VOLUME 3
Technical Specifications

Section 3
Specifications for Electrical, Instrumentation and SCADA Works

Content

1. GENERAL REQUIREMENTS

The general and particular minimum requirements for technological installations at the electrical traction substation (ETS) Trebešica are outlined on the following pages.
It shall be the responsibility of the Contractor to provide all detailed design of the installations, to ensure full coherence of all the equipment installed and to comply with the present minimum quality requirements.
All Works and equipment shall comply with the other requirements of this Tender Dossier.

2. SCOPE OF WORK

The work to be performed under this Section consists of the assembly and installation of supplied equipment and material as shown in the drawings or specified or directed by the Engineer, like gas insulated switchgear, traction transformers, disconnectors, circuit breaker, etc. It shall include transportation, testing, assembling, and furnishing, first filling with all needed operation means, of all materials, equipment and accessories required for completing the specified plant. It shall include, but not be limited to, the following parts: all field screws and bolts, electrodes for welding, anchor bolts, protective painting against corrosion, etc.
The Contractor shall strictly observe the related specifications and shall carry out all work in a skilled and workmanlike manner in keeping with modern methods of construction. The Contractor has particularly to observe all instruction for installations defined by the manufacturer of the equipment.
The equipment shall be delivered fully cleaned and flushed for immediate service. The equipment shall be properly preserved for transportation and storage.
Where the equipment is manufactured to require special tools for maintenance other than those normally available commercially, the Contractor shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment. All tools shall be of best quality hardened steel forgings with bright, finished heads and with work faces dressed to fit nuts. The set of tools shall be neatly mounted in a labelled tool box of suitable design provided with a hinged cover.
The Contractor shall obtain and submit from the manufacturer a list of suggested spare parts for each piece of equipment according to the provisions of spare parts of the general requirements. After approval, Contractor shall furnish such spare parts suitably packaged, identified with the equipment number, and labelled. Contractor shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment. All spare parts are intended for use by the Employer, only, after expiration of the guarantee period. Any spare parts which the Engineer permits the Contractor to use for start-up activities shall be replaced by the Contractor prior to the Employer's acceptance of beneficial use of the equipment.
Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a nameplate and rating plate. Upon these shall be engraved, in the specified language or languages, the manufacturers name, direction of rotation, type and serial number of plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as deemed necessary.
Equipment of similar design shall be from the same manufacturer. The Tenderer shall verify local representative for chosen equipment with full name, contact person, address and telephone. Also the representative's experience, service and spare parts organisation etc. shall be provided.

2.1 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,
- spare parts available in the Beneficiary Country,
- service available in the Beneficiary Country,
- 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.

2.2 DESIGN AND DESIGN LIFE

The Contractor shall design the Works in accordance with the Specifications and to the satisfaction of the Engineer. The design of works shall be in accordance with good modern practice and shall be such as will facilitate operation, inspection, cleaning, lubrication and repair to ensure long life and satisfactory operation under all service conditions. The Contractor's design calculations shall be submitted to the Engineer as required.
Works shall be designed for a long reliable operating life and shall be suitable for 24 hours per day continuous operation for prolonged periods in the climatic conditions applying and with a minimum of maintenance.
The Contractor may be called upon to demonstrate this for any component, either by the service record or evidence of similar equipment already installed elsewhere or by records of relevant type tests.
Wherever possible, works shall be designed and arranged so that the degree of skill required maintaining and servicing the works shall be minimal. Except for consumable items such as carbon brushes and the like, which normally require more frequent replacement, no part subject to wear shall have a design life from new to replacement or repair of less than five years of continuous normal operation, and, where major dismantling is required to replace a part, the life of such parts shall not be less than ten years.
Electrical contactors and switches shall have a minimum life under normal full load working conditions of two million operations without replacement of any part and two hundred thousand operations without maintenance of any kind. Electrical relays and light current switching devices shall not require maintenance of any kind before completing two million operations under normal full working load.
The works shall be designed for the prevention of corrosion, entry of insects and vermin, entry of dirt and dust, and to minimise risk and damage in the event of a fire. Works shall operate without undue vibration and parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service after loss due to any corrosion allowance, or the specified test condition including any corrosion allowance.
Works shall be designed so that when operating at the normal condition, the intensity of emitted noise in the working environment shall not constitute a health hazard to operators and other personnel or cause a nuisance outside the boundary of the works. The anticipated noise characteristics of all items of works and systems, which have high noise potential, shall be submitted to the Engineer early in the design stage of the Contract.
The Contractor shall ensure that all pollutants are discharged from the works in a controlled and safe manner.

2.3 STANDARDS, REGULATIONS AND ENGINEER'S APPROVAL

The design, workmanship, materials, strength and dimensions of all parts shall be the satisfaction of the Engineer and shall comply with one or more of the standards, as mentioned further in the text. Standards for particular equipment are included where applicable in the following pages.
Where no standards are stated in the Contract, all materials, components, equipment, workmanship and tests for which EN or their acceptable equivalents have been issued, shall be in accordance with such standards.
The electrical installations shall comply with and be tested in accordance with national or internationally recognised regulations or codes of practice subject to any specific requirements of the local electricity supply authority.
Material and equipment supplied and work performed shall comply with these standards and regulations as a minimum. Where manufacturers offer equipment to other standards, the standards shall be equal or superior to those specified and full details of the difference shall be supplied to the Engineer if requested.

2.4 TRANSPORTING AND STORAGE REQUIREMENTS

Before sending from manufacturer all equipment should properly protected with painting or other approved mean for all transporting, storage and installation period against corrosion and accidental damages.
Pipe flaps, valves and fittings should be protected. Pipe openings during installation and storage should be covered. Flexible connection sockets and flaps should be fixed.
Contractor should provide storage and loading area for intermediate equipment storage. The required room for devices will be provided on Site.
Storage rooms should be protected against environmental impacts, with good ventilation and firm floor covering. Storage room floors should be designed so as to cope with the weight of the petty items stored.
The following petty items should be stored in closed rooms:

- bolts, pins, instruments, insulation materials, electrical equipment and petty items to which electrical devices, electrical engines, welding materials and equipment are attached, all petty items and all petty item covered with painting.

2.5 PACKING, SHIPPING, TRANSPORT AND LIFTING DEVICES

2.5.1 Packing

The Contractor shall prepare and pack all materials and equipment for shipment in such a manner that they are protected from damage during shipment, and shall be responsible for and make good any and all damage resulting from improper packaging, whether this is done at his own works or in those of any Contractor.
All electrical parts and delicate mechanical parts subject to damage by moisture shall be packed in hermetically sealed metal containers, in plastic envelopes, or in other approved containers within their respective packaging cases, containing silica-gel bags.
Spare parts shall be packed separately for long-term storage and delivered to the Employer stores.
All cases, packages, etc. shall bear Employer standard shipping marks and shall be clearly marked on the outside to indicate net weight, gross weight and dimensions, the parts contained therein, contract number, port of destination, the position of the centre of gravity and the correct position of the slings, and shall bear an identification mark relating them to the relevant shipping documents. All these shall become the property of the Employer upon delivery.

Each crate or package shall contain a packaging list in a waterproof envelope. All items of material shall be clearly marked for easy identification against the packaging list.

2.5.2 Shipping and Transport

The Contractor shall be deemed responsible for the following:

- to load and transport the equipment and material from the place of manufacture, whether this is at his own works or any of his Contractor, to its final destination,
- to off-load, clear and transport to site all equipment, etc., including temporary storage,
- to obtain permission from relevant Montenegrin authorities to use docking, airport or Site unloading, railway, highway and bridge Facilities required for the transport of his equipment,
- to provide for insurance,
- to obtain and verify all information specified regarding transport restrictions,
- to obtain and verify all information specified regarding adequate handling equipment for unloading the heaviest pieces of equipment,
- to bear all costs of repair or replacement of the equipment arising from damage during transport and unloading (repairs to the damaged primary insulation is not acceptable),
- to select proper routes to meet his needs and shall bear all extra costs resulting from the selection of such routes.

The Contractor shall immediately report to the Employer where any claims made against him arising out of alleged damage to a rail, road or a bridge etc.

2.5.3 Lifting Devices

The Contractor shall provide bolts with shackles at conveniently selected spots of equipment in order to facilitate the handling and lifting of supplied equipment.
Special lifting and handling equipment, to be supplied by the Contractor in accordance with the Technical Specifications, shall be shipped together with the component for which they are provided.
The Contractor shall make his own arrangements and enquiries with regard to the loading, unloading and transportation of all construction equipment and material required for the Facilities. He shall make all necessary investigations as to the heaviest loads that can be handled at ports or transported to the Site by rail or road, in particular with regard to the weight-bearing capacity of all bridges and culverts, and he shall comply with all relevant regulations of the Government Department connected therewith.

3. ELECTRICAL REQUIREMENTS

3.1 AMBIENT TEMPERATURE

All electrical equipment and instruments for outdoor installation shall be designed for continuous operation at ambient temperature from - 40°C up to + 40°C. Moreover, temperatures directly in the sun shall be considered for additional temperature gain.
Indoor installations shall be suitable for ambient temperatures of at least 40°C.
Apparatus and material in enclosed metal unit cubicles and switchboards shall be designed for operating temperatures in excess of the maximum internal temperature attained inside the enclosure during continuous full rating operation.

3.2 ENVIRONMENTAL

The equipment and materials to be supplied in accordance with the present specification shall be designed considering the environmental conditions indicated in the General Technical Requirements and applicable to the corresponding substation.

3.3 MOTORS

All motors shall comply with IEC 60034 and dimensions with IEC 60072. They shall be capable of operating continuously under actual service conditions without exceeding the specified temperature increases, determined by resistance, at any frequency between 48 and 51 Hz together with any voltage between - 15 % + 10% of the nominal value.
All motors shall be totally enclosed, and if situated in the open they shall be weatherproof and suitable for outdoor operation.
Motors shall have insulation to Class F standards for ambient temperature of 40°C. The temperature rise shall be restricted to that associated with Class B insulation. Where the motor may be appreciably affected by conducted heat the class of insulation shall be subject to approval of the Employer.
All motors shall be suitable for direct starting at full voltage.
The motors shall feature sealed ball or roller bearings.
Where single phase motors are employed, the motors shall be grouped so as to form, approximately, a balanced three phase load.

3.3.1 General

Motors shall comply with the following general standards and norms:

- IEC 60034-1, 60034-5, 60034-6 and 60034-8,
- the relevant EN standards.

The motors shall be designed for the temperatures and humidity occurring on the Site and in the installation in which they operate.
The motors shall be delivered for direct start as design N, IEC 60034-12, apart from motors with a rated nominal power larger than 15 kW, which shall be delivered, for S/D start as design NY IEC 60034-12.

3.3.2 Mechanical Requirements

The degree of protection provided by enclosure for motors shall be min. IP 54 to IEC 60034-5.
Protection grade for outdoor motors shall be min. IP 55 and equipped with a drainage hole at the lowest point.
The motors shall be cooled so that the permissible operation temperature is not exceeded.
The motors shall be balanced according to ISO 2373 vibration class N. The noise level shall comply with IEC 60034-9 as a minimum.
All motor covers shall be delivered efficiently protected against corrosion.
The motors shall be insulated to class F in accordance with the IEC 60085. The limit of temperature rise during operation shall not exceed that for class B insulation.

