General Technical Specifications (GTS)

PPC

GREECE

RESTRICTED

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REPORT

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General Technical Specifications

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General Technical Specifications

LIST OF ABBREVIATIONS AND ACRONYMS

CFSM	Converter-Fed Synchronous Machine
DEM	Digital Elevation Model
DFIM	Doubly-Fed Induction Machine
D/S	Downstream
EOT	Electric Overhead Travelling
EU	European Union
EUR	Euro
USD	United States Dollar
GDR	Geotechnical Data Report
GBR	Geotechnical Baseline Report
GRA	Geological Risk Assessment
GU	Geotechnical Unit
HDPE	High Density PolyEthylene
HSS	Hydraulic Steel Structure
MW	Mega Watt
MVA	Mega Volt Ampere
PFS	Pre-Feasibility Study
PHS	Pumped Hydroelectric Storage
PPC	Public Power Corporation
RfG	Requirements for Generators
rpm	Rotation Per Minute
U/S	Upstream

0 PREAMBLE

The present document defines the general requirements, rules and principles applying to the overall electromechanical (EM) and hydromechanical (HM) equipment that comprise the scope of work for the Contract.

These general rules and principles shall be read in conjunction with the requirements defined in the Particular Technical Specifications for the equipment and other Contract documents, in particular the General Requirements.

Should the Particular Technical Specifications for the equipment contradict these General Technical Specifications, the most constraining rule shall prevail.

The general rules and principles stated herein, as well as the requirements of the Particular Technical Specifications, are not restrictive.

1 DESIGN OF THE EQUIPMENT

The design of all components of the electromechanical and hydromechanical equipment shall comply with current international Good Engineering Practices and be compatible with requirements of high reliability and durability.

The procurement and manufacturing of the components shall rely exclusively on materials, items and sub-components that are entirely new, of prime quality and free of defects. No repairs by welding, patch or any other means of repair shall be permitted to remedy a defect in material or an error in construction without the prior written consent of the Owner, who may impose any controls he deems useful, at the expense of the Contractor.

The Contractor agrees to perform all required studies and research necessary to justify the choices of technical and technological solutions proposed. These choices shall also be based, as far as possible, on experience acquired in the design and operation of comparable equipment.

In order to successfully complete his studies, the Contractor also agrees to undertake appropriate or necessary arrangements with other contractors concerning all topics involving areas of interface.

1.1 Design of the layout

The Installations shall be designed to ensure reliable and easy operation and maintenance under all circumstances, requiring only minimal maintenance resources and without the interruption of the plant routine operation.

Equipment design shall fully consider the prevailing environment at the site of the works – climate, seismic conditions, water quality, etc. The Contractor is required to fully ascertain these environmental conditions before submitting his Bid.

1.2 Design hypotheses and working stresses of materials

Ample factors of safety according to recognized design practices shall be used throughout the design of the equipment, especially in the design of parts and components subject to alternating stresses, vibration, impact or shock.

1.2.1 Hydraulic Steel Structure

Hydraulic steel structure comprise the structural steelwork subjected to loading due to water pressure: gate and stoplogs bodies, with seals and bearings, and the associated machinery and electrical equipment required for operating and supporting the gates, as well as dedicated handling equipment. It concerns both the fixed parts and the moving parts.

By extension, penstocks, steel liners as well as trash racks and their fittings shall also be considered as part of the hydraulic steel structures.

The design of hydraulic steel structures shall mainly comply with the requirements of the latest edition of the DIN 19704 standard for gates, stoplogs and trash racks and with the requirements of the latest edition of the ASCE and CECT standards for penstocks and steel liners.

In particular, the following design aspects will be based on the provisions of the applicable standards:

- Material characteristics
- Determination of actions and their characteristic values, including friction effects
- Analysis of the effects of actions,
- Analysis of resistances (allowable stress levels)
- Analysis procedures
- Ultimate limit states verification (equilibrium, stability, and structural strength)
- Serviceability limit state verification (deformations compatibility, closing pressure)
- Constructive requirements

1.2.2Hydraulic Machinery

Hydraulic machinery comprises the turbines, pump-turbines, generator, generator-motor, main inlet valve and their fixed and moving parts.

1.2.2.1Loading conditions:

In general, the loading shall be divided into 3 different classes according to the following typical examples.

Normal Operating Loading	Exceptional Loading Cases	Extreme Loading Cases
Unlimited number of occurrences	Happens 1 to 10 times per year	Happens 1 to 10 times per component lifetime
- Normal operation under the defined plant boundary condition within the limits defined, including normal flood conditions -Full load rejection -Start/Stops and transition as defined for the project.	- Failure of an emergency closing (valve, guide apparatus) - Activation of a safety element (shear pin, safety valve) - Runaway condition - Generator short circuit, bi and tri-phases - Earthquake (Operation Basis Earthquake) - Blocking of 1 servomotor for double servomotor operated servomotor - Operation against one locking device	- Failure of 2 emergency closing devices in series or parallel, if installed - Off-cam runaway condition for double regulated machines - Pressure test - Pipe or penstock rupture - Generator synchronization failure - Generator short circuit on 50% of the poles - Loading during installation and embedment - Earthquake (Maximum Credible Earthquake/Maximum Design Earthquake)

Such loading case definitions are linked to the stress levels described below.

1.2.2.2Strength requirements

The design of the hydraulic machinery shall be verified, with sufficient safety margin, against plastic collapse, local failure, buckling, and cyclic loading. Serviceability shall also be checked: the compatibility of the deformation/deflection of the components with the available clearances.

Stress levels and deformations shall be examined by mean of reference strength of material analytical methods or by the way of numerical stress analysis (e.g. Finite Element Analysis).

A numerical stress analysis shall conform to the detailed design procedure described in **ASME Boiler and Pressure Vessel Code Section VIII division 2 Part 5**.

The allowable stresses *S* are determined as a fraction of the minimum yield strength.

The various loads for normal loading shall be combined if physically possible, and the most severe combination shall determine the design conditions. At unusual and extreme loading, each unusual or extreme load cases shall be combined with the most severe normal loading. Unusual or extreme load cases need not be combined.

1.2.3Bolting design criteria

1.2.3.1General consideration

Smaller diameters and long length screws shall always be preferred. Only rolled thread shall be used.

1.2.3.2Material characteristics:

Bolting material shall be carbon steel alloy-steel or stainless steels.

1.2.3.3Allowable equivalent stresses

	Normal Operating Condition	Exceptional & Extreme Condition
Carbon Steel and Alloy-steel	Min (S_Y/3 ;S_T/4)	S_Y/2
Stainless steel	S_T/4	S_T/3

SY : Yield Strength
ST : Tensile Strength

1.2.3.4Bolt Pre-loading

Pre-load torque shall be sufficient to ensure permanent contact between elements or to provide a sufficient watertightness in assembled elements under pressure, however prestressing equivalent stress (combined tension and torsion) shall be less than 0.85SY. Bolts shall be higher material property classes (at least class 8.8 as per ISO831 for carbon steel) and tightened using a controlled tightening method.

1.2.4 Sizing Stresses exerted upon civil works

All equipment shall be properly anchored into the civil structural works.

- Anchoring system shall consist of :
- A Rigid fixture constituted by a metallic base plate,
- A set of embedded headed anchors.

Metal plates (both base plates and embedded head plates) supporting the equipment shall be properly dimensioned so that the most unfavorable loading situation shall not induce compressive stresses in the concrete exceeding 7 MPa.

Rotating machinery or equipment submitted to alternating loads shall be anchored by mean of pre-stressed embedded anchors or crossing pre-stressed anchors.

Shear forces on the anchoring system shall be resisted by the anchors, or by dedicated specific shear connectors in case of active (prestressed) anchor. Account for friction resistance at the concrete interface is not allowed.

The Contractor shall submit to the Owner all the necessary information related to the interface between the equipment and the civil work structure:

- The technical design of the anchor system (dimensions and materials, and pre-stressing forces whenever relevant)
- The total reaction forces and moments, distinguishing, for each load cases, the dead loads, the live loads and the service loads.
- The forces and moments reactions at each equipment supports, distinguishing, for each load cases, the dead loads, the live loads and the service loads
- All those information shall be consolidated in a dedicated foundation calculation report load report.

1.2.5 Sizing for seismic loads

Wherever relevant, the Contractor shall take into account seismic-generated stresses by combining vertical and horizontal accelerations in their most unfavourable configuration. For each of these accelerations, the site maximum peak ground acceleration shall be considered. The values to be considered shall not be less than 0.1g

1.3 Calculation notes

Calculation notes shall be submitted by the Contractor for review and comments by the Owner. However, the Owner may, at any time during the Contract period, request from the Contractor any additional calculation notes that he may consider useful; these calculation notes shall be

submitted and within a reasonable time period reviewed and commented by the Owner as indicated in the Contract

1.4 Grouping by functional units

In order to increase the overall reliability of the equipment and guarantee the safety of operating personnel, the various power equipment items, as well as the various monitoring, control and automation systems, shall be grouped in separate functional units. The organization will be reflected in the way to number the drawing and documents as well as in the way to identify systems, sub-systems and components.

The natural partition of the scheme shall be as follows:

- **Dam equipment**, including:
  - Bottom outlet
  - Spillway

- **Waterways**, including:
  - Water intakes
  - Headrace tunnel
  - Upper surge shaft
  - Lined shaft and penstock
  - Manifold feeder of the turbine-pump units
  - Draft tubes
  - Lower surge tank
  - Tailrace tunnel

- **Generating unit**, including for each unit:
  - Main Inlet valve
  - Turbine
  - Generator
  - MV (medium-voltage) connections
  - Main transformer
  - VHV (very-high-voltage) connections
  - HV (high-voltage) circuit breaker bay
  - VHV busbar section isolators
  - Hydraulic, mechanical and electrical auxiliaries dedicated to the turbine-alternator unit

- **High and Very High Voltage line**, including, for each line:
  - All the bay equipment from the VHV circuit breakers to the conductor supports of the overhead power lines.

- **Transfer and VHV busbars**, including:
  - Voltage transformers
  - VHV earthing switches
  - All transfer bay equipment found between the two VHV isolating switches
  - Differential busbar protection

- **Medium-voltage equipment**, including:
  - All incoming cubicles
  - Set of busbars
  - Voltage control
  - Outgoing cubicles of the underground and overhead types

- **General auxiliaries**, including:
  - All auxiliary systems shared by the Installation and not allocated to a turbine-alternator unit

- **Alternating current auxiliaries**, including low-voltage energy generation and distribution systems, as well as:
  - Transformers for the auxiliaries
  - Low-voltage switchboard
  - Emergency hydraulic unit
  - Emergency thermal unit / diesel generator
  - Automatic source-switching device

- **Direct current auxiliaries**, including the alternative sources, which include:
  - Electrochemical storage batteries
  - Charger-rectifiers
  - Direct-current general switchboards

1.5 Redundancy

Where the generation of electrical energy depends on the availability of essential and critical hydro-electromechanical auxiliaries, those auxiliaries shall be duplicated. Two complete sets or devices of redundant auxiliaries shall then be implemented.

In such a case, switching from the selected priority set or devices to the emergency one shall be performed by an automated mechanism, and the primary sensors initializing the emergency reactivation shall also be completely redundant.

1.6 Operation

The equipment shall be designed so as to facilitate operation, while taking particular care to ensure complete safety against the risks of operational errors, and to permanently allow convenient control of the equipment's satisfactory performance.

The Contractor shall take into account the fact that normal operation will be carried out by remote control and, during emergencies, operated locally in front of the equipment by the operating staff. Consequently, the equipment shall be designed to operate without local supervision, and shall include all necessary devices to remotely transmit the physical parameters of the process and any detection of faults, as well as anomalous operations.

The various components of the Project shall be laid out so as to be easily accessible for operation, maintenance, inspection and eventual repairs. Platforms, access ladders, manholes,

inspection holes, handling hooks, guardrails, handrails, emergency lighting, covers and laggings etc., shall be integral parts of the finished Installations delivered by the Contractor.

All equipment shall bear a nameplate displaying its main characteristics in English. The various components shall be located and painted according to conventions, in conformance with the lists of equipment, drawings and diagrams. Special care shall be taken to avoid painting of nameplates.

All spherical valves, safety valves, check valves and other various valves, as well as the equipment required for electrical switch-off and full isolation, shall be fitted with reliable position indicators that unambiguously display whether they are opened or closed, engaged or disengaged.

Lubrication systems, sensors and control components shall be easily accessible. Gauging or level measurement devices, manometers, flowmeters, thermometers and other indicators shall be of the direct-reading type, easy-to-read, graduated in legal units and suitably oriented.

Main components shall be equipped with elapsed time meters as well as operation counters that record the number of start-ups, engagements and disengagements, thereby allowing the possibility of programming maintenance operations and replacement of wearing parts.

1.7 Maintenance

The equipment shall be designed to facilitate assembly, disassembly, reassembly, maintenance and repair operations.

Aside from justified exceptions, explicitly agreed in writing by the Owner, the disassembly and reassembly of a unit shall not:

- Involve any interventions on any parts of civil works
- Involve the disassembly of another unit not directly concerned
- Require the intervention of specialists
- Necessitate the use of special tools and tool sets other than those explicitly provided by the Contractor

It shall be possible to carry out disassembly of any mechanical component, pump or valve, in complete safety, and requiring only minor draining of fluids from the circuit in which it is integrated. The procedures for draining circuits shall be provided by the Contractor. In order not to disturb operations, and thus the supply of electrical energy, all arrangements shall be made by the Contractor to allow, during ongoing operation, the replacement of sections of the Installation that require systematic interventions, such as:

- Replacement of a component part of a redundant arrangement
- Cleaning of filters
- Unclogging of water and oil circuits of heat exchangers
- Replacement of lamps, indicator lights, fuses, indicating instruments, cartridges, diaphragms, etc.

In this regard, the design shall include the following:

- During full operation, test devices shall activate electrical protection relays.
- Wiring continuity control devices shall guarantee the main sequences of disengagement.

Parts prone to wear during normal operation shall be provided with removable linings in order to allow their replacement, or their rapid and economic repair. The technical sheets describing these parts shall include operation and maintenance instructions.

Equipment elements shall include permanent devices facilitating their handling – handles, rings, lifting eye bolts, service clips, etc. Loosening screws shall be provided with parts likely to be disconnected. Accessories, devices and special tools necessary for handling, removal and storage – shackles, hooks, slings, wedges, hoists, monorails, dismountable floors, chairs, bases and various supports, etc. – shall be integral parts of the finished Installations delivered by the Contractor.

The Contractor shall include in his design guideline drawings of all relevant details related to the permanent devices to be embedded in the civil works, either first and second stage concreting whose purpose is to facilitate disassembly and reassembly operations (pins, hooks, pegs, plates, etc., embedded in concrete). Supply of these devices is an integral part of the present Contract.

The various technical levels and floors of the hydroelectric power station buildings and of the associated HV substation shall be equipped with access grooves. The appropriate covering of these grooves is an integral part of the present Contract.

All of the hydraulic structures (intakes, bottom outlets, penstocks, drainage and dewatering systems, etc.) and all hydromechanical equipment, in general, shall be designed to sustain industrial-grade operation for a minimum period of five (5) years between dewatering for inspection and maintenance.

1.8 Safety of personnel and protection of equipment

The Installations shall be designed according to the safety codes and regulation applicable in Greece and in the EU to ensure full and total personnel safety, to protect materials and equipment, and to prevent any accidental contact with moving or electrically operated components.

Materials and components such as insulators, supports, protection envelopes, etc., shall:

- Be protected against degradation by rodents
- Be fireproof
- Be flame-retardant
- Emit no harmful substances under all conditions

All bolts, screws, etc., of rotating parts, or subject to vibration, shall be made "self-locking and shake-proof" by appropriate locking devices, after having been tightened using suitable tools (such as a torque wrench).

Accessible mobile components shall be protected with cowlings, screens, grids or caps. When necessary, the Contractor shall plan, from the very first assembly operations, the installation of footbridges and safe work areas, and shall set up all required guardrails, ladders and railings. These provisions are integral parts of the present Contract.

The planned circulation paths for the operators shall be clear of any obstacle, with clearance heights and widths adequate for the purpose.

The various technical levels and floors of the hydroelectric power station buildings and the associated very-high-voltage substation shall be accessible, as follows:

- By means of staircases equipped with handrails
- With a stretcher for evacuation of casualties

All hazards or dangers shall be visibly indicated by the Contractor via pictograms or standardized representations and inscriptions written in English. Security instructions, locking procedures and building evacuation diagrams shall be legibly affixed to the Installations, in the necessary quantities. Exits and evacuation paths shall be indicated by escape way markers fitted with a self-contained independent lighting system.

All equipment shall be provided with all safety devices necessary for its use, maintenance and safeguarding. Mechanical and electrical locking devices, locks and padlocks, fixed and movable grounding devices, relief valves, double insulation with intermediate bleeding on pressure lines, etc., are integral parts of the present Contract.

In humid premises, lighting and required electrical outlets shall be supplied by a safe electrical power system protected according to good engineering practices.

In easily flooded locations, all required electrical material shall be guaranteed watertight.

Electrochemical secondary cell batteries shall be located within explosion-proof premises that are completely empty of other equipment. In addition, all equipment shall be of the explosion-proof type safely ventilated.

All locations prone to water and oil spills – mechanical workshops, assembly areas and rooms hosting mechanical and oil-hydraulic auxiliaries – shall be equipped with suitable drains and covered with non-skid compounds. In these locations, and in the associated staircases, tiled floors are prohibited.

Electrical insulation devices shall be of the visible switch-off type.

All metal parts or components, whatever their function, shall be equipped with grounding devices, according to the latest relevant standards and the Particular Technical Specifications. The Contractor shall submit all related assembly standards to the Owner for review and comments.

All rooms, premises, panels, cubicles, cabinets and enclosures shall be systematically locked. Keys shall follow a general hierarchical structure that the Contractor shall submit to the Owner for review and comments.

All doors leading HV and MV electrical equipment shall be equipped with one sided panic bars allowing for safe escape.

1.9 Standardization of the supplied material – interchangeability

Identical parts and systems shall be completely interchangeable.

