**GENERAL TECHNICAL SPECIFICATIONS**

**OVERVIEW**

There shall be 2 nos. 50KW Turbine Generator sets each generating at 415 volts. The generated power shall be synchronized and stepped up to11kV by 200kVA, 0.415/11kV transformer. The 11kV Power will be transmitted through 2.50 Km 11kV line to the nearest village, ie. Hrianghmun.

The generating sets will be provided with the latest regulating and protection system. There will be only fuse protection at the 11kV side and hence the sets and the L.T system should be rugged and should be able to withstand shocks.

One control and protection panel each will be provided for each set and there will be a common panel feeding the step up transformer, which will be an outdoor installed transformer.

The sets should be able to operate in parallel to feed isolated load. They should also be able to operate in parallel with grid.

1. **GENERAL INFORMATION** 
   1. **General**

The Tenderer shall strictly observe this General Technical Specification in conjunction with the Particular Technical Specifications. The Tenderer shall carry out all work in a skilled and workmanlike manner in compliance with modern methods of engineering. All design; calculations, materials, plant, manufacture and testing shall conform to the latest applicable standards. In addition, the Tenderer shall conform to all applicable regulations regarding the execution of construction and installation work, and shall follow all instructions issued by the competent Authorities and the Engineer-in-Charge of the Purchaser. The particular Technical Specifications shall take precedence over the General Technical Specifications in case of any contradiction. Clause number cross-references refer to the volume in which they occur unless stated otherwise.

* 1. **Scope of Work**

The scope of work in this Contract covered by the General Technical Specification is broadly Electro-mechanical equipment design and manufacture as per specifications, i.e. turbines, generators & associated equipments along with outdoor/indoor switchgear equipments, transportation and insurance from supplier’s premises to site and storage, erection, testing & commissioning. In addition to his Tenderer shall prepare detailed design, construction and installation drawings as well as calculations, material specifications, operating and maintenance instructions etc. The Tenderer shall manufacture, supply, install, test and commission the plant complete in every respect with the necessary accessories for reliable continuous operation, even if not all details are explicitly mentioned in the Specifications.

These Specifications include the performance of all work and the provision of all materials, permanent and temporary equipment, tools, accessories for transport to the site, including loading, unloading, if necessary intermediate storage/reloading, protection of the plant from the effects of the weather, cleaning, drying, complete installation, painting, testing and commissioning of all plant and its accessories.

The Tenderer shall make competent and experienced staff available for the training and assistance of the operating staff during commissioning and Test Service Period operation and, if required by the Purchaser, for a period after completion of the Test Service Period which shall be agreed separately.

* 1. **Standards**

Although Indian or IEC standards for workmanship material and plant have been selected generally in these specifications as a basis of reference, other standards and recommendations of standard international organizations will be acceptable provided they ensure equal or higher quality than those specified, and provided, furthermore, that the Tenderer submits for approval, detailed standards which he proposes to use.

Except where modified by this specification, plant and materials shall be in accordance with BIS (Bureau of Indian Standards), IEC (International Electro technical Commission) and ISO (International Organisations for Standardisation) Standards. If relevant BIS, IEC and ISO standards are not available in any cases then the Tenderer for approval by the Engineer shall propose relevant National Standards.

When BIS, IEC or ISO Recommendations or National Standards are referred to, the Edition shall be latest at the time of Contract signature, together with any Amendments issued up to date. The Tenderer of the plant shall give a list of national standards not complying with IEC standards to be used.

If requested by the Engineer the Tenderer shall supply at his own expense three copies in English and one in the original language of any standards that re applicable to the Contract.

The Tenderer shall indicate in the Technical Date Schedules, the materials and applicable standards for all major parts of the supply.

The materials shall be carefully selected for the intended purpose and due consideration of the site conditions and the tropical environment. Higher grade material shall be used where ordinary material is insufficient.

**0.3.1**

All plants, equipments, materials, workmanship, inspection and testing etc. shall have to follow relevant Indian Standard and any Indian Statutory requirement wherever applicable.

* 1. **Design Improvements**

The Purchaser or the Tenderer may propose changes in the specification for the equipment or quality thereof and if the parties agree upon any such changes, the specification shall be modified accordingly.

The Tenderer should however, note that changes proposed by him will have to be support with applicable type test reports or any documents considered essential in this regards.

If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Tenderer proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

* 1. **Quality Assurance Programme**

To ensure that the equipment and/or services under the scope of this Contract whether manufactured or performed within the Tenderer’s Works or at his Sub-Tenderer’s premises or at the work site of the Purchaser or at any other place of Work are in accordance with the specifications, the Tenderer shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be outlined by the Tenderer and shall be finally accepted and approved by the Purchaser after the discussion before finalisation of the Contract. A quality assurance programme of the Tenderer shall generally cover the following:

1. His organizational structure for the management and implementation of the proposed quality assurance programme.
2. Documentation control system.
3. Qualification data for Tenderer’s key personnel.
4. The procedure for purchases of materials, parts components and selection of sub-contractor’s services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
5. System for shop manufacturing and site erection controls including process controls and fabrication and assembly control
6. List of all tests / checks to be carried out during manufacturing ship assembly / site tests / pre-commissioning checks etc. List shall be detailed so as to identify the tests / checks to be witnessed by the Purchaser.
7. To identify the list of sub-contractors.
8. A detailed PERT network showing all the activities of the work is mandatory.
9. Control of non-conforming items and system for corrective actions
10. Inspection and test procedure both for manufacture and field activities
11. Control of calibration and testing of measuring and field activities
12. System for indication and appraisal of inspection status
13. System for quality audits
14. System for authorizing release of manufactured product to the Purchaser
15. System for maintenance of records
16. System for handling storage and delivery
17. A Quality Assurance Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment finished and or services rendered.

**0.5.1 Quality Assurance Documents**

The Tenderer shall be required to submit the following Quality Assurance Documents at the time of dispatch of the Equipment.

1. All Non-Destructive Test procedures, stress relief and weld repair procedure actually used during fabrication and reports including radiography interpretation reports
2. Welder qualification certificates (Boiler quality)
3. Welder’s identification list, listing welder’s and welding operator’s qualification procedure and welding identification symbols
4. Raw Material test report as specified by the specification and or agreed to in the Quality Assurance Plan.
5. The Quality Plan with verification of various customer inspection points, as mutually agreed and methods used to verify that the inspection and testing pints in the Quality Plan were performed satisfactorily.
6. Factory test results for testing required as per applicable standards referred in the specifications.
   1. **Design Co-ordination**

The Tenderer shall be responsible for the selection and design of appropriate equipments to provide the best-coordinated performance of the entire system. The basic design requirements are detailed out in this specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly/disassembly and maintenance.

The Tenderer has to coordinate designs and terminations with the Purchaser as well as their Consultants.

* 1. **Design Co-ordination Meeting**

The Tenderer will be called upon to attend design co-ordination meetings with the Purchaser and their Consultants during the currency of the Contract. The Tenderer shall attend such meetings at his own cost at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

* 1. **Units of Measurements**

The International System (SI) of measures and weights shall be used for documents, correspondence, drawing etc. relevant to the Tender and the subsequent Contract.

* 1. **Programme of Work**

According to the relevant articles in the ‘Condition of Contract’, the progress of the work shall conform to the basic Programme of Work on which the Contract is based.

The ‘Programme’ shall be submitted (detailed programme ‘ schedule of work) in accordance with the Contract Conditions, and shall include the following information.

* Design work
* Procurement
* Shop work and testing
* Construction of machine foundations, cable trench etc.
* Transportation to the Site
* Loading & un-loading
* Intermediate storage
* Storage and handling at site
* Erection, testing and commissioning
* Trial run operation
* Performance guarantees test
* Removal of erection equipment and clearing of Site
* Interdependence with work of other Tenderers.

The Tenderer shall pay particular attention to the dates established for the submission of ‘installation and foundation’ drawings with loading data, anchoring details, recesses, block-outs etc., and all information necessary for the preparation of the civil work design drawings.

Since the Schedule dates are dependent on the progress of other contracts, the Tenderer shall suitably co-ordinate his operations at the Site with those of other Tenderers.

**1 TECHNICAL DOCUMENTS**

* 1. **General**

Tenderer shall have to furnish their detail list of drawings / documents / catalogues / published papers etc. This Chapter specifies the general scope and gives a definition of the documents, which, together with those listed in the Particular Technical Specifications, shall be delivered by the Tenderer to the Engineer within the periods, and in a number and quality as specified. The engineer reserves the right to request the Tenderer for additional documents as may by required for proper understanding and definition of constructional, operational, co-ordination or other matters.

The Tenderer shall co-operate with other Tenderers in the exchange of drawings, dimensions, data and all other information required to ensure proper co-ordination f the work. All documents to be supplied shall be submitted in accordance with the agreed programme so that any change required by the Engineer can be taken into account before starting of the manufacture in the workshop and / or erection or installation at the Site.

If the Tenderer fails to submit such documents, then the later execution of changes requested by the Engineer and the resulting additional cost and / or delays shall be the Tenderer’s responsibility. The Tenderer shall not be relieved of his responsibility and guarantee after drawing and computations have been approved by the Engineer.

The Tenderer without the written authorization of the Engineer shall not sublet the preparation of drawings, computations or other technical documents. In such a case the Tenderer shall be fully responsible for such drawings, computations and other technical documents as if they were done by him.

On drawings, catalogue sheets or pamphlets of standard plant submitted to the Engineer the applicable types, paragraphs, data etc., shall either be marked distinctively or the non-applicable parts shall be crossed out. Documents not marked in such a manner will not be accepted and approved by the Engineer.

If required for proper understanding of the documents, additional descriptions / explanations shall be given on these documents or on separate sheets. All symbols, marks, abbreviations, etc., appearing on any document shall clearly be explained by a legend on the same document or on an attached sheet.

Each device appearing on any document (drawing, diagram, list, etc.) shall clearly be designated. The abbreviation mark used for an individual device shall be identical throughout the complete documentation so as to avoid confusions. All documents shall have a uniform title-block as outlined in the ‘Conditions of Contract’ and agreed by the Engineer. Beginning with the very first submittal to the Engineer, the Tenderer’s drawings shall bar a serial number corresponding to a drawing classification plan to be agreed by the Tenderer and the Engineer.

Revised technical documents replacing previously submitted documents shall be marked accordingly. Also, the revised part in the Document itself shall be marked clearly. Annexure No. 4 of the Volume specifies the documents to be supplied and the required status, namely ‘FOR APPROVAL’ (A) or ‘FOR INFORMATION’ (I), respectively.

Any comment given by the Engineer on an ‘I’ type drawing shall have the same effect as if it were given on an ‘A’ type drawing.

* 1. **Drawings** 
     1. **Loading Drawings**

For all larger pieces of plant, which, due to their dimensions and / or weight subject to transport limitations as dealt elsewhere in the specification, will require special means for their transportation, the Tenderer shall submit binding loading drawings indicating dimensions, weights, etc., of the respective pieces of plant and the necessary details of trailer for its transportation to the site.

* + 1. **Foundation Drawings**

If a piece of plant requires its own foundation or needs a special area for installation, the Tenderer shall submit drawings indicating all pertinent dimensions, static and dynamic loads, etc. They shall include all essential details required for proper design and construction of the foundations and / or buildings. Details drawings of all embedded parts shall be submitted.

In addition, they shall include openings, sleeves, slopes and arrangement of any supporting structure, i.e. base-frames or other steel constructions for permanent fixing or erection purpose.

If conduits are to be installed in the foundations, the relevant information such as diameter, length, and purpose shall be indicated on the drawings.

* + 1. **Arrangement Drawings**

All arrangement drawings shall be drawn to scale. The General Arrangement Drawings shall show the physical arrangement of plant (machines, complete switchgears, control panels, instrument cubicles, etc.) civil constructions (buildings, rooms, foundations, ducts, etc.) and reserved areas (for pipes, cables, lines, etc.) in relation to each other and to agreed co-ordinates and boundaries. Such drawings shall be prepared for the whole plot, for separate plots and for each building (building, hall, room, ducts and trenches, etc.).

The Arrangement or Layout Drawings of electrical, instrumentation and control equipment shall indicate the location of all apparatus wherever used, i.e. in or on machines, control boards, switchboards, cubicles, control desks and panels, etc. The apparatus shall be denominated with the same standardized abbreviations as used in all other documents.

* + 1. **Outline Drawings**

The Outline Drawings shall show all elements and the main dimensions of individual components where necessary in plan view, cross-section, side and top views. If reasonably possible such dimensions can be shown on Arrangement Drawings.

* + 1. **Design Drawings**

The Design Drawings shall include assembly, drawings, erection drawings, piping diagrams and piping arrangement drawings, etc., showing the dimensions, design and data of all apparatus and plant to be furnished under this Contract.

The drawings shall – where applicable – substantially conform to the Tender Drawings and shall show:

* Drawings of major assemblies manufacture for this contract
* Sub-assembly of the principal components of the plant with overall dimensions, adjustment and clearance tolerances, and numbers of corresponding detail drawings.
* Sub-assemblies in which the Tenderer proposed to ship the plant
* All necessary details of the parts connecting to plant supplied by others
* Location and sizes o auxiliary connections for oil, grease, water, air, etc.
* Location and size of the instruments and accessories provided.
* Method of lubrication and sealing
* Instructions for heat treatment, pressure tests, surface preparation and anticorrosive protection.
* Full details of parts for which adjustment is provided or which are subject to wear
* Method and sequence of installation, field joints, erection and lifting devices, jacks, grout plugs, anchoring details, etc., if not shown on foundation drawings.