3.3.3 Electrical Specifications

The motor performance and data shall be in accordance with IEC 60034-1 and shall be marked in a legible way with:

- manufacturer name, serial number,
- rated power, full load current, voltage, cos φ,
- frequency, number of phases,
- start-up current, rpm.

Each motor shall be provided with thermal protection. Motors over 5,5 kW shall have star-delta windings. Smaller motors shall be provided with bi-metal thermo switches.
Submerged gearboxes shall be provided with moisture sensor.
The motors shall be designed for the following parameters:

- voltage fluctuations +/- 10%. The voltage variations must not result in a temperature increase in excess of what is stated in IEC 60034-1,
- frequency: 50 Hz. Frequency variations +/- 1 Hz.

The motors shall be equipped with connection boxes with separate terminals for each winding end, and connection for protective conductor. The terminals shall be designed for twice the nominal current, however, at least 2,5 mm^2.
Thermo switches shall be connected to separate terminals inside the connection box.
The marking of connections and the rotation direction shall be in accordance with IEC 60034-8.
All motors shall be equipped with suitable number and dimension of cable glands.
All submerged pumps (and other motors) that can be taken out of operation and lifted to ground level by a hoist (or in an equal way) shall have power supply and signal cables connected by CEE sockets enabling electrical disconnecting without a use of tools. The sockets (the male as well as the female parts) shall be mounted in a location where flooding is impossible. The sockets shall be protected against rain and other weather conditions as described for outdoor instruments in general. If these demands cannot be met the degree of protection shall be IP 68 to IEC 60529.

3.3.4 Balancing

Revolving parts shall be balanced both statically and dynamically, so that for any combination of speed and load up to the maximum, there shall be no vibrations caused by out-of-balance forces.

3.4 MOTOR CONTROL GEAR

The control gear shall comply with the requirements of IEC 60947-4-1, the control gear being rated according to the duty imposed by the particular application.
The motor contactors shall comply with IEC 61095 class of intermittent duty 0-3, with type IP 54 enclosure protection and utilization category AC4. They and their associated apparatus shall be capable of switching the stalled current, and shall have a continuous current rating of at least 50 % higher than the full load current of the motors they control.
Each motor or group of motors shall be provided with a control gear for starting and stopping both manually and automatically. Short circuit, overload and single-phasing protection shall be provided.

3.5 BUSHINGS

All bushings shall comply with the requirements of IEC 60137 and the associated barrel porcelains shall comply with IEC 60233, together with the requirements of these Specifications. Arching horns shall be provided where required.
Where porcelain is used as an insulator in outdoor locations, such insulators shall be of smooth profile (i.e. without skirts) design.
The transformer and bushing design shall enable each applied bushing to be changed without opening the cover of transformer. Each bushing shall be fitted with testing tap.

3.6 CABLE BOXES

All cable boxes shall be suitable for cables entering from below. Cable boxes shall be dust, weather, rodent- and insect-proof, conforming to IP 65 of IEC 60529.
They shall be fitted with disconnecting links to permit cable testing and shall have bolted inspection covers for each compartment to facilitate maintenance.

The gland plates shall be insulated from the cable boxes and shall be of non-magnetic, or insulating material. If metallic gland plates are used, single core cable glands shall be insulated from the gland plate.

3.7 CUBICLE WIRING

Cubicle connections shall be insulated with PVC to IEC 60227. Wires shall not be jointed or tied between terminal points. Bus wires shall be fully insulated and run separately from one another along the top or bottom of the cubicle. Fuses and links or miniature circuit breakers (MCBs) shall be provided to enable all circuits in a cubicle, except a lighting circuit, to be isolated from the bus wires.
The DC trip and AC voltage supplies and wiring to the main protective gear shall be segregated from those for back-up protection and also from protective apparatus for special purposes. Control and alarm contactors shall be segregated as well. Each such group shall be fed through separate MCBs from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group. All wires associated with the tripping circuits shall be provided with red ferrules marked "Trip" in white. Employer's practice of wiring numbering should be adopted throughout.
It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.
Insulated stranded wire shall have not less than seven strands and each strand shall be not less than 0,67 mm in diameter. If a single conductor is used, it shall be annealed copper of circular cross sectional area of not less than 2,5 mm^2. Stranded wires shall be tinned at terminal connections.
When connections rated at 400 V and above are taken through junction boxes they shall be adequately screened.

3.8 TERMINAL BOARDS AND TERMINAL BLOCKS

Terminal boards shall be of good quality non-flammable insulating material, with a comparative tracking index (CTI) of not less than 500, to IEC 60112.
Studs of stud type terminal boards shall be locked in the base to prevent turning and all connections shall be made on the front of the terminal board using lock nuts or lock washers.
Terminals shall be of insertion clamp type incorporating captive pressure screws which do not bear directly on the wire but on a serrated clamping plate. The pressure screws shall have an inherent locking feature.
Where connections are to be made between the multicore cables supplied the terminal boards shall comprise a stud or clamp type terminal for the multicore cable joined by a withdrawable insulated link. These terminals shall also be provided with amenities for the insertion of test probes on both sides of the link.
Terminal boards for mounting inside cubicles shall not be less than 100 mm apart and shall be mounted at least 225 mm clear of cubicle floor. Where plastic cable channels are used, a minimum space of 50 mm shall be left between the channel and terminal boards.
The terminals shall be grouped according to function and labels shall be provided on the fixed portion of the terminal boards showing the function of the group. Terminals for connections, which exceed 100 V shall be separated from those of other circuits and shall be fitted with insulating covers.
The use of terminal boards as junction points for wires, which are not required in the associated cubicle shall be avoided wherever practicable.
Each terminal block shall have a minimum of 10 per cent spare terminals.

3.9 MINIATURE OR MOULDED CASE CIRCUIT BREAKERS

Miniature or moulded case circuit breakers shall be designed and tested in accordance with IEC 60947-2 and supplementary requirements of these specifications. They shall be suitable for use over the full range of expected voltage variations as specified in the Schedules.
They shall be suitably rated for both the continuous and short circuit loadings of the circuits.
For three phase circuits, the miniature circuit breakers shall be of the three pole type; for single phase circuits they shall be of the single pole type and for DC circuits they shall be of the double-pole type.
Where miniature circuit breakers are used in circuits containing inductive loads, e.g., operating coils, it is essential that they are suitable for satisfactory operation in the circuit in which they are used, i.e. account is taken of the circuit time constant.
All miniature circuit breakers shall be provided with auxiliary contact(s) for remote indication of circuit breaker operation.
Means shall be provided to prevent the miniature circuit breakers being inadvertently switched to the 'OFF' position.
Miniature circuit breakers shall be mounted in such a manner so as to give an easily visible indication of the breaker position and shall be grouped and spaced according to their function in order to facilitate identification and easy replacement.

3.10 MARSHALLING KIOSKS AND JUNCTION BOXES

The Contractor shall provide a marshalling kiosk for housing ancillary apparatus.
All outdoor boxes and kiosks shall be of sheet steel construction; hot dip galvanized, protection class IP 54 of IEC 60529 and shall be insect and rodent proof.
Heaters shall be controlled by suitable hydrostats and thermostats. They shall be suitable for operation with a 230 V 50 Hz supply.
All cables shall enter boxes and kiosks from the bottom.
Each compartment of all kiosks and junction boxes shall be provided with access doors at the front. Doors and access covers shall not be secured by nuts and bolts but shall be fastened with integral handles with a provision for locking. The door actuated lighting should be provided inside the kiosk/junction boxes.
The kiosk doors shall be of lift-off and hinged type and shall be provided with laminated glass windows of adequate size to facilitate reading of indicators from outside the kiosk. Facilities shall be provided to allow removal of the temperature indicators without the need to pass the capillary tubing and bulb through the various compartments.
Doors and covers under 15 kg mass may be of the slide on pattern, for indoor installation, but above this mass hinged doors shall be used.
If three-phase connections are taken through a box or kiosk, they shall be adequately screened or insulated and suitably marked with the phase colour code; a danger notice stating the voltage shall be fixed on the inside and outside of the kiosk or box.
A durable copy of the circuit wiring diagram shall be affixed to the back of the kiosk door and labels shall be provided inside each kiosk or box to describe the functions of various items of equipment.

3.11 DEGREES OF PROTECTION

In accordance with IEC 60529 IP 54 and IP 41 shall be applied for outdoor and indoor conditions respectively if not specified otherwise.

3.12 MULTI-CORE AND CONTROL CABLES

Cables for power supplies at voltages up to 600/1000 V and for all 100 V AC and DC protection, control, alarm and indication shall have copper conductors with PVC insulation, extruded PVC beddings, galvanized steel wire armouring, and/or with copper screen and with PVC over sheath.
The minimum conductor size shall be not less than seven strands of 0,67 mm diameter wire, or in the case of single wire conductors, the minimum cross-sectional area shall be not less than 2,5 mm^2. In special cases for light current installations, single strand annealed copper conductors with a cross-section of 1,5 mm^2 may be used. All sheaths shall be free from defects and impervious to water.
Multi-core and control cables shall be terminated in accordance with manufacturer recommendations and the cable cores shall be long enough to be terminated without addition of separate tails.
The DC trip and AC voltage circuits shall be segregated from each other and the circuits to the main protective gear shall be segregated from those for back-up protection.
The screens of screened pairs of multi-core cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly in a diagram.
All wires on panels and all multi-core cables shall have ferrules, which bear the same number at both ends. At those points of interconnection between the wiring carried out by separate Contractors where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment. The same ferrule number shall not be used on wires in different circuits on the same panels.

3.13 LV POWER CABLES

Cables for power supplies at voltages up to 600/1000 V shall have copper conductors with XLPE or PVC insulation and PVC over sheath.
The conductors shall be of plain annealed copper wire complying with IEC 60228 as applicable, with circular or shaped conductors. All cores shall be identified by phase colours.
All sheaths shall be terminated in accordance with manufacturer recommendations and the cable cores shall be long enough to be terminated without addition of separate tails.
The conductor sizes shall be in accordance with the loading of the individual circuits under site conditions and to the approval of the Employer.

3.14 HV POWER CABLES

To save room, the outgoing 110 kV feeder bays will be connected to traction transformers by single-conductor 110 kV cables. The cables shall have copper conductor with XLPE insulation. The conductor cables shall be of Cu wire. The conductors are manufactured to meet the requirements of the relevant national and international standards.
All sheaths shall be terminated in accordance with manufacturer recommendations and the cable cores shall be long enough to be terminated without addition of separate tails.
The conductor sizes shall be in accordance with the loading of the individual circuits under site conditions and to the approval of the Employer.

3.14.1 Technical Parameters of 110 kV HV Cables

- maximum service voltage 123 kV
- nominal voltage 110 kV
- maximum service power 10 MVA
- nominal frequency 50 Hz

3.15 TERMINATION OF CABLES AND WIRES

Where cable cores are liable to contact with oil or oil vapour, the insulation shall be resistant to oil.
PE sheathed cables shall be terminated by compression glands complying with last revision of IEC.
Auxiliary PVC insulated cables shall be terminated with compression type glands, clamps or armour clamps complete with all the necessary fittings.
All incoming and outgoing connections shall be terminated at a terminal block. Direct termination into auxiliary switches will not be accepted.