Interchangeability shall be provided as follows:

- By homologous parts of identical equipment for bearings, thrust bearing pads, cooling agents, guide vanes, rods, labyrinth rings, wearing plates, servomotors, shaft seals, turbine and pump wheels, complete alternator rotors and stators, complete rotor poles, stator bars and

connections, terminals, excitation devices, brake tracks and cylinders, electric pumps, various mechanical and electrical accessories, etc.

- By auxiliaries of the same nature and characteristics for components of various equipment items, such as electrical motors, pumps, valves and plumbing, stroke limiters, resistor probes, water circulation controllers, measurement indicating devices (pressure gauges, flowmeters, thermometers, etc.), regulation devices (pressure switches, flow controllers, thermostats, etc.), switchgears, electrical contact brushes and parts, fuses, circuit breakers, contactors, switches, pushbuttons, transducers, relays, lamps, medium-voltage cells, low-voltage valves, etc., and, naturally, for all replacement and wearing parts

The Contractor shall seek to standardize the construction, as much as possible, in order to reduce the amount of spare parts and facilitate maintenance, replacement and restocking operations.

At the very beginning of the design, the Contractor shall write a standardization brief concerning the various mechanical and electrical materials, which shall be reviewed and commented by the Owner. The Contractor shall abide by the standardization brief, and shall forward the standardization brief to his suppliers and subcontractors, in order to limit the number of brand names, types and references. The Contractor shall enforce the correct application of this requirement.

The actual measurements upon which the interchangeability demand shall be explicitly indicated on the Contractor's drawings and diagrams, as well as the execution tolerances.

1.10Lubrication

Special care shall be given by the Contractor to the lubrication efficiency of moving parts. Preference shall be given to self-lubricating or lifetime-lubricated devices. Otherwise, the lubrication points of the equipment shall be grouped in an easily accessible location that is clearly marked on the equipment and on the drawings.

The Contractor shall design the equipment to use the minimum number of different types of lubricant and submit to the Owner – according to a schedule agreed upon with the Owner– the brand names, types, detailed physicochemical characteristics and quantities necessary of each type of lubricant. The Owner, therefore, reserves the right to request from the Contractor the use of certain types of lubricants, oils, etc. The Contractor shall not be entitled to claim extra payment because of this request.

The proposed oils and greases must be marketed and available in Greece and the EU.

Oils shall be free of bacteria and shall contain suitable microbiocides to prevent any bacteriological growth when in service or during normal storage. The Owner will have the oil tested, and the Contractor shall replace the entire volume of any contaminated oil systems, followed by satisfactory cleaning of the affected systems.

Unless otherwise stated in the Particular Technical Specifications, the first oil or grease filling for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing, shall be included in the Tender Price. The Tender Price shall also include an excess of at least 25% of the net amount required.

Bearings, and other components in which oil is circulating, shall be designed to avoid air being whipped into the oil causing froth or an increase in oil volume. Contamination of air, water and ground by lubricants and fuel shall be avoided by means of appropriate designs and equipment layout, in conformance with the latest recognized standards for modern engineering practice.

The filling points for lubricating oil systems shall be provided with fine wire gauze filters to prevent ingress of dust, etc. Filling points shall be easily accessible. Drip trays shall be provided beneath filling and drain points, as well as in any other locations subject to oil leakage or spillage.

Self-lubricating bearings and bushings shall be preferred as far as the specific pressure on the bearing allows. Bearings and bushings subject to contamination from dirty water or air shall be further protected by suitable seals, and, if necessary, by additional grease lubrication. These bearings are required to operate for an indefinitely long period in or out of water, without any maintenance or lubrication.

Sliding surfaces shall be suitable for the pressure and velocity to be imposed, without any external lubrication. In general, the sliding material shall be either pure PTFE (polytetrafluoroethylene - Teflon), glass fibre reinforced PTFE, PTFE incorporated into sintered bronze, or certain designs of bronze impregnated with or having inert lubricating materials pressed in. The outer and inner races of the bearings shall be made of corrosion-resistant materials having sufficient strength, rigidity and thermal conductance.

Low-maintenance rolling bearings shall have stainless steel races and stainless steel balls or rollers.

1.11Noise

The equipment and its installation shall be designed for maximum reduction of noise of whatever nature – more specifically, noise caused by the main units, emergency units, transformers, pumps and compressors, and, more generally, by ventilation and fluid circulation.

Should the noise limits specified in the Particular Technical Specifications for the equipment concerned be exceeded, it is the obligation of the Contractor to undertake, at his own expense, and to diligently submit to the Owner as rapidly as possible, the remedial measures necessary to reduce noise strictly to the guaranteed level, such as the addition of soundproof cowlings and/or doors.

1.12Vibrations

The design of the equipment and its configuration shall not lead to the generation of vibrations or tremors that are harmful to the equipment or to the civil works and other materials in the vicinity of the equipment.

Measuring devices, security devices and sensors that must be installed in locations where unavoidable vibrations are generated by the Installations or the main equipment, shall be systematically sheltered from the effect of these vibrations (for example, by either mounting on adequate dampening devices – silent blocks or support plates provided with anti-vibration springs – or via mounting of measuring apparatus on independent supports).

1.13Industrial aesthetics

The layout of the equipment shall lead to harmonious appearance of the equipment.

The Contractor shall consider additional coverings and envelopes, when necessary, and also when these are requested by the Owner.

Dimensions of cubicles, panels, cabinets and wall-mounted enclosures shall be standardized.

At the start of the studies, the Contractor shall submit, for the Owner's review and comments, the general rules and guidelines for equipment installation, displaying the front view of cubicles and control panels, and the equipment components of panels, cabinets and enclosures.

1.14Sealing and degree of protection of the enclosures

Pipework dedicated to lubrication, refrigeration, compressed gas and other service fluids shall be perfectly sealed. No abnormal leaks will be tolerated.

All normal leaks, bleedings and condensates shall be carefully collected by means of suitable devices, such as funnels, drip basins, tubes, gutters, etc.

Except for locations sheltering storage batteries, which have to be sealed to avoid the possible accidental acid spillage, humid locations shall be equipped with floor drains connected to the drain network.

All measures shall be undertaken to prevent escaping oil vapours – especially those coming from bearings and rotating parts – from settling in the surrounding environment and, in particular, on electrical components.

The minimum degree of protection from the enclosures shall be as follows:

- IP42 –for equipment installed in dry and clean premises
- IP54 –for equipment installed in humid locations and in areas where water splashing can occur
- IP54 –for all sensors, whatever their natures, such as pressure controllers, thermostats, limit switches, detectors, etc.
- IP65 –for external lighting, and cubicle or cabinet exposed to the rain or immersed in water or other fluids.

1.15Choice of auxiliary equipment

The choice of auxiliary equipment is subject to the approval of the Owner.

In order to ensure easy maintenance, auxiliary equipment shall be from a recognized brand name and of current production. Equipment characteristics and reliability shall meet the service requirements of the Installations.

1.16Choice of materials and components

In the choice and use of materials and components in his equipment, the Contractor shall take into account climatic and environmental conditions. In general, all electrical materials and components shall be tropicalized.

In air-conditioned premises (with design temperature of 25°C and design relative humidity of 55%), a long-term failure of the air-conditioning system should neither prevent normal equipment operation nor cause damages.

Materials shall be non-hygroscopic, fungus-resistant and not prone to mould.

All metal parts, fittings, supports, frames, cable trays, sealing accessories, guardrails, gratings, gutter covers, etc., shall be either rustproof, hot-dip galvanized, or painted.

The choice of surface protection for each material shall ensure long-lasting qualities.

With regard to insulation, Class B is the minimum class imposed, provided that, should the Contractor retain a higher class, the guaranteed temperature rises shall remain those of Class B.

Consequently, all equipment proposed by the Contractor shall:

- Meet the Technical Specifications
- Be selected from among the best quality hardware currently produced by well-known manufacturers
- Hold credible references related to many years of operation testifying to their reliability, their robustness and their excellent performance under the same climatic conditions as the one prevailing at the site of the Installations
- Be perfectly adapted to the conditions of use

As far as possible, the principle of galvanic separation shall be used to protect against the dangerous propagation of voltage surges. This separation can be performed using transformers or, in circuits making use of electronics components, via optoelectronic couplers or relays.

1.17Electromagnetic compatibility (EMC)

The Contractor shall take all necessary measures to avoid electromagnetic disturbances in the control and command systems, the automated systems, the protection systems and the information transmission systems, and shall ensure the electromagnetic compatibility of the electronic systems.

Transitory electromagnetic and voltage surge disturbances, which could have fatal consequences, can originate in the following:

- Lightning shocks
- Electrostatic discharges
- Electric arcs due to defects in tools
- Electric arcs due to the switching or other operations of very-high-voltage equipment
- Electric currents of strong intensity at industrial frequency
- Ferro-resonance phenomena
- Corona effect on network elements at very-high-voltage
- Interfering resonances in electrical circuits, radio transmitters, radar beams, etc.

The electromagnetic disturbances shall not cause failures, defects, malfunctions or damage. At the request of the Owner, the Contractor shall provide all required explanations on the methods and devices implemented to protect the Installations against the effects of these disturbances.

1.18Lightning protection measures

One or more of the following systems shall be employed:

- Zinc-oxide lightning arresters on all high- and medium-voltage circuits
- Homopolar protection on all exposed low-voltage circuits
- Electronic grounding dedicated to low-current equipment
- Multiple ionic lightning conductors on the roofs of buildings

1.19 Quality Assurance Plan (QAP) and Health and Safety Plan (HSP)

Within the scope of his ISO 9000 certification, the Contractor shall submit to the Owner a Quality Assurance Plan (QAP), and a worksite Health and Safety Plan (HSP), according to a schedule agreed upon with the Owner.

The Quality Assurance Plan shall compel the Contractor to implement the organization models and procedures necessary for the execution of the activities linked to the various Project phases – studies, planning, procurement, manufacturing, factory testing, transportation, delivery, assembly, onsite testing, commissioning, semi-industrial operation, acceptance testing and warranty periods.

The Contractor shall maintain on site specialized personal to ensure the fulfilment of the agreed QAP and HSP.

1.20 Environmental protection

The Contractor shall be responsible for restoring to their original state all storage, work and borrow areas, as well as roads, surroundings and access trails. Wastes of all types shall be evacuated to suitable dumps, Owner and according to procedures reviewed and commented by the Owner. The Contractor shall maintain on site specialized personal to ensure the fulfilment prevention of environmental damage of the coping of environmental instructions.

1.21 Marking and identification of equipment

Each equipment item shall be marked according to an identification code to be proposed by the Contractor at the beginning of the Project and agreed upon by the Owner. The identification code shall be based on the Power Station Classification System (KKS standard) and, for each component, shall indicate the following:

- Functional group,
- Function,
- Material type
- Code number

In the field, each component shall be labelled with a tag indicating the identification number. The tag dimensions and locations shall be selected to be easily readable. Text shall be black on a white/beige background. Tags shall be affixed to equipment by reliable means; glue will not be acceptable.

Tags and Codes shall be identical to those indicated on the drawings.

2 STANDARDS AND TECHNICAL REGULATIONS

2.1 Standards and technical regulations

In their design and execution, the Works and equipment supplied shall be in accordance with the best and most recent state-of-the-art standards, the terms of the Contract and their consequences, as well as local laws and regulations

For the design, construction, transportation, installation and tests, the equipment items shall conform to the standards and technical rules indicated in these General Technical Specifications and in the Particular Technical Specifications and, failing this, to other standards and technical regulations, provided that:

- Those standards and technical regulations are established and published by an internationally recognized organization that is independent of the Contractor.
- Those standards and technical regulations shall be adapted to the material concerned.
- A copy of those standards and technical regulations, as well as their certified translation in English, shall be submitted by the Contractor to the Owner.
- Those standards and technical regulations, in the opinion of the Owner, are as demanding as, and shall lead to a supplied quality at least equal to that imposed by, the following standards and recommendations:

  - IEC International Electrotechnical Commission
  - UTE Union Technique de l'Electricité (Electricity Technical Union)
  - ISO International Organization for Standardization
  - EN Euronormes (European Standards)
  - DIN Deutche Industrie Normen (German Institute for Standardization)
  - VDE Verein Deutscher Elektriker (German Electrical Standards)
  - BS British Standards
  - ANSI American National Standard Institute
  - AISI American Iron and Steel Institute
  - IEEE Institute of Electrical and Electronic Engineers
  - ASME American Society of Mechanical Engineers
  - ASTM American Society for Testing of Materials
  - AWS American Welding Society
  - NEMA National Electrical Manufacturer Association
  - VSM Verein Schweizerischer Maschinen-Industrieller (Swiss standards concerning shafts and screw assembly)
  - FEM Fédération Européenne de la Manutention (European Federation of Handling Industries)
  - ASHRAE American Society of Heating, Refrigerating, and Air-Conditioning Engineers
  - NFPA National Fire Protection Association

The valid edition of the documents is the last published edition as of the date of Contract signature.

During the execution of the Contract, upon a justified request from the Contractor, any substitution would remain possible, subject to the written consent of the Owner.

The equipment shall, however, in all cases, be in conformance with the laws, decrees and orders in force in Greece, in accordance with the stipulation in the Contract.

Should any documents of the Contract, or should the laws and regulations in force in the country of the Project, contain more severe or particular requirements, those requirements shall always prevail over the international standards and technical regulations quoted, or those standards and technical regulations proposed by the Contractor.

Should the specifications refer to several standards explicitly quoted, and in the event of differences between these standards, the most severe and complete standard shall always prevail.

All materials and testing methods shall be in conformance with the standard chosen, insofar as the standard is not in contradiction with the Requirements of the Contract. In all cases, the Requirements of the Contract shall prevail.

The Contractor may have to apply his own recommendations, based on his expertise, processes, procedures, technical regulations and/or internal standards. In such cases, and at the request of the Owner, the Contractor shall provide copies of those documents in English for review and comments, according to a schedule agreed upon with the Owner.

2.2 Material standards

For all equipment, the material quality and designation shall clearly appear on drawings and/or material lists.

Materials for general purposes shall be delivered according to the following standards, or their equivalent. The grades used shall depend on stress levels, environmental conditions, resulting material thicknesses, manufacturing procedures and inspection procedures.

Unless otherwise specified, material grades shall be proposed by the Contractor, subject to the Owner's review. All standards shall be the latest edition as of Contract signature or as stipulated in the Contract whichever is more stringent.

- Structural steel, general-purpose:
  - EN 10025
  - ISO 630
  - ASTM A36/A36M

- Structural steel, weldable, fine-grained:
  - EN 10028
  - ISO 4950-1, -2 and -3 (1995) and ISO 4951-1, -2 and -3

- Fine grained, normalized steel for penstock and steel lining:
  - EN 10113-2 (1993), ASTM A516/A516M

- Cast steel for general engineering purposes:
  - DIN 1681
  - ISO 3755
  - ASTM-A27/A27M

- Iron castings, nodular:
  - DIN EN 1563
  - ISO 1083
  - ASTM A536

- Steel forgings for generator rotors:
  - ASTM 469

- Steel forging for shaft:
  - EN 10083
  - ISO 683-1
  - ASTM A668/A668M

- Stainless steel, general-purpose:
  - DIN 17740
  - ASTM A240, ASTM A269

- Stainless steel castings, general-purpose:
  - DIN EN 10213-1, DIN EN 10213-4 and DIN EN 10283
  - ASTM A487/A487M

- Bronze for bushings:
  - ASTM B584, ASTM B505/B505M

- Babbitt metal:
  - ISO 4381
  - ASTM B23

2.3 Standards for electrical equipment

Electrical equipment shall comply with the following codes, standards and regulations, or their equivalents. All standards shall be the latest edition as of Contract signature.

- Electrical equipment, in general:
  - IEC 60038 – Standard voltages
  - IEC 60529 – Degrees of protection provided by enclosures (IP rating)
  - IEC 60664-series – Insulation coordination for equipment within low-voltage systems
  - IEC 61000-series – Electromagnetic compatibility

- Equipment installed in hazardous areas:
  - IEC 60079-series – Electrical apparatus for explosive gas atmospheres

- Instrument transformers:
  - IEC 60044-series – Instrument transformers

- LV cables:
  - IEC 60028 – International standard of resistance for copper
  - IEC 60287-series – Electric cables: calculation of the current rating
  - IEC 60724 – Guide to the short-circuit temperature limits of electric cables with a rated voltage not exceeding 0.6/1.0 kV

- Earthing system:
  - ANSI/IEEE 80 – Guide for safety in A.C. substation grounding

  - IEC 61000-5-2 – Electromagnetic compatibility – installation and mitigation guidelines – earthing and cabling

- Auxiliary relays:
  - IEC 60255-series – Electrical relays
  - IEC 61810-1 – Electromechanical non-specified all-or-nothing relays – general requirements
  - IEC 62314 – Solid-state relays

- Control, relay and distribution panels, marshalling and boxes:
  - IEC 60269-series – Low-voltage fuses
  - IEC 60668 – Dimensions of panel areas and cut-outs for panel and rack-mounted industrial-process measurement and control instruments
  - IEC 60715 – Dimensions of low-voltage switchgear and controlgear. Standardised mounting on rails for mechanical support of electrical devices in switchgear and controlgear installations
  - IEC 60947-1 – Low-voltage switchgear and controlgear – general rules
  - IEC 60947-2 – Low-voltage switchgear and controlgear – circuit-breakers
  - IEC 60947-3 – Low-voltage switchgear and controlgear – switches, disconnectors, switch-disconnectors and fuse-combination units
  - IEC 60947-4 – Low-voltage switchgear and controlgear – contactors and motor-starters
  - IEC 61008-series – Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)
  - IEC 61009-series – Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
  - IEC/TR 61818 – Application guide for low-voltage fuse

- Cableways:
  - IEC 61537 – Cable management – cable tray systems and cable ladder systems

2.4 Unit system

The international metric system (SI) shall be the only system used, for units as well as symbols and notations.

Texts of third-party origin, provided by the Contractor and based on other systems of units (including non-metric norms), shall be revised by converting all units to metric units and adding translated indications based on the international metric system.

