the wastewater treatment plant. System should be expandable to include facilities planned for further phases (Part 2 – Implementation phase 2). Of course, the already built facilities, (if any, for example power supply system) should be integrated into Central Control System. By this, the central control room shall provide an overview of the whole plant, including also energy supply, emergency power supply, outdoor lighting, fire alarm systems, security systems, etc.

The offered prices shall include the complete service, including technical engineering, clarification, delivery, transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

## Process Control Computer System

The Contractor shall deliver, install, connect, program, test, and commission a complete state-of-the-art process-control computer system (SCADA-System) in a server-client configuration at the WWTP. This system shall comprise all hardware- and software-components to fulfill at least all following requirements:

1. One server-computer, one client-computer and 4 flat screens (24 inch) at least.
2. Receive data from and send data to the WWTP's PLC-control systems via an interface unit.
3. The software of the main computer of the process computer system consists mainly of the following blocks:

- complete computer operating software system

- complete process interfacing, communication and process control software system

- complete plant supervision and plant control software inclusive of data processing and archiving functions

- 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 (English and Montenegro language), database, spreadsheet, presentation, etc.

1. The main process control computer makes all process-data and archive-data available at an inner-office data-bus-system (Ethernet-bus) and allows all connected computers to access the data and to inspect, utilise, input, modify and store the data and perform all process-control-functions.
2. Two additional computers shall be delivered and connected to the inner-office-data-bus. The software al­lows the same functions as the software of the main computer. It shall be possible that the Employer may connect further computers with the same functions to the said data-bus at any time without problems.
3. Each computer shall be equipped with keyboard, pointing device (mouse), high-resolution colour screen, and printer.

## Software for the Process Control Computers

The software consists of the operating software and the application software including all the Supervising and programming. All services of the Contractor shall be performed in complete coordination and agreement with the Engineer.

The Contractors Supervising services, the software and the system's capabilities include additionally to the above men­tioned general functions all the following features:

* Compilation and submission of a detailed list of all requirements for and the complete functions of the computer system in coordination with the Engineer
* All system manuals in English language
* All plants data processing and data presentation in English or Montenegro according to the preference of the Employer.
* Installation of the software in all computers and delivery of the complete software on CD or DVD
* System suitable for and operating in a network environment
* 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 standardised operating systems (Windows NT) with multi-user and multitasking function
* Data-exchange for external data-processing on third-­party systems via Ethernet
* Possibility to add and connect third-party software by the Employer at any time without compromising the other functions of the software
* All data shall be stored in a data bank
* The software system shall be an open system that may be extended without modifications of the existing software modules
* Data-exchange with the PLC-system of the WWTP
* Display of all process data as dynamical graphic plant images, trend curves, etc.
* Software for the process control
* 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 archived process data also via menu-operated software without interruption of the process control or other software tasks
* Automatic on-line data backup on tape without interruption of other software tasks
* Operating hours counters for all motors of the WWTP, giving a warning if maintenance intervals are exceeded
* Storage and archive functions according to DWA M260
* Input of laboratory data at a later point in time into the existing archive
* All process-data shall be pre-processed, stored, and archived in 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 shall be generated, displayed at the monitor screens and printed automatically. The data to be subject to printing shall be software selectable
* 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 dynamically graphic plant images

The operation of the complete software system shall be easy to learn and to handle for the personnel. All

functions shall be menu-selectable, error-safe, self-explanatory.

### Process Data Points

The capacity of data that can be handled by the system shall be designed and the system shall be generated with such spare capacities, that the requirements of the implementation Phase I can be fulfilled inclusive the optimization after some experiences during the first year of operation. In addition, system has to be easily expanded for the implementation Phase II (if any).

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.

### Reports

The reports to be generated, shown, previewed at the monitors and printed shall be laid out according to the specifications of the DWA (DWA/ATV M 260) and include at least 10 kinds of reports as:

* Daily Report
* Monthly Report
* Annual Report
* Report of all Faults
* Report of all Status Signals
* Report of the Maintenance Status of all Units at the WWTP

The report generating software shall provide all tools to set up reports that shall be clearly arranged, expressive and explicit.

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 can be stored.

### 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 WWTP shall be shown in a way that they can be easily recognized even by not experienced 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 shall be fully displayed and updated shall be maximum 1 second. By usage of keyboard or mouse the personnel can choose a particular GPI and zoom and roll to the specific point of interest. After a specific object is selected by a mouse click, more data about this object shall be shown and a menu with further commands shall be displayed. By using this method the motors can be operated, set-points shall 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 following ways:

1. As symbols or texts with changing colours
2. As alphanumeric texts to appear or change
3. As changes of the display of analogue data (e.g. alarms)

Analogue Process Data shall be presented in 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 or bars (e.g. exceeding limits)
* As trend curves over the time as x-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 shall 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:

The Contractor shall make himself familiar with the exact functions of the WWTP. The GPI shall be designed by the Contractor after a discussion with the Engineer about the general concept of the GPI. Afterwards the Contractor presents a first proposal of the GPI as a colored paper-print. This proposal shall be discussed with the Engineer, corrected and a first revision shall be submitted. This process may be repeated until the third revision of the GPI on paper. Then the GPI shall be installed into the process computer as a first proposal of the final GPI. Afterwards 2 revisions may be necessary until the GPI is preliminary accepted by the Engineer. After 3 months of continuous operation of the computer by the personnel the GPI may be submitted for final acceptance. If not accepted, the GPI may undergo another 2 revisions for correction if the Engineer desires further changes.

Minimum 50 GPI shall be included.

The GPI shall be finally handed over as colored paper prints, as implemented GPI within the computer and on CD or DVD for storage.

### 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 data-bank can be searched through with software filters in order to get specific information about particular dates, machines, faults, conditions and so on.

The data shall be treated and stored as per DWA/ATV M 260.

## Computer Hardware

The process control computers shall be connected to the PLC via adequate interfaces to gua­rantee a failure-free exchange of operational data. All signals from all consumers and instruments shall be processed:

The systems extension up to the double amount of data shall be possible. Common com­ponents of hardware shall be used to allow the user to replace them by him.

The ***process-control computers*** shall be suitable for use in the operation room, build into a trolley beneath the control desk. It shall be based on an IBM-compatible PC with the latest Microprocessor technology

For data storage high volume optical disk and hard disks shall be provided for permanent data storage.

For hardcopies and reports a colour ink-jet printer on paper of DIN A4 size shall be included. It provides a resolution of at least 600 dpi, a printing speed of approx. 6 pages/minute (color) respectively 9 pages/minute (s/w) and a Centronics and RS-232C interface. The print head and 5 sets of ink cartridges as well as all accessories shall be also included.

For printing the plants documentation there shall be a colour laser-printer supplied, resolution min 1,200 dpi., paper format postcard up to DIN A3, printing speed min. 4 pages/minute (colour) respectively 16 pages/minute (s/w), memory min. 96 MByte, incl. interface and connection to Ethernet data bus 100 Mbit/s, incl. all accessories and 5 sets of toner.

The connection between the process control system and the PLC shall be carried out by a connecting system with diagnosis features. The required plug-in cards, power supply and communication units shall be included. The data shall be transferred from the PLC-system to the computer in real time mode. For monitoring the system, diagnosis of faults and fault signals with acknowledgement each digital outputs and inputs shall be installed. At a failure of data connection or any other fault an alarm shall be given.

The hardware of the ***two single computers*** shall be based PCs. The PCs software and hardware shall be approved by the Engineer.

The single computers shall be connected by a local Ethernet-bus for 100 Mbit/s communication speed, cabling (STP) and all accessories CAT 6, consisting of 4 connection units for computers. Communication of all par­ticipants shall be possible.

The computer system shall be delivered including the operating system, installation, all wiring, connecting cables, power supply units and cables, documentation, software installation and ope­rational mounting and mounting material. A complete product-information of the whole system shall be delivered with the offer. References of existing systems under similar conditions of operation on wastewater treatment plants shall be submitted.

## Contractors Design Report of all Required Functions of the Computer System

The Contractor shall carry out the realization of the computer systems according to the following work program, adjusted to the related programs regarding the whole electrical systems:

* Creation of description of functions, lists of consumers and measurements, circuit diagrams, workshop- and installation drawings for the whole electrical equipment
* Creation of the plant identification system
* Design of images for the control computers
* Creation of control algorithms
* Creation of program descriptions for PLC units and the bus system
* Creation, installation and implementation of the software, start-up
* Submittal of draft of the final documentation
* Training of operational staff
* Test-run for 6 months
* Multiple optimisation of the system according to the experience, gained by the operating personnel
* Creation and submittal of the final documentation, firmware and software

Before programming the software and supply of hardware for the computer system the Contractor shall compile a detailed design report of all functions of the proposed system and submit it to the Engineer for his consideration. All functions shall be discussed with and presented to the Engineer. The functions shall be demonstrated with the aid of a functional demonstration unit. Corrections according to the Engineers' direction shall be included into the description. After the final acceptance of the description by the Engineer the Contractor may begin the programming of the software according to the said description. Following aspects shall be covered:

* Operating System
* Application Software
* Communication with the PLC's
* Communication between the computers
* Graphical software functions
* Processing of status signals
* Reports
* Manual data input
* Menus for the operation of the system
* Laboratory data
* Calculations
* Archives
* Implementation of third party software
* Data Backup
* Network (Ethernet)
* Hardware
* Plant identification system, complete list
* List of all consumers and data
* List of all measurements and date
* Graphical display images, draft printout of all images

The description of the desired functions shall be completed and shall be submitted to the Engineer 4-fold for his ap­proval. The computer system shall be implemented exactly according to the approved description.