3.16 CONTROL AND SELECTOR SWITCHES

Switches shall comply with the requirements of the last revision of IEC, the particular duty and utilization category required being selected from the range stated, according to the duty imposed by the particular application.

3.17 INSTRUMENTS

All indicating instruments shall comply with IEC 60051. The size of instruments shall be harmonized with the existing conditions available on the sites and shall be determined by the Contractor during the preparation of the design documents, subject to approval by the Employer.

3.18 AUXILIARY SWITCHES

With each contactor, all necessary auxiliary switches and mechanisms for indication shall be supplied. Not less than four spare auxiliary switches of each type shall be provided. All auxiliary switches shall be wired up to a suitable terminal board on the fixed portion of the switchgear whether they are in use or not in the first instance, and shall be arranged in the same sequence on all similar items of equipment. The contacts of all auxiliary switches shall be strong and capable of adjustment according to the movement of the equipment.

3.19 EARTHING

Connections by a secondary conductor of an approved section shall be made from the earth terminal of each item of equipment to the system earth. Where necessary, or as required by the Employer, the earthing conductor shall be suitably cleated. All earthing conductors shall be made of copper.
Connections shall be protected where necessary against electrolytic action and shall be made between clean surfaces and under sufficient pressure to prevent burning caused by fault currents. Joints shall preferably be made by low temperature bracing or crimping. Where bolted joints are used in copper connections they shall have the joint faces tinned.

3.20 110 kV System

The basic technical values have been determined in accordance with the recommendations of IEC 60038, IEC 60071-1, IEC 60071-2 and other relevant IEC publications.

nominal system voltage (RMS value, phase to phase voltage)	Un = 110 kV
highest value of system operating voltage (RMS phase to phase voltage)	Um = 123 kV
standard rated frequency	50 cycles (Hz)

system configuration	3 phase / 2 phase, H connection
insulation coordination	according to IEC 60071-1 and IEC 60071-2

3.21 25 KV SYSTEM

The basic technical values have been determined in accordance with the recommendations of IEC 60038, IEC 60071-1, IEC 60071-2 and other relevant IEC publications.

nominal system voltage (RMS value, phase to phase voltage)	Un = 25 kV
standard rated frequency	50 cycles (Hz)
system configuration	1 phase, insulated
insulation coordination	according to IEC 60071-1 and IEC 60071-2

3.22 LOW VOLTAGE AC AND DC

The following basic technical values have been determined in accordance with the existing installations:

nominal system voltage	400/230 V, 50 Hz
voltage variation max.	$\pm$ 5%
system configuration	3 phase, 4 wire
test voltage	2,5 kV (1 min.)

3.23 CONTROL AND PROTECTION SYSTEM

nominal measuring voltage	110 V AC
nominal measuring current for 110 kV and above	1 A
nominal measuring current for 35 kV and under	5 A
auxiliary voltage DC	110 V
auxiliary voltage DC	24 V
auxiliary voltage AC	400/230 V, 50 Hz

4. EQUIPMENT REQUIREMENTS

4.1 STRUCTURES

4.1.1 Design of Structures

The circuit breakers, disconnectors will be mounted on a steel support. The design and construction of these equipment supports shall conform to the Technical Specification for Structural Steel and Iron Work.

The structures shall be designed to give at least the required minimum phase to earth and insulation height clearances, for all associated equipment and connections and shall be equipped with flag holders and appropriate fixtures for roping off equipment during maintenance, the location of these shall be to the approval of the Employer.

4.1.2 Construction

The compression members of steel structures shall consist of rolled steel sections and the tension members of rolled steel sections or flats.

All members, bolts and nuts and all fittings shall be galvanized in accordance with these Specifications.
Means shall be provided for fixing and bonding copper conductors to the steelwork at sufficient points to obtain efficient earthing. Earth connections shall be made to a vertical face, clear of the ground and foundation bolts shall not be used for their attachment.

4.1.3 Material

All rolled steel sections, flats, plates and bolt and nut bars used shall consist of steel manufactured by open hearth process. There shall not be inferior in strength or quality to the requirements of the relevant standards, the provisions of which, in respect of tests and analyses, shall be extended to include steel less than 6 mm thick. The steel shall be free from blisters, scales, laminations or other defects. Steel sections shall be to Metric Standard chosen with a view to avoiding in obtaining material.

4.1.4 Workmanship

All members shall be cut to jig and all holes shall be drilled or punched to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position, the holes will be truly opposite to each other before being bolted up. Drifting or reaming of holes will not be allowed. All burrs shall be removed before galvanizing.
The drilling, punching, cutting, bending and welding of all fabricated steelwork shall be carried out before galvanizing and shall be such as to prevent any possibility of irregularity occurring which might cause difficulty in the erection of the supports on the Site.

4.1.5 Terminals

HV terminals should be provided with connectors for "Horizontal" or "Vertical" aluminium conductor and the grounding terminal should be provided with a connector for stranded bare copper cable.

4.1.6 Insulator

Insulators shall be made of porcelain of brown colour.

4.1.7 Corrosion Protection and Painting

The corrosion protection and painting shall meet requirements stated in Volume 3, Section 2.
External surfaces shall be treated with anticorrosive and water-resistant paint and internal surfaces with water-resistant anti-condensation paint.
In any case the manufacturer shall submit for approval the proposed painting coats with their chemical content and recommended application guide of the manufacturer.
The equipment must be so designed that any features, which may encourage the formation of rust, are avoided.

4.2 110 KV SWITCH PLANT

The 110 kV switch plant will be an H-type with additional cross connection. The H coupling will make part of the 110 kV overhead lines loop. The outgoing feeders to traction transformers will be two-pole.
In order to save room, the proposed outdoor-type 110 kV switch plant will consist of two SF6-insulated 110 kV enclosed modules. The busbars and mutual connections of all HV devices will be provided by an AlFe rope. Cross connection between switch plant parts can be also insulated with SF6 gas.

4.2.1 Gas Insulated Switchgear

Current transformers combined and double combined disconnectors with earthing switches and power breakers will be encapsulated in two modules. Both the outgoing feeders to traction transformers and the transformers themselves will be two-pole.
The various devices will be controlled from the section control box, by the station control system. When the control system will have been modified, the H coupling can as well be controlled from the power distribution control centre.
Three pole gas insulated modules will consist of following parts:

- input disconnectors and disconnectors with an earthing knife,
- current transformers,
- circuit breakers,
- output disconnectors and disconnectors with an earthing knife.

4.2.1.1 Local Control Cabinet

All auxiliary electrical components for control, signalization, interlocking, etc. shall be located in separate on-site control cabinets. The main functions of the local control cabinet will be:

- local operation and visualization of the switching status by control buttons and position indicators,
- protection of operators and switchgear by realization of interlocking functions,
- acquisition and visualization of operational measurement values (voltage, current),
- visualization and handling of alarms, warnings and operation counters.

On the front panel of the control cabinet, the single line diagram of the switchgear with embedded position indicators and related control buttons shall be displayed. Key switches shall be in place for overriding the interlocking of switching devices, or for switching over from local to remote control.
The HV switching devices shall be connected to the control cabinet by control cables with coded heavy duty connectors. Inside the control cabinet, all signals to the station control centre shall be fixed on terminal blocks. The connection is realized by control cables.

4.2.2 Air Insulated Switchgear

The two-pole part with circuit breakers and disconnectors for additional cross connection will be of classical outdoor air insulated type. The two-pole classical air insulated parts will consist of:

- circuit breakers,
- single-conductor 110 kV cables between 110 kV feeder bays and traction transformers incl. cable heads,
- protective surge arresters,
- current transformers,
- voltage transformers.

4.3 INSTRUMENT TRANSFORMERS - VOLTAGE TRANSFORMERS

4.3.1 General Design

The voltage transformers shall be single-phase, oil-immersed for outdoor installation, hermetically sealed type. They shall comply with IEC 60044-2, IEC 60186 and other relevant IEC standards unless otherwise required in these Specifications.
The voltage transformer shall be composed of a sealed housing for cores and primary and secondary winding conductors, supported by a porcelain insulator and pedestal along with secondary leads, insulation and low voltage connection box.
The following facilities shall be provided:

- expansion chamber and diaphragm. This shall be by means of an internal bellows type oil gauge,

- oil level indicator for a visual means of determining the level of oil from the ground level within the transformers,
- oil drain cock and sampling device located at the base of the tank, where applicable,
- low voltage terminal box,
- earth terminal should be designed for the cable of 120 mm^2 so arranged that the earth connection cannot be inadvertently removed.

The voltage transformers shall feature the following accuracies:

- class 0,2 for tariff metering,
- class 0,5 for protection.

The voltage transformers shall have a secondary terminal, outside the high voltage housing, mounted in suitable accessible earthed boxes with a hinged door and a removable plate in the outside bottom of the box for cable entry. The secondary connections must be protected with m.c.b. and wired on the terminal strip in the relay building. The m.c.b. shall be located in the local box of the middle phase of the voltage transformer. Each terminal box is to be equipped with the thermostatically controlled heating element as well.
Each voltage transformer secondary winding circuit shall be earthed at one point only. A separate earth link shall be provided to each secondary winding.
The base tank or pedestal shall be made of metal, shall be of waterproof and hermetically sealed construction and shall support rigidly the transformer unit.
The HV terminals shall be provided with connectors for horizontal or vertical connections as per Technical Data Schedule.
The Contractor shall design the voltage transformer protective core so as to meet the transient performance requirements related IEC 60044-6 standard. The Tenderer shall submit, along with de drawings for approval, a calculation brief establishing proper sizing and characteristics of the cores.

4.4 INSTRUMENT TRANSFORMERS - CURRENT TRANSFORMERS

4.4.1 General Design

The current transformers shall be single phase for outdoor installation, oil-immersed, multi-core, hermetically sealed type. They shall comply with IEC 60044-1 and other relevant IEC standards if not otherwise required in these Specifications.
The current transformers shall be composed of a sealed housing for the cores and primary and secondary winding conductors, supported by a porcelain insulator and a pedestal along with secondary leads, insulation and low voltage connection box.
The following facilities shall be provided:

- expansion chamber and diaphragm. This shall be by means of an internal bellows type oil gauge,
- visual means of determining the level of oil from the ground level within the transformers,
- oil drain cock and sampling device,
- low voltage terminal box,
- earth terminal should be designed for the cable of 120 mm^2 so arranged that the earth connection cannot be inadvertently removed.

The current transformers shall feature the following accuracies:

- core I, class 0,2 for tariff metering,
- core II, class 0,5 for measuring.