* + 1. **Installation Drawings**

The mechanical, electrical and I & C Drawings shall provide detailed information on the disposition of the various items of a system (e.g. lighting fixtures, socket outlets, connection boxes, transmitters, actuators, loudspeakers, telephones, pipes, valves, pumps, compressors, etc.) and of the piping and wiring respectively included in the installation or assembly. They shall be based on dimension drawings of cubicles, rooms, buildings, or areas containing the plant.

* 1. **Diagrams**
     1. **Single Line Diagrams (SLD)**

This is a simplified diagram of the essential electrical plant and their interconnections. A single line only shall represent each circuit. It shall contain all required technical information of the plant represented, e.g. voltage, ampacity, short-circuit level, ratios, voltage variations, positive and zero sequence impedances, measuring transformer and protection relay indices, interlocking, kind of switch drive, code designation etc.

Single-line diagrams of individual main components and switchboards shall additionally show the control, indicating, measuring, metering, protection automatic, and other auxiliary electric devices separated for each individual installation site and location as applicable.

* + 1. **Circuit Diagrams**

The Circuit Diagrams shall show the power circuits in all phases with the main apparatus as well as the pilot circuits (measuring and control circuits). It shall show in full the functioning of part or all installations, plant or circuits with all required technical information.

The control part shall be subdivided into separately drawing ‘current paths’, each showing all its components regardless of their actual physical location. The individual circuits are to be drawn in a straight-line sequence, avoiding line crossings. The current paths (to be designated by numbers) shall be drawn starting from two horizontal lines which represent the control voltage source. All devices belonging to the plant or forming part of the plant or control devices shall appear between these two lines.

Contract developments of the installed switches, contactors, relays and other apparatus which appear in the diagram shall be shown below the respective contactor coil, indicating by means of numbers and, if not on the same, also the page No.., the current path in which the corresponding contact has been used.

Interconnections to other circuit diagrams shall be clearly marked by means of dotted line separations and the corresponding functional designation.

The power circuit portion of the installation shall be drawn at the left side of the drawing.

Circuit diagrams shall also contain all terminals and their correct designations. Terminals grouped together to terminal blocks of switchboards, distributors etc., shall be shown on the circuit diagrams in one fictitious horizontal line surrounded by demarcation lines. If, for any reason, the current paths of circuit diagrams must be separated, the corresponding counter terminal has to be indicated by all means.

The representation of electrical plant and control circuits shall not be terminated at the limits of the scope of supply, but has to be extended beyond this limit by all switchgear, protective, measuring and monitoring equipment required for full comprehension of the whole circuit. All terminals and functions of plant to be supplied by others shall be taken over as well.

Standards Circuit Diagrams are patterns of circuit diagrams which have been standardized with regard to scope, arrangement, representation and allocation of plant with the aim of simplification and easy surveillance of electrical circuitry.

* + 1. **Connection Diagrams**

The internal Connection or Wiring Diagrams shall show the wiring or tubing connections either within one apparatus or between several apparatuses of one group. They shall contain the single components or apparatuses of one group arranged in the correct physical location including terminals and terminal boards. The connections shall either be represented by lines or, in case of a ‘wireless’ connection diagram by a wire table.

* + 1. **Block Diagrams**

The Block Diagrams shall be used to show in a simplified manner the main inter-relationship between the elements of a system by means of symbols, block symbols and pictures without necessarily showing all the connections. The symbols used for the individual kinds of components, e.g. servo-motors, amplifiers, computing modules, etc., shall clearly be explained on the diagram or on an attached legend.

When recommendable, a Block Text Diagram may be prepared, consisting essentially of explanatory texts enclosed in outlines which are linked by lines showing the functional relationship that exist between the various parts of an installation, plant or circuit.

* + 1. **Logic Diagrams**

The Logic or Functional Diagrams shall be used for representation f logic and sequence controls and interlocking by showing only binary elements and their effect on the various process equipment disregarding their electrical realization. Logic function elements (AMD, OR, NOR, NAND, STORAGE, etc.) shall be used for processing and combining binary signals.

* + 1. **Process or P & I (P&ID)**

The Process or P&I Diagrams shall show the piping including type, dimensions, fittings, flanges, etc., and the flow directions. They shall also show the process data, measuring points, instrumentation, control functions and locations of the plant. All P&I Diagrams shall comply with the requirements of ISO – Standards 3511 (process measurement control functions and instrumentation-symbolic representation).

* + 1. **Terminal Diagrams**

Such diagrams shall be prepared for any type of terminal box, marshalling rack, control cubicle, switchboard, etc., and shall show the terminals (properly numbered) and the internal and / or conductors (wires or cables) connected to them.

The terminal diagram of each individual switchboard, terminal box, panel, etc., shall contain but not be limited to the following information:

* Terminal number of terminal board with targets (terminal number and current path) of incoming and outgoing cables and wires
* Cable designation
* Type of cable
* Number and cross-section of conductors
* Assignment of conductors
* Number of spare conductors
* Approx length of cable and its destination
  + 1. **Protection Co-ordination Diagrams**

These diagrams shall show in a graphical manner separately for each power supply circuit:

* A simplified single-line diagram of the circuit with technical data of all instrument transformers and relays
* Co-ordinated tripping curves of related protection devices
* Setting of the protection devices.
  1. **Specifications** 
     1. **Material or Plant Specifications**

Specifications shall be prepared for all principal plant and installations. They shall describe the performance (design, material, dimensions etc.) of the plant and include a list of components providing information on the manufacturer, type and technical data to obtain the following:

* Full information on the plant, completing the general requirements fixed in the Tender Specification by the data/information of the specific manufacture
* Proof of compliance with Contract Specification.

For standard plant catalogues or pamphlets can be submitted as described under Clause 1.1.

* 1. **Lists and Schedule**
     1. **List of pipes, valves, fittings etc.**

This list shall include all the main pipes, valves & fittings etc. required for different purposes and shall contain at least the following information / data.

* Plant identification number
* Description
* Name of manufacturer & type
* Size & material
* Nominal pressure
  + 1. **List of pumps, strainers & filters etc.**

This list shall be prepared according to the requirement of the plant the details of pumps, strainers & filters covered under this contract.

* Plant identification number
* Description
* Name of the manufacturer & type
* Dimension / weight of complete pump (with motor)
* Dynamic head
* Speed of pump
* Discharge m3/sec
* Shut off head of pump
* No. of pump impeller / material or impeller
  + 1. **List of motors, heater, motor operated valves**

The lists shall be prepared according to the switchgears and distribution boards, the consumers (motors, heaters, motor operated valves, etc.) are connected to, and shall contain at least the following information / data:

* Plant identification number
* Description
* Manufacturer, type, rated data of driven machine
* Rated capacity
* Service factor (ratio between motor output and power requirement of the driven machine)
* Rated speed
* Rated voltage
* Rated current
* Ratio of starting current to rated current
* Ratio of pull-out torque to rated torque
* Power factor at rated capacity
* Efficiency at rated capacity
* Power consumption at machine design loading
* Total weight
* Design/enclosure/cooling (acc. to IEC)
* Duty (continuous/intermittent/start-up)
* Denomination of feeder
* Protection
* Applicable Standard Circuit Diagram (Category)
* Maximum number and overall diameter of power cables(s)
* Manufacturer and type of bearing(s)
* Manufacturer, type and quantity of lubricant, service interval
* Manufacturer, type, number, size, spring pressure and service interval of brushes.
  + 1. **Motor Starter Lists**

The motor starter lists shall include all starters and contactors used for motors and contain the following technical information as a minimum:

* Plant identification number
* Electrical design data as nominal and actual current rating, voltage rating, coil rating, making and breaking capacity, mode of operation
* Maximum power cable size
* Maximum control cable size
* Current transformer ratio, class and capacity
* Type of protection relaying and catalogue number
* Setting of protection relays and maximum continuous rating of the protected circuit
* Type and current rating of the back-up fuses / MCB’s for the main and control circuits.

*Note: Motor Starter Lists can be substituted by adequate plant lists, already forming part of switchgear manuals.*

* + 1. **Cable Lists**

The Cable Lists shall include for each individual cable the following as a minimum:

* Cable number, in accordance with Identification System, Annex.6
* Cable type
* Rated voltage
* Number and size of conductors
* Overall diameter
* Cable termination at each end
* Connection point at each end with cubicle / plant identification and terminal numbers
* Cable routing
  + 1. **List of Measurements**

This list shall indicate all measurements, local as well as remote, and shall contain at least:

* Item / code number, function code
* Description and denomination of measuring loop
* Data of tapping point
* Data of local devices (as detectors, instruments transformers, transmitters)
* Data of remote devices
  + 1. **Alarm Lists**

These lists shall indicate all alarms and shall contain at least:

* Item / code number, function code
* Description and denomination of alarm
* Data of alarm detector (contact)
* Data of alarm annunciator (location and clear text labeling) collection of group alarms
  + 1. **List of Final Control Elements**

This list shall indicate all control actuators and control valves and shall contain at least:

* Item / code number
* Data of pipe and valve connections
* Data of valve layout
* Maximum required and rated power
  + 1. **Workshop Test Schedule**

Individual Workshop Test Schedules shall be prepared for plant / installations (such as machines, switchgears, control gear, cables) and shall contain at least:

* Plant identification number
* Manufacturer
* Place of manufacture
* Place of test
* Date of test
* Objective of test (all individual tests)
* Standards applied
* Certification
* Inspection (by Engineer / Independent Test Authority / Tenderer / SubTenderer)
* Release for shipment
* Remarks

On the above schedule or on separate sheets the Test Procedure shall be specified giving for each test item (kind of test) a description, test method / Standards, used instruments, sample / routine test, test judgment.

* + 1. **Site Test Schedule**

Scope as in 1.5.9. above – as applicable.

* + 1. **List of Tools and Appliances**

List of Tools and Appliances shall detail for all tools and appliances included in the scope of supply:

* Item and code number
* Description
* Quantity
* Weight
* Gross storage requirements (separate for open-air, indoor, air-conditioned) for individual component sets.
  + 1. **Spare Part Lists**

Spare parts lists shall detail for all parts included in the scope of supply:

* Item and code number
* Description
* Quantity
* Weight
* Gross storage requirements
  + 1. **List of Consumables**

List of Consumables shall include the following:

* Item and code number
* Description
* Quantity
* Weight
* Gross storage requirements (separate for open-air, indoor, air-conditioned) for individual component sets.
  + 1. **List of Plant Identification Number**

This list shall contain the used plant identification numbers in alphanumeric order and for each of them a description (the defined plant denomination, for example as written on the plant label) and the location (short definition of outdoor area and level elevation or building / room with elevation and room number).

* 1. **Calculations**

In addition to the drawings or whenever the contractual documents do so require, the Tenderer shall submit to the Engineer for checking, the appropriate results of calculations for determining the main sizes, dimensions & operational characteristics.

* + 1. **Short-Circuit Calculations**

The short-circuit calculations shall be performed in accordance with relevant Indian Standards or IEE 909

Wherever applicable, the following maximum values for plant layout and maximum and minimum values for protection system layout shall be calculated for the individual plant components:

* Initial symmetrical short-circuit capacity S”K(3) and current J”K(3)
* Symmetrical breaking capacity SA(3) and current JA(3)
* Peak asymmetrical short-circuit current JS(3)
* Sustained short-circuit current JK(rms) (3)

Moreover, the following values shall be calculated for solidly or partially earthed network systems:

* Maximum single-pole short-circuit J”K(1)
* Maximum earth fault current JE as determined by the earthing resistance RE
* Maximum contact voltage as determined by the values as stated above.
  + 1. **Voltage Drop Calculations**

The voltage drop calculations shall be determined for different networks / feeders of the complete electrical system.

* + 1. **Earthing Network Calculations**

The Earthing Network Calculation shall determine on basis of the short-circuit currents the relevant design criteria for the layout of the plant’s Earthing Network and the potential gradient control system, such as:

* Earthing resistance
* Earth electrodes or conductors (number and dimensions)
* Mesh network and other means for potential gradient control for different locations (mesh widths and dimensioning)
* Maximum contact, step voltages & transferred voltages
  + 1. **Generator Earthing System Calculation**

This calculation shall prove the correct selection of the generator earthing equipment.

* + 1. **Load Evaluations**

The load evaluations shall demonstrate for each voltage (AC and DC), and for each individual distribution board / MCC, the following data:

* Rated capacity of all consumers

Maximum number of identical consumers which can operate simultaneously

* Total electric demand in kVA and the power factor at nominal service of the driven machine, subdivided into:
* Start-up
* Rated service
* Shut-down
* Stand-still

The maximum load on one of the MV or LV auxiliary supply transformers shall be determined with due consideration of the most unfavourable condition when feeding specially in case of emergency, several main and sub-distribution boards.