3 SPECIFICATIONS RELATED TO THE GENERAL DOCUMENTATION

This paragraph describes the specific requirements applicable to the documentation of Electromechanical and Hydromechanical Equipment and will be completed in the future by the Owner's General Requirements. In case of ambiguity between the documents the more stringent will prevail.

3.1 Documents to be submitted by the Contractor

Within the scope of the Contract, the Contractor shall provide drawings, diagrams, reports, instructions and calculation notes, as well as a compilation of documents provided by the Contractor's suppliers and subcontractors. The documentation provided shall include the following:

3.1.1 List of drawings and documents for all supplied works

To be completed in a later time according to the Owner's General Requirements.

3.1.2 General drawings for installation of supply components

These drawings shall provide the general Project installation layout of the hydro-electromechanical equipment, drawn to scale, and shall also specify their exact implementation method and the main dimensions. These drawings shall be submitted to the Owner for review and comments.

3.1.3 Design directive drawings to allow civil engineering studies

The design directive drawings shall indicate, inter alia, the following:

- The normal and exceptional loads and pressures generated by the hydro-electromechanical equipment upon the civil engineering structures – intensity; direction and orientation; and eventual coefficients of increase for static and dynamic stresses
- Suggested successive phases of concreting
- Bases
- Necessary structural openings either those that will remain open as well as those to be closed by concrete or another material.
- Conduits to be covered with concrete for anchoring or passing ducts
- Electrical conductors
- Pipework, gutters, drains, etc.
- Heavy and/or bulky equipment
- Access to various premises

For all parts to be covered with concrete, including those to be used for fastening of the equipment's positioning accessories during assembly, the foundation drawings shall specify the layout of the bearing plates and other erection bases to be supplied by the Contractor, which are to be sealed by the contractor of the civil works contract.

With regard to heavy and/or bulky equipment – gates, shells, parts of scroll cases, parts of housings, bulkheads, draft tubes, test rings, parts of alternators, transformers, etc. – the Contractor shall provide detailed handling drawings.

All drawings shall be submitted to the Owner for review and comments.

3.1.4 Equipment manuals

The Contractor shall provide manuals for equipment operation and maintenance that provide a detailed description of the operation and maintenance of the mechanical and electrical systems, as well as their particular components.

All manuals shall be submitted to the Owner for review and comments. For manuals content see 3.1.12

3.1.5 Calculation notes

Calculation notes shall be provided for each component or system. The calculation notes shall allow the Owner to judge the conformance of the studies to the General Technical Specifications and the various Particular Technical Specifications. These notes shall be prepared and submitted jointly with the preparation of the Detailed Drawings, and shall be subject to the review and comments of the Owner.

A list of the required calculation notes shall be drawn up at the beginning of the studies by mutual agreement with the Owner (as part of the documents and drawings list). However, the Owner reserves the right, during the course of the Project, to request from the Contractor any additional or complementary calculation notes that the Owner may consider useful. Each calculation note shall include, at a minimum, the following headings:

- Summary of the object and its Technical Specifications
- Hypotheses and design methods, including the standards used and bibliographical references
- All relevant data
- Loading cases
- Account of the results and of the ensuing technical and technological choices

Partial calculation notes may be submitted to the Owner according to the various stages of execution of the Works (for example: sealing , fixed parts, structures, handling components, etc.). A complete calculation note grouping, including all the partial calculation notes, shall then be submitted to the Owner.

The calculation notes shall be detailed as much as possible.

3.1.6 Mechanical detailed engineering drawings of the equipment

The mechanical detailed engineering drawings of the equipment shall include the following:

- Overall drawing of the sub-assemblies
- Detailed plans of component parts
- Equipment lists and quantities, etc.

The equipment's detailed Drawings shall be prepared by the Contractor and/or his subcontractors and submitted to the Owner review and comments before any start of manufacturing. The drawings shall include all drawings, elevation and cross-sectional views necessary to show the equipment's design, functionalities, methods of assembly, and operation & maintenance.

These overall drawings, subsets and details, shall include, in addition to the manufacturing dimensions, the following:

- Indication of assemblies, sub-assemblies major components
- Tolerances
- Assembly and operation clearances, with the minimum and maximum acceptable variations
- Weld categories
- Types of non-destructive tests to be carried out on welds

The Owner can demand, and the Contractor shall provide, any required detailed manufacturing drawings for better understanding of the equipment – e.g., equipment operation; equipment installation and sealing problems; equipment disassembly and maintenance, etc.

Generally, detailed drawings of assemblies, sub-assemblies and main components, as well as bills of material, shall be submitted to the Owner for review and comments, whereas the detailed drawings of component parts shall be submitted for information only.

3.1.7 Drawings of fluids networks

The fluids networks drawings shall include the following:

- Operation manuals
- Detailed functional diagrams (block diagrams and Process and Instrumentation Diagrams [P&IDs])
- Lists of apparatus
- Supplier's documentation for the components used
- Circuits layouts

The Contractor shall ensure proper consistency between:

- Identification code of the various devices on the diagrams of fluid networks
- Identification code of these same devices on the diagrams of the corresponding electrical and automated system connections
- Identification code marked on the tag physically attached to the devices (and on their package, in the case of spare or wearing parts)

For ease of reading, these diagrams shall include a list of symbols used, as taken from the standard. The physical representation conditions shall be specified.

For each equipment item, the list of apparatus shall indicate the following:

- Nature of the equipment item and its specific purpose
- Identification number
- Quantity
- Supplier

- Manufacturer
- Catalogue number
- Degree of protection of its envelope
- Location in the Installation
- Range of the controlled parameters
- Electrical power capacity (if / relevant)
- Connection voltage (if / relevant)
- Number of conductors to connect (if / relevant)

All documentation related to fluid networks shall be submitted to the Owner for review and comments.

3.1.8 Drawings of the electrical circuits

The drawings of the electrical circuits shall be established in accordance with the IEC61082 and shall include the following:

- Single-line diagrams
- Standard and block diagrams
- Logic diagrams of the automated system and interlocking
- Internal wiring drawings of boards, cabinets, consoles, etc.
- Equipment connection drawings
- Cabling and Wiring layouts
- Cable classification lists
- Instrumentation diagrams
- Equipment layout drawings of boards, consoles, cabinets and enclosures
- Lists of apparatus
- Supplier's documentation for used components
- Lists of instructions and reproducible copies of programs (software) used in protection relays, programmable controllers and the supervisory control and data acquisition (SCADA) system

Single-line diagrams, standards and block diagrams, logic diagrams of the automated system and locking, as well as flow diagrams, are subject to the review and comments of the Owner.

To facilitate their reading, the diagrams shall include a list of symbols and identification markings used, as taken from the norms and standards. The physical representation conditions of the diagrams shall be specified – for example: control voltage, empty tanks, ambient temperature, etc.

All contacts of a relay or a primary detector shall be represented only once on the diagram, indicating the unused and available contacts. The representation method used shall be agreed by the Owner at the beginning of the Project.

For each cable, the cable classification lists shall indicate the following:

- Cable number
- Manufacturer
- Type
- Purpose
- Cross-section
- Voltage
- Composition

- Ins and outs
- Numbers of corresponding connection diagrams
- Insulation type

The list of equipment for the various boards, consoles, cabinets and enclosures shall, for each apparatus, shall indicate the following:

- Nature and specific function
- Identification number
- Column number in the flow diagram where it appears
- Quantity
- Supplier
- Manufacturer
- Catalogue number
- Location in the equipment
- Main nominal characteristics

The cable layouts shall include, at intervals, the list of cable numbers passing the location.

3.1.9 Detailed schedule of studies, procurements, manufacturing, tests, deliveries, assemblies and commissioning

Based on the Project's general schedule, the Contractor shall prepare, not later than 2 months after submission of the Program (duration to be confirmed in the future by the Owner's General Requirements), a detailed schedule of studies, procurement, manufacturing in factories, equipment deliveries and the various phases of assembly and commissioning.

This schedule shall specify, inter alia, the following:

- Date of Contract signature and the contractual date of completion of the execution period
- Deadlines when information pertaining to the Installations, premises or equipment will be made available to the Contractor responsible for the civil works. This extends to other Contractors, if the case applies.
- Details of the dates on which the main orders for raw materials, sub-assemblies and equipment shall normally be placed, as well as the expected factory delivery dates
- Dates on which the Contractor shall submit to the Owner, and/or to the other contractors, information or documents required by the Contract
- Time required for manufacturing, processing and factory testing
- Estimated dates of packing and shipment for the various components supplied, taking into account the hazards of transport and the assembly schedule
- Various phases of assembly and commissioning tests for the main equipment
- Dates of performance test.

Once agreed by the Owner, the detailed schedule shall be periodically updated by the Contractor – as often as necessary, and, at a minimum, once per quarter – according to actual observed progress and any circumstances causing a delay in Contract execution. An updated schedule shall be included in each Quarterly Report prepared by the Contractor.

The Contractor shall immediately inform the Owner of difficulties that may be encountered in the execution of the Contract, their impact on the execution period and measures proposed to recover lost time and/or overcome these difficulties.

3.1.10Procedures and control programs for inspections, factory (shop and laboratory) testing and onsite testing

The Contractor shall submit, for review and comments by the Owner all test procedures as well as an Inspection & Test Plan (ITP) that covers all supplied components.

All relevant documents shall be submitted not later than 6 month before the pertinent test shall be done as for the project's approved time schedule.

3.1.10.1TEST PROCEDURES

The detailed test procedures that the Contractor intends to follow shall be submitted for review and comments by the Owner, according to the dates indicated in the drawings and documents list

These procedures shall include, at a minimum, the following:

- Description of the methods of control, with reference to the relevant standards
- Personnel and resources implemented
- Outline of the future test report, including:
  - Choice and calibration of measuring devices
  - Experiment assembly diagram
  - Conditions of use
  - Precautions to be taken for personnel safety
  - Precautions to be taken for safeguarding of equipment
  - Error analyses, etc.

- Test datasheets
- Required results, and acceptance criteria

3.1.10.2PROGRAMS OF CONTROLS, INSPECTIONS AND FACTORY (SHOP AND LABORATORY) TESTING

Before initiating the procurement of raw materials for the production of each component supplied, the Contractor shall submit, for review and comments by the Owner, the control, inspection and test programs describing all controls, inspections and tests that must be carried out for each component during its manufacturing, including the following:

- Controls for the raw materials
- Controls during assembly and welding
- Controls during machining
- Final controls at the end of manufacturing

Furthermore, the Contractor is expressly responsible to immediately inform the Owner of any flaws, defects or malfunctions, detected during the course of manufacturing, in the raw materials, materials, parts, works, sub-assemblies and equipment, and to present the Owner with a detailed proposal for acceptance, repair or rejection of the defective elements.

3.1.10.3PROGRAM AND PROCEDURE OF COMMISSIONING TESTS

The program and detailed procedure for preliminary tests and controls for commissioning shall be prepared by the Contractor and submitted to the Owner for review and comments. This program shall be submitted, at the latest, six (6) months before the beginning of the commissioning tests and shall follow the PPA stipulations and IEC Ltd requirements. Commissioning tests shall be carried out in conformance with the Contract and Particular Technical Specification requirement and relevant Standards, in particular:

- Turbine performance testing according to IEC 60041,
- Generator performance testing according to IEC 60034.
- Transformer testing according to IEC 60076,
- Functional tests on mechanical and electrical equipment.

3.1.10.4REPORTS CONCERNING INSPECTIONS AND TESTS

All agreed-upon controls, inspections and tests shall result in reports to be prepared and submitted by the Contractor. These reports shall indicate all test condition and results obtained, as well as all eventually inferred calculations and error analyses, in order to establish that the equipment characteristics meet Contract requirements and guaranteed values.

These reports will basically support:

- The acceptance of equipment shipments determined by the inspections, controls and tests during and at the end of manufacturing
- The completion of the equipment assembly determined by the controls during assembly.

3.1.11Assembly and disassembly instructions

The assembly and disassembly instructions shall include all information and sketches required for proper understanding of the assembly/disassembly processes. In particular, they shall describe the use of the assembly platforms with dimensional sketches, lifting and handling devices, special tools and corresponding instructions, detailed sequence of operations, machining allowances and tolerances, assembly allowances and tolerances, required controls, etc.

The assembly/disassembly instructions shall indicate, for each assembly/disassembly step of each main component, the dimensional and other checks to perform. These indications shall be provided in the form of explicit sketches and shall be presented in the form of individual control sheets. These control sheets shall include:

- Types of measuring instruments to be used
- Reference dimensions and tolerances
- Particular implementation conditions
- Places to record actual measurements

All control sheets filled out during assembly shall become part of the manufacturing and assembly document compilation to be submitted for use in operation of the Installations.

3.1.12Start-up, operation and maintenance instructions

These instructions shall provide all relevant information regarding equipment start-up/shutdown, operation, adjustments, troubleshooting, repair and preventive maintenance.

All relevant instructions shall be submitted not later than 6 month before the plant start up and commissioning date as for the project's approved time schedule.

The Manuals shall include drawings and diagrams, as well as photographs, aimed at facilitating understanding of the instructions. The Manuals shall include, at a minimum, the following volumes.

- **Volume 1 – General Description:**

  The General Description can include all or part of the operational instructions provided during the studies.

- **Volume 2 – Operation:**

  This volume shall describe:

  - Main characteristics of the equipment
  - Verifications prior to start-up
  - Sequence of start-up and shutdown operations
  - Locking system
  - Frequency of the tests to be carried out on little-used equipment
  - Dimensions/parameters whose periodic measurement is required for maintenance
  - Operational procedures
  - Tables listing possible operational mishaps, the most frequent damages, their causes and how to deal with them

  Volume 2 shall comprise the following:

  - **A. General Description:**
    - o This description shall summarize the main characteristics of the equipment.
  - **B. Start-up Instructions:**
    - o These instructions shall indicate, in the proper sequence, the operations required to start the equipment.
    - o These instructions shall include precautions to be taken and shall emphasize critical points to observe.
    - o These instructions shall be subdivided as follows: "Step-by-Step Manual Start-up", "Initial Start-up and Adjustments", "Sequenced Automatic Start-up", etc.
  - **C. Operation Instructions:**
    - o These instructions shall include precautions to be taken and critical points to observe.
    - o These instructions shall recommend a method for periodic reading of indications and recording in an operation log.
    - o For each item, a table shall be included that indicates possible operational difficulties, their probable causes and how to deal with them.
  - **D. Shutdown Instructions:**

- These instructions shall indicate, in the proper sequence, the operations required to stop the operation of the equipment.
- These instructions shall include precautions to be taken and shall emphasize critical points to observe.
- These instructions shall be subdivided as follows: "Normal Shutdown", "Shutdown on Network Faults, either Mechanical or Electrical" and "Emergency Shutdowns", when relevant.

- **E. Graphs and Diagrams:**
  - This part of Volume 2 shall include characteristic operational graphs and diagrams; hill-type curves for the turbines; and characteristic curves of pumps and valves.

- **F. Equipment Consignment:**
  - The Contractor shall describe with precision the operations related to the consignment and the release from consignment of the equipment supplied.
  - Key operations shall be described in their proper sequence, with each equipment item mentioned in the description recorded according to its tracking number, which is the tracking number used in the drawings and diagrams on which the equipment is represented, and on the equipment itself.

- **Volume 3 – Maintenance:**

This volume shall describe:

- Instructions for preventive maintenance
- Verifications to be performed, adjustments, tolerances, lubrication frequencies, etc.
- Designation and potential sources of purchase, quantities, qualities, levels to follow, etc., for all fluids used, preferably in the form of tabular summaries
- Instructions for the replacement of wearing parts
- Reference tables and diagrams for the procurement of spare parts
- Minor and major periodic servicing
- Corresponding publications

Volume 3 shall comprise the following:

- **A. Disassembly Instructions:**
  - These instructions shall indicate the procedures to follow, operation-by-operation. Exceptional care and precautions to be taken shall be emphasized.

- **B. Maintenance Instructions:**
  - These shall include instructions for preventive maintenance and frequency of interventions, as well as lubrication information.
  - Programs that indicate the shutdowns and verifications to be performed after the various periods of operation shall be included.
  - A description summary and the identification of the special tools required shall also be included with these instructions.

- **C. Adjustments and Clearances:**
  - Information in tabular form concerning adjustments of the instruments, alarm and shutdown thresholds, operational clearances and necessary adjustments for a proper operation, shall be provided.
  - This section of Volume 3 shall also indicate, in tabular form, operating conditions, such as temperature, pressure, flow, current intensity, etc. The tables shall include recommended values alongside those measured during assembly and/or onsite testing.

- **Volume 4 List of Equipment**
  - Detailed list of all equipment supplied and installed
  - List of manufacturers and catalogue numbers of each piece of equipment supplied and installed
  - List of Spare Parts supplied with the corresponding catalogue numbers and names of manufacturers and as instructed in the Contract
  - List of recommended spare parts as instructed in the Contract

3.1.13 Compilation of manufacturing and assembly documents intended for operation

This important compilation shall include the following:

- "As-built" drawings
- Suppliers' detailed documentation
- Tables indicating the various clearances and adjustments carried out during assembly and start-up
- Calculations that justify the adjustments of the protection relays
- Reports and certificates from factory controls, inspections and tests carried out on the equipment
- Collection of reports and certificates from controls, inspections and tests carried out during onsite assembly and start-up

This compilation shall comprise, at a minimum, the following documentation:

- **"As-built" documents** – These documents shall include the general Installation layouts; foundation and detailed mechanical engineering drawings; calculation notes; fluid, logic and flow diagrams; lists of equipment; fluid circuit and electrical wiring layouts; and operation handbooks, as listed in Subsections 3.1.1–3.1.8 above, duly corrected and supplemented in order to be in perfect conformance with the Installation as implemented, with regards to connection layouts, electrical and mechanical adjustments, etc.

- The complete collection of **reports concerning factory inspection and tests** – These documents shall include all reports and/or certificates of controls, inspections and tests carried out by the Contractor and/or his subcontractors in laboratories and in factories during the manufacturing process.

- The complete collection of **in situ test reports** – These documents shall include all reports and/or certificates of controls, inspections and tests carried out during assembly and during start-up of the Installations. This collection shall be supplemented with tables indicating the most recent adjustments of the various components of the supply carried out during the tuning phase.