The current transformers shall have a secondary terminal, outside the high voltage housing, mounted in suitable accessible earthed boxes with a hinged door and a removable plate in the outside bottom of the box for cable entry. All secondary leads must be wired to shorting type terminals on the

terminal strip in the relay building, as well. The low voltage terminal shall be provided with voltage limiting device.
Each current transformer secondary winding circuit shall be earthed at one point only. Wherever possible, the connection to earth shall be at S2 terminals.
The base tank or pedestal shall be made of metal, shall be of waterproof and hermetically sealed construction and shall support rigidly the transformer unit.
The HV terminals shall be provided with connectors for horizontal or vertical connections.
The Contractor shall design the current transformer protective cores so as to meet the transient performance requirements IEC 60044-6 standard. The Tenderer shall submit, along with de drawings for approval, a calculation brief establishing proper sizing and characteristics of the cores.

4.5 CIRCUIT BREAKERS

4.5.1 General Design

The circuit breakers shall be outdoor type.
The circuit breakers shall comply with the requirements of IEC 60265, IEC 60273, IEC 694, IEC 815, IEC 62271-100 and other relevant IEC standards if not otherwise required in these Specifications.
Beside the rated short circuit breaking current, the circuit breakers shall be capable of making and breaking the excitation current, including inrush current of the transformer and purely charging current without restricting and generating harmful over-voltage.
The circuit breakers with two breaking chambers shall be constructed to provide voltage distribution per breaking unit not above 55 % of the total voltage, and the attached capacitors shall feature such values that significant capacitive currents would not occur even in the worst case.
External parts of the circuit breakers, which are under continuous electrical stress, shall be made of porcelain.

4.5.2 Operating Mechanism

The operating mechanism shall be of motor wound-spring charged type.
The motor shall be of maintenance-free type.
However, the operating mechanism of new generation (“state-of-the art”), which could guarantee the same or better performances than a motor wound-spring charged type, might be proposed, subject to acceptance by the Employer.
If a motor wound-spring charged type is being used, it shall be possible to charge the operating springs with the circuit breaker in either the open or closed position. In normal operation, recharging of the operating springs shall commence immediately and automatically upon completion of the closing operation. Closing, while a spring charging operation is in progress, shall be prevented, and the release of springs shall not be possible until they are fully charged.
A manual spring release shall be provided.
The operating mechanism shall possess have a hand-charging feature and it will be possible to discharge operating springs on Site from a charged condition without difficulty.
The state of charge of the operating springs shall be indicated by a mechanical device which shows "spring charged" when operation is permissible and "uncharged" when operation is not possible. Also, a provision shall be made for remote indication of "spring charge fail" conditions. Therefore, a spare spring-drive limit switch contacts and necessary time delay relays shall be provided.
In case of a pressure drop in the SF6 system (pressure drop under level S1), a provision for alarm shall be obtained.
However, if the pressure drops in any of the single-phase circuit breakers under level S2, a provision to open automatically all three poles of the circuit breaker and block the circuit breaker's any further operations, shall be obtained.

In case of inadmissible pressure drop in the SF6 system (pressure drop under level S3), a provision to block the circuit breakers any further operations, shall be obtained.
The control circuits shall be connected to the DC supply coming from the control and protection panels and from the DC distribution panel respectively. However, the charging motor shall be connected to the AC supply from the AC distribution panel.

4.5.3 High-Speed Reclosing

The circuit breakers shall be constructed for high speed re-closure of the two poles simultaneously or of a single pole at a time, as per the Technical Schedules which also provides the operating cycle times and breaking capacity to be met during this operation. Reclosing applies only to circuit breakers used for the transmission line feeders.
The operating mechanism shall be suitable for auto-reclosing (cycle 0 – 0,3 s - CO – 3 min – CO). After a loss of power supply, the operating mechanism shall be capable of performing a complete cycle.

4.5.4 Control Circuits

4.5.4.1 Conditions for Operation

Circuit breakers shall be equipped with two electrically independent trips and one close coil per phase. The close coil shall be supplied with anti-pumping devices. The trip coils shall be suitable for application of trip circuit supervision relays. Means shall be provided to prevent the mechanism from responding to a close signal when the trip coils is energized. The commands shall be single-pole (in the “plus” side only).
The circuit breaker shall be designed and equipped with, at least, the following control devices:

- open and close push buttons,
- local/remote selector,
- a maintenance switch lockable in the neutral position. In the "maintenance" position, remote open/close control and protection tripping shall be disabled. Selection of this position shall be indicated on the remote control panel with an alarm – "protection out of service". Closing of a circuit breaker with "maintenance" position selected depends upon the adjacent isolators of the pertaining bay being in the open position. Suitable interlocks shall be provided to satisfy this requirement;
- a manual emergency trip device suitable for operation in event of failure of electrical supplies. The device shall be distinctly labelled and protected against inadvertent operation.

The circuit breaker shall be equipped with an amenity for manual operation for maintenance purposes.
The control circuits shall be designed to operate under the following conditions:

- remotely, from a control centre,
- remotely, from the substation control building,
- locally, by electrical push buttons,
- automatically, by protective relays,
- locally, by a manual operating push buttons.

Each pole of the HV line feeder circuit breakers shall have, its own distinct, an operating mechanism with the controls grouped in a central control cabinet where all the electrical functions will be performed.
The 110 kV circuit breakers for traction transformers may be with a single mechanism for two-pole operation that could include all controls devices in the same enclosure as the mechanism as per the Technical Schedules.

4.5.4.2 Design Criteria for the Control Circuits of HV Circuit Breakers

Control circuits shall be designed taking into consideration the following points:

- the circuit assigned to the reclosing coil and the first tripping coil shall be separate from the circuit assigned to the second tripping coil. This means that there are two different DC supplies. The supply of the two circuits will come from separate feeders located in the panels of the control building;
- the power supply for the motor operated mechanism and for the control circuit supply are to be protected by moulded circuit breakers;
- the contacts of the spring limit switch and SF6 gas density monitor associated with the first tripping coil shall be different and independent from those of the second tripping coil. If a single repeating under pressure relay is used, separate relay contacts for each of the tripping coils shall be provided;
- the motor circuit shall be protected by moulded circuit breakers. The manufacturer shall insure coordination of the protection device with the upstream feeder protection;
- protective tripping of the circuit breaker by use of coils 1 and 2 shall not be blocked by the selector switch "Local/Remote";
- an alarm contact shall be provided to signal a longer than usual time for spring charging. This circuit shall be realized by means of a limit switch contact and a timing relay;
- a three-position "Manual/Local/Remote" selector switch shall be provided in the central control cabinet;
- a manual operating crank for each circuit breaker mechanism shall be provided;
- "Close-Trip" push buttons shall be provided in the central control panel and in each individual pole mechanism;
- the mechanism cabinet and the central control panel shall be a weatherproof enclosure with pad lockable hinged doors and a removable bottom access plate used to support the incoming control, protection and power supply cables;
- a heating element and thermostat, along with a 230 V outlet and an interior light shall be provided;
- the terminal blocks will be installed on asymmetrical rails. The terminal block arrangement and identification shall be strictly in accordance with the Technical Specifications;
- the wiring shall be polymeric fluoride insulated stranded tinned copper conductors with a minimum section of 2,5 mm^2;
- the wires shall be of the various colours;
- test switches for power supply and control circuits shall be provided;
- a time delayed adjustable alarm contact for "phase discrepancy" condition shall be provided;
- this is only applicable to two phases circuit breakers with single pole mechanisms.

4.5.4.3 Auxiliary Contacts

The manufacturer shall provide, for each mechanism, a sufficient number of normal-close and normal-open mechanically operated auxiliary switches. In addition, at least four spare contacts of each kind shall be provided.
Where any particular scheme requires special timing of auxiliary contacts, these shall be provided.

4.5.4.4 Position Indicator

A visual, mechanical, circuit breaker “Open-Closed” position indicator clearly visible from the ground level and without the opening of any access door, shall be provided. It shall be positively driven (cord drives excluded) directly from the mechanism.

4.5.5 Operating Counter

Each operating mechanism is to be equipped with an operation counter.

4.5.6 SF6 Gas System

The SF6 gas system shall include the followings:

- temperature compensated SF6 density relay with lock-out-trip and alarm contacts,
- gas filling device,
- gas sampling device,
- density indicator and
- filter for SF6 decomposition by-products and humidity.

4.6 DISCONNECTORS

4.6.1 General Design

The disconnectors shall be double-column centre-brake outdoor type. The disconnectors shall comply with the requirements of IEC 60265, IEC 60273, IEC 60694, IEC 60815, IEC 62271-102 and other relevant IEC standards if not otherwise required in these Specifications.
The disconnectors shall be designed for rated currents. They shall be able to interrupt the capacitive charging current of the substation.
External parts of disconnectors which are under continuous electrical stress, shall be made of porcelain.

4.6.2 Operating Mechanism

The operating mechanism shall be of motor-operated type with a facility for emergency manual operation. An emergency manual operating device shall be placed in a readily accessible position. The emergency manual operation must be possible in operation inoperative (mechanically disconnected). Motor shall be of maintenance-free type.
The drives of both two poles of one disconnector shall be coupled to ensure synchronised switching.
It must be possible to mechanically block and padlock the disconnector in either operating position.
The operating mechanism shall be complete with local/remote selector switch and open and close push-buttons.
Electrical bolt interference interlocks shall be provided and energized in the case of hand operation, only when the operating handle of the hand mechanism is brought into the working position. Visible indication shall be provided, normally locked, whereby the bolt can be operated in the event of loss of auxiliary supply.
The operating mechanism housing shall be provided with anti-condensation heating. The degree of protection of the operating mechanism housing should be at least IP 54.

4.6.3 Control Circuits

4.6.3.1 Conditions for Operations

The disconnectors shall be equipped with motor operating mechanism with a facility for emergency manual operation.
The disconnectors shall be designed and equipped with, at least, the following control devices:

- open/closed push buttons,
- local/remote and manual/electric selector switches,
- open/closed interlocked contactors,
- a maintenance switch lockable in neutral position. In the "maintenance" position remote open/close control shall be disabled. Closing of the disconnectors with "maintenance" position selected depends on the adjacent circuit breaker being in the open position. Suitable interlocks shall be provided to satisfy this requirement;
- test and limit switches,

- a manual emergency trip device suitable for operation in the event of failure of electrical supplies. The device shall be distinctly labelled and protected against inadvertent operation.

The disconnectors shall be equipped with a facility for manual operation for maintenance purposes.
The control circuits shall be designed to operate under the following conditions:

- remotely, from a control centre,
- remotely, from the substation control building,
- locally, by electrical push buttons,
- locally, manually by means with a crank which shall be inserted in an opening of the motorized mechanism to access the reduction gear coupling.

4.6.3.2 Design Criteria for the Control Circuits

- The power supply for the motor operated mechanism and for the control circuit supply are to be protected by molded case circuit breakers;
- The motor circuit shall be protected by molded case circuit breakers. The manufacturer shall insure coordination of the protection device with the upstream feeder protection;
- A manual operating crank for each mechanism shall be provided;
- "Close-Open" push buttons shall be provided in each individual pole mechanism;
- The mechanism cabinet shall be a weatherproof enclosure with pad lockable hinged doors and a removable bottom access plate used to support the incoming control, protection and power supply cables. A heating element and thermostat, along with a 230 V outlet and an interior light shall be provided;
- The wiring shall be polymeric fluoride insulated stranded tinned copper conductors with minimum section of 2,5 mm^2;
- The wires shall be of different colours.