* + 1. **Selection of LV Breakers and Minimum Cable Cross Sections**

This paper shall prove the correct application of LV breakers and – where required – of short circuit current limiting devices.

The minimum size of cable connections shall be calculated applying the max. admissible temperatures and ratings (continuous and short circuit conditions).

The results shall be shown in a table containing at least:

* The maximum initial symmetrical short circuit current before and behind the switchgear (breaker/fuse)
* The breaker setting range
* The let-through current
* The resulting minimum cable cross section
* The applicable standard cross section

The Tenderer shall have to furnish all test certificates as given in the relevant parts of tender document. All test certificates shall be submitted as specified.

* 1. **Operation and Maintenance Manuals**
     1. **Contents**

The Operation and Maintenance Manual shall be provided. All information necessary for the reliable operation and maintenance of the equipment shall be summarized in the form of ad A4 size manual incorporating the documents described below:

Volume Tile

1. Operating Instructions
2. Part A – Mechanical Plant, Part B – Electrical Plant
3. Control, Metering and Protective Equipment

(IV.) Hoisting and Lifting Equipment

(V.) Domestic Installations

The above volumes shall be bound in covers with different colours. Individual volumes shall contain at least the following documents and data:

Vol. (I) General description of the equipment, operation particulars

Main technical characteristics

Connection to external systems (electricity, water, etc.)

Instructions for operating personnel including periodic tests, check-points, actions required following each individual alarm signal, etc.

Summary of important rules, standards, safety precautions and instructions to be followed during equipment operation and maintenance

Safety and warning signs to be placed on the equipment

Important principle diagrams (piping, electrical services) and layout drawings

Parts lists.

Vol. (II) List of all SubTenderers and suppliers with addresses

Standard documents (catalogues, etc.)

Detailed data sheets with all technical characteristics necessary for operation, ordering or new parts and maintenance for motors, valves, etc.

Operation and maintenance instructions indicating the maintenance intervals, special safety precautions, special tools, description / sketches required for maintenance works, etc.

Lists of spares with identification codes and all information necessary for direct ordering from the manufacturers

Assembly drawings and important detail drawings

Copies of all test certificates for plant and equipment such as pressure vessels, safety valves, cranes, hoists, etc., in English. (Originals to be bound in book from and submit to Purchaser after Taking Over Certificate (TOC).

Vol. (III) As in (II) above plus

All main single line diagrams, main layout and arrangement drawings

Cable lists of power cables and layout of cable ways

Circuit and wiring diagrams of power and control systems including terminal designation

Apparatus and equipment detailed diagrams and descriptions of function and maintenance requirements

Detailed functional diagrams for regulation, control, metering and protection systems, circuit diagrams of all printed circuit boards (PCB)

Detailed diagrams for remote control, signal transmission and communication systems

Cable list of control and metering cables

List of information / signals to be exchanges with other Tenderers.

Vol. (VI) and

Vol. (V) applicable documents as per above volumes

(catalogue’s data-sheets, illustrations ……)

Sections on ‘maintenance’ shall be divided into two parts:

1. Current (preventive) maintenance indicating inspection periods, routine clearing and lubricating procedures, safety checks, adjustments, etc.
2. Repairs and overhauls describing the dismantling, removal and replacement of parts (with spare parts), trouble-shooting guides, repair instructions including heat treatment processes, welding procedures etc.
   * 1. **Performance**

The Engineer reserves the right to specify a uniform cover (loose leaf binder) for all openings and maintenance instructions prepared by the various Tenderers for individual lots. The Tenderer shall not be entitled to claim extra payment for this requirement.

Furthermore, the Engineer may required the Tenderer to adapt drawings (single line, wiring, terminal diagrams, etc.) to drawing of another Tenderer in order to facilitate maintenance, surveillance, repair of faults, etc. Each kind of drawing aforementioned shall have a uniform size. The Engineer shall decide the final size of drawings for the Operation and Maintenance and Manual. Catalogue sheets, illustrations, printed specifications, etc., shall be checked and prepared by the Tenderer in such a way that the figures, statements and data valid for the delivered sizes and types of the plant concerned are clearly marked. All figures, statements and data valid for sizes and types not delivered must be crossed out.

* + 1. **Revisions and Supplements**

The completeness of the manual shall be checked during installation, testing, commissioning and trial operation jointly by the Tenderer and Engineer.

If it becomes evident during the installation, commissioning trial operation and defects liability period of the plant that the Operation and Maintenance Manuals are inadequate or incorrect, the Tenderer shall supply immediately the necessary supplements and corrections. This shall be handled in the following manner:

Deletions

One sheet of errata, printed on pink paper, shall be issued indicating the pages and date of issue of those pages which are to be deleted and are no longer valid.

Corrections, Revisions, Replacements

New sheet or sheets shall be issued to replace the wrong pages. Whenever a new sheet is added to the instruction manuals, this sheet shall be given the new date of issue and a revision symbol, and an indication ‘Substituted for….’ and a marking of the corrected / revised items.

Insertions, Supplements

Insertions or supplements shall be accompanied by a new respective ‘Table of Contents’ page, where the latter shall be handled as described above under replacements.

The revisions and supplements requested by the Engineer shall be made by the Tenderer of the Site as far as possible and shall be submitted in each case to the Engineer for checking and revision as stated above.

Before issuing the ‘Taking-Over Certificate’, the revised copies of the Operation and Maintenance Manual shall be submitted together with the specified number of complete sets of drawings of the Works as completed. The Works shall not be considered complete for purposes of taking over under the terms of the General Conditions of the Contract until the above documents have been supplied by the Tenderer.

* 1. **Installation Manual**

The Tenderer shall provide the Engineer and the Purchase with an Installation Manual covering erection and installation procedures and instructions to facilitate smooth erection and assembly of all equipment to be installed on site.

The instructions therein shall specify the exact procedures to be followed during installation, indicate data to be measured and recorded (adjustments, setting of limits, etc.) quantities, dimensions and tolerances to be checked, etc. The manual shall include information on handling and slinging the major pieces of equipment, erection tolerances, settings and adjustments and special precautions to be taken during erection and installation.

* 1. **Commissioning Manual, Commissioning Report**

The Tenderer shall provide the Engineer and the Purchase with a Commissioning Manual which shall be similar in size and form to the Installation Manual and include procedures and instructions to be followed during the commissioning of all equipment to be installed.

The instructions therein shall specify the site testing and describe the exact procedures to be followed during commissioning and shall indicate all data to be measured (and where appropriate recorded in the manual itself) and all adjustments, settings of limits etc., quantities, dimensions and tolerances to be checked.

In addition to the above manual, the Tenderer shall provide a Commissioning Report which shall be historical account of the commissioning procedures undertaken including a complete record of all settings and adjustments made an all tolerances checked.

* 1. **Progress Report**

During erection the Tenderer shall, before the tenth (1oth) day of each calendar month, submit 4 (four) copies of the monthly progress reports in a format acceptable to the Engineer, detailing the progress of the work during the preceding month. The report shall contain but are not be limited to the following information:

* A general description of the Works performed during the reporting period on each main activity and include any notable problems which were encountered.
* The total overall percentages of erection works completed, with reference to the CPM programme. Appropriate comments shall explain any differences.
* The percentages of each main work activity completed during the reported month with reference versus the scheduled programme. Appropriate comments shall explain any differences.
* A list of all activities of schedules and actual progress during the reporting period including actual starting dated versus schedule starting dates and actual completion dates versus scheduled completion dates for each activity. Appropriate remarks shall explain any differences.
* A list of activities schedule to be started within the next period of two (2) months, with expected starting and completion date. If the expected starting and / or completion dates are different from those shown on the CPM programme, an explanation shall be given.
* A list of local manpower (by trade classification) employed during the reporting period.
* A list of expatriate personnel (by position) employed during the reporting period
* A list of the Tenderer’s Equipment and materials presently located at the Site. Also a list of equipment and materials, which arrived at the Port of arrival and is in the process of being cleared through customs.
* Progress photographs of significant events. The Engineer may direct the inclusion of specific photographs is deemed necessary
* Main items of temporary facilities constructed during the reporting period.
* A statement detailing the status of progress on the overall programme and how to regain any lost time or set-back which may have occurred.
* A list of inoperable temporary equipment, and the estimated date when the repair will be completed.
* A statement concerning potential problems and recommendations on how they could be resolved.

1. **SPARE PARTS AND TOOLS**
   1. **Spare Parts**

All spare parts to be supplied shall be interchangeable with the corresponding parts of all the plant supplied under these Specifications and shall be of the same material and workmanship. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Taking-Over Certificate the spare parts shall be checked and tested at the Site by the Tenderer in present of the Engineer.

Acceptance of any spare parts will not take place before the Tenderer has submitted the complete final detailed list of all spare parts and tools.

All spare parts shall be protected against corrosion and shall be marked with identification labels in the Ruling Language. The identification shall be in accordance with the agreed Plant Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. The Tenderer shall label and conveniently store all spare parts in racks provided by him in ready to use manner before handing over to the Purchaser.

* + 1. **Mandatory Spare Parts**

At least the quantity of general spare parts specified in the Schedule of Requirements shall be included in the Total Tender Price and consequently in the Scope of Works f the Contract.

* + 1. **Recommended Spare Parts**

If any additional spare parts are recommended by the Tenderer, these shall be stated in quantity and description in the Technical Data Sheets for each item.

Prices for additional recommended spare parts shall not be included in the Total Tender Price.

* 1. **Mandatory Tools and Appliances**

Tenderers shall supply all mandatory tools & appliances as specified in particular technical specification and schedule of requirement. Tenderer shall also suggest any addition and deletion in the list specified by the purchaser required for total assembly and disassembly of all parts of the supplied plant and accessories for maintenance of the plant.

* 1. **Recommended Special Tools and Equipments**

The Tenderer shall have to furnish the list of recommended special tools and equipments. Prices for recommended special tools & equipments shall not be included in the total tender.

1. **DESIGN AND MANUFACTURE**
   1. **Design and Construction Requirements**

The following directions, information and technical requirements for layout, design and erection shall be observed as far as they are applicable to the plant to be offered. The technical requirements of the General Technical Specifications are valid for all parts of the Works except where they are varied by additional and / or special requirements, specified in the Particular Technical Specifications.

The following directions, information and technical requirements for layout, design and erection shall be observed as far as they are applicable to the plant to be offered. The technical requirements of the General Technical Specifications are valid for all parts of the Works except where they are varied by additional and/or special requirements, specified in the Particular Technical Specifications.

Whenever a Tenderer deviates from these Specifications, he shall furnish the data called for in the Technical data Schedules and give a summary of and the reasons for all deviations in the “List of Deviations from Specifications”. Failure to accomplish this may cause the elimination of his Tender, especially when a major deviation is involved.

Any changes of the design of any part of the plant which may become necessary after signing the Contract have to be submitted in writing to the Engineer for approval, being sufficiently substantiated and justified.

The plant shall be designed, manufacture, arranged and installed to provide functional design and neat appearance. All parts of the plant shall be arranged to facilitate surveillance, maintenance and operation. All control sequences shall be simple and rational.

The parts of the plant shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without involving large scale dismantling of other parts of the plant. They shall be designed, and manufactured in accordance with the latest recognized rules of workmanship and modern engineering practice.

The regulations, standards and guidelines listed in these Specifications hall be observed in the design, calculation and manufacture of the Plant.

All parts of the plant shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions prevailing at the Site.

Special attention shall be given to plant, parts of which are delivered by different manufactures. Problems arising in this conjunction shall be solved by the Tenderer and be defined in writing.

For individual items of the plant, materials and design are to be selected which are best suited for the operating conditions to which the parts in question will be subjected. Only such design and types of plant shall be offered which has confirmed its reliability in long-term continuous operation. Innovations cannot be accepted for the Main Tender but can be offered as an alternative proposal.

Manufacturers shall take appropriate measure to prevent the ingress of dust into any plant (such as bearings, relays, control and measuring equipment, etc.) which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where required of where they will be useful for erection and dismantling.

Pockets and depressions likely to hold water shall be avoided, and if not avoidable they shall be properly drained.

Parts of the plant principally intended for standby purposes shall be protected from any part of deterioration due to prolonged storage by careful choice of material and if necessary, by additional means; these should not reduce their continuous standby readiness.

All design details and layout matters shall be discussed in periodic meetings with the Engineer. The first design meeting between the Tenderer and the Engineer shall take place within 28 days after the Date of Commencement. Further design meetings shall take place as agreed between the participants until the design work is completed.

* 1. **Allowable Stress**

The layout of the parts of items of plant shall fundamentally consider the most severe conditions to which they will be subjected during testing and operation.

The stresses which occur in a section of a part when subjected to the most severe operating conditions or test pressures shall not exceed 70 percent of the yield point of the material of the respective part.

If different stress values are given in the General/Particular Technical Specifications or in the relevant standards and regulations, then the more stringent values shall be applicable.

When exposing complicated steel castings or welded parts to a pressure test, the maximum allowable stress limit of 70 percent of the yield point may be exceeded locally in limited zones if these zones are small in extent and do not endanger the strength of the part. To check these stresses in the critical zones, the Engineer may require strain gauges to be mounted during pressure tests.