All documents under this paragraph shall be submitted not later than 6 month before the plant commissioning date as for the project's approved time schedule.

3.1.14 Other Documents

- **Subcontract Documents** – Before ordering various materials and components, the Contractor shall transmit all subcontract documents to the Owner for control, on which the commercial price of purchase of the supply could be hidden.

- **Bills of Lading** – Before each shipment of equipment, the Contractor shall submit five (5) copies of the bills of lading to the Owner. The bills include details on the contents of each crate or package shipped in the form of detailed bills of materials, as well as various indications qualifying the particular shipment.

- **Quarterly Reports and Interim Reports** – To be completed in a later time according to the Owner's General Requirements.

- **Health and Safety Plan (HSP)** – To be completed in a later time according to the Owner's General Requirements.

- **Quality Assurance Plan (QAP)** – To be completed in a later time according to the Owner's General Requirements.

3.2 Formal provisions related to the documents

All documents shall be completed and published via an indelible process, entirely paginated, elaborated following a consistent method, perfectly legible and shall allow rapid and reliable identification of their subject.

All documents shall be provided in English and shall bear the standard uniform title block of the Project. Each document shall include a document number in conformance with the numbering rules of the Project, document Title, Author, Revision N and Date. A document without identification, therefore impossible to archive, shall not be regarded as a component part of the Project.

The numbered documents, including technical-commercial documentation from suppliers and subcontractors, shall include a flyleaf displaying the standard uniform Project title block.

3.2.1 Drawings

All drawings shall be exclusively provided in the standardized DIN A4, A3, A2, A1 or A0 formats, or folded A4 format, with insert band for structured presentation in ring binders. The apparent fold, after folding, shall show the standard uniform Project title block. Each transmittal of drawings shall be accompanied with a digital copy of same transmittal

3.2.2 Other documents

Instructions, reports, lists and nomenclatures shall be provided exclusively on numbered A4 (and A3 folded in two folds) format paper sheets. The first page shall include the standard uniform Project title block, which includes the complete title and document number, as well as the date and index pertaining to the last modifications made to the various sheets. Each transmittal of documents shall be accompanied with a digital copy of same transmittal

3.2.3 Diagrams

Fluid diagrams and single-line diagrams shall be drawn on A0 format, with A3 format copies provided. Logic and flow diagrams shall be drawn on A3 format in the form of stapled packages,

excluding any other formats. A diagram shall be composed of several sheets, which shall be numbered, with the total number of sheets indicated on the title page. This page shall also carry the standard uniform Project title block, which includes the complete title and document number, as well as the date and index pertaining to the last modifications made to the various sheets. Columns or sections, numbered starting from "1" on each sheet, shall facilitate the location indication of a particular element on the sheet.

In the event of partial modifications to documents having several pages, the whole file shall be updated and resubmitted.

Diagrams, drawings and instructions shall be prepared using the notations, signs and symbols, as well as the requirements, stated in various IEC publications (in particular recommendations 27, 113 and 617), and in various ISO publications (in particular recommendation R 1219).

The identification of circuits, apparatuses, terminals and cables, the Contractor shall follow the recommendations of IEC 113, 391 and 446.

Numerical references given by ANSI/IEEE C37.2-1979, "Electrical Power System – Device Function Numbers", shall be exclusively used in the electrical single-line and flow diagrams.

The flow diagrams shall represent the detailed and exhaustive development of each circuit. The polarities shall be represented by continuous bars – the positive polarities at the top of the sheet, and the negative polarities at the bottom of the sheet.

The flow diagrams shall be read from top to bottom and from left to right, with the relay and actuator coils being generally polarized to the negative pole. The representation of the relay's contacts shall be exhaustive under the coils outside the field of polarities. The cross-references (page and section) to the circuits in which the contacts are used shall be clearly stated.

All equipment terminals shall be illustrated, including intermediate input/output terminals. Electrical circuits shall be identified by equipotential numerical references. Sufficient space shall be allocated for possible modifications to the diagram.

3.2.4 Numbering of the documents

The magnitude of the Project is such that Owner and the Contractor need to implement a comprehensive and unique document numbering system, sufficiently general to cover the entire Project.

The details of this numbering system, based on KKS standard shall be prepared by the Contractor submitted to the Owner for its review and comments.

3.2.5 Distribution of the documents

To be completed in a later time according to the Owner’s General Requirements.

3.2.6 Modified, corrected or updated documents

Documents that had to be revised, for whatever reason, during the studies or as documents intended for use during construction and operation, shall be redistributed according to the rules stated in the future by the Owner's General Requirements

The Contractor shall be held responsible for any delays or damages that may be caused by the absence of, or by delay in the submission of, the modified, corrected or updated documents.

3.2.7 Schedules for submission of drawings and documents

To be completed in a later time according to the Owner's General Requirements.

3.2.8 Conservation of the manufacturing drawings and documents

The Contractor shall maintain, for a minimum period of ten (10) years, without charge, all manufacturing drawings and including foundry patterns drawings, as well as all information from the studies that is likely to facilitate the performance of repair and maintenance in the Installations.

3.2.9 Review and comments of documents

To be completed in a later time according to the Owner's General Requirements.

4 MATERIALS AND MECHANICAL EQUIPEMENT

4.1 Choice of materials

All materials incorporated in the equipment supplied shall be of the quality, grades and conditions specified in the standards defined in Section 2 above.

For all equipment, the material quality and designation to apply shall clearly appear on drawings and/or material lists.

Materials not specifically designated herein shall be subject to the Owner's review. Such materials shall be suitable for their purpose and shall comply with the latest issue or revision of the designated standards, or their approved equivalent.

The Contractor shall justify the choice of materials specified for the procurement of components. This justification shall be based on analysis of the following:

- Stress levels
- Weldability (including repairs by welding)
- Risks of alteration of mechanical properties during operation
- Risks of sudden failure due to fatigue (considering size of the critical defects for the considered lifespan)
- Risks of embrittlement, corrosion of any type and erosion
- Behaviour of coatings during operation

The grades used shall depend on stress levels, environmental conditions, resulting material thicknesses, manufacturing procedures and inspection procedures. Unless otherwise specified, the material grades shall be proposed by the Contractor, and are subject to the Owner's review.

4.2 Cast parts

All castings shall be true to pattern and of uniform quality and condition, free from injurious blowholes, porosity hard spots, shrinkage defects, cracks and other defects, as determined by visual inspection, and shall be satisfactorily cleaned for their intended purpose. Casting surfaces that do not undergo machining, particularly those surfaces in contact with water, shall be dressed smooth, with all joints blended into adjacent surfaces, and shall be free from foundry irregularities – projections, ridges, hollows, honeycombing, pock marks, chip marks, etc. – so that they do not require surface smoothing operations prior to painting.

All steel castings shall be heat-treated in accordance with the relevant standard. All iron castings shall be mild annealed in a suitable annealing furnace to relieve casting strain before machining.

The Contractor shall retain all patterns required for production of the plant for a period not less than 10 years from the starting date of production.

The processes of casting inspection and repair shall meet the requirements of CCH 70-3.

Defects in steel castings may be repaired to the extent and by methods reviewed by the Owner, including review and comments of welding procedure, pre- and post-weld heat treatment and non-destructive testing.

All defects shall be fully recorded and investigated, and castings shall not be repaired, plugged or welded without advance written authorization from the Owner. Such authorization will be given only when defects are small and do not adversely affect the characteristics of the castings.

No repair welds in excess of 20 mm depth shall be permitted without stress relieving, unless otherwise agreed to by the Owner. Repair welding on steel castings, other than repair welding of minor defects, shall be done by the metallic arc process, followed by thermal stress relieving.

Repair of stainless steel castings shall be carried out with low-carbon electrodes of the same chemical composition as the casting material. Before repairs are made, repair procedures shall be submitted to the Owner for review and comments.

No welding shall be carried out after the casting undergoes final heat treatment.

Test coupons, from which test specimens are prepared, shall be attached to all castings weighing 250 kg or more. The number, size and location of the test coupons shall be recorded, and the records made available to the Owner upon request. Test coupons shall be located in areas of maximum stress.

For the main castings, the steel shall be made by the electric furnace process with separate refining process such as Vacuum Degasing (VD) and Vacuum Oxygen Decarburization (VOD) for stainless steel casting. Chemical analyses shall also be carried out and recorded at the time of pouring. The times and temperatures of pouring shall also be observed and recorded, as well as the times of removal of the casting from the mould. This information shall be submitted to the Owner at the time of inspection.

All steel castings that will be rotating parts during operation shall be given a double heat treatment. In each heat treatment, the casting shall be held at the desired temperature for a sufficient amount of time to ensure proper grain refinement throughout the casting. Such castings shall be furnace-cooled after the final heat treatment. The grade, composition and ASTM specification number shall be subject to the Owner's review.

The castings shall be clearly stamped with the heat number and serial number in such locations as to be readily visible.

4.3 Forged parts

Forged shafts and all other forgings, unless otherwise specified, shall be in accordance with ASTM recommendations or better.

Ingots from which the forgings are made shall be cast in metal moulds. Sufficient discard shall be taken from each ingot to ensure freedom from piping and undue segregation. The original cross-sectional area of the ingot shall be at least four times the area of the finished forging. Flanges and other enlargements on the shaft need not be reduced in this proportion, but shall be reduced in a ratio of not less than 1.7 to 1.

Test coupons shall be provided in accordance with ASTM 668 recommendations or similar, unless otherwise specified.

All forgings shall be given such uniform heat treatment as may be required to produce materials conforming to the requirements of the specifications. All forgings, however, shall be annealed, or normalized and drawn, as final heat treatment. In the case of solid forged shafts, which are required to be bored, the final heat treatments, i.e., annealing, or normalizing and drawn, shall be performed after forgings have been rough-bored. Upon request, a record of the heat treatments to which the forgings have been submitted shall be supplied to the Owner during the inspection.

All shafts 300 mm in diameter and over shall be bored axially throughout their full length, and shall have a finish of approximately 6.3 micrometers (Ra).

All hollow-bored shafts shall be finish-bored after the final heat treatment.

Forgings shall be clearly stamped with the heat number and serial number in such locations as to be readily visible.

No repair of forgings may be carried out without prior submission of the defect localization record and the proposed repair procedure – including welding procedure, pre- and post-weld heat treatment and non-destructive testing – to the Owner for his review.

4.4 Piping systems, pipes and accessories

4.4.1 General

Piping systems shall be designed according to ASME B31.1 (2001), DIN EN 13480-3 (2002) or an equivalent recognized standard.

All piping shall be furnished complete with flanges, unions, expansion joints, gaskets, packings, valves, drains, vents, pipe hangers, clamps, supports, etc. In addition, the Contractor shall provide steel structures, walkways, platforms, stairs and ladders, all designed according to the safety requirements and equipped with handrails, over large diameter pipes lying more than 600 mm above the floor.

All pipes shall be carefully cleaned before installation; carbon steel pipe shall be cleaned by a chemical process. A detailed procedure shall be submitted for the Owner's review and comments.

All piping, valves and fittings, flanges and joints shall be designed for the highest pressure occurring in the actual system in service, including water hammer and other pressure transients where appropriate. Unless otherwise stated, all piping, valves and fittings shall, as a minimum, be classified as PN 10, at an ambient temperature of 40°C, but not below the highest working pressure or the highest working temperature of the environment or as indicated in the Particular Technical Specifications (PTS).

All piping systems shall be pressure-tested at 1,5 times the maximum design pressure (design pressure shall be calculated for the max. water hammer case).

All pipes and fittings (flanges, elbows, valves, taps, etc.) of the piping systems shall be colour-coded painted, or banded and labelled according to a recognized standard. The colour coding and labelling scheme shall be submitted to the Owner for review and comments.

All piping systems shall be marked with arrows showing the direction of flow. Arrows shall be marked at every change of direction and at 20 m intervals in straight sections. The direction arrows will be located at completely visible points.

Fluid velocities in pipes shall be limited to 4 m/s in pressure pipe and 1 m/s in suction lines.

4.4.2 Pipes

Steel pipes shall be seamless pipes, with the exception of embedded pipes kept at atmospheric pressure.

All embedded steel pipes shall be made of steel, with 2 mm additional wall thickness for corrosion allowance.

The use of cast iron and nodular cast iron pipes for pressurized systems is completely forbidden.

Pipes in oil systems of nominal diameter of DN100mm or less shall be of stainless steel. Pipes of higher nominal diameter shall be of carbon steel.

Pipes in water systems of nominal diameter of DN100mm or less shall be of stainless steel. Pipes of higher nominal diameter shall be of hot galvanized carbon steel.

The danger of galvanic corrosion and induced electric currents in the piping systems shall be considered, with the necessary isolating flanges provided and the ranking order of different materials taken into account.

Unless authorized by the Owner, the use of plastic pipes is forbidden.

Welding, as well as application of corrosion protection coating, shall be done in the Contactor's facilities as far as possible. Flanged connections and unions shall be provided, as necessary, for transport and installation, or in order to facilitate dismantling for repair purposes.

If the piping crosses expansion joints of civil structures, then, subject to review of the Owner, the piping shall be provided with flexible joints to allow for vertical, horizontal and angular deviations between the centrelines of connected pipes.

Pipes installation, whether aerial, underground or embedded, will allow full and easy drainage without undrained pockets.

4.4.3 Flanges and Gaskets

Metric flanges conforming to ISO 7005-1, ISO 7005-2 and ISO 7005-3 shall be used throughout. Flanges shall be of the weld neck or slip-on type. Sealing faces shall be machined.

Welded flanges for steel pipes shall be of material quality DIN-EN 10025 (1994) Grade Fe 360C, or better. Welded flanges for stainless steel pipes shall have a material quality corresponding to the pipe material.

Flat gaskets shall be of the rubber, metal mesh reinforced type, or better, and shall be guaranteed asbestos-free.

4.4.4 Fittings

In general, fittings shall be of the same or better material as the connecting pipes, with suitable corrosion protection. Threaded fittings shall not be used for dimensions larger than 50 mm (DN 50). For high-pressure oil systems, fittings with rubber seal sealing provisions shall be used.

4.4.5 Valves

In general, valves shall be delivered according to DIN 3230 norms and related standards, and shall be leakproof – Rate 1 DIN 3230 Part 3 (1982) – either in flow direction or in opposite direction.

As far as practicable, all valves for similar service shall be of the same make and type, and shall be interchangeable. Their type and material shall be adapted to the intended use, and the following rules shall apply:

- Small-sized valves, with nominal pressures less than 10 bar and nominal diameters less than DN 50 for water, may be made of cast iron or a suitable copper alloy, and shall conform to DIN 3230, Parts 1 and 2.

- Medium-sized valves, from DN 50 to DN 150, shall conform to DIN 3230, Part 4. Valves body shall be of nodular cast-iron (ductile iron) of quality not less than EN 1563 (2003) GGG-40 for nominal pressures up to PN 25.

- Small- and medium-sized valves shall be delivered with test reports conforming to EN 1024 (1995) 2.2 requirements.

- Larger valves, with diameter and pressure ratings exceeding the limits above, shall conform to DIN 3230, Part 6 (1987), with inspection certificate conforming to EN 10204 (1995) 3.1.B requirements, unless otherwise specified. Their valve bodies shall be made of nodular cast iron, cast steel or welded steel, as specified in DIN 3230, Part 6 (1987).

- Spindles, seals, seats and other wearing parts, where applicable, shall be made of suitable corrosion-proof material. The valves shall be designed so that vibrations will not occur when in service or when being set at nearly-closed or nearly-full-open positions. All valves shall be designed for opening and closing against the full pressure without undue cavitation or vibrations. If necessary, bypass valves of ample size shall be provided.

- Generally, all isolating valves, or valves on pipes leading directly from the headwater or the tailwater, shall be flanged.

- Gate valves of the free-flow rubber-lined-gate epoxy-lined-body type shall be preferred for nominal pressures less than 16 bar and dimensions less than DN 400.

- Other valves may be of the gate-type, ball-type (which is preferred for small dimensions and for high pressures) or butterfly-type (for larger dimensions and up to a maximum nominal pressure of 16 bar). Butterfly valves shall be of the flanged-type, epoxy- or rubber-lined, with rubber seals.

- Where flow regulation is required, butterfly valves are not allowed, as only open/close positions are allowed.

- Handwheels and handles shall be of ample size and, where necessary, shall have extended spindles and gearing so that any valve may be easily and conveniently operated by one man under service conditions. If extended spindles are used, a sufficient number of bearings shall be provided. Where passing through concrete, a sleeve shall be installed for protective purposes. The entire assembly shall be made of suitable corrosion-proof materials, subject to the Owner's review.

- Valves shall close with a clockwise rotation of the handwheel or handle and shall be provided with position indicators, rising-stem or equivalent.

- Valves actuators, whether electric, pneumatic or hydraulically operated, shall be constructed of materials suitable for the relevant operating media and the environmental conditions. The actuator shall have a local position indicator, adjustable limit switches for open and closed position and means for manual operation. Electric actuators shall be protected to an IP54 degree of protection, unless otherwise specified, with limit switches and additional torque limiters.

- Ball valves for automatic operation shall have two-sided bearings of the ball.

- Pilot valves, operated manually or via solenoids, shall be made of corrosion-resistant materials and shall have ample dimensions, with a minimum of head loss. Leaks shall not cause uncontrolled opening/ closure, but shall be drained through separate ports.

- Pressure-relief valves, safety valves and similar components shall work without vibrations and shall have a clearly defined pressure range within which the closing and opening will take place. They shall be workshop-tested and provided with a calibration certificate.

- Orifices shall be made of stainless steel.

- Piping works shall be designed in order that valves can be easily dismountable, where ever required, dismounting sleeves or coupling shall be forecasted.

4.4.6 Supports, hangers, brackets and frames

Supporting of pipes shall be carefully considered to reduce vibrations and undue deflections, and to allow temperature expansion.

4.4.7 Grates and strainers

Strainer housings shall be made of corrosion-proof material or protected by means of hot-dip galvanizing or appropriate epoxy coating. Strainer elements shall be dismountable without interrupting the current operation of the system. They shall be designed for easy removal of the inner parts from above. Strainers shall be made of cleanable and completely corrosion-proof materials. Strainers will be designed to withstand maximum operation pressure when completely clogged.