4.6.3.3 Auxiliary Contacts

The manufacturer shall provide, for each mechanism, a sufficient number of normal-close and normal-open mechanically operated auxiliary switches. In addition, at least four spare contacts of each kind shall be provided.
Where any particular scheme requires special timing of auxiliary contacts, these shall be provided.

4.6.3.4 Position Indicator

A visual, mechanical disconnector “Open-Closed” position indicator connected directly and permanently to the drive mechanism and clearly visible from the ground level and without the opening of any access door, shall be provided. Cord or chain drivers are excluded.

4.7 110 KV CABLE HEADS

The cables will be terminated by cable heads and surge arresters mounted on steel supports. The cable heads will be:

- outdoor, for insulated type of conductor, with total creepage distance 2 850 mm.

Upon laying the cables and prior to their commissioning, the line will be submitted to model tests. The model tests are performed by an authorised entity. Total earthing resistance and model short circuit of the line will be measured. Depending on the test results, a set of precautions will be defined for safe operation of the cable lines.

4.8 SURGE ARRESTERS

The surge arresters shall be outdoor type. The surge arresters will be suitable to protect 110 kV cable sheath against tensions in the sheath induced by normal or short-circuit currents.

4.8.1 Operating Counter

Each surge arrester is to be equipped with an operation counter.

4.9 TRACTION TRANSFORMERS

4.9.1 General Design

The traction transformers shall be of oil-immersed, single-phase type with on-load tap changer for outdoor mounting. They shall comply with the requirements of IEC 60076-1, IEC 60076-2, IEC 60076-3, IEC 60076-4, IEC 60076-5, IEC 60214, IEC 60551 and other relevant IEC standards if not otherwise required in these Specifications.
The traction transformers and associated equipment shall be designed so as to meet the properties required in this Technical Specification at ambient site conditions.
The traction transformer shall meet state-of-the-art requirements concerning design, construction and materials.
The traction transformer and all associated amenities (e.g. tap changer) shall be able to withstand the effects of short-circuit currents, defined as symmetrical short circuit current, when operating in any tapping position according to the requirements of IEC 60076-5.
All metal parts of the traction transformers, with the exception of the individual core laminations, core bolts and associated individual side plates, shall be maintained at the same fixed potential. The earthing structure shall be designed to carry, without damage, the maximum possible earth fault current for duration at least equal to the short circuit period of the main windings.
The design and manufacture of the traction transformer and auxiliary plant shall be such that the noise level is at a minimum and that the level of vibration does not adversely affect any clamping or produce excessive stress in any material.
Noise measurements shall be made at the manufacturer's facilities in the presence of the Employer. The average surface noise level of each transformer shall not be greater as in typical installations.
The traction transformers shall be designed with particular attention to the suppression of harmonic currents, especially the third and fifth, so as to minimise interference with communications circuits.
The traction transformers shall be designed so as to ensure that the leakage flux would not cause overheating in any part of the transformers.

4.9.2 Core

The traction transformer core should be designed with substantial knowledge of state-of-the-art equipment requirements and technologies.
The core shall be built up of high-grade, non-ageing, low-loss and high-permeability steel sheets. Both sides of each steel sheet shall be insulated by a durable, hot oil and heat resistant baked enamel varnish or other chemical treatment. The steel sheets shall be of thin lamination.
The cores shall be clamped and braced to withstand, without damage or deformation, the forces caused by short-circuit stresses, transportation, or handling, and to prevent the shifting of the core laminations. The bolts, nuts and end plates of the assembly and clamp structure shall be of a non-magnetic type, and shall be effectively insulated and locked so that they ensure an even pressure on the whole core assembly and are not loosened by vibrations caused by transport and operation. The supporting framework of the cores shall be designed to avoid the presence of pockets, which could prevent complete draining of the tank or cause the trapping of air when filling during service.
Suitable axial cooling ducts shall be provided to ensure free circulation of oil and efficient cooling of the core. The ducts shall be so dimensioned that the maximum temperature at any point remains within the admissible limits.
Particular care shall be given to the design and construction of the corner joints between columns and yokes to avoid concentration of mechanical and magnetic stresses whilst allowing an easy dismantling of the joint for maintenance at site.

Adequate metallic bridges shall be provided between the core lamination packets in order to keep all portions of the core assembly at the same potential.
Lifting eyes or lugs shall be provided at suitable points of the core assembly.
The core shall be earthed at one point only with a removable connection, readily accessible from outside through an appropriate manhole, made in such a way that it can be easily opened to test the core insulation without draining oil.
The core shall be free from over fluxing liable to cause damage or to cause malfunction of the protection equipment when operating under the continuous overvoltage conditions specified in the Technical Schedules. Under this steady overvoltage condition, the magnetising current must not exceed 5 per cent of the rated load current at nominal rated voltage.

4.9.3 Windings

The windings shall be of high conductivity electrolytic copper of 99,9% purity, insulated by paper made of pure cellulose.
The conductors shall be transposed at sufficient intervals to minimize eddy currents and equalize the current and temperature distribution along the winding. Coils shall be constructed to avoid abrasion of the insulation, (e.g. on transposed conductors), allowing for the expansion and contraction set up by changes of temperature or the vibration encountered during normal operation.
Windings shall be designed so as to obtain an optimal value for series and shunt capacities in order to have a favourable distribution of the voltage for full waves and chopped waves.
Leads from winding to bushings shall be adequately supported to prevent injury from vibration and short-circuit forces.
Permanent current-carrying joints or splices shall be welded or braced, properly formed, finished and insulated to avoid concentration of dielectric stresses.
The windings shall be subjected to a thorough shrinking and seasoning process. Adjustable devices shall be provided for taking up any possible shrinkage of coils in service.
The coils, windings and leads shall be sufficiently braced and fastened to form rigid assemblies, preventing any relative movement due to transport, vibrations or other circumstances that may occur in service.
The windings shall be designed to reduce to a minimum the out-of-balance forces inherent in the transformers. Tappings shall be arranged at such positions on the windings as will preserve, as far as possible, electro-magnetic balance at all voltage ratios.
The tappings shall not be brought out from the inside of a coil or from intermediate turns.
The assembled core and windings shall be dried in a vacuum to ensure proper moisture removal.

4.9.4 Tank

The traction transformer tank shall be of “cover” design, fabricated from high tensile strength steel plate.
The tank shall be of adequate strength so that, when containing the core plus coil assembly and fully oil filled, any packing, lifting, rolling and handling shall not cause overstressing of any part of the tank or any leakage of oil or gas. The main tank body, tap changing compartments, radiators and associated piping amenities shall be capable of withstanding full vacuum when empty of oil.
The tank shall be absolutely watertight and hot-oil tight, and be suitably braced to withstand, without distortion or buckling, the stress imposed during transport and operation. The gasket and welded joints adhered to hot oil with temperature of 100°C shall be designed to obtain the full sealing of the transformer tank.
The tank shall be provided with a minimum of four jacking pads conveniently located to allow the raising or lowering of the completely mounted and oil filled transformer. The load carrying capacity of each jacking pad shall not be less than 50% of the total weight of the transformer. Lifting eyes or lugs for lifting the complete transformer and tank cover and amenities for the pulling and pushing of

the transformer in any direction shall be provided. Tank stiffeners and mounting brackets shall be continuously welded to the tank.
The movement of the transformer shall be achieved by a set of wheels. The change of the direction shall be made after lifting the transformer.
The traction transformers, when erected, will be left standing on their wheels. The wheel blocking devices necessary to fix the position of the transformer shall be supplied together with the transformers, and shall be designed to withstand seismic forces acting upon the transformers.
Wherever possible, the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 20 mm and, if necessary, shall be protected against mechanical damage.
The shape and arrangement of the tank cover and external stiffeners shall permit rain water to flow easily and completely to the ground.
All oil-tight joints shall be made with machined flanges and approved types of gasket.
The gaskets shall be tight under all conditions; especially against the hot oil (synthetic rubber or neoprene-bonded cork will be preferred). Means shall be provided to prevent over-compression of the gaskets.
The tank shall be provided with bolted type manholes for easy inspection of all bushings and windings.
The transformer shall be fitted with the thermometer pockets, for oil and winding temperature indicators, with a captive screw cap and be located in the position of maximum oil temperature at continuous maximum rating.
A pressure relief device of self-resetting type and sufficient size capable of functioning without electrical power, shall be provided for the rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment, but it shall be capable of maintaining the oil tightness of the transformer under all conditions of normal service. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tanks and shall be designed to prevent further oil flow from the transformer during its operation.
The relief device shall be mounted on the main tank and if mounted on the cover, it shall be fitted with a skirt projecting inside the tank to prevent an accumulation of gas within the device. Two sets of contacts shall be provided to initiate the alarm and trip relays.
Terminals shall be provided close to each corner at the base of the tank for earthing purposes and each shall be designed to meet system fault levels.

A name plate and cooling system plate with the specified by IEC 60076 shall be fixed to the transformer tank at an approximate height of 1,75 m above the ground level. The plates shall be in Montenegrin language and are subject to the approval of the Employer.

4.9.5 Valves

Valves shall be of the fully sealing full-way type and shall be opened by turning counter-clockwise when facing the hand-wheel. They shall be suitable for operation between the minimum ambient and the maximum oil temperatures stated in the Technical Schedules. Valves other than filter and drain valves shall be provided with an indicator, readily visible from ground level, to show clearly the position of the valve. The valves should be placed so as to be easily accessible.
The transformer tank shall be fitted at least with the following:

- one 50 mm valve at the top and one 50 mm valve at the bottom of the tank, mounted diagonally opposite each other, for connection to oil circulating and oil filtering equipment. Both of these valves shall also function as a drain valve;
- an oil sampling device at the top, middle and bottom of the main tank (for gas chromatographic analyses, as well);

- all parts containing oil, and liable to trap air during filling, shall be fitted with a flanged type air release plug at their highest points.

4.9.6 Conservator

The conservator shall be made of welded steel. It shall be designed to withstand full vacuum. The conservator shall be of sufficient volume to enable expansion and contraction of oil within the highest and lowest oil levels in the conservator.
The conservator vessel shall be mounted at the highest point of the oil system and shall be connected to the highest point of the tank through a straight sloping pipe. Adequate isolating valves shall permit the removal of the Buchholz relay while the conservator is still connected to the tank by a pipe by-passing the relay.
The conservator vessel contains two compartments, one for oil in the main tank and the other for the oil associated with the current making and breaking contacts of the tap change equipment. There shall be no communication between the two compartments in respect of the oil and air spaces. Each compartment shall be provided with the fittings as detailed in this Clause.
For each conservator, a synthetic diaphragm ensuring an airtight seal shall be provided. A description of the proposed system shall be submitted with the Design. An inspection windows shall be provided for checking the diaphragm surface. Additionally, the air outlet from each conservator vessel or its compartment shall be connected to a dehumidifying breather.
Transformers shall be provided with automatic repetitive cycle-type breathers. Where silica gel type breathers are used on traction transformers, they shall be of a modular design, coupled as necessary to give the required capacity. The breather and associated pipework shall be firmly fixed to the transformer tank.
Each conservator compartment shall be equipped with a filling valve, a drain valve, lifting lugs, etc. A magnetic oil level gauge shall be used for alarm purposes. The oil levels at 10°C, 40°C and 90°C shall be marked on the gauge to be clearly visible from ground.