In the design of the plant, the maximum stresses due to normal operating conditions shall not exceed one-third of the yield point or one-fifth of the ultimate strength of the material, whichever is lesser, with the exception of safety elements which shall be designed to fail in the event of destructive overload, thus preventing damage to other parts of the plant.

Increased size or thickness, by at least 1 mm, is required for parts subject to corrosion or erosion and for parts mainly designed for rigidity.

The dimensions of the parts which are exposed to repetitive and alternating stresses as well as to impacts and vibrations shall take into account the safety measures approved in practice.

The calculation is performed by the Tenderer when dimensioning the main parts of the plant shall be submitted to the Engineer at his request.

* 1. **Standardisation of Plant**

Every effort shall be made to standardize parts and minimize costs of the plant throughout the plant in order to facilitate keeping stocks, maintenance, replacement, interchangeability, etc.

The Engineer, therefore, reserved the right to request the Tenderer to use uniform types or make of plant and materials. The Tenderer shall not be entitled to claim extra payment due to this request. This request shall especially be applicable to small mechanical and electrical plant such as:

* Valves
* Thermometers
* Pressure gauges
* Flow meters
* Water level gauges
* Sight flow indicators
* Terminals and terminal racks
* Indicating instruments and meters
* Auxiliary relays
* Contactors, fuses
* Motor protection switches
* Control devices
* Lights, bulbs, plugs, sockets

The types or makes to be used shall be decided later the Engineer.

All instrument scales shall be written in the Ruling Language of the Contract and in the international SI-System of units.

* 1. **Quality of Materials and Plant**

No welding, burning, filling or plugging of defective castings or any other components shall be permitted without the Engineer’s agreement in writing.

Any steel castings which have been repaired by welding with the Engineer’s consent shall be subjected (after the final heat treatment) to whatever crack detection, radiographic and/or gamma ray examination or any other tests which the Engineer may require. The cost of theses and other additional tests shall be borne by the Tenderer.

Where stainless steel cladding consists of plates welded to mild steel sections, the welds shall be adequate to ensure that the stainless steel is securely fixed for all conditions of load and wear. Generally, all stainless steel parts shall be welded with stainless electrodes. The thickness of the stainless steel cladding shall not be less than 3 mm.

* 1. **Noise**

The noise level caused by the installed plant shall not exceed the following values if not otherwise stated in the Particular Technical Specifications:

* Machine hall, workshops, etc. max. 90dB(A) at any place 1 m distant from operating plant
* Offices, control rooms, first aid rooms, canteens, etc. max. 55 dB(A)
* Residential areas, daytime max. 50 dB(A), night time max. 35 dB(A)
* Emergency diesel generators max. 85 dB(A) at 1 m distance from the engine.

The noise level definition and measurement shall be in accordance with latest ISO and IEC. The values stated shall be adhered to taking a normal civil construction into account.

* 1. **Security Precautions**

All equipment shall be arranged so that unauthorized persons cannot operate it or incorrectly operated by the operating staff. All valves and switchgear shall be provided with locks to prevent access of unauthorized persons. Three keys shall be provided for all locks, each key being provided with a small metal or plastic label stating the equipment for which the key is provided. All keys shall be provided in lockable key boxes. All locks shall be different in order to prevent accidental operation f the wrong valve or other item of equipment but a master key system shall be incorporated.

* 1. **Identification Plates**
     1. **General**

All duty labels, data, name plates and instruction plates shall be provided and fixed to all items to indicate the purpose and function of the Plant and its components so as to ensure safe and convenient operation and maintenance of the Plant. The types, size, information and position of them shall be to the approval of the Engineer. They shall be in English, of engraved stainless steel or similar approved material, which shall be securely attached by screws, rivets or other, approved means. Die stamped plastic is unacceptable.

* + 1. **Manufacturer’s Nameplates**

The following data shall be shown in accordance with the relevant standards:

* Manufacturer’s name and address
* Plant’s serial number and date of manufacture
* Main design data

As a general rule, standardized components, such as small or medium-sized electric motors, transformers, instruments, etc., may be delivered with the manufacturer’s standard name plate which shall be completed or replaced at the request of the Engineer.

The design of the Manufacturer’s name plates for the main components such as turbines, pumps, synchronous machines, governors, cranes, gates, main transformers, etc., shall be submitted for the Engineer’s approval sufficiently in advance.

* + 1. **Functional Plates**

Each part of the Plant including all valves, controllers, indicators, gauges etc., appearing under a certain symbol or number in functional diagrams, piping diagrams, in the Operation and Maintenance Instructions, etc., shall be equipped with a plate showing the same symbol or number and the corresponding drawing number.

Schematic diagrams of oil, air and water piping engraved on stainless steel plates indicating positions of control elements in normal operating condition shall be fixed in required locations identified by the Engineer.

* + 1. **Instruction Plates**

All plates showing designations or instructions for operation, safety, lubrication, etc. shall have a uniform design.

Adjacent to each oil filling cap of the Plant, a plate indicating the type and grade of oil shall be fixed.

* 1. **Colour Code**

The colour code for electrical and mechanical plant, such as generators, transformers, switchgears, parts of turbines, pumps, valves, gates, cranes, servomotors, piping for water, oil, air, combustible, poisonous or aggressive liquids or gases, etc., shall be according to relevant Indian Standard / International Standard or mutually agreed by Tenderer & purchaser.

Pipes shall be uniformly painted and be provided with colour bands in the colour given for the marking or pipes according to relevant Indian and International standards. The flow direction shall be marked by black arrows.

* 1. **Workmanship**
     1. **Finished Surfaces**

Where the finish is not indicated or specified, the type of finish shall be that type which is most suitable for the surface to which it applies and shall be consistent with the class of fit required.

Surfaces to be machine-finished shall be indicated on the shop drawings by symbols. Compliance with the specified surface shall be determined by the sense of feel and by visual inspection of the work compared to applicable “Standard Roughness Specimens”. Or with roughness feeler gauge instruments. Both “Standard Roughness Specimens” and feeler gauge instruments shall be procured by the Tenderer at the request of the Engineer.

* + 1. **Unfinished Surfaces**

As far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined to secure proper alignment.

Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts shall be filled in a manner approved by the Engineer.

* + 1. **Protection of Machined Surfaces**

Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces or large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other approved means.

* + 1. **Roundings, Chamfers, Edges**

The edges of surfaces to be painted shall be rounded (minimum radius 2 mm) or chamfered accordingly. This requirement must be stated in all shop drawings for the relevant parts.

* 1. **Welding and Heat Treatment**
     1. **General**

All welds shall be as shown in the detailed drawings and shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum.

The Tenderer shall submit with his Tender adequate information concerning the proposed:

* Extent to which automatic welding techniques will be applied
* Extent to which manual welding techniques will be applied
* Extent to which it is the Tenderer’s intention to use pre-weld heat treatment, post-weld stress relieving, full anneal stress relieving or normalizing consistent with the thicknesses and types of material proposed.
* Weld electrodes, welding wire and flux which will be used with the selected plate material or materials.
* Standard tolerances for the deviations of mating weld profiles.

* + 1. **Welding**

Pieces to be joined by welding shall be cut accurately to size including the required allowances. According to the proposed welding method, the welding edges shall be sheared, flame-cut or machined to allow through penetration and fusion of the weld with the base material.

The cut surfaces shall be free of all visible defects, such as laminations, surface defects caused by shearing or flame-cutting operations. The edges and surfaces to be welded shall be free of rust, mill scale, grease, oil, paint or any other foreign matter. Welding over zinc primers shall be permitted subject to submission of a certificate of a recognized institution stating the pertinent limiting parameters for this welding procedure. In all other cases, welding over paint shall be prohibited; all painting materials next to the joint to be welded shall be removed well beyond the heat-affected zone.

Design, preparation, performance and testing of welded constructions shall suit the kind of stresses and the grade of risk, considering a supposed failure of the welded member.

The following table shows a general classification by means of numbers with the signification of each number explained thereafter.

Any structure not especially mentioned shall be classified by the Tenderer and shall be subject to approval by the Engineer.

STRESS

|  |  |  |  |
| --- | --- | --- | --- |
|  | Compression | Bending,Tension >0,9 allowable stress | Alternating, Dynamic |
| **Small risk** |  |  |  |
| Stairs, rails, doors, pipe supports, cable trays | 0 | 0 | 1 |
| **Medium risks** |  |  |  |
| Cranes, roof trusses, bridges. Switchyard supporting structures and towers | 4 | 1, 4 | 4, 7 |
| **High risk** |  |  |  |
| Pressure pipes  Turbine | 1, 4, 7 | 1, 2,4 | 1, 2, 4 |

**Significations**

0 = Without special prescriptions. Only skilled welders shall be employed which follow proven rules of workmanship.

1 = Full penetration welds. The weld preparation shall allow the filling of the weld profile without defects. The root of double welded butt joints shall be ground before welding the second side. If the second side is inaccessible for welding. Such single welded butt joints shall be built up against a backing strip.

2 = Weld ground flush. The weld shall be ground on both sides of the steel plate. The weld surface shall be finished so as not to reduce the plate thickness by more than 3%. Butt welds with a smooth surface and a chamber of less than 8% of the width of the top layer need not be ground.

3 = connections rounded. Where stresses are to be deviated, already the design shall care for a reduced notch effect. Welds shall be smoothly ground and rounded.

4 = Welder qualification test. All welders and welding operators shall have passed qualification tests in accordance with IS 1181 and IS 817 or the respective National Standard or rules of AWS – American Welding Society.

5 = Welding procedure test. The Tenderer shall be describe the proposed welding procedure. Further he shall prove with tests, that the properties of the weld and transition zone are at least equal to those specified for the base material.

The welding procedure test may be combined with the welder’s qualifications test.

6 = Welding performance test, executed during fabrication at site welding. Run-off plates shall be tack-welded to one end of the plate under work. The weld shall continue on the run-off plate (test plate), welded in the same manner and under normal working conditions.

One test plate is required every 20 m of weld seam, but at least one of each weld type.

The laboratory tests shall cover the same range as the welding procedure tests.

On request by the Engineer test plates shall be welded in his presence.

7 = Ultrasonic and/or radiographic test. Depending on the location of the weld seams and the plate thickness, ultrasonic and/or radiographic tests shall be performed. The Tenderer shall submit a proposal subject to approval by the Engineer. If not stated different in the detailed Technical Specifications, 20% of the weld length shall be radiographed, but at least one film per weld type. The Tenderer shall be recording the results of the ultrasonic and /or radiographic testing in these reports and drawings.

8 = Marked with welder’s stamp. The welder shall mark every seam welded by him with his number, so it can be recognized until the end of the fabrication period.

* + 1. **Welding Qualifications**

For welding of principal stress carrying parts, the standard of welding procedures, welders and welding operators shall conform to relevant Indian Standard or Standards equivalent to the requirements of the ASME Boiler and Pressure Vessel Code. For welding of less important parts, the standards and qualifications shall conform either to the relevant Indian Standard. All welders and welding operators assigned to the work shall have passed a performance qualification test. If more than one year has elapsed since the welder or welding operator passed his last test, then he shall again be tested.

Welders’ and welding operators’ test certificates shall be submitted to the Engineer.

* + 1. **Welding Work**

The standard of welding works shall be in accordance with relevant Indian Standard ciety). In addition, the Tenderer shall follow the statements regarding welding in the latest revisions of relevant of Indian Standard. All welding (except welding of thin plates or piping of small sizes) shall be performed by the electric – arc method and where practical, with process controlled automatic machines.

For any welding work, only the appropriate rod, either arc or gas, shall be used. The properties shall conform to the material to be welded as specified in the respective standards.

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 with each container. Electrodes for manual welding shall preferably be of the heavily coated-type and shall be suitable for welding in any positions.

Tacks shall be removed before welding.

Electrodes shall be dried in electric ovens before use.

After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather-edges without overlap, and no porosity and clinker. Visual inspection of the ends of welds shall indicate good fusion with the base metal.

Where weld metal is deposited in successive layers, each layer shall be thoroughly preened before the next layer is applied.

Particular care shall be taken in aligning and separating the edges of the members to be joined by butt welding so that complete penetration and fusion at the bottom of the joint will be ensured.

All pinholes, cracks and other defects shall be repaired by chipping or grinding the defects to sound metal and re-welding. Where fillet welds are used, the members shall fit closely and shall be held together during welding.

The ignition of weld electrodes shall not be started at the plate beside the weld, but at the seam flanks to prevent detrimental increments of local hardness. Where ignition points of electrodes are discovered, they shall be ground appropriately.

Where auxiliary structural members are welded to components for the purpose of assembly or installation, these connecting welds shall be given particular care.

These auxiliary structural members hall be removed not by knocking them off, but by7 burning, followed by grinding the affected areas flush with the plate, without producing additional thermal stresses.

* 1. **Preheating**

Welding of mild steel shall not be undertaken when the plate temperature is 0 deg. C or below.

Mild steel plates conforming to IS 226 and thicker than 20 mm and plates conforming to IS 2062 and thicker than 25 mm may require preheating of the parent plate prior to welding. In welding materials or uneven thickness the thicker part shall be taken for this purpose.

Base metal shall be preheated as required to the temperature given in table below prior to welding or tack welding. When base metal not otherwise required to be preheated is at a temperature below 0 deg. C it shall be preheated to at least 20 deg. C prior to tack welding or welding. Preheat shall bring the surface of the base metal to the specified preheat temperature and this temperature shall be maintained as minimum interpass temperature while welding is in progress.