# Instrumentation

## General

For automatic control, measuring and monitoring of the Wastewater Treatment Plant, instruments and SCADA components following the specifications in this Chapter shall be completely supplied, installed, calibrated, tested, commissioned and documented, wherever required.

The Contractor shall deliver a complete and functioning instrumentation for the Wastewater Treatment Plant, including all Supervising and all accessories that are necessary to get a very reliable measuring system that meets the present state of the art.

The offered prices shall include the complete service, including technical Supervising, clarification, delivery, transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services. Each measuring signal shall be transmitted standardized and potential-free by 0/4..20 mA. Indicating instruments shall be analogue or digital indicators. Measuring units shall be easily accessible for maintenance and calibration.

The terms and names used shall be in accordance with VDE 0410, EN 60873 and DIN 19226. All measuring and controlling devices shall be of good quality that guarantees a smooth and stable operation of the whole plant. All automatic control devices shall have the quality and performance as described in DIN 19226.

Graphic signs in control scheme drawings shall be based on DIN 19227-2.

All instrumentation shall be solidly installed with and to corrosion-free fittings. It shall be mounted in an appropriate way using a mounting structure made of high-grade steel (W 1.4301/ANSI 304), so that the devices can easily be removed for maintenance and repair. In areas where the said steel is not suitable (e.g. chemical tanks), other materials that are long lasting and corrosion-free shall be used. All instruments and sensors shall be installed in a way, that they can be calibrated and inspected / repaired without interruption of the process.

The material and construction of all sensors for use in wastewater shall be suitable for this purpose. Instruments for installation in chlorine or other chemicals shall be made of other non-corrosive material according to the medium. Devices that are installed in potentially explosive atmospheres shall be approved for this purpose.

All instruments shall be fit to operate under high humidity as present within the works. They shall operate without problems under the condition of power supply as given at the place of installation.

All measuring transmitters and signal processors shall be equipped with appropriate overvoltage protection for all power- and signaling lines at both ends, cable inlets shall be water-tight and shall fit to the cable size.

All measuring transmitters shall be installed together with the overvoltage protection to a mounting pole including cable duct with protective roof and housing to protect the device against sunlight and weather (W 1.4301/ANSI 304). The lifespan and reading of displays shall not be affected by sun­light.

The distance between the measuring sensor and the measuring transmitter respectively signal processor shall be as short as possible but with enough cable length for easy maintenance of the sensor. Extra lengths of cables shall be orderly arranged on cable holders next to the measuring transmitters.

The service includes all accessories and materials that are necessary for the correct operation of the measurements, as well as adjustment and on site calibration, *by a representative of the original manufacturer*. All spare and wear parts, as well as calibration devices; tools, calibration liquids and gases for two years shall be delivered with each instrument.

For each instrument 1 ea. analogue instrument of the size 24 x 96 mm shall be included. Optionally, instrument can be electronic with digital readouts. This instrument shall be mounted inclusive of all wiring into the respective marshalling / instrumentation cabinet next to the LV switchgear cabinets / PLC cabinets.

For each instrument with pulse output (e.g. flow meter, kWh meter, etc.) one electronic pulse counter with LCD display of the size 24 x 96 mm shall be included. Optionally, instrument can be electronic with digital readouts. This counter / indicator shall be mounted inclusive of all wiring into the respective marshalling / instrumentation cabinet next to the LV switchgear cabinets / PLC cabinets.

Where a certain principle of measurement is used for the level measurement and where at the same location a second level indicator is utilized for backup and safety switching purposes (for instance ultrasonic level meter to control pumps in a pump sump and separate level switch for dry running protection), the backup system shall utilize a different method of measurement.

The method of measurement for the backup system (secondary instrumentation), if not shown on the instrumentation table or on the drawing shall be indicated by the Contractor and based on his design philosophy for control / protection and as described in this section.

It is on the Contractor responsibility to conceptualize the control / protection concepts in accordance with adopted designing philosophy in regard to chosen automatic control modes. (For example, decision between (a) derivation of the discrete levels from the analogue transmitter in PLC realized comparators (with consequence not to have automatic operation in the case of PLC faults or (b) usage of relay outputs from the measuring transmitters, when automatic work can be realized without operational PLC, but with healthy measuring transmitter (with built in comparator functions) or (c) usage of complete independent discrete measuring sets (float switched, tuning forks…) for realizing automatic control function (in which case the status of analogue transmitter is not relevant or (d) combination of those systems (for example remote automatic mode only PLC based, local automatic work with discrete probes….).

Redundant systems shall be used wherever possible. In the textual part of the designing documentation detailed description and justification of the adopted control system should be described in details and full Instrumentation list, Process Flow and P&I Diagrams submitted.

All measuring signals shall be transmitted in a standardized range of 4...20 mA. The receiving unit shall indicate a transmission fault, if the signal level is less than 2.5 mA.

The overall accuracy of each instrument shall be 0.5% of the measuring range.

Each measured value shall be indicated (1) at the measuring transmitter itself, and (2) at an instrument in the relevant panel at the LV process distribution or marshalling / instrumentation cabinets. Furthermore each measured value shall be indicated (3) at the central control room of the WWTP on the central computer system of the WWTP.

If specifications of instrumentation are given elsewhere in the Tender Documents, these shall be regarded in addition to the specification made in this chapter.

The Tenderer shall submit a detailed list of all electrical measuring devices together with his offer, giving detailed information for each device about the manufacturer and type, the measuring range, the accuracy, the purpose and location, as well as the processing of values in the automation system.

Measuring and automatic-control devices shall be constructed in a way to guarantees a stable behavior of the control system at any load of the plant. All indicating, counting or reporting device shall meet DIN 1301 (latest version). With flow-rate-measuring units both the analogue and the pulse output shall be processed.

Electrical kWh- respectively kVArh-measuring units and flow meters shall always be equipped with a counting pulse output to enable the calculation of totals to the PLC. The PLC units shall be equipped with special counting input modules that are suitable for the actual counting pulse rates.

All measuring and controlling devices shall be tested for and be suitable at usage in water treatment and water distribution. They shall mainly be built up of a modular structure with easily replaceable groups (plug-in units). They shall allow the operating personnel to carry out tests, calibrations and maintenance by itself with a minimum expense. The regulations of DWA/ATV shall be noted.

If measuring devices shall be put to rest regularly while the plant is at work e.g. for calibration, suitable devices, e.g. maintenance-switches with key lock which make the automatic control system change to an alternative value, shall be installed. Faulty signals from the measuring device shall also be substituted. This change shall be defined within the clarification of technical details.

Process-measuring units shall be put to operation by the personnel from the original manufacturer. The Contractor shall be present, report the start-up and together with the manufacturer certify the smooth and correct functioning of the unit.

Cabinets, mounting brackets and fittings for measuring units which are installed near aggressive water, waste water or sludge shall be made of high-grade steel or other suitable not corroding steel (material no. 1.4571). Near chlorine treatment sections or chemical treatment areas other corrosion free materials shall be used. Pipes for taking samples of water shall be descended to the point of sampling. Inspection openings, sectioning points and fittings for cleaning shall be provided at suitable intervals.

A representative of the original manufacturer shall carry out the training of the staff.

## Electromagnetic Flow Meter

Purpose : To measure the flow rate and quantity of waste water, sludge or other liquids

Location : Excess sludge lines at WWTP

Mechanical Dewatering, inlet sludge

At all flow measuring points, where electromagnetic flow meter is possible

Services and Deliveries:

The electromagnetic flow meter uses the principle, that an electrical conductor (in this case the floating medium) induces a voltage if moved in a magnetic field that is proportional to the average flow velocity. This voltage shall be measured with two electrodes inside the pipe, while two coils mounted on the pipe generate the alternating magnetic field. From this the measuring transmitter determines the flow value of the medium.

The measuring sensor shall provide:

* Flow rate: suitable for the required purpose
* Diameter of the sensor: adequate to the media pipe
* Magnetic field: alternating by pulsed direct current
* Protected against flooding: min. 24 h, 3m, according to location
* Permissible pressure: min. PN10, according to location

Materials: pipe: Steel, coated with PTFE electrodes: High grade steel 1.4571

casing: Aluminium, powder coated

* Medium temperature: 0°C....90°C
* Min. conductivity of medium: 5 µS/cm
* Degree of protection: IP 67

The measuring transmitter shall provide:

* Digital display for momentary flow rate and total quantity, separately mounted (8 digits) at a location, where it can be easily calibrated, operated and read
* Monitoring of pulsed magnetic field
* Automatic zero calibration
* Field-mounted housing, powder coated die-cast aluminium, IP 67
* Output signals, 0/4...20 mA, counting pulse, status output
* Power supply, 230 VAC, 50 Hz

All surfaces being in contact with the medium shall be coated with suitable material, so that cleaning is not necessary and accuracy is not impaired during operation. The selected material shall be suitable for use in wastewater, sewage sludge, and chemicals or as required by the respective purpose.

The flow meter shall be mounted to the pipes, regarding the right 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 shall 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 installed, if electromagnetic flow meters are not applicable (e.g. in open channels, concrete pipes, etc.).