4.9.7 Transformer Oil

The transformer oil shall comply with IEC 60296 and other relevant IEC standards if not otherwise stated in this Tender Document. The oil shall be a highly refined mineral oil suitable for use as an insulating and cooling medium in transformers.
The transformer oil shall be free of synthetic additives of all types and shall be inhibited.

4.9.8 Cooling Plant

Oil-immersed natural cooling, not less than 60% rated power, ONAN/ONAF cooling shall be used for the transformers. However, should the manufacturer conclude that this type of cooling system is not sufficient for a proper and effective cooling of 10 MVA transformers, taking into consideration the purposes of these transformers as well as climate conditions, they may propose a more efficient cooling system which will be subject to Employer investigation and approval.
Coolers shall be hot dip galvanized or painted by zinc-oxide paint. Their design shall be such as to allow ease of cleaning and painting when in position.
A minimum of two independent groups of cooler banks shall be provided for the transformers.
Cooling shall be arranged in such a manner that the loss of one cooling assembly does not cause the temperature to rise above permissible values.
The coolers shall be supplied with several valves and pipework amenities:

- a valve at each point of connection to the transformer tank,
- plugs at the top and bottom of each radiator for filling and draining,
- shut-out valves at the top and bottom connections of each cooler to permit removal of the cooler under service conditions,

- oil filtering valves 50 mm at the top and the bottom of each cooler, the bottom valve shall also function as a drain valve,
- a thermometer pocket with a captive screw cap on the inlet and outlet oil branches of each cooler.

A complete set of loose blanking plates to suit the blanking of all the openings on the transformers, including the openings for bushings, radiator and cooler connections to the main transformer tank, opening for the pipes, etc., shall be supplied complete with gaskets and delivered to Employer stores. All flange joints, which are separated from the main transformer tank by gaskets, shall be connected thereto via adequately rated copper earthing connections.
Where forced air cooling is provided it shall be possible to remove the fan, complete with its motor and supporting structure without disturbing or dismantling the cooler framework or pipework.
The fans shall not be mounted directly on the radiator fins or radiators themselves. The fans shall be numbered and have clearly marked their direction of rotation.
Stainless steel wire mesh guards shall be provided to prevent accidental contact with the fan blades. Metal guards shall also be provided over all other moving parts. The guards shall be designed so that a Standard Test Finger to IEC 60947-1 can touch neither the blades nor other moving parts.
Each motor or group of motors shall be provided with a three-pole electrically operated contactor and control gear of approved design for the manual start and stop. A provision shall be included for automatic starting and stopping initiated from a contact of the winding temperature indicating device. Where small motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring on a single motor. All contacts and other parts, which may require periodic renewal, adjustment or inspection, shall be readily accessible.
Motor-driven air fans and oil pumps shall be designed for 400/230 V AC and shall be properly operating at a voltage variation from -15% up to +10%.

4.9.9 Voltage Control

The transformers shall be equipped with an on-load tap changer placed at the neutral point with the possibility of voltage regulation under load. The on-load tap changer shall comply with the requirements of IEC 60214 and other relevant IEC standards if not otherwise required in these Specifications. It shall be suitable for power flow in both directions.
The diverter switch unit shall be placed in a separate gas tight compartment, which shall be, like the whole tap changer, integrated in the transformer tank (in-tank mounting). The diverter switch shall have an oil system completely separated from other transformer's oil and shall be equipped with a conservator, pressure relief device with trip contacts and other devices stated for the main tank. A separate gas actuated relay is to be provided in the connection between the on-load tap changer tank and conservator.
The diverter switch compartment shall be easily accessible for inspection and it shall be possible to remove the diverter switch without difficulties for maintenance purposes. The inspection and maintenance of the diverter switch shall be possible without lowering the oil level in the main tank. Four sets of lifting tackle shall be supplied to facilitate removal of the tap changer unit. Necessary attachment amenities shall be incorporated in the main tank design.
Any enclosed compartment not oil-filled shall be adequately ventilated and designed to prevent the ingress of vermin. All contactors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation.
The Contractor shall be obliged to supply devices for indication of tap changer positions in the control room, as well as all equipment necessary for remote selection of the regulation, control and signalisation from the control room, as well.
Means shall be provided to ensure that the operating mechanism can be locked only when the switches are making full contact.

The driving motor shall be rated for 400/230 V AC and shall be equipped with thermal and overload protection to be installed in the motor drive cubicle. Limit switches shall be provided to prevent the tap changer mechanism from overrunning. These shall be directly connected to the operating motor circuit. In addition, mechanical stops shall be fitted to prevent the mechanism overrunning under any conditions. For on-load tap changer equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap changing equipment. The terminals of the operating motor shall be clearly and permanently inscribed with numbers corresponding to those on the leads attached thereto.
A device shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.
The tap changer shall be arranged for local hand and electrical operation, remote electrical operation and for automatic control.
Equipment for local and remote electrical and local hand operation shall comply with the following conditions:

- it shall not be possible to operate the electric drive when the hand operating gear is in use,
- it shall not be possible for any two electrical control points to be in operation at the same time,
- each step movement shall require separate initiation at the control point,
- all electrical control switches and the local operation gear shall be clearly labelled in an approved manner to indicate the direction of tap changing,
- the remote or supervisory-remote raise/lower control shall be blocked when the AVC selector is in on "automatic" position,
- the local control switches shall be housed in the marshalling kiosk. These switches shall be so arranged that it is necessary for the AVC selector to be in a non-automatic position and the "local/remote" selector switch, located in the transformer marshalling kiosk, to be in the "local" position before operation is possible. Under these conditions, the local selector switch shall have overriding control. If the "local/remote" switch is not in "local" position, then local operation of tap-changer shall not be possible.

The equipment shall be arranged so as to ensure that when a step movement has been commenced it shall be completed independently of the operation of the control relays or switches or failure of auxiliary supply or any other contingency.
The control and signalling equipment shall be provided:

- to give an indication mechanically at the transformer and electrically at the remote control point of the tapping in use. The indicator at the transformer shall show the number of tapping in use and the indicator at the remote control point shall show clearly the actual voltage ratio in kilovolts and the tap number representing this ratio. The numbers shall range from 1 upwards. Adjacent taps shall be numbered consecutively in such a manner that, when moving to a new tap position having a higher number, the no-load voltage of the untapped winding shall increase;
- to read with digital circuit voltmeter based on L.C.D. displays.

4.9.10 Bushings

The transformers shall have bushings with terminal connections compatible for the type of connection.
The 110 kV side of transformer shall be equipped with glazed porcelain bushings of oil filled condenser type preferably of the draw lead type to facilitate removal, equipped with the following accessories:

- oil filling plug and drain valve if not hermetically sealed,
- tap for capacitance test (tan δ measurement).

The 27 kV side of transformer shall be equipped with glazed porcelain bushings.

The bushings shall be capable to withstand all the voltage, thermal and mechanical stresses including partial discharges to IEC 60137 and IEC 60270.
The transformer and bushing design shall enable each applied bushing to be changed without dismantling of the cover of the transformer. The revision window for each cover of the bushings should be provided.
The bushing castings shall be free from blowholes, surface blisters, cracks and cavities and all sharp edges and corners shall be blurred and rounded off. All ferrous parts shall be hot dip galvanized.
The terminals and all other current carrying parts shall be designed and manufactured to have minimum contact resistance. The terminals shall be cooper made and silver plated. The bushing connections shall be designed to reduce the effect of corona and radio interference to the minimum.

4.9.11 Protection, Measuring and Indicating Devices

The transformers shall be equipped with several protections, measuring and indicating devices supplied by the transformer manufacturer:

- a Buchholz relay shall be fitted to the transformer main tank, and on each compartment where oil is separated from the other oil in the transformer.

Diverter switch chambers shall be equipped with a gas or oil actuated relay.
They shall feature:

- alarm contacts which close when gas collects or at low oil level,
- tripping contacts, which close following an oil surge, and gas collection in the 2nd stage.

The normally open, electrically separated, alarm and tripping contacts shall not be exposed to oil.
Winding temperature indicators separated for the series and common windings shall be associated.
One indicator shall basically serve as a thermometer for winding temperature, mounted in the control cubicle. It shall be of conventional construction with a sensing bulb positioned in a separate pocket, arranged in the top oil capillary connected with a dial. A separate pointer to register the maximum temperature reached shall be incorporated in the dial. Two adjustable trip/alarm contacts shall be provided.
The second winding temperature indicator shall be preferably of electronic simulated design with adjustable contacts for cooling control, trip and alarm and with mA output suitable for remote and supervisory remote measuring of winding temperature. It shall be connected to the resistance (platinum 100 Ω at °C) inside a stainless steel tube placed in a pocket located in the top oil capillary.
The characteristics of the winding temperature indication devices shall be forwarded to the Employer for approval prior to the delivery of the transformers and shall also be included in the operating and maintenance instructions.

- A dial type oil thermometer with two (alarm/trip) adjustable contacts shall be mounted in the control cubicle. It shall be of conventional construction with a sensing bulb positioned in the separate pocket arranged in the top oil capillary and connected with a dial.
- An oil thermometer, connected to the resistance (platinum 100 Ω at °C) inside the stainless steel tube placed in a pocket located in the oil, suitable for remote and supervisory remote measuring.

4.9.12 Topping Up with Oil and Drying Out on Site

If oil is to be added to a transformer on Site prior to commissioning, the oil in the transformer shall first be tested for dielectric strength and water content and each container of additional oil shall be tested similarly. The Employer or his representative shall witness all tests.
Should it be found necessary to resort to oil treatment before a transformer is commissioned, the Contractor shall submit to the Employer, in writing, a full description of the process to be adopted, the equipment to be used and a statement of the precautions being taken to prevent fire or explosion.

Should a transformer arrive on Site without positive pressure of gas in the tank, it shall be dried out on Site at the Contractor's expense.
Clear instructions in Montenegrin shall be included in maintenance instructions regarding any special precautionary measures, which must be taken before vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand vacuum treatment shall be provided for each type of transformer. The maximum vacuum, which the complete transformer, filled with oil, can safely withstand without any special precautionary measures being taken shall be stated in the Maintenance Instructions.

4.9.13 Control Cubicles

The transformer shall be fitted with a control cubicle of welded galvanized sheet steel housing, mounted on the transformer tank, in a position easily accessible from the ground level. The cabinet shall contain all control and protective equipment for the cooling system, as well as the termination of all secondary circuits.
The internal arrangement of the cabinet shall keep the various circuits clearly separate from each other, permitting easy and safe independent maintenance and repair of each of them without disturbing the others.
Additionally, local control tap changer cubicle shall be provided as required in previous Clauses. All control cubicles shall be of IP 54 degree of protection, weather, vermin and insect-proof with sufficient ventilation and equipped with humidity controlled heating and sufficient illumination switched on and off by door contacts as well as one socket outlet 230 V AC, 10 A.