Min. Preheat and Interpass Temperature for Welding

Thickness of thickest part Other than low hydrogen Low hydrogen welding

at point of welding welding electrode IS 226 electro or sub-merges arc

Steel or IS 2062 welding IS 226 steel or

IS 2062 steel

Upto 20 mm for incl. None None

IS 226 and upto 25 mm

incl. for IS 2062

Over 20 mm for IS 226 and 100 Deg. C 20 Deg. C

over 25 mm for IS 1062

upto 40 mm incl.

Over 40 mm to 63 mm 120 Deg. C 100 Deg. C

included.

Preheating may be applied by external flame heating equipment by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance of four times the thickness of the plate on either side of the joint is obtained.

Thermo-chalk or other approved methods shall be used for measuring the plate temperature.

All butt welds with plates thicker than 50 mm and all tension members with plates thicker than 50 mm shall require post weld heat treatment of entire assembly.

* + 1. **Heat Treatment**

All weld-fabricated parts and castings except minor parts, parts where stress is not important or parts, which are not specifically exempted from stress relieving, shall be designed, fabricated, stress relieved and inspected in accordance with an approved “Boiler and Pressure Vessel Code”. All such parts shall be stress relieved as a unit prior to final machining.

Heat treatment of welding-joints to be made in the field shall be performed according to the specifications for the welding procedure for the corresponding parts, which shall be submitted to the Engineer for approval.

* + 1. **Quality and Procedure Control**

Quality control methods, e.g. radiography, ultrasonic crack detection, etc., shall be done in accordance with the appropriate manufacturing code. However, the Tenderer shall indicate clearly along with the tender the extent to which these methods shall be used.

Additional non-destructive controls can be required when it is desired to examine the acceptability of any welds when, in the opinion of the Engineer, serious doubt exists as to their quality; in this case, the expense of this examination shall be borne by the Tenderer.

When required in the Particular Technical Specifications, the detailed description of welding procedure (including type of welding electrodes, sequence of welding seams, etc.) for certain parts of the delivery shall be submitted to the Engineer before commencement of manufacture.

* + 1. **Inspection of Welds**

**3.11.3.1Visual Inspection**

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawings. It may be slightly over sized but should not be under sized. The profile of weld is effected by the position of the joint but it should be uniform. In case of butt and corner welds, the profile shall be convex. The welds should have regular height and width of beads. The height and spacing of ripples shall be uniform. The joints in the weld run where it has been recommended shall as far as possible be smooth and should not show any humps of crater in the weld surface. Weld shall be free from crater on the surface, under-cuts, slags on the surface and visible cracks. Such inspection shall be done after cleaning the weld surface with steel wire brushes and chisel to remove the sputter metal, scales, slag, etc. If external defects mentioned above are noticed the work shall be dismantled and redone duly replacing the defective materials including basic members.

* + 1. **Rectification of Defective Welding Work**

Wherever defects like improper penetration, extensive presence of blow holes, undercuts cracking, slag inclusion, etc. are noticed by visual inspection/other tests, the welds in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary and re-welded. The gouging shall be as far as possible done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Purchaser.

* + 1. **Acceptance of Welded Structures**

The acceptance of the weld shall depend upon correct dimensions and alignment, absence of distortions in the structure, satisfactory results from the examination and testing of the joints and the test specimens as per IS, soundness of the welds and upon general workmanship being good.

Random D.P. test shall be conducted after welding on auxiliary structures.

* 1. **Corrosion Protection**
     1. **Scope of Work**

The Tenderer’s services shall cover the procurement of all materials, and the preparation and application of the paining and other protective coats as specified; all costs shall be included in the Tender Price.

* + 1. **Painting Materials**

The Tenderer shall provide a complete, reliable coating system. Coating materials shall be standard products of a paint manufacturer with proven experience in the field of corrosion of the type of plant to be supplied.

The Tenderer shall submit for the Engineer’s approval full details of the preparations, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the structures, machinery and plant.

With regard to materials, the Tenderer shall submit full details including the source of the basic raw materials, volatile matter content, nature of solvent, number of components, type of coat, coverage, time interval between coats and number of coats, compatibility of each coat with the previous coat, toxic properties, physical properties, shelf life, resistance against chemical attack, resistance against ozone and UV-radiations, compatibility with drinking water standards, etc.

He shall describe in detail the treatment he proposes to apply in order to give adequate protection during transport, site storage, building and concreting and subsequent erection.

The different coats of primer and subsequent coats shall be each of different shades of colour where practicable.

The Tenderer shall submit to the Engineer for approval an overall colour scheme in accordance with the “Colour Code” for the finished surfaces of all plant. All final coats shall be in the colours approved by the Engineer. On request of the Engineer, painting samples for the different coats and colours shall be provided.

All pigment, paints and primers shall be delivered to Site in sealed containers packed by the manufacturer. The manufacturer’s instructions for preparation and application of all painting and protective coats shall be strictly observed.

* + 1. **Painting Systems**

Annex 1 “Painting Schedule”, indicates painting materials considered suitable for the various parts of the work.

The Tenderer shall state in his offer the manufacturer and identification of the product which he proposes as an equivalent.

* + 1. **Surface Preparation**

The term “preparation”, as used below, includes any cleaning, smoothing or similar operations that shall be required to ensure that the material to be painted attains suitable conditions.

To be ready for painting, a surface should be clean, dry and sound. The surface to be coated shall be free from any deleterious material liable to impair good paint adhesion or attack the coat.

For removing rust and mill scale on structural steel, piping and other steel surfaces, those parts suitable for sandblasting shall be sandblasted to a grade specified or required in accordance with relevant Indian Standard or SIS 05.59.90 (Sveriges Standdardiserings Kommission) or the American’s SSPC-SP standard. This applies particularly to parts which will be in contact with water, exposed to heavy condensation and humidity or subjected to high temperature.

For health reasons, sandblasting with quartz sand shall be avoided.

All parts of the plant shall be sandblasted at the shop unless otherwise specified or approved by the Engineer. The sandblasted surfaces shall receive a shop coat with a quick-dying pigmented 2-pack zinc-rich primer, unless otherwise specified.

Parts which cannot be sandblasted shall be cleaned of rust by power tool cleaning to the highest degree possible.

Hand or power tool cleaned parts of minor importance and not exposed to water or humidity may be coated with a quick-drying rust-proof primer formulated on a combination of synthetic resin (ready-mixed paint).

* + 1. **Execution of Painting**

The Tenderer shall supply full details regarding the extent to which the sandblasting and subsequent painting shall be performed in his workshop, on the Site or in site after installation. A properly equipped paint shop shall be set up at the Site with a crew of specialists experienced and skilled in the preparation and application of protective coatings, to deal with all site protective treatment.

Unless otherwise specified under the present Specifications, painting shall be done in accordance with relevant Indian Standards or DIN 55928 “Protective Coatings for Steel Structures” or other equivalent standard approved by the Engineer.

Painting operations shall only be made in dry weather and shall be interrupted in case of rain, fog or condensation. Painting shall not be carried out at temperatures below 5 degrees Celsius or at temperatures (air or surface) above 50 degrees Celsius and humidities above 80%. During the entire erection period the Tenderer shall make available two sets of thermometers and humidity gauges.

Painting works shall only proceed when the prevailing temperature is 3 degrees Celsius minimum above dew-point.

Each coat shall be free from pores, runs, pinholes, and sags. Each coat shall be allowed to dry or to harden before the succeeding coat is applied. Where pore-free coats are specified, it shall be compulsory for the Tenderer to prove this quality with adequate instruments.

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

The first coat shall be applied (manual application by brush) immediately after sandblasting and shall be finished within six hours to avoid new corrosion.

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

Oil and grease shall be removed before mechanical cleaning is started. Clean cloths and clean fluids shall be used to avoid leaving a film of greasy residue on the surfaces being cleaned. Any required wash treatment shall be done in accordance with the manufacturer’s painting instructions.

The Tenderer shall consider that damage to paint-work during shipment, storage and erection is practically unavoidable and the application of all protective treatment should be programmed accordingly. It is essential that before any coat of paint is applied, the surface shall be prepared as described above so that it is clean and free from all deleterious matter and completely dry.

Temporary or permanent welding shall not be permitted on areas where the welding will damage paint or other protective coatings, unless the areas of coatings which would be damaged thereby are accessible for repairing and inspection. Material which has been painting shall be handled with care and protected as necessary to preserve the coating in good conditions.

* + 1. **Quality Control**

The first and each successive coat shall not be applied without inspection and approval by the Engineer.

The minimum dry-film thickness prescribed in these Specifications shall be observed. Of each 100 m2, one area of 10 m2 will be measured for dry-film thickness. No measured thickness shall be less than the specified thickness.

Where the minimum thickness is not achieved, the coat shall be repaired to reach the specified minimum dry-film thickness.

The dry-film thickness shall be measured by approved gauges;

For checks on porosity, the Tenderer shall furnish a DC variable high tension test instrument with built-in pore counter. The test voltage shall not exceed 2000 V. The tests shall not be performed within 0.5 m distance from uncovered, corrosion resistance surfaces.

Upon completion of each coat, the painter shall make a detailed inspection of the painting finish and shall remove from adjoining work all spattering of paint material. He shall make good all damage that can be caused by such cleaning operations.

A detailed inspection of all painting work shall likewise be made, and all abraded, stained, or otherwise disfigured portions shall be touched up satisfactorily or refinished as required to produce a first-class job throughout and to leave the entire work in a clean an acceptable condition.

* + 1. **Galvanizing**

Unless otherwise specified, all structural steel including ladders, platforms, hand rails and the like and all exterior and interior steel surfaces of outdoor plant, as well as bolts and nuts associated with galvanized parts shall be hot-dip galvanized, electrolytically galvanized or sheradized, as may be appropriate to the particular case.

Galvanizing shall be performed in accordance with IS : 728 or other relevant Indian Standard. Material for galvanizing: Only original blast – furnace raw zinc shall be applied, which shall have a purity of 98.5%.

The thickness of the zinc coat shall be:

* For bolts and nuts, approx. 60 micrometer
* For all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 70 micrometers.
* Switchyard supporting structures and towers, approx 80 micrometers
* For hydraulic steel structures or parts intermittently or permanently submerged in water, approx 140 micrometer.
* Cleaning: All material to be galvanized shall be cleaned carefully of rust, loose scale, dirt, oil, grease, and other foreign matters. Particular care shall be taken to clean slag from welded areas.

Galvanizing of plates and shapes: Where pieces are of such lengths that they cannot be dipped in one operation, great care shall be exercised to prevent warping.

Finished compression members of steel structures shall not have lateral variations greater than one-thousandth of the axial length between the points which are to be supported laterally. Finished tension members shall not have lateral variations exceeding 3 mm for each 1.50 m of length. Materials with sharp kinks or bends shall be rejected. All holes in material shall be free of excess spelter after galvanizing.

Galvanizing of hardware: Bolts, nuts, washers, lock-nuts and similar hardware shall be galvanized in accordance with the relevant standards. Excess spelter shall be removed by centrifugal spinning.

Straightening after galvanizing: All plates and shapes which have been warped by the galvanizing process shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. Materials that have been harmfully bent or warped in the process of fabrication or galvanizing shall be rejected.

Repair of galvanizing: Material on which galvanizing has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanizing repair compound; in this case, the compound shall be applied in accordance with the manufacturer’s instructions.

Soldering shall be done with a soldering iron using 50/50% solder (tin and lead). Surplus flux or acid shall be washed off promptly and the work shall be performed so as not to damage the adjacent coating or the metal itself. Any member on which the galvanized coating becomes damaged after having been dipped twice shall be rejected.

* 1. **Metal Work, Floor Load**
     1. **Embedded Metal Work**

The Tenderer shall supply and install all anchors, fasteners, embedded metal work, piping, and sleeves associated with and required for the equipment to be installed under this Contract, except if otherwise mentioned in the Specifications.

As far as practicable, the supports shall be of consistent design throughout and preferably of an approved proprietary type.

Attachments to concrete shall wherever practicable be by means of embedded inserts of an approved proprietary type.

The Tenderer shall show the location and full details of all embedded components on his drawings and shall be responsible for the completeness and accuracy of his drawings and the information supplied to others. The Tenderer shall be responsible for the adequacy and accuracy of the location of al embedded components supplied by him whether installed by himself or by others.

All adjustments to foundation levels, embedment, bedding and grouting of plant on foundations and cementing into walls and floors will be carried out by the Civil Tenderer, but al leveling and adjusting of plant on foundations shall be carried out by the Tenderer.

The grouting will be carried out by the Civil Tenderer under the supervision of the Tenderer and the mix and grouting pressure shall be approved by the Tenderer. The Tenderer shall satisfy himself that the grouting has been carried out to his entire satisfaction.

Any steel work which is to be built into the concrete foundations shall not be painted or coated unless otherwise approved or specified.

* + 1. **Miscellaneous Metalwork**

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Tenderer shall supply the following:

All platforms, ladders, guards and handrails necessary for an easy and safe access to plant supplied under the Contract. Handrails shall be of tubular steel construction except that the top rail shall be of flat bar, fitted with a formed plastic covering.