## Ultrasonic Flow Meter

Purpose : Measurement of flow rate and total quantity of waste water, sludge or other liquids

Location : Inlet “Venturi” measurement

Optional (where electromagnetic flow meter as specified above is not suitable)

Services and Deliveries:

At these flow meters the water flow shall be measured with a “Venturi” channel, where the channel profile is constricted in a way that the flow changes from laminar to turbulent. In this case the flow can be determined by a single level measurement upstream of the throat. For this an echo measurement shall be used: An echo system transmits ultrasonic pulses towards the surface from above and receives the returning echo. It determines the level from the speed of sound, the propagation time, the devices' height and the channel construction. Variations of the ambient temperature shall not influence the measurements' accuracy and therefore shall be compen­sated automatically by use of a temperature sensor. The complete measuring system consists of the “Venturi” channel, the ultrasonic level meter, the measuring transmitter and the signal pro­cessor to calculate the flow rate and to generate count pulses according to the quantity of water passing the sensor.

The “Venturi” channel shall provide:

* Type: “Venturi”, rectangular cross section
* Size: Fitting to the channel
* Materials: Sealed polypropylene, zinc plated steel reinforcements
* Flow rate: suitable for the required purpose

The ultrasonic sensor shall provide:

* Integrated temperature sensor for compensation
* Temperature: -20°C...+80°C
* Measuring range: suitable for the required purpose
* Degree of protection: IP 68
* Connection to processor: Via 5 m cable

The signal processor shall provide:

* Digital display for momentary flow rate and total quantity (4 digits)
* Continuous flow measurement
* Field-mounted housing, IP 65
* Output signals, 0/4...20 mA, 1 status contact, counting pulse, all potential-free
* Power supply, 230 VAC, 50 Hz

The components of the “Venturi” channel shall be delivered and integrated into the concrete structure of the channel during the time of con­struction. The inlet stretch and outlet stretch shall 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 shall not be affected by these phenomena.

The sensor shall be mounted above the channels' middle to a cantilever that shall be fixed to poles on both sides of the channel. The distance to the water sur­face shall be more than the sensors block distance. The measuring ultrasonic signal shall not be disturbed by any fittings inside the channel to get reliable results. The original manufacturer shall calibrate the flow meter on site. A certificate stating the accuracy at least at 10 different flow rates within the total range after installation at the wastewater plant shall be submitted.

All fittings shall be easy to access and to remove for maintenance or repair. All mounting ma­te­rial also shall be provided.

## Ultrasonic Water and Sludge Level Meter

Purpose : To determine the level of various media in tanks, channels, chambers, etc.

Location :

* Inlet channel
* Sludge thickeners
* Chemical storage tanks (such as FeCl3)
* Further locations as required

#### Services and Deliveries:

At this measuring instrument an echo system transmits ultrasonic pulses towards the medium surface from above and receives the returning echo. It determines the level from the speed of sound, the propagation time, and the sensors' height. The complete measuring system consists of the ultrasonic level meter and the fitting-measuring transmitter.

The ultrasonic sensor shall provide:

* Integrated temperature sensor for compensation
* Temperature: -20°C...+80°C
* Measuring range: suitable for the required purpose
* Degree of protection: IP 68
* Connection to transmitter: Via 5 m cable

The measuring transmitter shall provide:

* Digital display for momentary level respectively level difference (m, %) and volume (cu.m, %), 4 digits
* Permanent measurement of the medium level
* Field-mounted housing, IP 65
* Output signals, 0/4...20 mA, 1 status contact, 2 limit contacts, potential-free
* Power supply, 30 VAC, 50 Hz

The installed meter shall be resistant against gases, humidity and weathering. The function and accuracy of the meter shall not be affected by these phenomena.

The sensor shall be mounted according to the purpose. At open channels or tanks it shall be fitted to a cantilever that shall be fixed to a pole on the edge of the channel or tank. Closed pipes or tanks shall be supplied with a suitable flange fitting with gaskets. The material of the mounting devices shall be suitable for the material of the respective tank or pipe and shall be thermo-insulating. The distance to the medium surface shall be more than the sensors block distance. The measuring ultrasonic signal shall not be disturbed by any fittings inside the channel, tank or pipe to get reliable results. All fittings shall be easy to access and to remove for maintenance or repair. All mounting mate­rial shall be included. In order to avoid excessive condensation at the sensors membrane, the sensor shall be mounted in a thermal-insulated manner so that the temperature of the sensor follows the air temperature. The membrane of the sensor shall be water-repellent and shall be shaped in a way that there is no built-up of water films.

## Hydrostatic Level Meter

Purpose : To determine the level of various media in tanks, channels, chambers, etc.

Location : Upstream and sownstream the screens at WWTP

Inlet pumping station, pump sump

SBR feedin pumping station, pump sump

Equalization tank

Grit chamber, pump sump

Gravity pre thickener

As dry running protection in related pump stations, alternatively the float switch or conductive or tuning forks can be used for this purpose, see note

Further locations as required

#### Services and Deliveries:

The hydrostatic level meter shall be mounted at the bottom of the respective tank to measure the pressure caused by the medium. From this the level can be determined, if the medium density is known. Thus effects like foam on the medium surface do not influence the measuring unit.

The sensor shall provide:

* Suitable for installation in potentially explosive atmosphere (if required)
* Measuring range: suitable for the required purpose
* Output signal: 0/4...20 mA
* Degree of protection: IP 65
* Medium temperature: -30 ... +100 °C
* Housing and mounting material made of high grade steel (material 1.4301)

The measuring transmitter shall provide:

* Self monitoring
* Noise-free, two wire signal transmission
* integrated linearization
* two limit contacts with adjustable hysteresis
* power supply for measuring sensor
* Suitable for installation in potentially explosive atmosphere (if required)
* Field-mounted housing, IP 65
* Input signal: 0/4...20 mA
* Output signals: 0/4...20 mA, 4 limit contacts, potential-free
* Power supply for transmitter unit, 230 VAC, 50 Hz
* LCD display, 4 digits

The sensor shall be mounted to a suitable flange fitting with shutoff valve and vent valve. The material of the mounting device shall be suitable to the material of the respective tank or pipe. All fittings shall be easy to access and to remove for maintenance or repair. All mounting mate­rial shall be also included.

## Limit-Detector

Purpose : To detect liquids in tanks, channels, chambers, etc.

Location : Each underground part of buildings within the plant

Each underground valve chamber

Each channel, tank or pump sump where an overflow alarm is required

As dry running protection

Further locations as required

Services and Deliveries:

For the verification of the existence or the permissible level of liquids in a tank or sump, for instance to prevent a basement against flooding by giving an acoustic alarm signal, limit detectors shall be installed. The limit detector works by using the vibration principle. The sensor in the form of tuning fork shall be made to vibrate at its resonant frequency. In case of the sensor is immersed in the liquid, the resonant frequency changes. The frequency change is detected and then converted into a potential free switching signal.

The Limit-Detector shall provide:

* Rugged design
* Standard or length extension version according to the location
* Temperature: -20 °C ... +70 °C
* Switching hysteresis: approx. 5 mm
* Potential free contact: 230 VAC, 3 A
* Power supply: 230 V, 50 Hz
* Degree of protection: IP 66
* Sensor material: Stainless steel (material 1.4571)
* Housing: Aluminium with epoxy coating

The service includes the delivery and the complete installation at the correct position of the respective location including all necessary accessories, mounting materials, adjustment, etc.

## Automatic Sampling Units

Purpose : To take waste water samples for laboratory analysis

Location: Inlet of WWTP

Outlet of WWTP

Services and Deliveries:

Samples of water shall be taken automatically by the sampling system, mounted 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 the electrical signal from the respective flow measurement shall be transmitted to the sampling system. The instrument shall be 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 shall be filled into a PE bottle by a distribution system that shall be switched either time based or on the number of samples per bottle. A build in refrigerator keeps the temperature of the samples at approx. + 4°C (adjustable).

The sampler shall provide:

* 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
* Power supply by mains 230 VAC, 50 Hz
* Output signal, 1 status contact, potential-free

The service 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. These accessories shall be fixed at locations that guarantee reli­able results.

## Pressure Measuring Device

Purpose : For measuring the pressure of liquids or gas

Location: Air pipes

Further locations as required

Services and Deliveries:

Pressure-measurements shall be realized in several parts of the plant, e.g. the air-pipes of the aeration. Where the value of pressure-differences is needed this value shall be calculated electronically from the pressures measured by two identical pressure-measurements as described below and a suitable calculating transmitter.

Each pressure-measurement consists of the sensor and the related signal transmitter.

The sensor shall provide:

* Measuring range: suitable for the required purpose
* Temperature range of medium: -30°C...+100°C
* Permissible overpressure: 400%
* Output signal: 0/4...20 mA
* High grade steel housing
* Degree of protection: IP 65

The measuring transmitter shall provide:

* Self-supervision of function
* Display: LCD, 4 digits
* Degree of protection: IP 65
* Power supply: 230 VAC, 50 Hz
* Output: 0/4...20 mA,
* 4 signalling contacts, potential-free
* Connection-cable to the sensor

The sensor shall be mounted to a suitable flange fitting with shutoff valve and vent valve. The material of the mounting device shall be suitable to the material of the respective tank or pipe. All fittings shall be easy to access and to remove for maintenance or repair. All mounting mate­rial shall be also included.