4.9.14 Corrosion Protection and Painting

The corrosion protection and painting shall meet requirements stated in Volume 3, Section 2.
Conservator vessel, radiators, fan grills, pipework, control boxes or cubicles, marshalling cubicles shall be hot-dip galvanized or painted by zinc-oxide paint or similar.
The proposed method for tank corrosion protection manufacturer shall be submitted for approval.
External surfaces shall be treated with anticorrosive and water-resistant paint and internal surfaces with oil-resistant anti condensation paint.
In any case, the manufacturer shall submit for approval the proposed painting coats with their chemical content and recommended application guide of the manufacturer.
The equipment must be so designed that any features, which may encourage the formation of rust, are avoided.

4.10 25 KV SWITCHGEAR

The proposed 25 kV switchgear system is a single-phase SF6-insulated indoor switchgear. It will be supplied by 110/27 kV traction transformers. The feeders from T1 and T2 transformers will be brought to the R25 switchgear and separated by disconnectors. The various R25 parts will be structured into separate sections which will allow eliminating the scope of the gear failure if there is any (gas leak). The system will contain outgoing-feeder bays to supply the overhead contact line bound to Podgorica, Beograd and Railway Station (RwSt) Trebešica. The outgoing-feeder bays will be separated from the main busbars by power breakers.

4.11 ALTERNATIVE POWER SUPPLY (AUTOMATIC START-UP DIESEL GENERATOR)

4.11.1 General Design

The Diesel generating set shall provide power in case of a grid failure; i.e. its power output shall be designed as a standby set.

The power rating for the generating set shall be selected to ensure that the generating set is not more than 90% loaded when all specified equipment is operating at the same time at maximum capacity at the given power factor and at site conditions.
The number of consumers operating at the same time shall have to be defined for cases of power failure. A starting scenario, as well as a selection of the consumers supplied will be pre-set at SCADA system.
The following equipment/installations shall be able to operate fully and at the same time during a power failure:

- station's control system with accessories,
- terminal for the remote control of section disconnecting switches,
- instrumentation and the PC system,
- building installations,
- lighting system,

The rating and performance shall be in accordance with the ISO, at site conditions:

- rating: Continuous running at variable load for duration of an emergency situation,
- voltage reg.: +/- 5%,
- governing: Electronic type/Class A 1,
- load Acc.: 60 % in one single step and sufficient to run as specified in this clause.

The prime mover and the alternator shall be factory-mounted on a common steel chassis frame with a built-in anti vibration system.
A flexible coupling shall be provided between the alternator and the engine. All piping and electrical connections shall be flexible to prevent damage by movements of the generation set.
A local authorized representation in the country shall be able to provide service and maintenance. The name, address and a list of services and references, as well as the response time shall be provided for the local representation.

4.11.2 Prime Mover

The prime mover shall be a 4-stroke multi-cylinder (preferably a 6-cylinder engine), direct injection industrial standard diesel type according to ISO 8528.
The engine shall be suited for the purpose and shall have a proven record of long life operation with a minimum of maintenance.

4.11.3 Fuel System

The fuel system shall at least include the following:

- fuel storage tank with a capacity for 24 hours continuous operation,
- reservoir for the fuel storage tank to prevent oil spillage to the surroundings in case of leakage,
- level indication on fuel storage tank (accuracy +/-10 litres),
- local fuel tank incorporated in the frame, with a capacity for 8 hours continuous operation,
- drip tray under the sump to collect oil spillage,
- fuel oil booster pump (electrical or forced driven),
- fuel oil filters for the duplex type; filter elements of paper and of disposal type,
- injection pumps,
- injection valves,
- fuel water separator,
- piping, valves and fittings,
- dual flexible fuel lines.

4.11.4 Fuel Specification

The Diesel engine shall operate on diesel fuel.

4.11.5 Combustion Air

The combustion air system shall include but not be limited to the following:

- dry element air filters,
- service indicator (restriction indicator),
- all necessary air ducting between filter and engine.

4.11.6 Lubrication System

The lubrication system shall at least include the following:

- lubrication oil pump (forced driven),
- hand operated pump for emptying engine oil,
- lubrication oil tank (only if a dry sump is used),
- lubrication oil filter of the duplex type with replaceable filter elements and by pass function,
- facility for pressure gauge and low voltage switch,
- piping, valves and fittings.

The filters shall be mounted in accessible locations enabling easy changing of filter elements without the necessity of disconnecting piping or other engine equipment.

4.11.7 Exhaust System

The exhaust system shall include but not be limited to the following:

- silencer provided with adequate drainage facilities,
- expansion joints,
- all necessary exhaust system piping inclusive hangers,
- exhaust pipe.

The exhaust silencer shall be of welded construction designed for outside mounting. Pressure drops through the silencer shall not exceed the engine manufacturer's recommendations. The exterior of the silencer shall be treated to resist rust.
The exhaust pipes shall be properly insulated in accordance with the recommendations of the engine manufacturer.
On leaving the engine room, the exhaust pipe shall pass through a weather proof flange. The piping shall have as few bends as possible.
The exhaust system shall be designed to reduce the heat transmission inside the room as much as possible.

4.11.8 Starting System

Batteries (maintenance free, lead type) for starting shall be included. The battery shall have a capacity sufficient for at least 10 abortive start attempts, each of 10 sec. duration, without recharging.
The engine shall be equipped with an alternator and voltage regulator for re-charging batteries when running as well as a static charger with manual boost charging function. The static battery charger shall be built-in.
It shall be possible to start the engine from any crank position.

4.11.9 Cooling System

The cooling system shall include but not be limited to:

- radiator cooler,
- cooling water pump for circulation of water through diesel engine and radiator cooler, engine driven,
- cooling thermostatic valve, designed to fail open to radiator circuit,
- expansion tank,
- facility for temperature gauge and high temperature switch,
- all necessary piping, valves, vents, drains, etc.

4.11.10 Speed Control

An adjustable droop governor shall be provided complete for the Diesel engine and shall be of the electronic/hydraulic type. The governor shall be capable of maintaining the frequency within the limits set in ISO 8528 for standard types.

4.11.11 Alternator

The alternator shall be of flange-mounted, brushless, self-exciting, self-regulating standard type.
Alternator enclosure shall as a minimum be IP22.
Both ends of the generator main leads shall be brought to a terminal box and star connected.
The alternator shall be able to sustain unbalanced loads up to 20% without affecting the voltage regulation.
The insulation of alternator and exciter windings shall be class H, and the manufacturer shall guarantee that the insulation is suited for use in tropical climate. Alternatively, a special varnish shall be applied to achieve the required guarantee.
The alternator shall be capable of producing short circuit currents of 3-5 times IN, enabling the protection devices in the panels to function.

4.11.12 Automatic Voltage Regulator

An automatic voltage regulator of the static type capable of maintaining the voltage within the limits set in ISO for best grade of voltage regulation shall be incorporated.
The system shall incorporate a low-speed protection that would decrease the excitation current in case that the alternator is operated at a speed lower than nominal. The system shall provide full security for the excitation system against overload.

4.11.13 Arrangement of the Diesel Generating Set

The Diesel generating set shall be installed in the generator room on a solid concrete block. The concrete block shall be isolated from other building works by provision of flexible expansion joints, in order to isolate seismic motor vibrations from spreading to building structures producing cracks.
Noise reduction measures shall be included in order to reach not more than 85 dB(A) in 1 m from the generator room. The measures shall include air intakes provided with noise reducing baffles and heavy-duty isolation of the entrance door to the generator room. Refer the civil works specification for further information.
The Contractor shall include installations (if necessary), such as forced ventilation of the generator room, in order to reduce the indoor temperature rise as much as possible, when the Diesel generator set is in operation, according to manufacturer instructions. Heat reduction measures must not reduce noise reduction precautions.
All equipment located outside shall be provided with sun cover in order to be protected against direct sunshine.

4.12 ELECTRICAL INSTALLATIONS

4.12.1 Lighting

Lighting shall be installed in all rooms of the substation as follows. The lighting outside shall be installed in the R110 substation, the 110/27 kV transformer outpost and around the substation building. The exterior lighting will be proposed consisting of hinged poles, carrying high-pressure discharge lamps.
The exterior lighting shall provide a light level sufficient for safe orientation. The exterior lighting shall also include luminaries near installations that require regular maintenance or supervision.
The average light intensities for control room, stairs, working areas etc. shall be obtained according standards.

The Contractor shall, if required, present a protocol of measurements to the Employer.
All luminaries shall be delivered and installed complete with lamps, ballasts, power factor correcting equipment, starters, etc.
The power factor shall be as minimum 0,9.
Luminaries for the control room, day room etc. shall be of the decorative and anti-glare type suitable to be used with computer monitors. Other luminaries for the substation building shall be of a type suitable for the specific use. Luminaries in the working areas of the plant shall be the industrial type and as a minimum be in protection class IP 67.
Luminaries for working areas shall be the fluorescent dust-proof type. The luminaries shall be an anti-vandal type with reflector, mounted on a wall-fixed pipe support, on the building structures or suspended.
When luminaries are to be installed in rooms with a suspended ceiling, they shall be suspended from the slab. No weight shall be applied to the ceiling structure.
The following luminary types shall be provided for all locations, except working areas where luminaries with sodium or mercury lamps may be used.
Each luminary shall be connected through a connection box.
The lighting in each room shall be controlled by means of manual switches placed at each door in the respective room.
All luminaries and associated gear shall be earthed.
In no case, a flexible cable shall be used for connection of more than one luminary.
All cables to be used in lighting installation shall be PVC-insulated copper cables with a minimum cross sectional area of 1,5 mm^2.
The cables for connecting the fluorescent luminaries to fixed installations shall be flexible, with a minimum cross sectional area of 0,75 mm^2.

4.12.2 Emergency Lighting

Emergency lighting shall be provided for the control room and for all rooms with distribution panels.
The emergency lighting shall automatically switch ON when the normal power supply fails. The emergency units shall be supplied from a battery unit that can provide light in a minimum of 1 hour.
The units shall be complete units provided with housing (IP44), fluorescent light (18W), battery, charger, indication of battery OK etc. Recharging of the battery shall be automatic.

4.12.3 Outdoor Lighting

4.12.3.1 General

Lighting outside shall be installed along the Site circumference, next to its fence. The lighting outside shall provide a light level sufficient for safe orientation (5-10) lx. Potentially dangerous locations shall be illuminated as well.
The power factor shall be 0,9 as a minimum.
In no case, a flexible cable shall be used for connection of more than one luminary.
All cables to be used in lighting installation shall be PVC-insulated copper cables with a minimum cross sectional area of 1,5 mm^2.

4.12.3.2 Outdoor Lighting Equipment

The outdoor lighting system shall be provided with all equipment necessary including poles, fixtures, cables, foundations etc.
No masts for light may exceed the height of 5 m. Each lighting pole shall be provided with terminals and fuses housed inside the pole.
Fixtures shall be made of weather resistant material. Changing of bulbs shall be easy and not involve special tools. The protection class shall be IP 65.