The use of ladders shall be kept to a practicable minimum. Where ladders are approved for use they shall be of steel, have an inclination of 70° to the horizontal and a minimum width of 450 mm.

Safety guards at each point where normal access provision would permit personnel to come within reach of any moving equipment to be provide under the Contract.

All covers for pipe and cable trenches, required for completing the floors around and over plant supplied under the Contract will be supplied and installed by the Civil Tenderer. Unless otherwise approved, floor plates shall be of an angular pattern.

Covers and curbing for dismantling hatches in main floors will be provided by the Civil Tenderer.

**4 MECHANICAL PLANT**

**4.1 General**

All mechanical plant and steel structure of any mechanical or electrical installation shall comply with this General Technical Specification and the requirements of the Particular Technical Specification.

All plant shall be of an approved, reliable design providing the highest possible degree of uniformity and interchangeability.

The design and arrangement of plant and installation shall facilitate erection, test, operation and maintenance.

All plant shall be pre-assembled in the manufacturer’s premises to an utmost extent.

Revolving parts shall be truly balanced both statically and dynamically that when running at normal speed and at any load p to the maximum, there will be no vibration due to lack of such balance.

**4.2 Bolts, Screws, Nuts, etc.**

All bolts, studs, screws, nuts, and washers shall be to the ISO metric system except other standards will be considered for specific applications. The extent to which other standards are proposed shall be indicated by the Tenderer. Bolts and nuts shall be hexagonal headed. Sizes smaller than 4 mm shall be used only for instrument and relay internal connections.

Where mild steel bolts and nuts are used, they shall be of the precision cold forged washer faced type if commercially available in the size required. Alternatively, approved hot forged bolts and nuts, machined so that the undersides of bolt head and nut are faced and parallel to one another when assembled, may be used. In the latter case, a suitable fillet shall be machined between the bolt head and shank. All parts other than structural steel work, bolted together, shall be spot faced on the back to ensure that nuts and bolt heads bed down satisfactorily. Bolts machined from bar stock shall not be used without approval of the Engineer. All bolting material shall be adequately treated against corrosion before dispatch from the workshop. Mild steel nuts and bolts shall be zinc or cadmium plated.

All bolts or studs which will be subject to high stress and / or temperature shall be of approved high tensile material with nuts of approved material. All bolts and studs larger than 60 mm in diameter which are not accessible for tightening and un-tightening by commercially available pneumatic impact wrenches shall be drilled for heaters.

Washers shall be provided under bold heads and nuts unless otherwise approved by the Engineer. All ferrous nuts and bolts on plant items where dismantling may be required during the life of the plant shall have their threads coated with an approved anti-seize compound. When in position, all bolts or studs shall project through the corresponding nuts by at least one thread, but this projection shall not exceed three threads, unless more length is required for adjustment. All nuts and set screws shall be securely fastened, to prevent loosening due to vibrations, using spring washers, lock nuts, split pins, self-locking inserts or ‘Loctite’ as appropriate for the purpose and material used.

The Tenderer shall supply the net quantities plus 5 percent of all permanent bolts, screws and other similar items and materials required for installation at the Site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the plant has been completed shall become spare parts and shall be wrapped, marked and handed over to the Purchaser.

* 1. **Drives and Gears**

All moving parts of machinery including shafts, couplings, collars, projecting key heads, gear wheels, rope/belt-drives shall be completely guarded to provide full protection. All set screws on revolving shafts shall be countersunk or suitably protected. The guards shall be of approved design and shall be fitted, where necessary, with inspection doors / openings. All guards shall be arranged so that they can be removed without disturbing the parts of the gears and plant which they protect.

Gears shall be designed so that all stresses are within allowable limits when the maximum loads are being handled. All gears shall be designed and calculated in accordance with relevant Indian standard or equivalent international standards, or widely-approved methods and to the individual experience of the manufacturer. On request of the Engineer, the manufacturer shall submit the calculation of the gears.

Where worm gears are used as a direct drive, they shall have the same load and time rating as the motors driving them. The gears shall work in oil and the temperature rise of the oil bath shall not exceed 40°C - 50°C under normal working conditions at site. The materials of the mating faces of worm wheel and worm shall be of a bronze/steel alloy.

Where practicable gear wheels shall be forced fit on the shaft and in additional, shall be keyed adequately to prevent any relative motion between the wheel and shaft. Where gears and couplings are secured in position by means of keys, they shall be easily accessible for tightening or removal. All keyways shall be machine cut. Couplings and collars shall be the shrouded or protected-type, free from projections of any kind.

All bearings shall be mounted in dustproof housings. Base of bearing supports shall be machined, and shall rest on machined-surfaces.

* 1. **Lubrication, Lubricants, Fuel**

Efficient means of lubrication, suitable for use under Site conditions, shall be provided for all moving parts.

Self-lubricating types of bearings shall be given preference, unless otherwise specified or practicable.

The contamination of the air, water and soil by lubricants and fuel shall by all means be avoided by applying of an appropriate design and layout of the plant in conforming to the latest recognized standards for modern engineering practice.

The number of different lubricants oils, oils for pressure systems, etc., used in the items of plant throughout the plant shall be limited to a minimum in order to facilitate keeping stocks and maintenance.

The Purchaser reserves the right to request the different Tenderers to use certain types of lubricants, oil, etc. The Tenderer shall not be entitled to claim extra payment for this request. All different types of oil, lubrications, etc., shall be stated in the Tender and are subject to the written approval of the Engineer.

Unless otherwise stated in the Particular Technical Specifications, the necessary oild or grease fillings required up to the completion of Test Service Period, for bearings, pressure oil system, transformers, etc., including the necessary quantity for flushing and for any oil change, shall be included in the Tender Price.

* 1. **Piping, Fittings, valves and Gates**
     1. **General**

Unless otherwise stated, all piping shall be designed for a *“nominal pressure”* PN 10. All piping shall be tested with 1.5 the design/nominal pressure. All required piping shall be furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports etc. Steel structures, walkways, platforms, stairs and ladders shall be provided to cross pipes with diameters of 600 mm and larger.

Welding as well as application of corrosion protection coats shall be done in the manufacturer’s shop as far as possible.

Flanged connections or joints shall be provided only as required for transport, installation or for reasons of dismantling for repair.

Metric – flanges shall be used throughout. Welded flanges shall be weld-neck or slip-on flanges. The raised face shall be machined.

If the piping crosses over joints of civil structures of different settlement, the piping shall be provided with flexible joints to allow for vertical, horizontal and angular deviations.

Piping installation shall be sloped to prevent trapping of air bubbles. Where ever required, suitable venting systems shall be provided.

Adequate clearance shall be given to parallel pipes to allow for easy maintenance without disturbing other lines. All overhead piping shall have a minimum clearance of 2.00 m from operating floors and platforms.

* + 1. **Piping, Fittings**

Steel pipes of a diameter less than100 mm shall be mild steel. Steel pipes larger than 100 mm in diameter shall be made of mild steel, unless otherwise specified in the Particular Technical Specifications. Pipe connections embedded in concrete shall be welded. Other pipe connections shall be flanged. The flange material shall be in conformance with the pipe material. The Tenderer shall select the location of the weld meters as to ensure sufficient access for adequate touch-up treatment for corrosion protection.

Stress calculations of steel pipes shall be in accordance with relevant Indian standards / International Standards. “In no case, the superimposed stress of bending, tension, compression, etc., calculated to the shape variation hypothesis, shall exceed 0.7 of the yield point at maximum applied load at any point of the piping.

The maximum applied load shall take into account test pressure, water-hammer pressure waves, thermal forces, dead weight, etc. calculation on pipes stresses has to be submitted by the Tenderer. The calculation will be subject to the Engineer’s approval.

The minimum steel pipe wall thickness shall be the “normal” or “standard” wall thickness as stated in the applicable standards.

Bends shall preferably be of required standards. Mitered bends shall be allowed for larger sizes subject to the Engineer’s approval. For smaller fittings ductile iron will be permitted too.

Fittings of the cutting-ring type are only acceptable for pipe diameters smaller than 12 mm.

* + 1. **Valves**

Small valves and gates shall conform to relevant Indian standards. Generally, valves shall be leak-proof in either flow direction (except for non-return valves) when the nominal pressure is applied.

All valves with design pressure higher than PN 10 *(nominal pressure)* and diameters larger than DN 100 *(nominal diameter)* shall be workshop-tested to relevant Indian standards for tightness and soundness of materials.

The change of the disc seals of butterfly valves shall be possible without dismantling of disc and body.

Valves shall close clockwise and be provided with position indicators. The drive units of motor-driven valves shall also be provided with hand-wheels for manual operation. The hand wheel shall be operable under all conditions and shall be independent of the motor drive. Further, it shall not be rigidly coupled to the motor drive and shall not compulsory turn when the motor is energized.

To facilitate operation, large valves and gates shall be provided with by-pass lines for pressure balancing, if required.

Valves spindles and pins shall be of stainless steel, spindle nuts and bushes of bronze, the body at least of improved cast iron.

Valves for water over 50mm bore shall be of external rising spindle type. Valves for oil shall be of non-rising type.

All pressure reduction valves, safety valves and similar components shall be workshop-tested and provided with a relevant as per Indian / International Standards.

All valves shall be readily accessible for both operation and maintenance, and where necessary for ease of operation the spindle shall be extended and an approved form of pedestal wheel shall be provided at a safe and convenient operating floor level.

All the valves shall be provided with means for padlocking. Exceptions shall be to the approval of the Engineer.

* + 1. **Oil Piping**

Piping of a diameter less than 50 mm shall be of non-corrosive material. Pipes larger than 50mm in diameter shall be made of seamless steel, unless otherwise specified in the Particular Technical Specifications, Oil pipes shall be as far as possible be prefabricated in the Tenderer’s workshop. They shall be welded except at terminal point and as necessary for erection and future dismantling. The Tenderer shall select the location of the weldments as to ensure sufficient access for adequate touch-up treatment for corrosion protection.

All piping shall be hydrostatically tested at a pressure 1.5 times of the maximum working pressure. The entire pipe arrangement shall be subjected to the pressure test after complete assembly at the site.

Oil pipes shall not be embedded in concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete.

All oil piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues.

This treatment shall be applied to workshop and site manufactured piping respectively.

The piping can either be treated in an acid-bath or being completely filled with acid. The duration of the treatment shall be approx. 6 hours. After that the piping shall be neutralized, flushed and corrosion protected for final installation.

* 1. **Mechanical Instruments**

All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water, etc.

Pressure gauges shall be provided with a damping liquid, e.g., glycerin, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer.

* 1. **Pressure Oil Systems**

Pressure tanks shall be designed, fabricated and tested in accordance with approved standards. The appropriate inspection certificates shall be furnished. If the pressure is held by compressed air or gas, then the requirements outlined in “Compressed Air Systems” of these General Technical Specifications shall also be applicable.

Oil sump tanks shall be provided with:

* Suitable access openings
* Fine mesh strainer combined with a magnetic filter through which all oil returning from the servomotors shall pass. The strainer shall be readily removable for cleaning.
* Dehumidifying air filter
* Flush-mounted oil-level indicator
* Filling connection with a suitable strainer
* Drain connection with hand operated shut-off valve.

Sump tanks shall be installed so that the bottom of the tank and the drain connection are at least 40 cm above the floor. The bottom of the tank shall be inclined in the direction f the drainage. The pumps shall be removable without the necessity of emptying the tank.

Servomotors shall be provided with suitable connections for pressure gauges on the pressure and suction sides of the piston. Servomotor piston rods shall be provided with a hard chromium layer of approximately 0.04 mm thickness. A suitable protection for the piston rod seal shall be provided.

* 1. **Compressed Air Systems**

The provisions for safety of the entire compressed air system shall conform to internationally accepted standards. The standards proposed by the Tenderer will in any case be subject to approval of the Engineer.

Vessels shall be of the cylindrical, vertical type and shall be mounted on a structural steel base. The inner surfaces of the vessels shall be protected with an appropriate paint coating. Each vessel shall be equipped with the following devices:

* 2 inlet sockets with valves
* 2 outlet sockets with vales
* 2 pressure safety valves
* 2 dial pressure gauges, one of the gauges with 3 electrical contacts
* 1 manhole or inspection hole
* 1 drain vale.

In case the pressure vessel is used for pressurized oil or water systems, the vessel shall further be equipped with:

* 1 transparent level gauge with shut-off vales at both ends
* Level indicators with electrical contacts in a number as required or specified.

Compressors shall be provided with:

* Automatic lubrication
* Air-intake filter and silencer
* Thermometer for measuring temperature of the compressed air
* Automatic shut-down if the discharge air temperature exceeds a predetermined, adjustable value
* Discharging vales
* Water drain valves
* Water/oil separator
* Pressure safety valve
* Compressed air cooler
* Non-return valve
* Inlet pressure valve
* Outlet pressure valve
* Automatic moisture trap

The water / oil separator shall be equipped with an automatic solenoid-operated drain valve to achieve automatic draining during standstill. The compressor stages shall be equipped with discharge valves, which shall close time delayed after start to avoid compressor start against full pressure.