## pH - Measuring Device

Purpose : For measuring the pH value and the temperature of waste water at several locations within the plant

Location : Inlet of WWTP

Outlet of WWTP

Further locations as required

Services and Deliveries

The pH-probe consists of a measuring electrode with membrane glass, a reference electrode and a temperature sensor Pt100 for temperature compensation and temperature measurement, all combined in one sensor. The sensor shall be mounted inside and protected by a PVC armature. An adequate measuring transmitter is required with automatic temperature compensation and self-monitoring. The sensor shall be 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 provide:

* Measuring range: pH 1...13
* Temperature range: -5°C...+80°C
* Permissible pressure: 6 bar
* Shaft length: suitable for the required purpose
* Temperature compensation: -10°C...+55°C

The armature shall provide:

* Shaft length according to on site conditions
* Preamplifier and 5 m 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 provide:

* Display: LCD, range pH 0...14, -5°C...+80°C, status-indication, 4 digits
* Output: 2 x 0/4...20 mA for pH value and temperature
* Power supply: 230 VAC, 50 Hz
* Field-mounted housing
* Degree of protection: IP 65
* Output signal: 1 status contact, potential-free

Furthermore the service includes one complete spare sensor, spare parts, materials and calibration solutions for two years of operation. All fittings shall be easy to access and to remove for calibration, maintenance or repair. All mounting mate­rial shall be also included.

## H2S Measuring Device

Purpose : For measuring H2S in the atmosphere. Optionally, if measurement applicable.

Location: Screen House, if applicable

Further locations as required

* Concentration shall be indicated by LCD situated on the remote sensing head.
* Low installation costs through use of two-wire technology, 4–20 mA
* 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.
* Switch for alarm suppression during one-man calibration and service
* High selectivity for the component of interest.

Monitoring of gas operating system continuously is obligatory in order to protect the people, the environment and the plant from toxic substances such as H2S.

The range of the diffusion remote sensing heads shall be exceptionally flexible as a system, modular, reliable and economical.

The remote sensing heads can be connected to control systems, or can be used as stand-alone remote sensing heads with appropriate power and control units.

The remote sensing heads shall be small in size, have a long service life and shall be easily maintained.

The remote sensing head shall be designed for various measuring ranges for H2S. The remote sensing heads utilize electro-chemical cells with high selectivity, short response times and long term stability.

The anticipated service life of a sensor cell for toxic gases shall be usually be 24 months, the suggested replacement time shall be after 18 months.

The output signal from the remote sensing head shall be 4...20 mA.

One-man calibration shall be made possible by locating all adjustments at the remote sensing head.

The remote sensing head has been approved to the Directive 94/9/EC [ATEX 100a] for use in

potentially explosive atmosphere according to the EN 50014 and EN 50020. Class of protection: II 1G EEx ia IIC T6. The sensing head shall be powered by an intrinsically safe supply if used in hazardous areas.

Control Module for sensing heads described above as a stationary and continuously operating multipoint gas warning system.

This system consists of the following individual main components:

* Sensing heads, control module, rack or wall-mounted housing and data module.
* Highly reliable but flexible operation through use of a microcomputer
* Approved according to 94/9/EC [ATEX 100a]
* Configuration can be changed on-site by placing jumpers
* Integration interface power supply
* 2, 3, 4 or 5-wire system
* Versatile system functions
* Adaptable for transmitter connection
* One-man calibration
* Digital signal processing

The versatility of the control module permits the processing of a variety of current or voltage input signals.

The control module consists of the basic board, an A/D converter as signal input and the front display panel. The input signal shall be selected on the A/D converter and the signal shall be transformed from analogue to digital. The basic board operates completely digital and shall be equipped with a microcomputer. Here the calibration look-up tables shall be stored, the measured signals shall be processed, the alarm thresholds shall be monitored and the interface and sensor supplies shall be controlled and stabilized. Also the jumpers which select the various instrument functions shall be located on this board. One man calibration, the use of transmitters and the connection of intelligent sensors shall be possible. In addition, a remote calibration mode can be initiated.

The control module permits the individual setting for each alarm threshold as rising or falling, latching or non-latching. Common alarms or zone alarms can be selected as well as “first” alarm and “most recent” alarm identification.

The control module contains a relays for pre alarm, alarm and failure with an inhibit function selectable during calibration and service. During calibration the instrument still measures, processes the signal and raises alarms.

The front display panel shall be equipped with a 3-digit, 7-segment display which shows measured values, threshold values and internal signals as well as a single digit display to show the test routine. By choosing a suitable multiplier on the basic board, the actual measured value and over/under range signals shall be shown on the 3 digit display.

System should have 2 individually adjustable alarm thresholds, latching or non-latching, rising or falling alarms.

Permissible ambient temperature:

* control module – 10°C to + 55°C
* catalytic sensor –20°C to + 70°C
* electrochemical cell, depending on type,
* usually – 10 °C to + 40 °C

Power requirements:

* 230/115 V +/– 10%, 50/60 Hz, approx. 13 VA for catalytic sensor connected with 1500 m cable and 24 VDC + 20/–15%, approx. 9 W for catalytic sensor connected with 1500 m cable [parallel operation possible]

Outputs

* Display: Power on, alarm, failure LED’s, 3-digit 7-segment display for measuring values, separate test routine indication display
* Output contacts: SPDT contacts for each alarm threshold and failure alarm

Contact ratings:

* 250V max. switching voltage, 3A max. switching current, 100/750 VA max. switching power

Adjustments:

On the front display panel of the control module:

- potentiometers for alarms, zero, sensitivity;

- push button for LED test; alarm reset and selection of functions;

- switch and test socket to check the interface power supply and to inhibit alarm outputs;

- interface supply adjustment potentiometers on the main board of the control module

The service includes the complete installation including all accessories, mounting 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 shall be transmitted to the central control system and shall be indicated and processed as any other fault of the plant.

## Oxygen Measuring Device

Purpose : For measuring the content of oxygen in the waste water

Location : SBR (nitrification / denitrification tanks)

Further locations as required

Services and Deliveries:

A membrane-covered, ampere metric sensor following the potentiometer principle measures the oxygen content. This kind of sensor provides two measuring electrodes in an electrolyte, which shall be separated from the liquid being measured by a membrane, which allows oxygen to dif­fuse into the electrolyte.

A third electrode used as a reference electrode shall be used for several functions: Reduction of measuring errors, monitoring of calibration, membrane faults, and electrolyte quality, self-monitoring. The life-span of the probe shall be at least 1.5 years without refilling of electrolyte.

To complete the measuring system an additional measuring transmitter shall be provided. This shall 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 selected probe shall provide:

* Automatic zero calibration
* Self monitoring
* Construction: Compact probe with cable (6.5 m) and plug-in
* Mechanical fitting: Screw-in thread R1''
* Material:
* Casing: High grade steel / PVC
* Counter-electrode: Silver
* Reference-electrode: Silver
* Working-electrode: Gold
* Membrane-thickness: 45 µm
* Flow rate: > 0.005 m/s
* Max. permissible temperature: 50°C
* Temperature compensation: 0 - 50°C by two thermistors
* Degree of protection: IP 68
* Accessories for 2 years of operation, at least:
  + 2 spare membranes as exchangeable cartridges
  + 50 ml cleaning solution
  + 50 ml electrolyte
  + 50 ml cathode-cleaner

The selected measuring transmitter shall provide:

* Ampere metric three-electrode measuring principle
* No zero calibration
* Automatic calibration
* Automatic air-pressure compensation
* Self monitoring
* Display: LCD, range 0...60 mg O2/l, selectable scale, 4 digits
* Input: Socket for plug-in from the probe
* Output signals: 0/4...20 mA, 1 status contact, potential-free
* Power supply: 230 V, 50 Hz
* Field-mounted housing
* Degree of protection: IP 65
* High grade steel protective roof

Spare parts and material for two years of operation shall be included. The sensor shall be fixed to a submerged fitting made of PVC 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 together with the other Engineers to get a reliable result from the measurement. All fittings shall be easy to access and to remove for calibration, maintenance or repair. All mounting mate­rial shall be also included.

## Conductivity Measuring Device

Purpose : For measuring the conductivity of waste water

Location: optional

Services and Deliveries

This device shall be permanently measuring the waters' conductivity by using the electrode less in­ductive principle, which has no secondary polarization effects and shall be not affected by deposits. An integrated temperature sensor Pt100 shall allow the automatic temperature compensation. The sensor shall be attached to a PVC armature. The adequate measuring transmitter in a field-mounted housing shall be microprocessor-controlled.

The conductivity sensor shall provide:

* 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 5 m cable with plug (IP 65)
* The measuring transmitter shall provide:
* Front operation panel
* LCD-Display
* Measuring range: suitable for the required purpose
* Accuracy: ± 0.5%
* Output signal: 0/4...20 mA, 1 status contact, potential-free
* Power supply: 230 VAC, 50 Hz
* Field-mounted housing

Spare parts and material for two years of operation shall be included. 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 shall be easy to access and to re­move for calibration, maintenance or repair. All mounting mate­rial shall be also included.

## Temperature Measuring Device

Purpose : For measuring the temperature of waste water, sludge or ambient air

Location : Inlet of WWTP (If not included in pH measurement)

Optional outside of the operation building

Further locations as required

Services and Deliveries:

The temperature-measuring unit consists of a sensor Pt100 and the transmitter. The sensor shall be 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 sensor shall provide:

* Measuring range: suitable for the required purpose
* Temperature range: -20°C...+75°C
* Shaft length: suitable for the required purpose

The measuring transmitter shall provide:

* Display: LCD, 4 digits
* Output: 0/4...20 mA, 1 status contact, potential-free, 2 limit contacts
* Power supply: 230 VAC, 50 Hz
* Field-mounted housing
* Degree of protection: IP 65

The service includes installation, all fittings and mounting material. All fittings shall be easy to access and to remove for maintenance or repair.