Grates shall be dismountable and made of stainless steel or hot-dip galvanized carbon steel properly painted when size of more than 1 square meter. Grates shall, unless otherwise specified, be designed for one-sided pressure equal to the maximum static system pressure. Grates will be installed in a form that will avoid any vibration during maximum through flow.

Grates and strainers shall be provided with clogging indicators for local and remote indication.

4.4.8 Pumps

All pumps to be supplied for the Installations shall be from a reputable supplier and of a type best suitable for their purpose. They shall be furnished complete with electrically driven motors of ample capacity to provide safe and continuous service under all operating conditions of the respective system.

Pumps shall be delivered with complete test certificates covering verification of all pressure, flow and power characteristics. (See also following clauses concerning Tests).

For pumps rated 30 kW and above or of working pressure above 6 bar, the body shall be made of cast steel or nodular cast iron with quality not less than EN 1563 (2003). Pumps of operating pressure less than 6 bars, body may be made of cast iron of a quality not less than DIN EN 1561 (GG-25), or equivalent.

All wearing parts, sealing faces, shafts, etc., shall be made of corrosion-proof material and shall be easy to replace. Pumps shall be equipped with mechanical seal, seals shall be able to be replaced without extensive disassembly of the pump. Leak water shall be directed to suitable channels. Each pump shall have air and drain valves.

Water pump impellers and labyrinth rings shall be made of stainless steel suitable to water properties as specified in the “General information”.

Pump bearings shall be of the maintenance-free type.

All pumps shall be fitted with isolating valves (suction and discharge), pressure gages (suction and discharge), switch valves and check valves, as required. The use of suction strainers shall be considered on a case-by-case basis.

Pumps for hydraulic systems shall be of the positive displacement type.

Each positive displacement pumping array, will be equipped on the discharge side with a pressure relief valve (PRV). The PRVs will be of sufficient capacity to bypass the full delivery of the pumps, already at a pressure raise of only 10% above the system working pressure.

All pumps shall have a pressure rating, guaranteed by the manufacturer, of a minimum of 20% above the normal system working pressure. The rated power of the pump's driving motor shall be sized at 110% of the maximum pump capacity at any theoretically possible pump operation condition according to the pump curve.

4.4.9 Threaded fasteners

All machine bolts, stud bolts, screws, nuts, and any other type of threaded fastener., shall have standard metric threading and conform to the relevant standards with regards to shapes and tolerances. They shall be marked by the manufacturer's symbol and class of strength.

All bolts, studs, nuts, washers, screws, etc., used in steel structures, of a size M 10, shall be made of stainless steel or other corrosion-resistant or hot-dip galvanized metal, except for bolts above Strength Class 8.8, for which corrosion-resistant or electrolytic zinc-coating materials shall be required.

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Bolts, nuts, studs and screws that require frequent tightening and unbolting during inspection or maintenance procedures shall be made of stainless steel.

In all cases, the material for bolts shall be chosen with attention to the surrounding material, as to avoid any possible formation of electrolytic couples.

All bolts, screws nuts and whatever threaded fastener shall be secured by an agreed method against loosening during operation.

The Contractor shall supply the net quantities plus 10% of spares of all permanent bolts, screws and other similar items and materials required for onsite installation of the works. All such bolts, screws,

etc., that remain as surplus after installation of the equipment has been completed shall become spare parts and shall be wrapped (with lubricated wrappers), marked and handed over to the Owner.

4.4.10Lubricants

Oil of an agreed grade and quality shall be used for all purposes. In particular, bearings, governors and other lubricated systems shall use the same grade. For hydraulic circuits at pressures higher than 10 MPa, a high quality hydraulic oil shall be used.

Only oils and lubricants which are commercially available in Greece and in the EU shall be used. They should be in conformity with ISO 8068, ISO 6743-5 and ISO 4406 specifications. Oil classification shall take into account NAS 1638 and ISO VG definitions.

The Owner therefore, reserves the right to request the use of a particular type of lubricant or oil. The Contractor shall not be entitled to claim extra payment because of this request.

Oils shall be free from bacteria and shall contain suitable microbiocides to prevent any bacteriological growth when in service or during normal storage.

Hydraulic systems oils will incorporate additive such as anti-foam and anti-freeze to insure their properly operation throughout any environment and operation conditions.

4.4.11Cranes and other lifting equipment

Generally, for the design, stress calculation, manufacturing and installation of cranes and other lifting equipment, the following Fédération Européenne de la Manutention (FEM – European Federation of Handling Industries) standards shall be applied:

- Section I: Heavy Lifting and Handling Equipment – Rules for the design of hoisting appliances (steel structures and mechanisms)
- Section IX: Series Lifting Equipment – Rules for the design of series lifting equipment (mechanisms)

In case of discrepancy between the standards the more stringent will prevail.

The Contractor shall propose the group classifications of cranes and auxiliary hoists, subject to the review and comments of the Owner.

All lifting equipment shall be subject to static and dynamic testing, with overloads as follows:

- 1.25 x nominal load for static testing
- 1.1 x nominal load for dynamic testing

The Contractor is responsible for supplying the test loads and dynamometers.

The average pressure exerted by the crane rails and their anchoring elements upon the concrete shall not exceed 10 N/mm^2.

All lifting equipment shall be subject to the rules and test required by Greek law and standards.

4.4.12Rubber seals for hydromechanical equipment

Rubber seals for hydraulic steelworks shall be of first-quality non-ageing chloroprene rubber material, which shall be unaffected by wetting/drying or temperature changes, and shall be protected against UV radiations

The Contractor shall furnish the name of the manufacturer and technical data of the gate seal material for the Owner's review.

All bolts, nuts and flat bars for fastening the seals shall be made of stainless steel.

4.4.13Stairs, ladders and platforms

Stairs shall have a preferable inclination of approximately 35°. Ladders shall have a preferable inclination of approximately 75°. Stairs shall be provided with handrails of a minimum of 110 cm in vertical height on the inclined part. Platforms will be provided with handrails of a minimum of 110 cm in vertical height. Both stairs and platforms and handrails shall be designed according to EU standards provided with toe boards 10 cm in height.

Vertical ladders more than 3 m in height shall be caged.

Vertical ladders of more than 6m high shall be installed staggered with sections of maximum 6m long. At the end of each section a metallic hand railed platform will be provided.

Unless otherwise specified or stipulated in the applicable standards, the load assumptions for ordinary platforms shall be as follows:

- For platforms used by personnel and for support of light equipment with single weights of less than 500 N:3,000 N/m^2
- For all other platforms:5,000 N/m^2

Platforms and stairs shall be provided with slip-resistant gratings and/or checker plates.

Subject to the Owner's review, stairs, ladders, platforms, etc., may be manufactured in aluminium, if the rigidity of the structures is duly considered.

4.4.14Mechanical instrumentation

Mechanical instruments – manometers, pressure gauges, switches, transducers, thermometers, limit switches, etc. – shall generally be of the heavy-duty type and of the highest quality, with stainless steel piping and interior parts. Visual indicators shall be graded in bars, °C or any other SI unit. Instruments mounted outdoors or in humid environments shall have stainless steel or brass housings having a degree of protection of not less than IP54.

Mechanical instruments shall generally be supplied in 1% accuracy class and 100 mm minimum scale diameter.

Instruments, switches and transducers shall not be mounted on vibrating components, and all mechanical parts shall be suitably protected against shocks, vibrations, heat, humidity, splashing water, etc. At difficult locations, instruments may be filled with a damping liquid, e.g., glycerine, to reduce environmental effects or the effects of vibrations.

Switches shall have large-sized contacts, at least one normally-closed and one normally-open contact, and shall be easily adjustable.

Pressure, level and other transducers shall have 4–20 mA output with 2- or 3-wire connections. Temperatures to be remote-indicated and to be recorded shall be measured by means of duplex resistance thermometers of Pt100 platinum element type, with 100 ohm resistance at 0 °C.

All pressure gauges, switches and transducers shall have isolating and drainage 3 way valves and provisions to connect temporary instruments.

To allow instrument withdrawal without draining the system, temperature gauges, switches and transducers shall have feeler pockets.

5 MANUFACTURING

5.1 Manufacturing technical program

For each main component supplied, the Contractor shall prepare a technical manufacturing procedure to be submitted to the Owner. The procedure shall describe the various steps that the Contractor intends to follow in the manufacturing of the components.

Particular information shall be provided regarding the manufacturing process of forged and cast components, and the welding, heat treatment and non-destructive test procedures.

5.2 Welding

5.2.1 Preparation for welding

All welds shall be performed as shown in the detailed drawings and shall be made in such a manner that residual stresses are reduced to a minimum. Weld seams shall, as far as possible, be positioned outside zones of stress concentration.

Full information and specifications of all principal weld seams shall form part of the design drawings. The drawings shall indicate the type of weld and the choice of electrodes, wires and welding powders to be used. The number of welding passes shall be made in relation to the thickness of the plate. Each pass shall be thoroughly de-scaled before the next pass is applied.

Members and sections to be joined by welding shall be cut accurately to size, with their edges ground or machined to suit the required type of welding, and to allow full penetration and fusion of the weld with the base material.

The surface of members or sections to be welded shall be free from rust, grease, mill scale, and other foreign matter for a distance of at least 30 mm from the edge of the weld. All paint materials shall be removed well back of the heat-affected zones. Welding over zinc primers shall be avoided.

5.2.2 Welding procedure

All welding shall be performed by the electric-arc method, and according to relevant standards, unless otherwise agreed by the Owner.

The welding works for main structures and components shall be in accordance with the requirement of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, and performed according to Welding Procedure Specifications (WPS) and Procedure Qualification Reports (PQR) established according to ASME Section IX and AWS code ("Standard Qualification Procedure").

WPSs and PQRs shall be submitted to the Owner for review and comments, and shall be issued with full information on all factors set forth in the respective welding forms according to the actual standard, e.g., QW-482 and QW-483 of ASME Section IX.

The welding procedures shall be selected in consistency with the composition and properties of the base material, type of weld and working stresses of the welded joint. Whenever required and in

accordance with the requirement of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, preheating and heat treatment of the welding seam shall be applied.

The mechanical properties of the weld shall conform to the base material, as specified in the respective standards, and shall be confirmed by mechanical test on a sample during the qualification procedure phase.

All joining of plates in the principal stress direction shall be carried out using either single-welded or double-welded butt joints. Adjacent plates, carrying high stresses, shall in general not differ more than 3 mm in thickness. If the difference is greater, the thicker plate shall be chamfered at a maximum of 1:4.

Principal welds shall be ground as specified in the welding procedure. In addition, all welds exposed to water having a velocity of 4 m/s or more shall be ground flush with the plates, unless otherwise agreed by the Owner.

In order to prevent the presence of residues in double-welded butt joints, the root shall be completely removed by grinding or back-gauging before proceeding with welding on the other side.

Welding of auxiliary structural members to components of the Plant for the purpose of assembly and installation works is completely prohibited, especially on high-grade material (e.g., the stay ring of the turbine). In extreme cases when it is allowed by the Owner, once the installation has been completed, auxiliary structural members shall be removed by burning them off, followed by grinding the affected areas flush with the plate, without introducing additional local thermal stresses. At a minimum, dye penetrant checks shall be performed on restored surfaces. Knocking-off of such members shall not be permitted.

The electrodes for arc welding shall be classified on the basis of mechanical properties of the as-welded deposited weld metal, type of covering, hydrogen absorption, welding position of the electrodes and type of current.

Electrodes shall be used only in the positions and under the conditions of intended use in accordance with instructions of each container. Electrodes for manual welding shall be suitable for welding in any position.

During welding operations, electrodes shall be stored and dried in electric heating furnaces prior to welding, according to manufacturer's instructions.

5.2.3 Welding repairs

In all welded assemblies, defects beyond the criteria of acceptance shall be eliminated. Depending on the size and number of defects to be eliminated, the Contractor retains responsibility for choosing between performing more or less numerous and important local repairs and that of a new assembly after cutting or entirely gouging the concerned weld. The Contractor's choice is subject to the agreement of the Owner.

If the extent of repairs of a weld performed by an automatic process is likely to extend beyond one-fifth of its length on at least its total thickness, the weld shall be redone and controlled once again.

For all welding repairs, the x-ray films or the results of the ultrasonic control revealing one or more defects of origin shall be submitted by the Contractor for Owner's review.

All repairs shall be performed either according to the qualified welding procedure for the execution of the welds, or according to the qualified repair procedure. Welding repairs either in manufacturers'

premises as well as on site shall be carried out by qualified welders as well as all current welding works.

However, if the defects, at the origin of one or more repairs, do not bring into question the qualified welding procedure followed during construction, and, if the Contractor decides to apply this procedure to perform the said repairs, no qualification test will be imposed. The repair shall performed by a qualified welder or operator.

All repair operations shall include the following:

- Verification of elimination of defects
- Non-destructive control of the zone repaired
- New heat treatment (local or global), unless justifications are brought by the Contractor and agreed by the Owner

At the same location, only two repairs by welding are allowed. The Contractor shall not continue beyond that before having submitted a report analysing the reasons for these successive repairs and receiving authorization from the Owner.

5.2.4 Heat treatment

The need and method for heat treatment shall be determined in accordance with the agreed design standard and ASME Boiler and Pressure Vessel Code, taking into account the stress levels, design temperatures, material properties (notch toughness, material thickness, etc.) and forming, welding and inspection procedures. Shop heat treatment of welded components shall be performed prior to final machining.

Procedures for heat treatment shall be submitted to the Owner for review and comments.

Site welding heat treatment shall be performed according to the specifications of welding procedures for the corresponding parts, which shall be submitted to the Owner for review and comments.

5.2.5 Welders qualifications

Welding shall be carried out only by experienced qualified welders. Welder qualification tests shall conform to ASME Code – Sections VIII and IX, or AWS B3.0.

All welders' and welding operators' test certificates shall be submitted to the Owner upon request. Welders for onsite work shall be tested no earlier than three (3) months prior to commencing onsite work operations.

5.3 Machining

Machining of all parts shall be accurate and to specific dimensions and tolerances, so that replacements made as per design drawings may be readily installed. Equivalent parts and spare parts shall be interchangeable.

Unless otherwise specified or agreed upon, all work performed shall conform to the requirements of the latest editions of the agreed standards.

All machining shall be performed so as to secure proper matching of adjoining surfaces. Unfinished surfaces shall be true to the lines and dimensions shown on the drawings, and shall be ground to be free from projections and rough spots.

The surface finishes of all parts and components shall conform to the respective strength and service requirements, and shall be in conformance with the drawings. Surfaces to be finished by machining shall be indicated on the design drawings by corresponding standard symbols.

The following surface roughness [rms (µm)] or better shall be achieved:

- Runner:As required by IEC60193
  -
- Surfaces in contacts with water: As required by IEC60193 with at least
  - Wicket gates upper wearing ring 1.6
  - Wicket gates lower wearing ring 1.6
  - Runner Chamber 6.3
  - Head cover and bottom ring12.5
  - Wicket Gates 12.5
  - Wicket Gates – contact surface 3.2
- Machined surfaces:
  - Shaft at location of bearing 0.8
  - Bearing surface 0.8
  - Other shaft surface6.4
  - Servomotor rod and piston 0.8
  - Surface at location of self-lubricated Material and dynamic seals1.6

Corners and edges shall be eliminated, by grinding, lathing etc. to produce a noticed chamfer.

5.4 Surface treatment and painting

5.4.1 General

The Contractor shall provide complete and reliable surface treatment and protection against corrosion of the furnished equipment. Such works shall include workshop painting and coating and paint “touch-ups” and finishing at construction site. The protections shall be applied, as much as practicable, in the workshop.

Unless otherwise specified, coating and painting shall be carried out in accordance with these General Technical Specifications and DIN 55928, "Protection of steel structures from corrosion by organic and metallic coatings", or other equivalent standard.

In all cases, the Contractor shall, however, fulfil the requirements imposed by the onsite conditions – water quality, climatic conditions, environmental conditions, etc. – that may, in many ways, affect the quality and suitability of the surface protection. The surface protection shall ensure lifelong protection of the equipment and minimize its maintenance.

The Contractor shall submit, for the Owner's review and comments, anti-corrosion protection procedures with full details regarding the preparation, type of materials, methods and sequences of application the Contractor intends to use for the protection of structures, machinery and equipment during transport, site storage, building, concreting, erection and operation.

The Contractor shall ensure that his proposed materials, methods and sequences comply with relevant safety rules and health standards, and do not contaminate the environment.

Coating materials shall be standard products from reputable manufacturers with suitable experience in the field of corrosion protection for the type of equipment to be supplied. Coating materials shall be adapted to the quality of fluid in its most sever condition. The Contractor shall justify his use of the proposed product according to the proposed procedure.

In general, stainless steel components, as well as machined surfaces, shall not be painted or galvanized. Machined surfaces shall be protected against corrosion during transportation and storage by an easily removable varnish.

The painting materials of each individual painting system will be of the same manufacturer and will be compatible.

5.4.2 Steel structures and surface protection systems

The Contractor shall define structure and surface protection systems for the different cases:

- System No. 1 – Surfaces in contact with water
- System No. 2 – Ladders, stairs, railings, outdoor surfaces of auxiliary equipment
- System No. 3 – Surfaces in contact with air
- System No. 4 – Surfaces in contact with oil (internal oil tank)

5.4.3 Protection of auxiliary equipment

The protection system of the auxiliary equipment shall be in accordance with the protection scheme described above. However, the standard system from the component supplier can be proposed to the Owner for his review, as an alternative, with the submission of complete documentation.

5.4.4 Surface preparation and painting

Before any coat is applied, surfaces shall be properly prepared. For removing rust and mill scales, blasting shall be carried out down to clean bare metal, according to ISO 8501-1, Grade Sa 2.5. The average surface roughness after blasting shall not exceed 50 microns. Sandblasting or grit blasting shall be performed by dry compressed air or rotating wheel. If the blasting material is recuperated it shall be thoroughly cleaned before reuse.