The compressor shall be delivered as package units on common frame with the appropriately sized A.C. squirrel cage motor and the respective motor starter panels, ready for operation.

Each vessel shall pass a pressure test at 1.5 x nominal pressure for 8 hours in the manufacturer’s workshop before coating is applied.

If requested by the Engineer, each compressor shall pass a performance test in the manufacturer’s workshop as per relevant Indian standard or any relevant standard without extra cost. The readily assembled compressors, controls, and switchgear shall be subjected to functional tests.

Each vessel shall be furnished with a test certificate of an independent, reputable underwriters’ society.

* 1. **Pumps (Water)**

Non-submersible pumps and motors shall be mounted on common frames

Material of the pumps shall be:

* Casing C.I.
* Impeller bronze / cast stainless steel
* Shaft stainless steel
* Sleeves stainless steel / bronze
* Wear rings bronze / wear resistant stainless steel
* Keys stainless steel

The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits.

Shafts sealed by packing glands shall be fitted with sleeves. Seals shall be exchangeable without extensive disassembly of the pump. Leakage water shall be directed to suitable drainage facilities.

Each pump shall be fitted with:

* Check valve at the discharge side
* Air and drain valve
* Pressure gauges to indicate delivery and suction side pressure

The size of the pump motor shall be 15% higher than the maximum power required by the pump at any operation point.

For submersible pumps, pump and motor shall be contained in the same casing and designed as a package unit with incorporated suction strainer and check-valve.

All submersible pumps shall be provided with quick connectors, guide rails, lifting chains etc. for easy removal in maintenance works.

The impeller shall be of bronze / cast stainless steel, and the material for the other parts as specified for the non-submersible pumps above. For dirty water pumps, the water passages of corrosive material shall be rubbed-lined.

The motors of submersible pumps operating in potable water shall not be filled with oil or other media detrimental to potable water. Motors of submersible pumps operating in dirty water may be filled with oil.

Dirty water submersible sump pumps with the motors mounted on top of the pump shall be suitable for running dry continuously, without damage to seals, bearings, or motors.

For all other items, the requirements described for non-submersible pumps shall apply.

For any pump, the overall pump-motor efficiency for the specified rated head and discharge shall not be less than 60%.

1. **ELECTRICAL PLANT**
   1. **General**

The electrical items of plant of any electrical or mechanical installation to be provided under this Contract according to the Particular Technical Specifications shall – if not stated otherwise therein - fulfils the requirements of this Section.

All components shall be of an approved and reliable design. The higher extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The plant shall be pre-assembled to the highest possible extent in the Tenderer’s or Sub-Tenderer’s workshop, complete with all devices and wired up to common terminal blocks.

The power supply and control able shall be laid up to these common terminal blocks. The required control and protection devices, instruments, etc., within the different scopes of work shall be supplied and connected by the relevant Tenderer.

Unless otherwise agreed, ratings of main electrical plant (infeeds, bus-ties) as selected or proposed by the Tenderer, whether originally specified or not, shall generally include a safety margin of 10% under consideration of the worst case to be met in service. Prior to approval of such basic characteristics, the Tenderer shall submit all relevant information such as consumer lists, short circuit calculations, derating factors, etc.

Short-circuit calculations shall be evaluated giving full evidence that every electrical component can withstand the maximum stresses under fault conditions, for fault levels and durations obtained under the worst conditions, e.g. upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device.

All plant shall be suitable for the prevailing climatic conditions.

* 1. **Standards**

The design, manufacture and testing of all plant and installations shall strictly comply with the latest edition of the relevant IEC publications & Bureau of Indian Standard.

* 1. **Colour Code**

The colour code for electrical plant shall be as described as per relevant standards.

* 1. **Electric Motors**
     1. **General**

All motors shall be of approved manufacture and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply, as far as applicable IS / IEC Standard motor dimensions.

The general construction shall be stiff and rigid, no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eye bolts as suitable

AC motors shall have squirrel cage type rotors.

* + 1. **Rating**

The rating of the motors shall be adequate to meet the requirements of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

Power Demand of Driven Machine Service Factor

Up to 5 kW 1.2

More than 5 kW 1.1

AC motors shall be capable of operating continuously under rated output conditions at any frequency between 97% and 103% of the rated frequency and / or with any voltage variation between 85% and 110% of the nominal voltage.

D.C. motors shall be capable of operating continuously under rated output conditions at any voltage between 85% and 110% of the nominal voltage with a fixed brush setting for all loads. Unless otherwise approved, the speed drop between no-lad and full-load shall not exceed 10% of non-load speed.

* + 1. **Starting**

AC motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite busbar at 110% of the nominal voltage with an inherent resident voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary busbars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

* + 1. **Windings and Insulation Class**

The insulation of all motors shall be of class F but maintain in operation the temperature limits of class B.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hydroscopic. The stator winding shall withstand the maximum fault current for the period determined by the protective devices.

The rotor winding shall be designed to give trouble-free continuous service including repeated direct-on-line starting. The rotor shall be subjected to a 120% over-speed test for 2 minutes without showing any winding dislocation.

* + 1. **Ventilation and Type of Enclosure**

All motors shall be of the totally enclosed fan-cooled type, protection class IP 44, outdoor IP 55, according to IEC 144 & IS 4691.

They shall have a closed internal cooling air circuit recooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weather proof design shall be chosen. A hole shall be provided at the lowest point of the casing for draining condensed moisture. Motors of size 132 and above according to IEC shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during stand still periods. Such AC heater shall be suitably fixed inside the motor casing, the leads shall be led to a separate LV terminal box and shall be controlled by thermostat.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc.

* + 1. **Bearings**

As far as applicable, self-lubricating ball and roller bearings with solid races shall be provided for all motors; vertical motor shall have approved thrust bearings. All motors with ratings of about 1kW and about shall be equipped with lubricators permitting greasing while the motor is running and preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun.

Where sleeve bearings are being used, they shall be of the self or forced lubricating type. If forced lubrication is required, it shall be arranged common to both the motor and the driven machine and provisions shall be made to ensure lubrication during start-up and shut-down operations without the necessity to start an auxiliary lube oil pump. Self-lubricated bearings shall be equipped with an easily accessible oil reservoir with overflow pipe and oil collecting vessel.

All bearings shall be easily controllable during operation or stand-still without dismantling the bearings. The bearing shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

For the transport of motors equipped with ball or roller bearings, special bearing inserts shall be provided to prevent transport damage.

Service hour meters shall be installed if maintenance work such as regreasing, oil change etc. depends on the operation time of the motors.

* + 1. **Shafts and Couplings**

The motors shall be provided with a free shaft extension cylindrical shape with key and keyway according to IEC 72-1 and with the motorside-coupling which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

* + 1. **Terminal Boxes and Earthing**

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

Terminal boxes located indoor shall have a protection degree of at least IP 44, located outdoor IP 55, if not specified otherwise in the Particular Technical Specification.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

Terminal boxes shall permit the examination of the terminals without disturbing the cables or conduits.

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.

* + 1. **Measuring and Monitoring**

All motors (above 50 kW) shall be provided with slot temperature detection devices (resistance thermometers) embedded in each phase of the stator winding, the leads of which brought out of the motor terminal box.

Out of these measurements at least one max. temperature contact shall be derived either thermostatically or electronically giving alarm and / or trip the associated motor starter.

* + 1. **Noise Level and Vibrations**

Under all operating conditions the noise level of motors shall not exceed 85dB (A).

In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced.

Vibration displacements or velocity shall be measured in accordance with relevant Indian Standards or DIN 45 655 for motor sizes 80 to 315 according to IEC. The results for all motors shall be within the “R” (reduced) limits.

* + 1. **Tests**

Each motor shall be factory tested and shall undergo a test at Site. The following tests shall be performed under full responsibility of the Tenderer.

Routine Tests:

Tests shall be conducted as per relevant Indian Standards / International Standards.

Site Tests:

* Measurement of insulation resistance
* Measurement of polarization Index.
  1. **L V Switchgears, Cubicles and Panels**
     1. **General Design and Construction Features**

Electrical switchboards shall be constructed of braced rolled steel sections, with recessed panels, and supporting structures for mounting of power and control cables. All steel work shall be made of min. 1.5 mm thick sheet-steel.

To avoid wobbling of doors, rear or side covers, etc. they shall be adequately braced.

The cubicles shall be of robust and rigid construction, of the self-supporting floor mounted type. They shall be supplied complete with lifting lugs and eye bolts, with all required base frames, anchors, fixing materials etc.

Cubicles mounted in rooms with computer floors shall have their own supporting structures made of steel profiles, being fixed to the concrete floor.

Wherever the correct operation of instruments and relays makes it necessary, adequate vibration and shock-absorbers shall be installed.

All panels and cubicles shall be of standard dimensions, having a uniform appearance.

The switchgears shall be of the indoor, completely enclosed (protection class IP42), metal-clad type with fixed/plug in type switching devices as specified or shown on the drawings.

The construction shall be such that the various components of the switchgears are segregated electrically from each other; it shall be possible to gain access to the circuit-breaker and to the cable box chamber in any cubicle without having to take the busbars out of service. Hinged doors and bolted panels shall be provided.

The terminal blocks, relays and instruments shall be located so as to be safely accessible while the plant is in service. Suitable interlocks shall be provided for preventing access to live parts.

All instruments, relays, and control and selector switches, indicating lamps, push buttons and trip levers shall be flush-mounted and located at convenient heights on the front of the switchgear in a logical and clear manner. The layout of these panels is subject to the approval of the Engineer.

Cast resin insulators are permitted within individual cubicles but bushings entering or interconnecting different cubicles (for example busbars) shall be of absolute fire-resistant type (for example epoxy-resin).

The design of cubicles shall facilitate a possible extension at either end.

The cubicles shall have front access and – if not specified for erection at the wall – rear access for easy cable termination work and for maintenance and repair of the main and auxiliary equipment accommodated in the interior. Means shall be provided to limit the opening angle of doors to about minimum 100°.

Cubicles and panels shall be provided with interior lighting, controlled by door switches.

The cubicles shall be complete with all locks, cable and boxes, colour coded busbars, internal wiring, terminal blocks and accessories.

Busbars shall be suitably mounted in enclosed compartments running the full length of the distribution boards. Access to the busbars shall be possible only by removing bolted covers.

Opening the back or front door of any circuit-breaker cubicle shall not expose the busbars. Busbar connections laying outside the busbar compartment shall be insulated or eliminate hazardous accidental contact while working on other parts of the switchgear. Means shall be provided or expansion and contraction of the busbars resulting from temperature variations.

All switchgears, busbars and connections shall be capable of withstanding all electrical mechanical and thermal stresses they may be subjected to under normal or fault conditions.

Clearances between live parts and to earth shall be in accordance with the relevant standards.

Each cubicle shall be provided with devices for earthing the incoming cables, preferably each phase separately. Provision shall also be made for earthing the busbars. Such earthing shall be interlocked with the incoming circuit breaker(s). safety interlocks shall be provided to prevent earthing of lives parts.

An earthing bar with a minimum cross-section of 40 x 6 mm shall run the full length of the distribution boards. This bar shall be connected to the main earthing system, and all metallic parts not forming part of the live circuits and all instrument transformer terminals to be earthed shall be connected to it.

Each cubicle / panel shall be equipped with a suitable mimic diagram.

All panels / cubicles shall have approx. 10% spare room for mounting of future auxiliary devices.

Piping transporting water, steam or oil is not permitted in the cubicles.

Floor openings below cubicles shall be covered and sealed by the Tenderer after laying of cables, etc., so as to obtain fire-proof and vermin-proof installations.

Where required gland plates with suitable glands shall be provided.

Phase rotation and colour markings shall be employed throughout the plant.

* + 1. **Switchgear / MCC (Motor Control Center) Feeders and Starters**

Circuit breakers, fused load break switches and motor starter units shall be of the fixed/plug in type. Where two or more starters or feeders are contained in the same cubicle, they are to be separated by barriers of sheet steel or fire proof insulating material. The panels shall contain all respective starters and contactors with their main incoming and outgoing power feeders.

The drawout switching devices shall be mounted on trucks or slide in chassis having adequate guidance by greased sliding rails and / or rollers. They shall be connected to the busbars by means of a self-aligning plug and socket arrangements. Complete isolation of each circuit shall be attained by drawing out the switching device.

The main contacts shall have shutters which automatically close upon withdrawal of the switchgear. The withdrawal of large circuit breakers shall be facilitated by means of cranks, gears or other facilities.

The contacts shall be amply sized and sufficiently strong to withstand maximum short circuit currents and carry continuously the rated currents without damage or overheating of any kind.

The control circuits shall also be provided with plugs and sockets.

The withdrawable units shall have clearly marked service, test and isolated (ready for completed withdrawal) positions. A mechanical interlocks shall be provided to prevent withdrawal of the unit unless the main circuit has been opened. The unit shall positively be locked in the test position before it is manually released for complete withdrawal. The test position shall permit local and remote closing and tripping of the relevant switchgear with the main contacts isolated from the power circuit.

All circuit breakers shall be able to padlocked at its open / racked out position.