Services and Deliveries

Air and gas flow measurement shall be by the voltex low head loss flow meter. The measuring sensor shall either be flanged or flanged between flanges. Flanges shall be according to PN10; DIN 2501, DIN 2519. Meter body and sensor shall be made of stainless steel suitable for the measures media, i.e. stainless steel grade 1.4571 (AISI 316 Ti).

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.

The following parameters shall be assured.

* Output signal shall be to 20 mA;
* Protection class IP 65;
* Maximum pressure loses < 20-50 mbar;
* Lower losses will be given preference;
* Accuracy ± 1 % or better;
* Air temperature range – 50 °C/+ 100 °C;
* Environmental temperature 0 °C to + 50 °C.

Vibration, temperature, pressure compensation shall be suitable for a maximum air velocity not exceeding 50 m/s.

## NH4 Measurement

Purpose : For measuring the content of ammonium in the waste water

Location : SBR tanks (nitrification / denitrification)

Further locations as required

Services and Deliveries

Main service in WWTP is monitoring activated sludge basins.

The measuring system is planned to function as an analyzer with sedimentation unit. By using an air-lift system integrated in the sedimentation unit, wastewater or activated sludge is conveyed to the sedimentation cylinder. After sample conditioning, the Analyzer sample pump conveys permeate to the mixing vessel. The reagent pump adds reagent at a specific ratio.

As a result of the reaction with the reagent, the sample turns a characteristic color which is measured in the photometer.

The selected probe shall provide:

* Direct reaction in photometer at constant temperature
* Low system volume required
* Low reagent requirement
* Small sample volume
* A set of selectable measuring ranges
* Compact instrument design
* User-friendly user interface
* Sample stream monitoring and plain text error menu
* Measured value storage using integrated data logger
* Automatic self-cleaning
* Automatic calibration

The following parameters shall be assured.

Measuring parameter: Ammonium

Measuring range: 0.1 ...5 ppm NH4-N resp., 0.13 ...6.5 ppm NH4 (mg/l)

0.2 ...15 ppm NH4 -N resp., 0.26 ...19.5 ppm NH4 (mg/l)

0.5 ...30 ppm NH4 -N resp., 0.65 ...39 ppm NH4 (mg/l)

Measuring time: up to 3 min

Accuracy: 3% of upper measuring range

Sample requirements 15 ml/measurement,1 ml/min

Reagent requirements 2 x 0.5 ml/measurement, 2 x 2.2 l/month

Analogue output: 0/4 ...20 mA

Permitted load: max.500 Ω

Relay outputs: 2 limit contacters,1 error signalizing contactor

Load rating: up to 30 VA (max.48 V AC), 30 V DC at 0.5 A

Power supply: 115 V AC /230 V AC ±10%, 50/60 Hz

Spare parts and material for two years of operation shall be included. The sensor shall 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 together with the other Engineers to get a reliable result from the measurement. All fittings shall be easy to access and to remove for calibration, maintenance or repair. All mounting mate­rial shall be also included.

## NO3 Measurement

Purpose : For measuring the content of nitrate in the waste water

Location : SBR tanks

Services and Deliveries:

Main service in WWTP is monitoring the nitrate content in SBR tanks.

The measuring system is planned to function as an analyzer with sedimentation unit. By using an air-lift system integrated in the sedimentation unit, wastewater or activated sludge is conveyed to the sedimentation cylinder. After sample conditioning, the Analyzer sample pump conveys the permeate to a mixing vessel. The reagent pump adds reagent at a specific ratio.

As a result of the reaction with the reagent, the sample turns a characteristic colour which is measured in the photometer.

The selected probe shall provide:

* Nitrate process analyzer unit for optimizing the denitrification time in the activated sludge basin for nitrate- nitrogen
* Ready to use compact unit in spray proof stainless steel housing.
* Analysis unit with sample vessel with compressed air lift, sedimentation unit and automatic cleaning.
* Thermostatically controlled photometer with 2 wavelengths.
* Measurement and evaluating unit with digital display and plain text menu operation for configuration, calibration and diagnosis.
* Reagent chamber, with optional chemical cooling.
* Automatic calibration.
* Data logger
* Measurement principles: Chromotropic acid- sulphuric acid
* Measuring range : 0,2 to 20 mg/ l NO3- N or (1 to 50 mg/ l NO3- N)
* Measuring interval T 100 : >= 7 min., adjustable
* Output : 0/ 4- 20 mA, max. 500 Ohm
* Accuracy : 3 % f. s.
* Contacts : 3 change- over contacts

Spare parts and material for two years of operation shall be included. The sensor shall 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 together with the other Engineers to get a reliable result from the measurement. All fittings shall be easy to access and to remove for calibration, maintenance or repair. All mounting mate­rial shall be also included.

## ORP Measurement

Purpose : For measuring the redox potential in the waste water

Location : SBR tanks

Services and Deliveries:

The ORP-probe consists of a measuring electrode with membrane glass, a reference electrode and a temperature sensor Pt100 for temperature compensation and temperature measurement, all combined in one sensor. The sensor shall be mounted inside and protected by a PVC armature. An adequate measuring transmitter is required with automatic temperature compensation and self-monitoring. The sensor shall be 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 ORB-probe shall provide:

* Measuring range: 0 – 400mV (off set)
* Temperature range: -5°C...+80°C
* Permissible pressure: 6 bar
* Shaft length: suitable for the required purpose
* Temperature compensation: -10°C...+55°C

The armature shall provide:

* Shaft length according to on site conditions
* Preamplifier and 5 m 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 provide:

* Display: LCD, range pH 0...14, -5°C...+80°C, status-indication, 4 digits
* Output: 2 x 0/4...20 mA for redox pot value and temperature
* Power supply: 230 VAC, 50 Hz
* Field-mounted housing
* Degree of protection: IP 65
* Output signal: 1 status contact, potential-free

Furthermore the service includes one complete spare sensor, spare parts, materials and calibration solutions for two years of operation. All fittings shall be easy to access and to remove for calibration, maintenance or repair. All mounting mate­rial shall be also included.

## Explosive Atmosphere Detector

Purpose : For detection of explosive gases

Location : Screening Building

Further locations as required

Services and Deliveries:

These detection units shall be mounted in each building with potential explosive atmospheres. They shall be using the principle of infrared light absorption to determine the concentration of methane in the air. When the concentration reaches an adjustable value, an acoustic and optical alarm shall be given.

The field sensor shall provide:

* 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. %
* (according to the gas)
* Line aeration 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

The service includes the required racks and power supply units for 230 VAC, 50 Hz. Calibration chambers and test-gas with approx. 40 % of the explosive limit methane shall be provides in a sufficient number for the calibration of all delivered units. Mounting, non-corrosive mounting material, adjustment and calibration shall be included.

## Field Control Unit for Instruments with Maintenance Switch

Purpose : To provide an alternative value to the automatic control system to prevent control failures during maintenance of a measuring device

Location : At the location of the respective measuring device

Services and Deliveries

In case of maintenance or repair of a measuring device, the control system might get false or senseless values and therefore affect inadequate measures. To avoid this, an alternative value shall be stored at the PLC and provided to the control by operating a key lock maintenance switch that shall be installed at the location of the measuring device. For this encapsulated switchgear assemblies according to VDE 0660 with the degree of protection IP 65 shall be installed. They shall be suitable for use in wastewater treatment plants and outdoor mounting. The casings for surface mounting shall be installed vertically, with cables fitted from below to a screwed watertight gland according to the cables. Labels, white with black inscription, shall be fixed with screws.

The switchgear assembly consists of key lock switch according to plant's locking system, with abrasion-proof label "Normal operation/Maintenance", key removable in both switch positions.

Due to heat, dust and rain all field-mounted key locks shall be subject to heavy abrasions and may be blocked by dirt if no special precautions are taken. Therefore the Contractor shall propose various adequate locking systems like safety-lock, square key, triangular-key, etc. to the Engineer for consideration.

The whole switchgear assembly shall be surface-mounted into a weather-proof casing made of high-grade steel (W 1.4301/ANSI 304) installed on a suitable pole with protective sun and weather roof, made of high-grade steel (W 1.4301/ANSI 304), each key lock provides a protective cap to protect the cylinder from being affected by dirt. The installation ready for operation and all mounting and installation material shall be included.

# Building Installations

## General

The Contractor shall supply all buildings with suitable installations, which provide safe and convenient working conditions to the operating personnel. For this purpose, a sufficient number of lighting devices, lighting switches, socket outlets, etc. as specified below shall be installed at convenient locations.

The Contractor shall deliver complete and functioning building installations, including all engineering and all accessories that are necessary to get a comfortable building installations system which meets the present state of the art.

The offered prices shall include the complete service, including technical supervisory, clarification, delivery, transportation, insurances, installation, testing, documentation, commissioning, etc. any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

The Contractor shall be liable for the correct design of all parts of the building installation according to the relevant DIN, international and Montenegrin standards, such as DIN VDE 0100, IEC 364, SRPS N.B2.741, SRPS N.B2.741 . The offered equipment shall include all required services, devices and materials that are necessary for this purpose.

In areas where explosive atmosphere may occur, the entire electrical installation shall be carried out accordingly.

All parts of the equipment shall meet the specifications given for the LV systems.