Blasting and coating shall, as far as possible, be performed after the structures and components are welded and machined. Equipment that cannot be blast-cleaned after the last machining shall be blasted, primed and given one topcoat prior to machining.

Painting will be carried out as much as possible immediately after completion of surface preparation.

Parts that cannot be blast-cleaned, such as pipes, shall be cleaned by power-tool and chemical agents.

All equipment parts shall be blasted in the manufacturer's shop unless otherwise specified or agreed by the Owner. The blasted surfaces shall receive a primer coat within a limited time after

sandblasting. All work shall be executed under acceptable climatic conditions and with efficient ventilation for removing dust and thinner vapours.

5.4.5 Cleaning of welds

Erection welds and their heat-affected zones created during erection, which have already been blast-cleaned and painted, shall be re cleaned by sandblasting to Sa 2.5 on an area of at least 100 mm on each side of the weld and repainted.

5.4.6 Painting and marking

Paints shall preferably be applied by means of airless equipment. Areas difficult to reach may be brush-coated or coated using a glove. Other application methods require agreement by the Owner.

Coating of any surface shall not take place unless the temperature and humidity conditions are such that a perfect result may be expected. Steel temperatures shall always be at least 3 °C higher than the dew-point temperature of the ambient air. Painting works shall not be carried out on surface temperatures below +5 °C or above +35 °C, unless agreed by the Owner. During painting works, the ambient air temperature shall be kept within the limits recommended by the paint manufacturer. Application of paint shall never be undertaken under conditions where dust, sand, etc., can settle on the wet paint film.

Care shall be taken to maintain full paint thickness at all chamfers, corners and edges, and special attention shall be paid to the application of protective coatings over welds, mitre joints, etc.

Each coat shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks, and shall be allowed to dry or cure before the succeeding coat is applied, the period of time not more and not less than instructed by the paint manufacturer.

Shop coats shall be checked for good quality and, where necessary, before proceeding with onsite painting or coating operations, the Contractor shall clean and repair all shop coats that are defective or damaged.

The Contractor shall consider that damage to paint work during shipment, storage and erection is unavoidable, and the application of all protective treatments shall be programmed accordingly. All parts subjected to mechanical machining such as guides, slides, tools etc. shall be protected by soluble, high intensity substances to ensure protection during sea transportation and lengthy storage.

Painting repair shall be done at site after installation.

All paints and primers shall be handled and delivered to the painting site according to manufacturer’s instructions and in sealed containers packed by the manufacturer. The manufacturer's instructions for preparation and application of all painting and protective coats shall be strictly followed.

Each paint shipment will be accompanied by the manufacturer’s certificate of date of manufacturing. Storage period of paints will be as short as possible. Paints whose storage period has passed the manufacturer’s recommendations will not be used and be withdrawn from the site.

It is forbidden to store paint containers with the cover upside down.

Painting parameters – temperature, hygrometry, dew point, product batch number, coat thickness, etc. – shall be recorded in a painting record sheet to be established for each painting operation carried out in workshop and site and submitted during component inspection.

6 ELECTRICAL COMPONENTS

6.1 General requirements

The Contractor shall submit to the Owner the manufacturer's name, type and full technical details for all electrical components that he proposes to use. An electrical device shall be defined as any device that has electrical connections.

Electrical components shall be labelled with the same name given in the design drawings and manuals.

Furthermore, the Contractor shall supply type test certificates for the main electrical equipment, such as high-voltage equipment (circuit breakers, disconnecting switches, insulators, etc.), CTs and VTs, motors and motor starters, power meters, transducers, protection relays and control equipment.

All electrical components shall be subject to the Owner's review.

6.2 Motors

6.2.1 General

All motors shall be in accordance with IEC 60034, Class F insulation, suitable for continuous operation and direct-on-line starting. The starting current at full voltage shall not exceed six times the full-load current.

All motors shall be capable, without injurious overheating, of continuous service operation at rated output, at any frequency between 47.5 Hz and 52.5 Hz, and at +/- 5 percent (5%) of nominal voltage, at nominal frequency.

All AC and DC motors shall have a degree of protection of IP54, with openings required for ventilation effectively screened. Submersible motors for drainage pumps shall have a degree of protection of IP68. Motors to be used outdoors or located in humid atmosphere shall be provided with heaters that maintain the motor temperatures at approximately 5 °C above ambient. The heaters shall operate continuously when the motor is not running.

Motors of 20 kW rating and above shall be fitted with embedded thermistors for thermal protection.

As far as found to be applicable, self-lubricating ball and roller bearings with solid races shall be provided for all motors. All vertical motors shall have thrust bearings. All motors with ratings of about 1 kW and above shall be equipped with lubricators that allow greasing while the motor is running and prevent over-lubrication. Additionally, the bearings shall be fitted with grease nipples that allow the use of a universal grease gun. The bearings shall further be protected and sealed against dust penetration and leakage.

Terminal boxes shall be weatherproof and vermin-proof IP54, fully enclosed and firmly attached to the motor frame. The arrangement of the terminal box shall be such so as to facilitate installation of cables and allow the fastening of weatherproof cable glands.

A permanently attached connection diagram shall be mounted inside the terminal box cover.

For earthing purposes, each motor shall have adequately-sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw.

The insulation of all motors shall be Class F, but shall maintain during operation the temperature limits of Class B materials. The insulation shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapours, and for considerable fluctuations in temperature.

Noise levels of electric motors shall not exceed the overall level of 80 dB (A), measured at a distance of 1 m from the main surface of the machine and shall comply with pertinent EU regulation.

Motors shall always be of the three-phase type. If the power is lower than 0.75 kW, the motor may be single-phase and designed for a nominal voltage/frequency of 220 V / 50 Hz.

All motors shall be supplied with their data sheet completed.

6.2.2 Stator winding support

Stator windings shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions, as mentioned above. Rotor windings shall be designed to give trouble-free continuous service including repeated direct-on-line start-up operations. Rotors shall be subjected to a 120% over-speed test for two minutes, without showing any winding dislocations.

6.2.3 Magnetic switches and motor starters

The rated voltage, current and duty of contactors and motor starters shall be suitable for service conditions. Starters and contactors shall comply with IEC 60947-4-1 and IEC 61095, and shall be suitable for direct-on-line starting and continuous electrical duty. The use category shall be not less than AC-3, in accordance with IEC 60947-4-1 and IEC 61095.

At a minimum, motor starters shall include the following:

- Lockable isolating switch, with padlock
- Magnetic protection by adjustable circuit breaker with manual resetting. Fuses shall not be used.
- Thermal protection by thermal overload relay fitted in each phase (<100 kW), or thermal relay supplied from secondary of CTs on each phase (>100 kW), with manual resetting
- Ammeter
- Control switches to operate the motor locally

Coordination between magnetic switch and magnetic and thermal protection of motor starters shall be at least Type 2.

6.3 Transformers

6.3.1 Current transformers

Unless otherwise specified, current transformers shall conform to IEC 60044-1.

For all current transformers used for protective schemes, magnetization characteristics, turn ratios, secondary resistance values and secondary burden and accuracy classes shall be submitted for the review and comments of the Owner.

Primary polarity designation and secondary terminals shall be clearly marked via an agreed method on the appropriate faces of each current transformer. A local junction box shall be provided for each group of current transformers located near each other. Connections from the secondary terminals shall be taken via these junction boxes.

For all current transformers, the primary winding conductors shall have a short-circuit current and time rating not less than those of the associated switchgear.

Secondary windings of each current transformer shall be earthed at one point only.

6.3.2 Voltage transformers

Unless specified otherwise, voltage transformers shall conform to IEC 60044.

Terminal markings shall be permanent and shall be shown on the Contractor's drawings. A rating plate shall be provided on each voltage transformer. Where voltage transformers are installed in cubicles, a separate label shall be attached to the cubicle, identifying phasing and grouping.

A local junction box shall be provided for each group of voltage transformers.

The secondary terminals shall be connected to the junction boxes, which shall contain MCBs for secondary circuit protection.

Sub-circuits shall be individually protected and switched, and the MCBs shall have auxiliary contacts.

The Contractor shall determine the burdens and accuracy classes of the secondary windings, taking into consideration the most unfavourable conditions.

6.4 Solenoids

Solenoids shall withstand the specified voltage variation and shall be equipped with protection against voltage surges (RC filters).

Solenoids shall be equipped with an LED (light-emitting diode) lamp.

6.5 Heat relays

Heat relays shall be installed next to the contactors. They shall be built and tested in accordance with IEC 60947-4-1.

6.6 Electrical relays

Electric protection relays shall be the standard product of an experienced and reliable protection relay manufacturer. They shall be of the static type and they shall not be affected by external magnetic fields or any other influence (radio, computer, signals, impulses, etc.), consistent with the

place or method of mounting. Electromagnetic relays shall have a transparent cover with appropriate seals and proper packing.

The relays shall comply with all IEC 60255 norms and have a maximum operating time of 40 ms. They shall be equipped with all necessary auxiliaries, such as tripping units, time relays, external resetting devices (hand reset flags with seal-in operation). The relays shall provide easy access for testing and setting purposes.

Protection relays shall, preferably, have serial communication to its applicable controller in the control system. Tripping of a protection system, as well as the sources of the protective action, shall be indicated and recorded as an alarm. Unless otherwise required for special purposes, protection relays shall remain in the tripped position until the operator resets the relay manually.

The control and auxiliary relays shall be grouped according to their sequence numbers and mounted on plug-in modules or stationary-mounted on swing frame with separate plugs and sockets to feature easy replacement and testing. The construction shall be sturdy and such that all parts are easily accessible for adjustment. Spare relay plug-ins shall be arranged in appropriate locations so as to further install more relays. Spare contacts shall be provided and connected to terminal blocks.

Relays installed in switchboards shall be arranged in compartments separated from the switchgear.

The coils shall be rated for continuous operation and shall have a finish adapted to tropical conditions. Coils shall be suitable for operation between 80% and 110% of their nominal voltage. Contacts shall be sized according to the voltage, current and type of load to be supplied and to withstand 1 million operations determined based on the supplier's curves.

Relay contacts connected to high impedance input of electronic equipment shall be silver-plated.

Time delay relays shall be of the solid-state type. It shall be possible to adjust the timing delays easily and the relays shall hold that adjustment.

In addition to the contacts required by the control scheme, at least one spare normally-open contact and one spare normally-closed contact shall be provided on each relay.

The manufacturer shall adapt the relay design to the special environment: vibrations caused by large rotary machines and dust.

The operation of each element of the relay shall also be identified by an LED.

Contact multiplying relays will not be acceptable.

6.7 Indicating instruments

Instruments shall conform to IEC 60051 (Particular Technical Specifications 1-9) and IEC 61554, and shall be of Class 1.5 or better. Instruments using electrical means for indication shall be capable of withstanding, or shall be adequately protected from, vibrations encountered during operation.

All electrical instruments shall be of flush-mounted design, dust-proof and moisture-proof. Instrument size shall be at least 96 mm x 96 mm.

All indicating instruments shall generally withstand, without damage, a continuous overload of 20% in reference to the rated output value of the corresponding instrument transformers. Ammeters shall not be damaged by fault-currents within the rating and fault duration time of the associated switchgear via the primaries of their corresponding instrument transformers.

All instruments and apparatus shall be capable of carrying their full-load currents without undue heating. Means shall be provided for zero adjustment of instruments without dismantling.

Energy meters shall be of the electronic type with an accuracy class of 0.5 S, according to IEC 60521. They shall have transmission contacts.

All instrument scales shall be in accordance with IEC 60051, printed in black numbers and divisions on a white background. The unit measured shall be clearly marked on the instrument dial in black capital letters in an abbreviated form (e.g. A for amperes). Instruments shall have 90° or 240° circular scales calibrated 0–120%.

6.8 Electronic equipment assemblies

Modules and parts of all solid-state equipment shall be assembled from proven modules and components.

All components shall be conservatively rated. The surface temperature of any component shall be at least 5°C lower than the maximum test temperature of the equipment.

The printed circuit boards shall be of the plug-in withdrawable module types mounted on standard-width racks, which when mounted in racks or cubicles shall allow full unobstructed front and rear access to the boards and their connectors. About 10% of unused locations on the rack shall always be kept as spare locations to allow the Installation of additional boards.

Withdrawable boards, modules and cable plugs shall be key coded or otherwise identified to avoid the possibility of making replacements in the wrong position. Board frames shall be equipped with locking devices to prevent unplugging of boards due to vibrations or accidental disturbances.

Control systems or components using microprocessors shall have their programs and configuration date stored in a suitable non-volatile memory such as EPROM. The use of RAM memory with battery backup shall be avoided.

The Contractor shall include in his supply all the equipment, software and information necessary to enable the Owner to reprogram or reconfigure the control systems or the components. Following successful commissioning, the Contractor shall supply the Owner with a backup copy of all final software along with fully commented and indexed program listings. Spare parts shall be programmed and configured by the Contractor before their delivery.

Modules performing identical functions shall be interchangeable. The electronic components used in modules shall be of the highest quality having a designed in-service life of at least ten (10) years.

Replacement modules for all parts of the control system shall be easily available so that the Owner can carry out his own maintenance and repair work. It shall be guaranteed that spare components shall be available for a period of twenty (20) years.

6.9 Cabinets and enclosures

6.9.1 General characteristics

The instructions below concern low-voltage electrical cabinets and enclosures. The cabinets and the enclosures shall be made of sheet metal steel of a minimum thickness of 1.5 mm, or 2 mm, if these

metal sheets support equipment. All metallic parts shall be protected by zinc plating after a white metal blasting followed by an in-factory adapted anticorrosion protection coating.

The envelopes shall insure equipment protection against direct contacts with live parts, against the penetration of dusts, against splashing water and against mechanical damages. This equipment shall correspond to, at least, the following degrees of protection:

- IP41 –for cabinets and enclosures installed in dry and clean premises
- IP54 –for cabinets and enclosures installed in humid locations, and in places likely to be exposed to splashing water
- IP65 –for cabinets and enclosures installed outdoors

Depending on the thermal constraints, efficient natural or forced ventilation inside of the cabinets and enclosures may be necessary. In such a case, in the lower part, an air intake is provided with a wire mesh and a dust filter. For the cabinets and the enclosures installed in air-conditioned premises, it shall be verified that a breakdown of the air-conditioning for a few hours does not result in an increase of temperature that could damage the components installed in these cabinets and enclosures. Heat dissipation design and calculations shall be provided for Owner's review.

The enclosures and cabinets containing equipment shall include an anti-condensation heating device of adequate overall power and controlled by a hygrostat, as well as lighting controlled by a door contact.

The cabinets and enclosures shall be generously dimensioned and provide extra space for eventual additions (in the order of 20% extra space). Enough space is left between each component to allow connection, installation and convenient maintenance. Particular attention is given so that the extra space left for external cable connections is sufficient.

All components installed in cabinets and enclosures shall be tagged in conformance with the tags indicated on the drawings.

The cabinets and enclosures shall be provided with a front facing closing system (with square or triangular locks or key locks) which shall be standardized for all enclosures and cabinets on the installation. The hinges and locks shall be made of chrome-plated corrosion-resistant metal. The hatch or doors shall have the possibility to open at least a full 120°, and to be blocked in the open position. They necessarily include a grounding strand of 25 mm² cross-section.

The closing panel and doors include adapted sealing linings.

The cabinets shall be installed on a rigid metal base of 200 mm thickness; it is provided with a number of adapted lateral windows which can be closed by means of removable plates, allowing the installation and tightening of cable compression glands.

The wall mounting of enclosures, as well as cabinets, when specified, shall always be performed on the back face.

Cable entries shall always be from the bottom face of enclosures and cabinets. This face shall be provided with a removable bottom plate drilled on demand for fastening marine-type cable glands. This plate shall be fastened on the enclosure or cabinet by means of bolts with sealed joints. The plate and bolts shall be made of rustproof metal.

The connection devices for the cables coming from outside shall be sufficiently clear of the bottom part of the enclosure or cabinet in order to allow the spreading of the cables. Upon entry in the

cabinets or enclosures, the cables shall be properly fastened on metal supports especially dedicated to this purpose.

A grounding busbar made of copper shall be provided near the bottom of each enclosure for electrical equipment. The frame of electrical devices shall be connected to the grounding busbar.

6.9.2 Terminal blocks

Terminal blocks shall be of an agreed brand and type.

Terminal blocks shall be with screw-type terminals, sized according to the wire to be connected. Double or more terminal blocks shall not be permitted. Terminal blocks include the possibility to insert test points. Terminal blocks for CT circuits shall have some safe and easy means of short-circuiting the CT circuit.

Terminal blocks for power, control, CTs and VTs circuit shall withstand 2.5 kV rms for one minute between adjacent terminals and between terminals and earth. For terminals used in alarm circuits, the withstand voltage shall be of 1,000 V rms for one minute.

When withdrawable terminal blocks are used on internal components, the terminal blocks shall be secured mechanically.

In each enclosure, the Contractor shall provide sufficient terminal blocks to terminate all incoming cable cores, excluding spare cores. In addition, twenty (20) percent spare terminal blocks shall be distributed amongst the functional groups of terminal blocks (as indicated by the wire number series).

6.9.3 Internal wiring

The internal connections in the cabinets shall be made of copper wires, with coloured insulation sheaths according to the nature of the circuit, flame retardant, flexible multi-strands, minimum specified voltage of 0.6/1 kV. The minimum cross-sections of the wires shall be as follows:

- 0.8 mm²:For control-and-command and measuring circuits other than current or voltage connected to electronic systems of the programmed automaton type
- 1.0 mm²:For control-and-command circuits of the internal relay
- 1.5 mm²:For command circuits connected to actuators
- 2.5 mm²:For voltage-measuring circuits
- 2.5 mm²:For power circuits
- 4.0 mm²:For current-measuring circuits

The measuring and counter circuits, as well as the circuits of each electrical protection relay, shall pass through testing devices allowing coupling without the connection/disconnection of the test device.

The wirings of internal circuits of different types shall be distinctly separated. All wires shall be tagged at both ends.