4.12.4 Socket Outlets

4.12.4.1 General

Socket outlets substations shall be provided for power supply of maintenance equipment such as power tools and hand held lamps.
Socket outlets stations shall be provided for indoor and outdoor locations and the maximum distance to any station shall not exceed 25 m.
The socket outlets shall be installed in a socket outlet station, a box made of glass-reinforced polyester. The box shall be in protection class IP55.
The stations shall comprise the following socket outlets, each supplied from its own circuit breaker and RCCB:

- one 230 V,
- one 230 V, CEE type
- one 400 V, CEE type

230 V, 16 A socket outlets for supply of appliances shall be provided in all buildings and rooms of the plant.
The number of 230 V socket outlets shall depend on the area of each room and each socket outlet shall cover no more than 7 m^2.
The 400 V socket outlets shall be installed where required due to the location of machinery, maintenance procedures etc.
The socket outlets shall be equally distributed in the rooms.
230 V AC socket outlets, the socket outlets shall have active earthing contact. When a plug is not inserted, the plug holes shall be covered by a lid.
230 V socket outlets shall be 16A CEE-types.
400 V AC socket outlets, the socket outlets shall have active earthing contact. When a plug is not inserted, the plug hole shall be covered by a lid.
Each socket outlet shall be combined with a load switch.
400 V socket outlets shall be according to CEE.

4.12.4.2 Indoor Socket Outlets

In the substation building, in all rooms, there shall be a number of 230 VAC socket outlets, arranged according the architectural layout. There shall be one for each started 4 m^2. A maximum of 8 in a single room is allowed.
In the dressing room / day room, control room (office) and 25 kV substation, one independent socket outlet 230V AC shall be provided for supplying the local air-condition unit.
In the 25 kV substation room, there shall also be 16 A three phase socket outlets with neutral and protective earth. For heavy duty purpose they shall be of CEE type.
Service socket outlets shall be placed 1000 mm above the floor.
The service socket outlet shall be of heavy duty-type.

4.12.5 Uninterruptible Power Supply (UPS)

4.12.5.1 General

An UPS system shall be provided for the whole control and monitoring system and the instrumentation at the ETS.
The UPS system shall ensure the operation of the control and monitoring system in case of a power cut. The capacity of the battery shall be sufficient for operation over 8 hours.
All equipment necessary for operation of the control and monitoring system shall be provided from the UPS system including the following:

- substation including all connected equipment,

- PLC's,
- communication network,
- instrumentation.

The UPS system for the treatment plant shall comply with the following requirements:

- efficiency AC/AC min. 90 %,
- overload, 1 min.: 150 %,
- disturbance: <10 %,
- power factor: >0,9,
- EMC: VDE 871-B/0875-E,
- acoustic noise: max. 55 dB.

It shall include indications of:

- power source (grid or battery),
- charging,
- battery OK,
- inverter OK,
- charger OK ,
- grid ON.

4.12.6 Earthing System and Equipotential Bonding

A five-conductor earthing system (TN-S) pursuant to IEC 60364 with separate protective conductor (PE) and neutral (N) conductor shall be established from the main power source and throughout the new installations to be established. The N-conductor must not be connected to the PE-conductor at any point within the installation. The solution shall be approved by the power company.
A common equipotential bonding bar (CEBB) shall be installed, connecting:

- power transformer low voltage (LV) earthing points,
- plant protective conductor system (PE),
- building reinforcement,
- plant cross-bonding system,
- earthing system for external lightning protection system,
- lightning and overvoltage arresters.

The common equipotential bonding bar shall be made of copper and have a cross sectional area such that it can act as a circuit protective conductor on each item of the plant and equipment connected to it. The bar shall be clearly labelled to identify its purpose and bolted firmly to the building wall mounted on 50 mm distance pieces. Cable termination shall be made by compression-type cable lugs bolted to the bar.
An equipotential zone shall be created throughout all installations encompassing all metal structures. Extraneous metalwork, building reinforcement, metal supporting structures and machinery equipment i.e. pipes, conduits, pumps, motors etc. shall be cross-bonded and connected to the common equipotential bonding bar.
The earth resistance of the earthing system shall be as low as is practicable but shall in any event be such that the electrical resistance between the common equipotential bonding bar and the general mass of one earth group shall not exceed 4 Ω when any one group of electrodes is disconnected.
Earth groups within the plant shall be interconnected between them forming the general earthing system of the plant of $Rp \leq 2\ \Omega$.
Every construction shall be connected to the earth group through at least two points.
Protective conductors (PE) shall be made of stranded copper with overall green/yellow plastic covering.

4.12.7 Lightning and Overvoltage Protection

4.12.7.1 External Lightning Protection

An external lightning protection system of buildings shall be established to prevent damage to the building due to fire or mechanical destruction in the event of a lightning strike.
All devices to be installed outside the building for intercepting and discharging the lightning current to earth are described in DIN VDE 0185.
The lightning protection system to be adopted shall be performed according to protection class I requirements of IEC 61024, Protection of structures against lightning.
For buildings, the protective installation against lightning shall be too. The earthing system for external lightning protection shall be connected to the building reinforcement.

4.12.7.2 Internal Lightning Protection

The heart of the internal lightning protection system is the equipotential bonding system to be established. All from field incoming and outgoing to field power supply cables, signal and telecommunication lines shall indirectly be incorporated in lightning protection equipotential bonding system via lightning and overvoltage arresters.
The protection equipment for the power supply cables is classified in accordance with DIN VDE 0675 into classes A, B, C and D according to their use.
Every arrester shall have an alarm contact to open if the arrester becomes defect. The alarm contact shall be wired to the PLC.

4.13 SCADA SYSTEM

4.13.1 General System Description

A computer based control and monitoring system (SCADA system: Supervisory Control and Data Acquisition System) shall be provided for automatic control and monitoring of the electrical traction substation. The SCADA system shall be used for the following:

- collect logical signals representing the states of the respective process devices, provide for their transmission to the railway control centre,
- provide for the transmission of command signals from the control centre to the devices which exercise those commands in the process and – depending on the control algorithm – generate its own commands to process devices
- Read the values of analogue quantities, process them and transmit them to the railway control centre,
- communicate with the relevant process devices in the transformer substation by means of digital protections linked to the station control system through a fibre-optic system,
- store the status information of the technology process and its changes and allow viewing of the data stored,
- allow local control of the technology via an operating terminal whose role is to receive information on the state of process devices and other signals including measurements from the station control system and provide for their imaging in a format suitable for the operator, as well as allow the operator enter actuating commands for the technology,
- by means of the remote control terminal (RCT) as a substation of the station control system, allow remote control of the section disconnecting switches of the contact line.

The local monitoring part consists of one PC with monitoring software and a printer placed in the control room (office) in the substation building. The control system of the new ETS has to be fully compatible with the existing main dispatcher system in Podgorica.

The control part consist of a distributed system with distributed local intelligent controllers (PLC's) to carry out the control and monitoring of the equipment connected to the PLC's. The PLC's will work autonomously if the communication network fails and the control will continue.
The system shall be designed to operate 24 hours a day without any necessity of attendance by the personnel.
The station's control system (SCS) is intended to perform the following basic duties:

- The SCS device and the RCT will be powered by the substation service consumption switchboard and will be backed up by its own alternative power sources.
- The data connection between the station control system and the railway supervisory control station will be provided by connecting the transmission circuits of the SCS with the transmission system.

The requirements for the control and monitoring system are described below.
Automatic control of the component shall be possible when the control switch for the component in the front of the panel is in the "auto" position.
By-pass of the PLC control will be possible when the control switch is in the "manual" position.
The SCADA system consists mainly of the following hardware components:

- PC monitoring station,
- report and graphic printer,
- data network,
- PLCs,
- distributed I/O modules.

The system shall be provided with all hardware and software necessary for the operation including cables, modems, interfaces etc.

4.14 TELEPHONE SYSTEMS

The Contractor shall deliver and install a state-of-the-art telephone system. It shall comply with all relevant DIN VDE and national standards and regulations, especially with all conditions for the connection to the public telephone network. The Contractor shall carry out all required coordination and clarification with the Public Telephone Company at no additional costs. All costs, taxes and charges to be paid to the telephone company for connection to the public telephone network shall be included in the price offer.
The technical limit for the extension shall be stated with the offer. Cabling for communication purposes shall be carried out according to DIN 0250 and other relevant standards.
Telephone sets shall be connected to the system via telephone socket outlets compliant with the relevant standards, in order to provide the exchange of telephone sets without any hardware or software effort. The service includes all required devices, cabinets, telephone sets, installations, accessories and any further equipment, that may be required to implement a complete and functioning telephone system.
The offered price shall include the complete service, including technical engineering, clarification, delivery, transportation, insurances, installation, testing, documentation, commissioning, etc.
The central unit shall be an electronic private automatic branch exchange system, based on digital signal transmission. It shall meet the following characteristics:

- suitable for connecting all required extensions, regarding the reserve as mentioned above,
- interface for connecting auxiliary devices,
- power supply 230 VAC, 50 Hz,
- emergency power supply UPS.

The complete unit shall be installed in a suitable cabinet, including racks, power supply, and overvoltage protection for all power, signal and communication lines, and marshalling unit for all lines with 30 % space reserve, complete wiring and installation, all required material.
Telephone sets shall be supplied in a sufficient number to provide for a convenient internal and external communication. The 25 kV substation, alternative power source, dressing room / day room and control room (office) 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.

5. SPECIAL EQUIPMENT AND TOOLS

The works to be performed shall include the delivery of special equipment and tools for erection, installation, maintenance, test and operation purposes. Spare parts shall be defined as components or parts, either consumable or repairable, used to maintain or repair the equipment.
Beside mandatory spare parts and tools, the Contractor shall list in detail the recommended spare parts, he considers necessary for safe and reliable operation and maintenance, together with their individual prices, in the Volume 4, Section 5 - Breakdown of Recommended Spare Parts and Tools.

5.1 110 KV GIS MODULES

- SF6 density monitor with visible temperature compensated pressure reading MPa/bar scale, SF6 gas refilling kit
- Electrical motor for circuit breaker.

5.2 CIRCUIT BREAKERS

Special equipment and tools shall include, but not be limited to the following:

- SF6 gas pressure switch and instrument,
- SF6 gas cylinder with valve and instruments for refilling,
- toolbox of specialized maintenance tools.

5.3 TRACTION TRANSFORMERS

Special equipment and tools shall include, but not be limited to the following:

- lifting cables necessary to handle the transformers by crane,
- spreaders necessary to avoid damage of the bushings when lifting the transformer,
- hydraulic jacks,
- one mobile lockable tool chest comprising work table, drawers and compartment to accommodate an assortment of hand tools required for prevention maintenance,
- one set of hemp rope for bushing handling,
- one set of testing bushings,
- gas relay, pump, fan, oil flow indicator, dehydrating breather.

5.4 25 KV SWITCHGEAR

- circuit breaker, current and voltage transformer, disconnector, surge arrester.

6. SUPERINTENDENCE

The performance of all works covered by this Contract shall be supervised by a sufficient number of qualified representatives of the Contractor, and full cooperation and assistance shall be afforded by the Contractor to the Employer to check all Works at any request.
The Contractor's superintendents shall be responsible for care and maintenance of the Contractor's equipment and for adherence to all applicable safety standards and regulations.