## Building Distributions

Each building shall be equipped with a separate “LV building distribution”, which shall be installed in the respective LV panel room.

Operation buildings or other office buildings that provide more than one floor shall be equipped with separate LV building distributions for each floor.

### Panel boards

Panel boards for building distribution shall be totally enclosed. The degree of protection shall be at least IP 43 for indoor mounting. They shall be factory assembled. Each panel board shall be equipped with a sufficient bus bar and earthing bar. All panel boards shall be made of galvanized steel and be suitable for the ambient conditions. The surfaces shall be painted with top color RAL 7032 or as required by the Engineer. Panel boards shall be mounted to the wall.

Each panel boards shall be provided a main incoming circuit breaker of the fuse less type. A branch circuit breaker shall be provided for each outgoing circuit. A sufficient number of spare circuit breakers and a space reserve of 30% after completion of the works shall be regarded.

Doors shall be equipped with cylinder locks, fitting to the lock-system of the plant. Doors that are higher than 1000 mm shall provide a central locking system.

A list of all installed devices and circuits shall be fixed to the inner side of the door to provide an overview for all connected circuits. For this purpose, each device shall be labelled clearly with the respective circuit number.

### Moulded Case Circuit Breakers

Module case circuit breakers shall provide the following characteristics:

* totally enclosed, moulded case construction
* high temperature resistant, tropicalised[[4]](#footnote-4) insulation materials
* front operated handle mechanism for simultaneous operations of all contacts
* bimetal inverse time delay over current tripping
* instantaneous magnetic short-circuit tripping
* clear indication of the state by the operating handle

### Miniature Circuit Breakers

Miniature circuit breakers shall provide the following characteristics:

* thermal-magnetic tripping, not adjustable
* short circuit breaking capacity minimum 10 kA at 230/400 VAC
* 1-, 3- or 4- pole construction as required
* rated currents from 6 to 100 A as required

### Earth-Leakage Circuit Breakers

Earth leakage circuit breakers shall be supplied at least for all circuits that contain socket outlets. They shall meet the specifications given for LV systems.

## Indoor Lighting and Installations

### Lighting Switches

Interior lighting switches shall be made of shatterproof, anti-static, thermoplastic material with suitable installation boxes. The rated current shall be 10 A / 230 VAC.

### Lighting

The buildings in the wastewater treatment plant shall be illuminated with lighting fixtures suitable to the internal installation directives and the properties of the buildings. In the internal sections of the building the type and number of the lighting fixtures depend on the properties of the section, the lighting intensity required for that section and the type of the lighting needed.

The lighting of any part of the plant shall meet DIN 5035, EN 12464 and the relevant Montenegro standards and regulations concerning lighting and safety of working.

The offices, the switchboards and control rooms, the laboratory, the archives, the kitchen, the workshop and the warehouses shall be illuminated with fluorescent fixtures. Fluorescent fixtures shall also be used in the control rooms of the transformer and generating building the electrical cabinet and other specific buildings. Other fixture types shall be chosen in required places.

The pumping buildings, the blower building, the sludge dewatering building and other specified buildings shall be illuminated with waterproof fixtures.

For lighting of any room, suitable surface mounted lighting fittings shall be used. The support rail shall provide led through wiring 3x1.5 mm2. The ballast and the plug for the electrical plug connection shall be accommodated in the light insert.

Removing or putting in the lighting inserts shall be possible and safe when the lighting is switched on. For this purpose an advanced protective contact system shall be provided. Plastic coated turning locks shall be provided for fixing of the lighting inserts.

The cables shall enter into the end sides shall be provided with diaphragm seals. A 3-pole connecting piece without screws (plug connection) shall be mounted within the casing for cores up to 1.5 mm2.

For indoor areas the following degrees of protection and lighting intensities shall be achieved:

|  |  |  |
| --- | --- | --- |
| Area | Degree of Protection | Min. Light Intensity (Lux) |
| Office Rooms, Control Rooms | IP 20 | 250-500 |
| Switchboard Rooms, Panel Rooms | IP 20 | 250-300 |
| Engine Rooms, Working Areas | IP 54 | 250 |
| Corridors | IP 54 | 100 |
| Toilets, Depots | IP 54 | 100 |
| Canteens, Public Rooms | IP 20 | 200 |

The design of the entire lighting shall be based on the intensities of illumination set by DIN 5035, EN 12464 respectively the local regulations.

Furthermore the Contractor shall install an emergency lighting system according to the relevant DIN and Montenegro standards and regulations. The emergency lighting fittings shall be supplied by central or single batteries for at least 1 hour at total power failure. They shall be installed at least along the escape routes. Escape routes shall be marked with the prescribed signs.

### Socket Outlets

Within each engine room and LV panel room, at least two power socket outlets of the 5-pole CEE-type for 32 A and for 16 A shall be installed.

Each room within the buildings shall be equipped with a sufficient number of single-phase socket-outlets for 16 A / 230 VAC. A socket outlet shall be provided under each lighting switch. The number and location of outlets shall be so, that at each point in the buildings the distance to the next socket outlet may not be higher than 10 m.

Office rooms shall be supplied with a sufficient number of socket outlets for the connection of various consumers, such as computers, telephones, additional lamps, etc.

For wet areas waterproof sockets with self-returning cover shall be applied.

## Air Conditioning and Heating Installations

The air conditioning heating and ventilating installation shall be made for the buildings of the WWTP. Air conditioning and heating system shall be central type in some buildings and also shall be independent type in other buildings.

The operating building shall be air conditioned and heated by a main unit. In the controls rooms and regularly occupied sections of the other buildings, the required air conditioning and heating shall be obtained by the split type air conditioners and electrical heaters.

In humid buildings which need to be ventilated, to ventilating shall be made by the ventilators.

## Lightning Protection, Earthing and Grounding

If Montenegro law does not require more stringent, the following rules shall be observed. The lightning protection and earthing and grounding system shall meet BS DD ENV 61024-1 and IEC 61024. Material for use in potential bonding and earthing shall be selected according to DIN VDE 0151. The protective earthing system of MV-equipment shall be designed according DIN VDE 0141.

Earth electrodes for protective and operational earthing shall be carried out as surface- respectively buried earth elec­trodes. Metal building installations shall be connected by spark gaps according to the current regulations. Depending on the ground conditions, either galvanized steel strip 30x3.5 with a zinc coating of 500 g/m² or high-grade steel (W 1.4301/ANSI 304) with rounded edges shall be used as earth electrodes.

The total earthing resistance of all earthing electrodes shall be less than 2 Ohm or fulfill the requirements according to DIN VDE 0100 part 410.

The materials used and the connecting methods shall be in a way, that the deterioration of materials due to electrical respectively electro-chemical potential differences is avoided. Connecting lugs or earth points shall be provided in all rooms containing important electrical distributions, transformers and large machinery.

Earthing points shall be marked by numbered plates. Galvanized earthing rods, connecting the earthing electrodes to the lightning protection system, shall also be protected thoroughly against corrosion.

For all lightning protection systems, especially for those to be extended the earth-contact resistance shall be measured and a report about the installation shall be submitted to the Engineer. All resistances shall be measured again after 3 months of operation and measuring reports shall be submitted.

The components of the earthing system shall be individually connected to a potential bonding bus, so that they can be disconnected and tested separately at any time.

# Outdoor Installation

The Contractor shall provide the complete outdoor installations, consisting of outdoor lighting of the whole plant and combined outdoor socket outlets for portable drives, tools and general purposes. The offered equipment shall be complete and functioning and shall meet all relevant DIN- and Montenegro standards and regulations.

Before execution the Contractor shall submit a layout plan of the plant showing the locations of each device. Submitting the calculation of the light intensities shall proof the sufficiency of the outdoor lighting.

The offered price shall include the complete service, including technical engineering, clarification, delivery, transportation, insurance’s, installation, testing, documentation, commissioning, etc. Any objection or com­ments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

## Outdoor Lighting

The whole areas of the wastewater treatment plant shall be equipped with a suitable outdoor lighting system according to the requirements given in DIN 5035, respectively the relevant Montenegro standards. This includes all roads, streets, footpaths, outside of the buildings and all areas where wastewater treatment equipment is located, especially the grit and grease removal tanks, shafts, pump sumps, etc.

The field lighting shall be made with concrete or metal type poles. The lamp brackets shall be concrete brackets. The external lighting fixtures shall be ballast type mercury steamy fixtures.

The poles shall usually be build along the side of the road. But, if required the lighting may also be provided for units of different sections on the plant.

Besides that, the walking platforms, the upper stairs of the tanks and some other sections shall be illuminated with short galvanized steel poles.

The following minimum light intensity shall be guaranteed:

|  |  |
| --- | --- |
| Area | Min. Light Intensity (Lux) |
| Operation and Work Areas | 20 |
| Roads, Streets, Footpaths | 10-20 |
| Safety lighting | 5-20 |

The service shall include all required equipment and material, lighting devices, poles, cable trenches, etc.