Generally, the wiring is laid within insulated ducts such as wiring ducts provided with a removable lid. These ducts shall be made of material which does not propagate flame. The actual filling of these wiring ducts, inspected when the equipment left the factory, shall not exceed 70% of the maximum

capacity specified by the Manufacturer. The conductors laid in these ducts should have sufficient slack to allow eventual wiring modifications.

There shall be no more than two wires per terminal, with the exception of terminals for exterior couplings, for which only one wire is permitted on the exterior side.

The wiring threads and cable conductors, intended to be connected by screws, and cable supports shall be provided with a pre-insulated and crimped terminal end (sleeve), adapted to their cross-section. The crimping of this terminal end shall be performed with the help of a tool dedicated to this purpose.

6.10Cables

6.10.1General

The cable ends on a reel shall be hermetically sealed with a pressure cap.

The Manufacturer's identification, the rated voltage, size and number of conductors and the year of manufacturing shall be imprinted through the whole length of the cable. The space between two identification marks shall not be greater than 1000 mm.

Sequential metrical markers (every metre) shall be printed on the outside surface.

The external sheath of all of the electric cables shall be chemically treated, during manufacturing to obtain permanent protection from rodents.

All cables shall be flame-retardant. Type test certificates, according to IEC 60332, shall be submitted upon request.

6.10.2Medium-voltage power cables

Medium-voltage power cables shall comply with IEC 60502-2, with the main conductor in copper or aluminium, single-core or three-core, with individual metallic screen. The assigned voltage shall be selected according to the circuit for which they are intended to be used.

Cable accessories shall comply with IEC 60502-4.

6.10.3Low-voltage cables

- **Power cables:**
  - Low-voltage power cables shall comply with IEC 60502-1, with the main conductor in copper, semi-rigid and assigned voltage of 0.6kV/1kV. Cables outside buildings shall have an external metallic sheath.
  - Sizing of the conductors: The thermal behaviour in continuous operating conditions and short-circuit, as well as the overload capacities, shall take into account eventual downgrading due to the various methods of installation.
  - Acceptable current in continuous operating conditions: The power cables shall be selected to have the capacity to permanently transmit 120% of the current corresponding to the maximum load of the supplied equipment, taking into account the ambient temperature and

heating due to the other cables, and all this without exceeding the maximum temperature stipulated in the IEC recommendations.

- **Control and measuring cables:**
  - Low-voltage control cables shall comply with IEC 60502-1, with main conductor in copper, semi rigid and assigned voltage of 0.6kV/1kV. Cables outside buildings shall have an external metallic sheath. The conductors shall have a minimum cross-section of 1.5 mm^2.
  - Low-voltage measuring cables connected to CTs and PTs shall comply with IEC 60502-1, with the main conductor in copper and assigned voltage of 0.6 kV/1kV. Cables outside buildings shall have an external metallic sheath. The conductors shall have a minimum cross-section of 4 mm^2 for voltage measurement circuits, and 6 mm^2 for current measurement circuits.
  - Instrumentation cables shall be twisted pair (or triple) each individually screened. The screens shall be 0.05 mm thick aluminium tape with overlapping edges. In contact with the screen, a continuous soft electrolytic copper wire shall be provided. Each cable shall have an overall aluminium screen covering the entire cable. Instrumentation cables shall have a rated voltage of Uo/U of 450/750 V.

6.11General rules for cabling material and works

6.11.1General

The Contractor shall prepare cable schedules and termination diagrams for all equipment included in the Contract, and to be submitted to the Owner's for review and comments in order to allow onsite cabling work operations and maintenance.

Termination diagrams shall show the following details for each cubicle, cabinet, device or other equipment to which the cabling defined in the Contract is to be connected:

- The designation of the cubicle
- A wire number (or blank space in the case of a spare terminal) next to each terminal
- For each cable: the cable identification number, the total number of cores and number of spare cores and the destination of the cable
- The wire number for each core in each cable

Termination diagrams shall refer to the associated circuit diagram and wiring diagram drawing numbers, including the revision number.

Cabling for protection, alarm, control and indication circuits shall be separated from the power supply or high-voltage cabling. Emergency control cabling shall be separated from all other cabling. Circuits with similar properties or functions shall be arranged in the same terminal block.

The Contractor shall provide the following minimum number of spare cores in each multi-core control cable:

- Up to 4 core cables:does not require spare cores
- Up to 12 core cables:shall have a minimum of 2 spare cores
- Up to 20 core cables:shall have a minimum of 4 spare cores
- Over 20 core cables:shall have a minimum of 6 spare cores

6.11.2Cable installation materials

- **Cable terminations:**
  - Unless otherwise specified, the terminations on each end of each cable shall include the following:
    - o Fastening the cable with an agreed gland (or clamp for bottom entry into floor-mounted indoor cubicles)
    - o Sealed thermally shrinkable termination
    - o Fitting an agreed lug to each core (except spare cores)
    - o Fitting an agreed phase or polarity identification to each power cable core
    - o Identification of each control and alarm cable core and cable identification tag

- **Cable identification tags:**
  - The Contractor shall provide and firmly attach stainless steel identification tags with appropriate dimensions to each cable, fastened longitudinally along the cable. Each identification tag shall be engraved with the appropriate cable number, in accordance with the cable schedules, the letters and numbers being not less than 5 mm high. PVC identification marks of the same characteristics can be acceptable subject to Owner's review and provided they are firmly fastened to the cables.

- **Cable glands:**
  - Cable glands shall be of the weatherproof compression type, and, for outdoor locations, shall be of non-ferrous metal. Cable glands for cables with an overall diameter over 20 mm shall be of metal, and as for single core, cable glands and locknuts shall be made of non-ferrous metal.

- **Conduits:**
  - Steel conduit shall be rigid screwed steel conduit with metric thread in ISO form. Fittings shall be of malleable cast iron. Conduit and fittings shall be hot-dipped zinc coated, both inside and outside.

- **Cable ladders, cable trays and supporting steelwork:**
  - All supporting steelwork shall generally be of adequate strength and made of stainless steel or hot-dipped galvanized steel after manufacturing
  - Cable ladder and tray systems shall be of an established design complete with horizontal bends, tees, inside and outside risers and all the necessary accessories including splices, support brackets, hangers, clamps, etc. Only known standard commercial types will be accepted.
  - Cable ladders and accessories shall be made of aluminium or stainless steel. Cable ladder rungs shall have slotted holes suitable for fastening cables with cable ties.
  - Perforated cable trays shall be made of aluminium or stainless steel of not less than 1.5 mm thick sheet steel.

- **Masonry anchors:**
  - Masonry anchors shall be corrosion-proof and of the expansion or resin adhesive type. The Contractor shall provide full details of the proposed masonry anchors, complete with typical pull-out values, for review.

6.11.3Cable installation

- **General:**
  - Cables shall be installed in accordance with IEC 60364. Wiring shall be neatly and securely fastened, enclosed in ducts or conduits, or supported on trays or ladders and run in the most

efficient manner from point to point. Wiring shall be fastened using plastic strips at suitable intervals.
- In all locations within 1,800 mm from the floor and in any other locations where cables may be exposed to mechanical damages, the Contractor shall provide and install suitable sheet cover to protect the cables or, alternatively, shall enclose the cables in steel pipes or conduits. For the connections to sensors, flexible metallic conduit protected by a PVC sheet may be used.
- Cables shall not be installed in a common trench with pipework. Where cables on ladders pass under or be adjacent to pipes containing fluids, they shall be provided with covers to divert any leaking fluid. All cables and supports shall be kept clear of the plant's walkways and operating spaces.
- All wiring shall be left sufficiently long and neatly looped to allow a fresh termination to be made should the original termination break off. Cables shall be properly laid and fastened so that no stress is transmitted to the different devices in particular sensors and terminals.
- The Contractor shall provide all necessary terminals, cable glands, ties, cleats, cable boxes and terminating facilities, except for terminals in equipment provided by other contractors, to which cables are to be connected. The Contractor shall supply and install all facilities for the purpose of supporting cables.

- **Power cables:**
  - Single-core power cables shall be fastened at intervals not exceeding 2,500 mm and on either side of bends or risers and before terminations.
  - Single-core power cables forming part of a three-phase circuit shall, unless otherwise specified, be held in trefoil touching formation by cable ties installed every 600 mm for straight runs and every 300 mm in curves.

- **Bending radius:**
  - The bending radius of cables shall not be less than recommended by the manufacturer and in no case be less than eight (8) times the outside diameter of the cable.

- **Sealing of openings:**
  - Any cableway crossing through a concrete wall, floor or ceiling or entering into cubicles shall be sealed with a fireproof sealing mixture agreed by the Owner. At the point of entry, cable pipes, ducts and trenches entering buildings shall have the fireproof seal overlaid with plastic weatherproof compound.
  - The seals around cables shall be trimmed as required to give a neat appearance.

- **Cable trenches:**
  - Cable trenches shall be fitted with covers. Covers shall be made of reinforced concrete and shall be fitted on hot deep galvanized steel angle supports embedded in the trench.

- **Cables laid in the ground:**
  - Cables laid directly in the ground shall be at the following minimum depths:
    - Cables 0.6/1 kV:600 mm under roadways, 500 mm in other locations
    - Cables above l kV rating:700 mm at all locations
  - Before any bedding sand is placed in the trench, the excavation shall be inspected by the Owner. The lowest cables in a trench shall be laid on a 50 mm bed of sand. Sand shall then be added until the top of the uppermost cable is covered to a depth of 50 mm. Particular attention shall be paid to maintaining cable spacing appropriate to the design cable rating.
  - Concrete or clay brick protective cable covering shall be placed on top of the bedding and shall include either of the following:
    - Pre-cast concrete slabs of 38 mm minimum thickness and l5 MPa minimum compressive stress
    - Concrete slabs cast onsite of l00 mm minimum thickness
    - Clay bricks laid close together lengthwise for cables rated 1 kV or lower and crosswise for cables rated above 1 kV.

- Before backfilling is started, the works shall be inspected by the Owner. Backfilling shall be carried out using the soil from the excavation. It shall be placed in layers not exceeding 300 mm loose depth. Each layer shall be compacted by hand or power ramming until dense firm compaction is achieved. Cable marker posts for direct-laid cables shall be supplied and placed at intervals of 30 m to indicate the position of the buried cables, and at every position where the cable changes direction.

7 INSPECTION AND WORKSHOP TESTS

7.1 General

The various parts of the supply shall be subject, either in the workshops and laboratories of the Contractor or of his subcontractors as well as on site, to all inspections and tests in order to ensure:

- The quality of the raw materials and other materials
- The correct execution of machining operations
- The correct execution of pre-assemblies and assemblies
- The work progress status.

The components and principal systems of the supply shall be subject to factory acceptance tests for which a forward programme is established by the Contractor and regularly updated. This program shall include the tests methods to be used for each component. The Owner shall be informed of the exact dates of the tests and places where they will be carried out, at least four (4) weeks prior. This schedule shall be submitted to the Owner for review and comments.

No equipment can be shipped without the factory acceptance tests having been made, and without all of the control documents and test report having been submitted for review and comment of the Owner. Factory tests, even if they are satisfactory, shall not replace, in any case, provisional acceptance of the materials, which can only be pronounced after assembly and the execution of conclusive onsite start-up tests.

All conveniences shall be given to the Owner to perform quality control activities in the various construction factories, including those of the Contractor's subcontractors. Generally, all inspections and tests are subject to the participation of the Owner.

The Contractor and his subcontractors are responsible for the following:

- To provide adequate advance notice to the Owner when inspections and/or tests are to be performed, as required by the Inspection and Test Plan (ITP) and/or as directed by the Owner
- To provide the Owner with all material resources and documents necessary to perform his inspections and/or tests

These controls can never, in whatsoever situation, detract from the Contractor's responsibility, which shall remain full and undiminished until the expiration of the warranty period.

Prior to any inspections or tests, before or during the course of manufacturing, the Owner reserves the right to carry out evaluations of the means and methods of manufacturing, as well as inspections and tests, that the Contractor intends to implement for the completion of part of the supply.

Generally, inspection and tests shall be carried out in conformance with the following:

- Inspection & Test Plan (ITP), established during the detail design of the equipment and submitted for the review and comments of the Owner, which shall specify, for each major component, the inspections and tests to be carried out. The ITP shall also specify the reference documents for implementation of the inspections and tests.
- Inspection and test procedures submitted for the review and comments of the Owner, which define the procedures, acceptance criteria and required test equipment

The list of inspections and tests described in Subsections 7.2–7.7 below is not restrictive. The Owner reserves the right to proceed, or to order to proceed, with any additional control that he would deem necessary, notably in the event of duly observed manufacturing defects; the exercise of this right would suspend the execution of the corresponding manufacturing.

7.1.1 Repairs

If any inspection and test on a components show any defect or non-conformity with the design documents or the technical specifications, the concerned component shall be repaired correspondingly. Such repair or modification shall in no way affect the quality, reliability of operation, interchangeability or lifespan of the component, and shall be performed only after obtaining authorization from the Owner.

If the repair or modification cannot be carried out in accordance with the terms mentioned above, the part or component concerned shall be rejected. Components presenting defects shall under no circumstances be delivered.

7.1.2 Tests of Spare parts

The spare parts shall be subject to the same inspection and test programs as those applicable for the main components with identical requirement in term of quality documentation.

Special care shall be taken by the Contractor concerning the reference number (for each component, part, sample, etc.) to enable appropriate monitoring of workshop tests.

7.2 Inspections and tests on mechanical components and sub-assemblies

An Inspection & Test Plan (ITP) shall be prepared and presented, indicating the all production quality controls, as well as all factory and onsite tests to be performed. All equipment shall be tested and inspected according to the ITP and the international standards or national standards accepted by the Owner.

7.2.1 General

All tests shall be done and certificates shall be issued by a licensed laboratory accepted by the Owner.

Non-destructive test procedures shall be established by a Level 2 qualified operator and verified by a Level 3 qualified operator according to the SNT-TC-1A or ISO 9712 – 2005. These procedures shall be submitted to the Owner review and comments.

Non-destructive tests shall be conducted by a Level 2 qualified operator, according to the SNT-TC-1A or ISO 9712 – 2005. Test reports will be sent to the Owner review and comments.

The test reports shall include the following information as minimum:

- Test description

- Procedures or items of the test standard, when applicable
- Test equipment and instrumentation including calibration certificates.
- Dimensions of samples (if necessary)
- Tabulation of data and test results
- Protocols
- Results of analyses

7.2.2 Inspections and tests to be carried out on main castings

Inspection	Appliance	Reference Standard
Chemical analysis	100% of the main castings (ladle analysis + attached coupon analysis)	ASTM A751:2021
Mechanical test	100% of the main castings – On attached coupon after final heat treatment. - Tensile test - Impact test - Bending test - Elongation (A% and Z%) - Nil ductility temperature test	ASTM A370:2023
Visual inspection	100% of the main castings	–
Ultrasonic test	100% of the main castings	EN 12680-1 CCH 70-3
Magnetic particle or dye penetrant test	100% of the main castings	EN 1369 CCH 70-3
Review of manufacturing process documents	100% of the main castings	–

7.2.3 Inspections and tests to be carried out on main forgings

Inspection	Appliance	Reference Standard
Chemical analysis	100% of the main forgings (ladle analysis + attached coupon analysis)	ASTM A751:2021
Mechanical test	100% of the main forgings – on attached coupon after final heat treatment - Tensile test - Impact test - Elongation (A% and Z%) - Nil ductility temperature test - Bending test - Hardness test	EN ISO 15461:2018 EN ISO 6892-1:2019 ASTM A370:2023
Visual inspection	100% of the main forgings	–
Ultrasonic test	100% of the main forgings after rough machining	EN 10228-3 ASME VIII-1
Magnetic particle or dye penetrant test	100% of the main forgings according to design after final machining	EN 10228-1,2 ASTM 165-02 ASTM 275-03

Review of manufacturing process documents	100% of the main forgings	

7.2.4 Inspections and tests to be carried out on structural steel plates

Inspection	Appliance	Reference Standard
Chemical analysis	Mill certificate - Test on sample per batch of material	ASTM A751:2021
Mechanical test	Mill certificate - - Test on sample per batch of material - Test according to material specification	ASTM A370:2023
Ultrasonic test	100% for plates with more or equal to 18 mm thickness	EN 10160 EN 10307 ASTM A577 A

7.2.5 Inspections and tests to be carried out on welds

Inspection	Appliance	Reference Standard
Structural Butt Welds		
Ultrasonic test	100% before and after heat treatment, and before final machining	EN ISO 17640:2018 EN ISO 11666:2018 ASME VIII-1 UW51 and Appendix 12
Magnetic particle or dye penetrant test	100% after heat treatment, and after final machining	EN ISO 23278:2015 ASME VIII-1 Appendix 6 and 8
Visual inspection	100% before and after heat treatment, and after final machining	No visible defects can be accepted
Structural Fillet Welds		
Ultrasonic test	According to the requirement of the drawings	EN ISO 17640:2018 EN ISO 11666:2018 ASME VIII-1 UW51 and Appendix 12
Magnetic particle or dye penetrant test	100% after heat treatment, and after final machining	EN ISO 23278:2015 ASME VIII-1 Appendix 6 and 8
Visual inspection	100% before and after heat treatment, and after final machining	No visible defects can be accepted
Non-Structural Welds		
Magnetic particle or dye penetrant test	According to the requirements of the drawings	EN ISO 23278:2015 ASME VIII-1 Appendix 6 and 8

Visual inspection	100% before and after heat treatment, and after final machining	No visible defects can be accepted

7.2.6 Dimensions and finish

Dimensional, tolerance and surface finish verifications shall be performed on all major parts, components and partial assemblies, to verify compliance of the manufactured part with the drawings' dimensions and insure their reliable operation and interchangeability.

In the same manner, profile, dimensional and surface finish verifications shall be performed on all the parts to confirm the scale-up between hydraulic model dimensions and prototype dimensions.

7.2.7 Inspections and tests to be carried out on painted surfaces

The Contractor shall keep constant supervision of the work and ensure that all specified conditions are met and keep a record at least twice every day and before applying any coats. The following items shall be recorded and signed:

- Date
- Name of painting company
- Working place
- Type of work (priming, painting, sandblasting)
- Air temperature
- Relative humidity
- Dew point temperature
- Steel temperature
- Paint type and production number
- Thickness of each coat (after drying)
- Comments on any irregularities

The records shall be filed by the Contractor, and will be reviewed during factory acceptance tests. At the site, copies shall be submitted to the Owner every day for review and comments and filed along with inspection and test reports.