### Street Lighting Luminaries

Luminaries shall provide the following characteristics:

* high pressure mercury vapor, safety class II
* degree of protection: IP 44 for the lamp, IP 23 for the terminal box
* housing made of glass-fiber reinforced polyester resin, color stone grey
* all material resistant against corrosion
* aluminum wide-angle mirror reflector, adjustable and polished
* heat resistant seal of the bowl to allow penetration of air, but to keep out dust, moisture and insects
* bowl made of poly methyl methacrylate (PMMA) to be unbolted without tools

Poles

Street lighting poles shall meet the following characteristics:

* made of centrifugal reinforced concrete or metal construction
* 450 mm above the base, with cut-in steel box, fuses and connector for in-out-cable
* height according to the offered luminaries to achieve the required light intensities
* earthing connection, accessible from the handhold

The complete pole with the top mounted luminary shall withstand the actual beat wind load, at least 150 km/h. Each pole shall be erected with a suitable concrete foundation. Installation of the poles, adjustment and aligning also shall included in the offered prices.

### Lighting Control

For automatic control of the street lighting system a photo-electric cell and suitable contactors shall be provided. The photo-electric cell shall be weather-proof and provide adjustment of light level from 10 to 100 Lux. The difference between turning on and off shall be 5 to 10 Lux.

In addition the lighting shall be switched automatically from full power to half power by a time switch. Lighting of bridges and paths on tanks shall be equipped with local light switches to turn on the light if required by the personnel. At the Central Control Room there shall be a switch to turn off these light centralized.

## Outdoor Socket Outlets

At several suitable outdoor locations within the wastewater treatment plant, a sufficient number of power-combined sockets shall be installed. They shall 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 shall 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, 3x16 A
* 2 single phase sockets, 3-pole, 16 A
* 1 heater with thermostat, 60 W
* earthing and neutral bus

# Cabling, wiring for Buildings and Outdoor Installations

The Contractor shall provide the complete cabling and wiring for building and outdoor installations of the whole WWTP with all required indoor and outdoor installations. Furthermore he shall deliver and install all required auxiliary material as cable trenches, cable ducts, trays, conduits, terminal boxes, watertight bushings, etc. as specified hereinafter.

The offered price shall include the complete service, including technical engineering, clarification, delivery, transportation, insurance’s, installation, testing, documentation, commissioning, ethic. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

## Cable Laying Material

Contractor shall follow general requirements according to relevant standards and technical recommendations.

## Under-floor Cable Duct

Under-floor cable ducts according to the requirements; dimension approx. 33 *x* 350 mm, suitable for covering with cement floor. The bottom shall be made of 1 mm galvanized sheet steel and welded to the top. The duct shall be divided into two compartments to separate the power- from the signal-lines. Floor outlet boxes also made of galvanized sheet steel shall be adjustable to the floor surface and suitable for the installed duct. They shall be also divided into compartments. The removable covers shall be made of 4 mm galvanized sheet steel and shall be suitable for the floor covering of the respective room. Flush covered outlets for connection of power-, control- or communication devices shall be adjustable and supplied with self-closing cover and inserts for horizontal installation. Inserts for installation of any connecting devices shall be supplied with strain relief clamps for cables of 4-13 mm diameter.

The whole under-floor duct system shall be in accordance with DIN 49073. The Engineer determines the colour of any visible part. The service includes all adjustments, connections between the duct elements and accessories as sealing material, carpet protection frames, etc. Mounting and all mounting material shall be also included.

## Cable Duct

Cable ducts according to the requirements, made of grey plastic (PVC) RAE 7035, the dimensions shall be approx. 30 x 60 mm - 60 x 110 mm as required, the bottom shall be punched for mounting, and clamps shall hold the cover. Mounting and non-corrosive mounting material shall be included.

## Cable Tray

If required, cables shall be laid upon cable trays suitable for indoor and outdoor installation according to DIN VDE 0100 part 737 made of 1 mm galvanized sheet steel for indoor mounting, outer color as required W by the Engineer. Outdoor cable trays shall be made of high-grade steel (material 1.4301 *I* V2A). The dimensions shall be:

* Height 40 mm up to 80 mm, as required
* Width 100 mm up to 400 mm, as required
* Following material shall be included in an adequate quantity:
* Adjustable telescope connections 0- 200 mm
* Adjustable angle connections 45-90
* T-shaped connections
* Cross-connections
* Vertical branches
* Vertical branches 90 twisted
* Connecting pieces for width reduction
* Partitions
* Covers for the entire length of the gutters
* Mounting cantilevers

If signalling and power cables are laid upon the same cable tray they shall be separated by suitable partitions. Plastic inserts to protect the cable insulation shall cover sharp edges. All mounting, adjustment and mounting materials shall be also included.

## Steel Conduit

If required, cables shall be laid in galvanized steel conduits for heavy mechanical load. The size shall be Pg 16 - Pg 42, as required. The service includes all required couplings and 90arches. Plastic inserts to protect the cable insulation shall cover sharp edges. Complete installation and all mounting materials shall be also included.

## Terminal Boxes

Terminal boxes shall be designed for surface mounting according to VDE 0606 and EN 60670. They shall be of suitable size. The degree of protection shall be IP 65. The service includes clamps, terminals, sealing, complete installation and mounting material.

Terminal boxes shall be readily accessible.

## Metal Constructions

Metal constructions as poles, fittings, gratings, railings, platforms, etc. shall be made of galvanized steel for indoor mounting and of high grade steel for outdoor mounting. The pieces shall be welded respectively screwed. The service includes all mounting, corrosion protection and stainless mounting material.

## Tap-Drill Holes

Tap-Drill holes shall be included according to the requirements. The drilling of tap-drill holes with diame­ters from 100 up to 300 mm through brickwork and concrete with a width of approx. 30 cm includes all nec­essary material.

## Watertight Bushings

If required, watertight bushings shall be installed. Watertight bushings in concrete walls shall be realized with mounting galvanized frames. These shall be integrated into the concrete construction. According to the number and size of the cables to be routed through the watertight bushings, their size shall be determined. The service includes laying of the cables and mounting in a gas- and watertight manner, including all mounting and sealing material. Bushings shall be readily accessible.

## Cables

The work to be carried out comprises the complete interior and exterior cabling. Under streets, pavements and otherwise sealed areas the cables shall be installed in pipes so, that 50% reserve space is kept for future extensions and maintenance. Within cable trenches the cables shall be laid out in a “snaked” manner, so that movements of the ground may not create extra forces.

All cables and wires shall be supplied with sufficient length to enable cutting, convenient maintenance and the installation free of mechanical tension. The cables shall be installed in partial lengths according to the requirements. There shall be no cuts or extensions within the lengths between start and end of each connection. At both ends the cables shall be identified permanently with clearly legible and long lasting special cable labels.

The price shall include:

Connection work and accessories, labels, glands, lugs; installation underground in cable trenches, in pipes, in cable conduits, on cable trays and on walls; cable-ducts and cable-conduits, floor- and wall-cuts and -holes, all making good and builders work, cable supports, terminal-boxes and junction-boxes, mounting materials, accessories, documentation, etc.

Power and Control cables for 0.4 kV systems shall be 1000 V grade with copper conductors according to DIN VDE 0271 and shall be one of the following:

* Multi-core, PVC insulated, armour of galvanized flat steel wires and counter helix of galvanized steel tape, with overall black PVC sheath, NYFGY type or equivalent
* Multi-core, PVC insulated, concentric conductor of copper wires (applied in wave snake formation) and copper tape (applied helically), with overall black PVC sheath, NYC WY type or equivalent
* Multi-core, PVC insulated, concentric conductor of copper wires and copper tape (applied helically), with overall black PVC sheath, NYCY type or equivalent
* Single- and multi-core, PVC insulated, with overall black PVC sheath, NYY type or equivalent
* Single- and multi-core PVC insulated, with overall PVC sheath, NYM type or equivalent
* Single- and multi-core PVC insulated, NYA type or equivalent
* Single-core, rubber insulated, according to DIN VDE 0250, NSGAFOU type or equivalent

Signal cables according to DIN VDE 0816 shall conform to the latest International Standards and be suitable for the proposed purpose (e.g. A-2YF(L)2Y type or equivalent, PYCYM type or equivalent, EBCY type or equivalent, IY(ST)Y type or equivalent, etc.).

### Optical Fibre Cable

If used, optical fibre cables shall conform to the latest International Standards an be suitable for the proposed purpose. They shall provide the following characteristics:

* Transmission rate: > 1 Mbit/sec.
* Cable Type: According to the requirements
* Number of fibres: 6
* Fibre size: 62.5/125 µm
* Attenuation: According to the requirements
* Wave length: 1,300 nm
* Type per DIN VDE 0888: A-VF(ZN)2Y 6G62.5/125LG type or equivalent
* Metal-free cable for direct underground installation, installation in PE-ducts or on cable trays

Construction of the cable:

Central glass-fibre-reinforced plastic core longitudinal water sealing by Petrolat filling, Bandage, strain relief devices, cable sheath.

Furthermore all amplifiers (e.g. for signal cables and optical fibre cables) and complete accessories necessary for faultless operation on a high level of reliability shall be included.

Fiber optic cables have to be properly mechanically protected overall the entire trace.

# Telephone Systems

## General Requirements

The Contractor shall deliver and install a modern telephone system that meets the present state of the art. It shall fulfil all relevant DIN VDE and Montenegro standards and regulations, especially all conditions for the connection to the public telephone network. External telephone cablings are not subject of this Tender. For the purpose this tender, the Contractor can assume external underground cable will be TK10 5x4x0.4mm laid down up to the TT manhole at the WWTP plot. The Contractor shall carry out all required coordination and clarification with the Public Telephone Company without extra costs. All costs, taxes and charges to be paid to the telephone company for the connection to the public telephone network shall be included in the offered price.

The system shall be suitable for future system-extensions without hardware or software efforts. The technical limit of extension shall be stated with the offer.

Cabling for communication purposes shall be carried out according to DIN 0250 with cable of the PYCYM type for indoor installation and A-2YF(L)Y-type for outdoor cabling with twisted pair conductors of at least 0.9 mm diameter.

For each telephone 2 per cable (one per is spare) shall be installed from the central telephone distribution box in the operation building. If necessary, the secondary telephone distribution boxes shall be used and suitable telephone cables with spare cores shall be installed between these boxes and the central telephone distribution box.

Telephone sets shall be connected to the system via 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.

The offered price shall include the complete service, including technical engineering, clarification, delivery, transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection or comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for the services.

### Central telephone unit (EPABX)

The central unit shall be an electronic private automatic branch exchange system (EPABX), based on digital signal transmission. It shall meet the following characteristics:

* 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 Montenegro 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.

The complete unit shall be installed in a suitable cabinet according to the requirements of LV cabinets, 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 shall 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 MV panel room, important machinery rooms and further rooms as required shall be supplied with telephone sets for wall mounting, meeting the following characteristics:

* repetition of calls
* switchable dialling 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.

# Fire Alarm System

## General Requirements

A fire alarm system shall be installed at all rooms where flammable material is handled or stored espe­cially at the diesel generating station, all fuel tanks rooms, storage rooms for fuel (if any), paint, solvent or other flammable material. Additionally the administration building shall 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 signalling devices, complete cabling and any further equipment to realize a complete and functioning fire alarm system according to DIN EN 54, DIN 14675, VDE 0833 and the relevant Montenegro standards.

At the administration building a building plan shall be provided showing the escape routes of the entire building, all manual alarm boxes and detectors and other components of the fire alarm system. It shall be fixed to the wall and protected by a glass cover.

The cabling shall be carried out with signalling cables, conductors at least 0.8 mm diameter, marked red along the entire length. The service also includes software, programming, adjustments, installation, configu­ration, and tests, mounting and mounting material.

### Central Fire Alarm Unit

The unit shall meet all relevant DIN, VDE and Montenegro standards and shall be suitable for the connection of automatic and manual alarm devices. It shall provide the following characteristics:

* 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 shall be transmitted to the central control system and shall be indicated and processed as any other fault of the plant.

### Manual Alarm Box

Manual alarm boxes shall be installed at the central control room, central points of corridors, stairs and es­cape routes. They shall be red colored, for installation in dry rooms according to DIN 14655 and provide the following features:

* integrated evaluation logic
* programmable address
* red plastic housing (colour RAL 3000)
* wall mounting
* Labelling “Fire Alarm” in English and Montenegro language
* 5 mm LED for release indication
* ambient temperature -30 ... +70 0C

### 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 provide the following characteristics:

* activity of radioactive material AM 241 *I* 4.4 kBq
* locating primary and secondary alarms
* locating faulty or dirty detectors
* infinitely variable adjustment of ambient conditions
* automatic sensitivity control
* 30 detectors per line possible
* 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.

### Signalling devices

For indoor mounting at the administration building, acoustic alarm horns according to DIN 33404,part , shall 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 shall be suitable for outdoor installation (IP 66).

# Intrusion Alarm System

## General Requirements

An intrusion alarm system based on motion detectors (PID) shall be installed to monitor different internal zones (rooms, corridors etc) in each building. Signals shall be transmitted through the SCADA system for processing at the Central Control Room.

# Earthing, Lightning Protection, Overvoltage Protection

## General Requirements

The WWTP shall be equipped with a complete earthing and lightning protection system according to DIN V ENV 61024–1 and the relevant Montenegro standards. All metal parts, which are not used for conducting electricity, shall be integrated.

The WWTP shall be assigned for lightning protection class 1 according to DIN V ENV 61024-1.

Before beginning the work, the resistance of the ground shall be determined, in order to chose required measures of earthing and lightning protection according to DIN V ENV 61024 –1 the result shall be certified and submitted to the Engineer.

The offered price shall include the complete service and including technical supervision, clarification, delivery, transportation, insurance's, installation, testing, documentation, commissioning, etc. Any objection our comments shall be stated by the Contractor in writing together with his offer. Thereafter the Contractor bears the complete responsibility for services.

## Earthing

In the WWTP all the MV 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 that are not used as electrical conductors shall be earthed effectively. Earthing shall be of TN-C-S type in accordance with IEC.364-3. Installations of lighting and socket outlets must fulfil the earthing requirements

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 shall be obtained as follows:

### Working and protective earthing in the transformer station

WWTP earthing system must be securely connected with the protective earthing of the transformer station.

### Foundation Earth Electrodes

Foundation earth electrodes will be embedded into concrete foundation of plants such as control and mechanical building, clarifiers, reservoirs, pump stations etc. For foundation earth electrodes as well as for up-leads, galvanized 25 x 4 mm, Fe/Zn tape shall be used.

Connection of foundation earth electrode with steel reinforcement shall be done at maximum 2 m intervals. For every room enough number of up-leads carried out up to (1-2) m above floor level, must be secured.

For connections between foundation earth electrodes and reinforcement, as well as for connections of up-leads with earthing grid, cross-joints tape-tape SRPS N.B4.936 or similar, shall be used.

The concrete inspection holders shall be installed for the tests and periodical inspection in the earthing network.

The total earthing resistance of earthing network shall be less than 2 ohm or fulfil the requirements according to DIN VDE 0100 part 410. The earthing networks, if required, shall be connected to each other in order to obtain an earth resistance less than 2 ohm.

In the earthing networks, the connection of the earthing conductors to themselves and to the earthing electrodes shall 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 bus bar 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 shall be installed with copper conductors or copper cables with suitable cross-sections.

The components of the earthing system shall be individually connected to a potential bonding bus, so that they can be disconnected and tested separately at any time.

### Control Earthing Electrodes

For all parts of the installation which are outside earthing grid and which are connected to the same, control earthing electrodes shall be foreseen. They shall be placed at a distance of approx. 1,0 m from the plant and buried at about 50 cm. Potential checking via control electrodes is not necessary if the surface of the earthing grid is covered by an insulating material. Covered area should be at least 1,5 m around conductive parts. Broken stones or gravel of 10 cm thickness may serve as the above cover. Asphalt of minimum 1 cm thickness may also be accepted as an insulting material.

Copper rope of minimum cross section 50 m2 may be used as a control electrode.

Earthing shall be of TN-S-C type in accordance with IEC 364-3.

Installations of lighting and socket outlets must fulfill the earthing requirements.

#### Outdoor Earthing Installation

For earthing of the equipment such as steel structures, ends of protection wires of transmission lines, fences: two copper ropes each of 50 mm2 cross-section shall be used.  
For the connection of equipment and steel structures appropriate double compression cable lugs should be used.

Control of voltage should be provided at the outer fence. This should be done by horizontal earthing electrodes. The same should be made of galvanized steel rope 25 x 4 mm laid at 1,0 m away from the fence on the outside side at a depth of 0,5 m. Fence and earthing conductor shall be connected at every 6 (six) meters.

#### Indoor earthing installation

For indoor installation earthing system is composed of main earthing conductors, earthing conductors to equipment and steel parts and earthing bus-bars. Main earthing conductor shall be galvanized tape Fe/Zn 25 x 4 mm. Main conductors shall be fixed on appropriate supports placed around rooms. Connection with up leads as well as with earthing bus bar shall be carried out by welding or by same other method which is approved by the Engineer. For all above mentioned indoor installations which is fastened onto walls adequate space shall be left between conductors and walls and possibility for easy access shall be secured.

All metal parts, which are during normal operating conditions voltage free, shall be connected to earthing bus bar by a copper rope of 50 mm2 cross section.

Door and window frames should be connected to nearby reinforcement or to the earthing system, while their moveable parts are to be connected to the frame by a flexible conductor of adequate cross-section.

#### 0,4 kV Installation Earthing System

Earthing system in 0,4 kV installation is of TN-C-S system, in accordance with the latest revision of IEC 364-3. This means that neutral and protection bus-bar are mutually connected in distribution boards while neutral and protection conductors are led separately throughout installations.

## Lightning Protection

Protection from lightning strokes shall be done by means of lightning protection installation. Each building should possess classical lighting protection which consists of catching system (network or roof), down leads and earthing grid.

Catching system on building's roof shall be of galvanized steel tape 25 x 4 mm, placed on supports fixed on the roof.

Down-leads shall connect catching system on the roof with foundation earthing system. They will be placed in steel pipe which is embedded in concrete wall of the building. Test connections shall be anticipated. The same should be placed at approximately 1,2 m above ground level and are protected by metal boxes. Complete lightning protection installation, together with all metal parts of the building shall form Faraday cage which is safe protection from lightning stroke.

For lightening protection system, the following material shall be used:

* Hot tip galvanized steel tape 25 x 3 mm
* Copper bus-bars 35 x 5 x 200 used for earthing bus-bars
* Copper conductor, of minimum 16 mm2 cross section, used for connection of metal parts.

1. MEICA = Mechanical-, Electrical-, Instrumentation-, Control & Automatisation [↑](#footnote-ref-1)
2. For main equipment, such as pumps, blowers, mixers, etc. [↑](#footnote-ref-2)
3. For main equipment, such as pumps, blowers, mixers, etc., on request of the Supervisor [↑](#footnote-ref-3)
4. The term “tropicalised” is used here and in throughput this Volume with meaning to provide protection against the destructive effects of moisture and fungi. [↑](#footnote-ref-4)