The Owner may inspect the work after the pre-treatment is finished (blasting and cleaning) before beginning the paint application. The Contractor shall give notice well in advance.

Upon completion of each coat, the Contractor shall perform a detailed inspection of the painting finish and shall remove all spattering of paint material. He shall correct all damages that may be caused by such cleaning operations and after the drying period shall measure and record the film thickness of the coat.

The factory acceptance tests shall be done by certified laboratory previously approved by Owner and shall include at least the following tests:

- **Dry film total thickness measurement:**

The specified DFT is to be understood as the mean value of ten measurements per 0.04 m2 (0.2 m x 0.2 m). No single measurement shall have a thickness less than 80% of the specified value. No single measurement shall show thickness greater than 250% of the specified value.

The mean DFT of the completed paint film shall not be less than 95% and not more than 200% of the guaranteed total dry film thickness, provided the number of coats is as specified.

The measurements shall be performed on completely cured paint, but not less than 24 hours after final application.

If the DFT per coat exceeds the specified value, the Owner can request a complete removal and a new application. If total dry film thickness of the fully-cured paint is less than specified, the Owner shall request additional coats until specified thickness is obtained.

- **Adhesion test:**

Unless otherwise agreed, the adhesion should be measured with an "Adhesion Tester", according to ISO 4624.

The adhesion of fully-cured paint must be more than 2.5 N/mm2 for epoxy systems or 2.0 N/mm2 for other paint systems. In cases the adhesion is less, the Owner may request complete removal of the paint film and new treatment.

After an adhesion test has been made, the Contractor shall ensure that the areas damaged during testing are touched up immediately to the specified coating thickness.

7.3 Workshop assembly

As a general rule, all equipment shall be fully assembled in the workshop after manufacturing, as much as found practicable. All site welds shall then be temporarily fastened by tack welds. The equipment shall be checked and accepted with regard to dimensions, tolerances and alignment. Functional tests shall be made wherever possible.

The Contractor shall clearly state, in his Tender, the items for which the shop assembly has not been planned and the reasons for this.

After the assemblies have been inspected and accepted by the Owner, the components shall be match marked, with an indelible paint, disassembled and prepared for shipment.

7.4 Inspections and tests on fluid systems

Components which, during operation, will be submitted to pressure, for example the turbine governor pressure tank, air pressure tanks, etc., shall be inspected and tested according to the ASME Section VIII-1 design code and pertinent EU regulation. The pressure test is to be performed applying water at the prescribed test pressure in accordance with the relevant code.

Those parts that may not or shall not be closed, and which are exposed during operation to only a low pressure of any liquid (e.g., bearing housings, oil containers, etc.), shall be subject to a tightness test with a suitable low-viscosity liquid. The testing period shall not be less than ten (10) hours, unless otherwise agreed.

All pipes and systems under pressure shall be pressure-tested at 1.5 times the design system pressure, for at least 30 minutes.

Additionally, a functional test of the entire system, as far as practicable, shall be carried out according to a test procedure to be submitted for the review and comments of the Owner.

7.5 Inspections and tests on babbitt surfaces

Tests and inspection of the babbitt surfaces of plain guide, thrust and counter thrust bearings shall include the following specific requirements:

- Ultrasonic test of 100% of the babbitt surface according to ISO 4386-1 Class 2 – Limit of acceptance: Group C, if not otherwise specified
- Dye penetrant test of 100% of the babbitt surface according to ISO 4386-3 – Limit of acceptance: Group C, if not otherwise specified
- Dye penetrant test of 100% of the perimeter of the babbitt layer. For each side, cumulative length of indications shall be not more than 5% of considered side.

7.6 Inspections and tests on nuts and bolts

Standard nuts and bolts for structural purposes shall be supplied with certificates of conformance.

Chemical composition and mechanical properties of special bolts and nuts shall be systematically verified by analyses and tests on specimens to be performed for each batch delivered.

7.7 Inspections and tests on standard components and procured items

7.7.1 Routine tests (individual tests)

Before shipment, all components shall be submitted to routine testing in factories as defined by IEC standards for the type of equipment considered. The purpose of these tests is to verify the satisfactory performance of the material and its compliance with specifications, performances and guarantees. Their main goal is to detect and eliminate any defects likely to later involve the refusal of certain components or sub-assemblies.

These tests shall mainly verify the operating characteristics. However, at the request of the Owner, a program of more specific test can be established by mutual agreement with the Contractor.

7.7.2 Type tests

The Contractor shall submit to the Owner the type test certificates of the various equipment items supplied. If necessary, the Owner reserves the right to request the performance, without additional charges, of certain type tests for which the Contractor has not submitted certificates of conformance or could not justify compliance with the General and Particular Technical Specifications.

The tests shall be carried out in accordance with the standards quoted in the specifications.

7.7.3 Tests on electric motors

Tests on electric motors shall be carried out according to IEC 60034, including, as a minimum, the following:

- **Routine tests:**
  - Resistance of windings (cold)
  - Starting torque and current
  - No-load losses and current
  - Excitation current at rated speed and rated armature voltage (DC motors)
  - Open circuit secondary induced voltage at standstill (wound rotor)
  - Direction of rotation
  - Withstand voltage test
  - Vibration test
  - Temperature stabilization test (P >200 kW)

- **Type tests:**
  - Speed/torque characteristics
  - Overspeed test (if auxiliary system is fed from hydro-generator output)
  - Maximum safe operating speed (if auxiliary system is fed from hydro-generator output)
  - Noise
  - Electromagnetic compatibility (for emissions by DC motors)

7.7.4 Tests on power transformers

Tests on power transformers shall be conducted according to IEC 60076. Special tests shall be carried out according to the requirements of the Particular Technical Specifications.

7.7.5 Tests on instrument transformers

Tests on instrument transformers shall be conducted according to IEC 60044. Special tests shall be carried out according to the requirements of the Particular Technical Specifications.

7.7.6 Tests on pumps

The pumps shall have to be fully inspected and tested at Manufacturer's premises prior to delivery, in conformance with the stipulations of the relevant standards. Suitable inspection and test Certificates to this effect shall be required.

The following tests shall be required:

(a) Hydraulic Test

The acceptance test shall be carried out as per the HYDRAULIC INSTITUTE STANDARD ANSI- HI.2.6-1994 (or equivalent subject to Owner's review)

Tolerances:Q tested= Q ordered +10%
H= +0
Pump efficiency= no minus tolerance

(b) Hydrostatic Test

(Shut-off head + max. inlet pressure) x 1.5 or (Condition point head + max. inlet pressure) x 2; whichever is greater (to be confirmed).

Operational/functional test of the pump driven by the project motor for verification of the basic parameters (pressure/flow/electric power/temperature/vibration)

7.7.7 Tests on air compressors

Routine tests on air compressors shall include, at a minimum, the following:

- Check of the air compressor's characteristics
- Operational test of the air compressor driven by the project motor for verification of the basic parameters (pressure/flow/electric power/temperature/vibration)
- Check of the associated instruments and actuators
- Functional test of the air compressor, verification of the protection

7.7.8 Inspection and tests on servomotors

Routine tests and inspection on the hydraulic cylinder shall include the following specific requirements:

- Inspection of raw material and welds, including 100% ultrasonic test (UT) and Dye-penetrant test (PT) or magnetic test (MT) test of the rod and the cylinder.
- Leak test of the piston and rod seal at the nominal pressure for six hours. No leakage will be accepted on the rod seals. Acceptable leakage on the piston seals will be evaluated on a case-by-case basis.
- Pressure test at 1.3 times the design pressure, for 30 minutes on each chamber.
- Strength test of the rod under pressure, at 1.3 times the design pressure, for 30 minutes. During this test, a tension strength, corresponding to 1,3 the design pressure of the servomotor, is applied to the rod which shall not be subject to permanent deformation.

7.7.9 Inspection and tests on electronic equipment

Routine tests on the main electronic equipment – programmable logic controller (PLC), speed governor, automatic voltage regulator, protection relays, etc. – shall consist of functional tests specified in the Particular Technical Specifications.

Type tests on main electronic equipment – programmable logic controller (PLC), speed governor, automatic voltage regulator, protection relays, etc. – shall mainly cover the field of electromagnetic compatibility and environmental and power supply withstand conditions.

The tests described herein correspond to the tests to be performed on the single components before integration into cabinets and/or cubicles.

- **Electromagnetic compatibility – type test requirements:**
  - Industrial nominal frequency voltage endurance test according to IEC 60870-2-1. Electronic modules shall at least comply with Class VW1 (effective 500V test voltage) in the same standard. Specifically for protection relay systems, the equipment shall be compatible with IEC 60255-5, Series C.
  - Surge voltage endurance test according to IEC 60870-2-1. The equipment endurance to high surges of short duration shall be in Class VW3. Specifically for protection relay systems, the equipment shall be compatible with IEC 60255-5, with surge voltage at peak value of 5 kV.
  - Endurance to repetitive fast transients test. The equipment endurance to repetitive fast voltage transients shall be that provided in IEC 61000-4-4, Severity Level 2, for equipment installed in the control room, and Severity Level 4 for equipment installed in the other environments. Specifically for protection relay systems, the equipment shall be compatible with the IEC 60255-22-4, Class IV.
  - Oscillatory wave endurance test. Endurance of the equipment exposed to dampened oscillatory waves (such as those induced by atmospheric charges, or resulting from switching with arch reigniting in medium- and high-voltage) shall be compatible with that provided in IEC 61000-4-12, Severity Level 1, both for the ring wave test and dampened oscillatory wave test. The equipment installed in environments with small exposure shall be compatible with the Severity Level 4 and 3, of said standard respectively, for the ring wave and dampened oscillatory wave tests. Specifically for the protection relay systems, the equipment shall be compatible with IEC 60255-22-1, Class III.
  - Electrostatic discharge endurance test. The endurance of the equipment to electrostatic discharges shall be Class 3 defined in IEC 61000-4-2. Specifically for relay systems, the equipment shall be compatible with IEC 60255-22-2, Class III.
  - Electromagnetic radiation endurance test. The endurance of equipment under the influence of electromagnetic fields shall be that of Severity Level 3 defined in IEC 61000-4-3. Specifically for protection relay systems, the equipment shall be compatible with IEC 60255-22-3, Class III.
  - Magnetic field endurance. The endurance of equipment under effects of magnetic fields shall be Severity Level 2, in accordance with IEC 61000-4-8.

- **Environmental conditions – type test requirements:**
  - Dry and damp heat test according to IEC 60870-2-2. Equipment installed in air-conditioned room shall be of Class Cn, otherwise of Class Dn.
  - Damp heat test according to IEC 60870-2-2.
  - Barometric pressure withstand test according to IEC 60870-2-2. The test reports presented shall show that the material is suitable for the site where it is intended to be installed.
  - Vibration endurance test according to IEC 60870-2-2 for equipment installed in places where the occurrence of vibrations is expected, such as the powerhouse's structural blocks, intake, spillway and places close to the turbines, generator or high-capacity machinery. The equipment to be installed in these locations shall have the following vibration endurance:

Aspect	Class
Low-frequency vibrations	VL3
High-frequency vibrations	VH1
Vibration severity	VS2
Time rating	VT1

- **Electrical power supply withstand – type test requirements:**
  - Digital equipment shall be set in the following classes, as stated in IEC 60870-2-1

Tolerances	Class	
	AC source	DC source
In relation to voltage value	AC3	DC3
In relation to frequency value	F3	–
In relation to harmonic presence	H4	–
In relation to ripple voltage	–	VR3
In relation to source interruption	VI3	VI3

7.7.10Miscellaneous components

Miscellaneous components – instruments, gages, safety valves, pressure reducers, transducers, etc. – shall be supplied with certificates of conformance and calibration certificates issued by the supplier.

They shall be subject to functional tests along with the system in which they will be integrated.

8 SPARE PARTS, CONSUMABLE MATERIALS, REPLACEMENT PARTS, SPECIAL TOOLS

To be completed in a later time according to the Owner's Requirements.

9 PACKING, LABELLING AND TRANSPORT

9.1 Cost of delivery

The materials stipulated in the Contract shall be delivered to the construction site, within the required time period and according to the specified conditions, under the care, risks and perils of the Contractor.

The delivery operations to the construction site include packing, transport and all associated inherent tasks thereto, such as: loading, stowage, sheeting, transhipments and eventual intermediate storages, unloading and unpacking of the supply at the sites of assembly, of pre-assembly or of storage that shall be under the sole responsibility of the Contractor.

All expenses related to these operations shall be paid by the Contractor.

9.2 Responsibility for transport operations

The Contractor is responsible for the transportation of all equipment and components supplied, as well as transportation of his own assembly equipment and tools, to the construction site.

The Contractor shall select an adequate route and means of transportation after having inquired on location regarding accesses, gauges, bearing capacity of infrastructure works, maximum permissible load per axle on trails and roads, available local lifting and handling facilities, available transportation facilities, etc. The Contractor shall obtain all administrative authorizations, contract for the required insurances, and complete required formalities with the relevant Authorities.

If certain special or exceptional transport is likely to cause stresses or damage to structures belonging to the public domain, the Contractor shall defray all protective or special measures requested by the Authorities concerned in order to protect and/or reinforce the aforementioned structures utilized.

No compensation can be granted to the Contractor to cover additional costs, of unspecified nature, which he would have disbursed for transportation and which he had not anticipated at the time of submission of the price of his Tender.

The Owner reserves the right to supervise the choice of carriers, to verify the weighing and packing operations, as well as to attend at all phases of shipment of the equipment from the manufacturing plants to destination.

9.3 Weighing of the supply

The Contractor shall determine and verify the dimensions and weight of the various components supplied, before and after packaging and shipment to the construction site.

The dimensions and bulk of the packages, which shall be indicated on the packing list, shall be compatible with the gauges and the admissible loads of the various transportation facilities and lifting gears that will be used during transportation.

9.4 Packing of the supply

The Contractor shall make all the necessary arrangements to ensure complete preservation of the quality of the material shipped, during transport, as well as during storage in open-air storage areas, which could possibly be prolonged due to uncertainties of the construction site.

All components supplied shall be carefully packed by the Contractor, taking into consideration risks caused by repeated and brutal handlings, corrosion in a maritime environment, humidity, bad weather, duration of open-air storage at quay or on the construction site, etc.

Generally, all components shall be packed in sturdy wooden crates, well-built and tightly closed. When found necessary, especially for fragile components such as electrical and auxiliary equipment, the items inside the crates shall be protected by sealed envelopes. These sealed envelopes, independent from the crates, shall be made of a thermosetting composite fabric, welded; moreover, a hygroscopic substance shall be placed inside the envelope.

Any machined steel parts not destined to be painted shall be protected with grease or a suitable removable coating. Other alterable steel parts shall be protected with paint. Parts that are to be painted onsite shall, at a minimum, be protected with a primary coat of paint. Machined surfaces shall be efficiently protected against shock that may happen during transportation.

Inside the crates, equipment shall be carefully wedged, and, when necessary, in particular for delicate equipment, the equipment shall be immersed in flexible chips to cushion any shocks.

For equipment having moving parts, the moving parts shall be anchored and maintained in position.

All fluid systems shall be emptied and properly cleaned. Certain components – such as pumps, compressors and servomotors – may be recommended to be transported filled with oil. The nature and type of the oil used for transport shall then be clearly indicated on a label affixed to the component. To avoid any risk of overpressure in the event of a temperature rise, these components shall never be filled to more than 75% of their volume.

All piping ends shall be firmly sealed (sleeves, plugs, caps), as well as both ends of electric cables (sealing caps made of cast synthetic material). Cable reels shall be firmly staved and ringed.

All packaging materials are to be regarded as lost; they shall be evacuated to waste dumps indicated by the Owner, and shall remain the property of the Owner.

Damage or loss due to inadequate packaging or protection may in no circumstances be invoked by the Contractor as a cause of an unforeseeable delay, and the Contractor shall bear full responsibility.

9.5 Package labelling

Each package supplied shall be clearly and indelibly identified by the Contractor in order to ensure delivery and facilitate storage and assembly. Spare parts shall be conditioned separately and individually labelled according to the KKS identification code valid for the project.

Methods of identification shall be captive and unable to be removed, and shall remain perfectly legible even after prolonged exposure to the elements.

Conventional ideograms and reference marks – indicating slinging points for handling, assembly orientation, degree of fragility, etc. – shall be affixed to all sides of the packages.

A complete packing list summary of the shipped material shall be placed in two (2) copies inside each package, and one (1) copy shall be placed in a small transparent and sealed envelope accessible from the outside.

In all cases, the following minimum information shall be indicated on each package:

- Name of the Owner
- Name of the Contractor
- Contract number
- Name of the hydroelectric Installation
- Batch number (and/or sub-batch number and/or item number)
- Site or place of delivery
- Packing list number
- Number of packages in the packing list
- Dimension of the package
- Gross weight
- Net weight

The labelling details will be transmitted to the Contractor during the Project implementation stage.

All boxes shall be labelled with the appropriate international symbols for transportation.

9.6 Shipment

The Contractor shall request final authorization to carry out shipment of the packages at least fourteen (14) days before the planned shipment date, and shall concurrently transmit, before the departure of the factory material, five (5) copies of the bill of lading, in which the following information shall be included:

- Contract reference
- Estimated date of delivery
- The shipment's sequence number
- The number of packages and a copy of their labelling
- Designation of the material per package
- Type of packing
- Specific storage instructions
- Gross and net weight
- Identification of the transportation methods, as well as pro-forma invoice indicating the value of the packaged material

The five (5) copies of the bill of lading shall be addressed to the following recipients:

- To the Owner:One (1) copy
- To the Owner's Head Office:Two (2) copies
- To the onsite Owner office:Two (2) copies

The Owner reserves the right to refuse, at the sole expense of the Contractor, the onsite unloading of packages that have not been properly announced or authorized, or for which the required formalities, whether administrative as technical, were not completed by the Contractor or his carrier.

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