All circuit breakers, load break switches, starters and contactors shall be suitably rated and controlled according to the electrical and mechanical performance and duties they are assigned for. They shall be of the continuously rated pattern generously rated to comply with the Site conditions and requirements. Automatically controlled feeders (motor feeders, outgoing feeders) shall be equipped with a time delayed automatic tripping device operating in case of voltage failure at the busbars or being actuated by another defined signal.

Motor feeders shall be equipped as follows:

LV Motors:

* MCB with auxiliary contacts and load-break switch,
* Starter combination
* Adjustable thermal overload and phase failure protection

Moulded case circuit breakers and miniature circuit breakers should be used and they should be properly selected to stand the maximum short-circuit current.

All starter and contactor units of the same rating shall be interchangeable. Remote controlled motors starters rated 5kW and above shall include provisions for remote current indication.

Circuit Breakers:

Circuit breakers shall be of the trip-free type with a driving mechanism composed of a spring loaded, energy storing closing and tripping device. Remote controlled circuit breakers shall be provided with an electric spring loading driving motor, manual spring loading or others and control shall also be possible. Means shall be provided to prevent pumping.

The circuit breaker phases shall be separated by barriers of approved heat resisting, non-tracking insulating material. The LV breakers shall be provided with main and isolating contacts, and with suitable arcing contacts, magnetic arc quenching devices, arc chutes.

The spring release of the closing mechanism shall be affected by means of a DC solenoid coil and by means of a mechanical pull out handle. Tripping shall be effected by means of DC solenoid shunt trip coil and by means of a mechanical push-in button.

The closing mechanism can alternatively be of the AC solenoid coil operated and latched type.

The moulded case circuit-breakers shall have shunt trip coil and trip-free operating mechanism of the quick-break type. They shall have a thermal overload of 125% of the normal full load current and instantaneous magnetic trips which operate at currents exceeding 500% of normal full load currents or 600% of motor full load current whichever is applicable.

Miniature circuit breakers (MCB) shall be single or three-pole with adequate current ratings. The operating as well as the overload mechanism shall be sealed. The mechanism shall provide positive closing, contact roll and wipe, trip-free action with follow through on opening. The contacts shall be of anti-welding silver tungsten tips fixed on high conductivity copper backings. The contacts of control relays and of higher rated circuit breakers and Tenderers shall be silver-plated.

Contactors:

LV contactors shall be of the air break type with arc shields, according to IEC Standards. Butt contacts of the rolling, self-cleaning type shall preferably be utilized and all portions likely to suffer from arcing shall be easily removable.

When closed, the contactors shall withstand the system fault current determined by the next coordinated short circuit tripping device. The associated thermal overcurrent releases shall be adjustable in order to fit the motor requirements and the temperature compensated up to 70°C ambient temperature.

Load Break Switches:

The load break switches shall permit manual operation from the front panel but they shall be designed to allow mounting of a remove control device.

They shall have a padlocking device and self-cleaning contacts with a high resisting anti-arc and with quick-making and quick-breaking action, capable to switch the specified rated currents.

If suitable, the load break switches can be combined with the HRC-fuses.

* + 1. **Switchgear / MCC Control**

For local switchboard control all circuit breakers and motors-starter contactor units shall have:

* One (1) green-coloured illuminated push-button for “ON”
* One (1) red-coloured illuminated push-button for “OFF”
* One (1) position indicator of either the semaphore-type for circuit-breaker, electrically controlled, or indicating lamps, included above.
* One (1) amber-coloured indicating lamp for fault indication of local protection equipment (tripping of protection relay or device, blowing of power fuse, tripping of miniature circuit breaker of control circuits). This lamp shall remain lit until cancelled by resetting of the device having caused the fault indication. Facilities shall be provided to repeat the alarms, individually or group-wise for remote indication or recording.

Remote-controlled incoming and outgoing feeders as well as motor starters shall be equipped with key-operated LOCAL-REMOTE selector switches.

The “OFF” control shall be effective at all locations independent of the selector switch position while the “ON” control shall be restricted to the set selector switch position.

All manual operated plant has mechanical indications clearly indicating the relevant position. Each bus section of a distribution board shall have a blue-coloured signaling lamp indicating that the control supply is healthy, and each cubicle a yellow-coloured signaling lamp indicating heater “ON”.

Indicating lamps shall be of an approved low consumption type. The hoods covering the lamps shall be made of transparent coloured glass moulds or any other equivalent heat-resistant and break-proof material and shall be either of the screw or any other approved type to facilitate replacement of the lamps.

All indication lamp fittings of similar use shall be of the same size and type. Where suitable, LED indicating devices are preferred to pilot lamps; they shall be of the multi-element type.

Lamp test facilities shall be provided on each panel. Up to 3 panels, forming an assembly, can be fitted with one common lamp testing device.

Individual panels or panel suites shall include indicating lamps for:

* Heaters on
* Control voltage
* Alarm / Tip

Generally, all signal, monitoring and protection circuits as well as shunt trips of circuit-breakers shall be fed by the specified standard DC voltage(s). All other circuits may be controlled by AC contactor-operating circuits shall be controlled by AC with the Tenderer solenoids preferably designed for DC, with pre-connected rectifier bridges. Where required, latched contactors shall be provided. All aforesaid circuits shall be protected individually by means of miniature circuit-breakers with position monitoring. AC control circuits shall be derived from the relevant busbar system via supervised main fuses, isolating transformer and the above-mentioned individual miniature circuit breakers.

Closing of the circuit-breakers and contactors shall be possible between 85% and 110% of the rated control voltage. Holding of contactors shall safely be affected at 70% of the rated control voltage. Tripping devices shall operated at 50-120% of the rated control voltage in case of mains dependent and at 75-110% in case of separate control voltages (DC System).

For local control all motors, valves, drive etc., the following case-aluminium push-button station shall be provided:

* One (1) key operated selector switch having three positions; fixing the mode of operation of operation of the drive regard to the following criteria:

1st Position “OFF” (there is no access to that drive nor by the incorporated push button nor by the superposed control system)

2nd Position “Local” means, the drive can be operated only by the incorporated ON-OFF push button (mainly used for tests and or maintenance purposes).

3rd Position “Remote” The drive is controlled by the superposed control system only.

* One (1) “ON” – push button.
* One (1) “OFF” – push button.
* One (1) “Emergency OFF” – push button, which remains locked upon actuation and which can be released only by means of a special key. The effectiveness of this emergency push button shall not be restricted by any other facility, or whatsoever, for having a protection function for the human being.
  + 1. **Small Wiring**

All wiring within panels, racks, boards, etc. shall be PV insulated standard copper wires.

The insulation material shall be of polyvinyl chloride (PVC), tropical grade, or of other approved type. The wring shall be capable of withstanding, without deterioration, the conditions prevailing at the individual location of installation. The bare ends of stranded wires shall be provided with squeezed sleeves or pins.

All secondary wiring shall be arranged and protected to prevent it from being damaged by arcing or by mechanical effects.

Wiring shall be neatly run, bundled or in rigid PVC plastic wireways filled not more than 70%.

Cable cores and all secondary panel wiring terminated to terminals / terminal blocks shall be fitted with numbered ferrules of yellow, moisture and oil-resisting insulation material having a gloss finish, with the identification numbers clearly engraved in black being the same as for the relevant terminals. In case different terminal boards are arranged close to each other the ferrules shall contain the terminal board denomination and the terminal number. The ferrules shall be fitted in such a way that they cannot become detached when the wire is removed from the terminal. All internal wiring shall enter the terminal block at one side only.

Wiring shall terminate in one or more terminal blocks, arranged at the side or bottom of each panel or compartment. Internal wiring between instruments or other devices not using the terminal block shall be permitted within the same compartment only.

Terminal blocks shall be numbered consecutively beginning with 1 from left to right or top to bottom and shall consist of single “insertion” type terminals of non-tracking, non-inflammable synthetic plastic lined-up in one row. All terminals shall have two (2) separate pressure clamping plates suitable for connection of incoming or outgoing, stranded and solid conductors, respectively. Other solutions have to be approved by the Engineer.

Terminals with clamping screws in direct contact with the conductor are not acceptable. The following categories of terminals shall be provided and arranged as follows:

1. Terminals for power circuit (one group)
2. Terminals with short-circuit facilities for current transformer circuits (one group).
3. Terminals for measuring and control circuits, where required, with bridging facilities to the neighboring terminal (one group).

All terminal blocks shall contain 20% spare terminals of category C, mentioned above. Insulating barriers shall be provided between each pair of power circuits and between the terminal categories. The height and the spacing shall be such as to give adequate protection to the terminals whilst allowing easy access to the same.

* + 1. **Tests**

The workshop tests shall be performed in accordance with applicable standards. For the individual switchgear components (i.e. circuit breaker, load break, switch, etc.), type and routine test certificates of the manufacturer shall be supplied.

The following site tests shall be performed:

* Visual inspection
* Megger test (to include plant and internal wiring but excluding electronic equipment)
* Functional tests of controls, interlocks, measurements)
* Setting of protection relays, adjustment by means of special testing equipment and operational checks
* HV test as required by applicable standards.
  1. **Auxiliary Plant**
     1. **Auxiliary Switches**

Where appropriate each item of plant shall be equipped with all necessary auxiliary switches, contactors and devices for indication, protection, metering, control, interlocking, supervision and other services. All auxiliary switches shall be wired up to terminal blocks on the fixed portion of the plant.

All auxiliary switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism and are to be protected in an approved manner. The contacts of all necessary switches shall be strong and shall have a positive wiping action when closing.

Control Switches:

Control switches for electrically operated circuit breakers shall be of the pistol grip or discrepancy type. They shall operate clockwise when closing the circuit breakers and anti-clockwise when opening them. The control switches shall be so designed as to prevent them from being operated inadvertently, and where switches of the discrepancy type are used they shall require two independent movements to effect operation. Discrepancy type control switches shall be so designed that when released by the operator, they return automatically to the neutral position after having been turned to the “closed” position and shall at the same time interrupt the control voltage supply to the operating mechanism of the circuit breaker.

Switches for other apparatus shall be operated by shrouded push buttons or have handles of the spade type; the pistol grip type shall be used for circuit breaker operation only.

Control, reversing, selector and test switches shall be so mounted, constructed and wired as to facilitate the maintenance of contacts without the necessity for disconnecting wiring.

* + 1. **Anti-Condensation Heaters**

Each individual enclosure accommodating electrical plant which is liable to suffer from internal condensation due to atmosphere or load variations generally all equipment located outdoor shall be fitted with heating devices suitable for electrical operation at the specified standard AC voltage, being of sufficient capacity to raise the internal temperature by about 5°C above the ambient temperature. Heaters in motors and similar shall be switched on automatically upon opening of the motor starter, and vice-versa. Heaters in switchgear/MCC cubicles, control cubicles, panels, desks, etc., shall be controlled automatically by adjustable hygrostats / thermostat (setting range about 50 – 100% relative humidity). The electrical apparatus so protected shall be of such design that the maximum permitted temperature is not exceeded if the heaters are energized while the apparatus is in operation.

Heaters shall be equipped with a suitable terminal box. All plant, whether fitted with a heating device or not, shall be provided with suitable drainage and be free from packets in which moisture can collect.

* + 1. **Instrument Transformers**

Current and voltage transformer are to be housed and designed to suit their particular duties. They shall meet the requirements of the technical specification and latest relevant approved standards for metering and for protection and be capable of withstanding without any damage or deterioration.

* The continuous thermal current rating of the associated switchgear and
* The maximum short-circuit level of the circuit for a period of one (1) second

Separate cores shall be provided for protection and metering circuits. Switching of current transformer (CT) circuits is not permitted.

All CT’s shall be capable of carrying rated primary current with an open-circuited secondary winding for one minute without damage or deterioration. The secondaries of CT’s shall be earthed with the earth connection easily accessible.

The nominal values of CT and PT secondary windings shall be as stated in particular technical specification. The instrument transformers shall have adequate accuracy, saturation factor and rated burden.

The Tenderer shall determine the burdens and accuracy boards and earthed at one point in the circuit. Potential transformers shall be fused on the secondary side by means of miniature circuit-breakers with auxiliary contacts.

All measuring transformers shall be provided with a plant label giving type, ratio, glass, output, serial number, and connections.

The Tenderer shall supply manufacturer[s test certificates on test and measurements to be performed in accordance with applicable standards. The CT’s and their associated circuits shall be tested on Site by the primary injection method.

* + 1. **Electrical Connections**

Bolted connections shall correspond to the applicable Indian or DIN Standards and have two washers and one spring washer. Bolt terminals of machines (motors, transformers, etc.) shall be equipped with secured nuts, two washers and spring washer, all the above elements being of corrosion-proof material or plated accordingly.

Tightening of such bolt connections shall be done with a torque wrench set to values to be given by the Tenderer before commencement of erection work.

Busbar interconnection of individual units (switchgear / busducts / transformers) shall be done by flexible joints. They are to be rated as the respective busbars are, the length shall ensure the flexibility against vibrations and for thermal or operational displacements and also withstand the dynamic short circuit streses.

* + 1. **Protection Devices**

The main parts of the plant shall be protected and interlocked so as to prevent mal-operation and other fault occurrences, and to maintain safety during all operation phases.

Electric protection relays shall be the standard product of an experienced and reliable protection relay manufacturer. They shall be of the static or mechanic / magnetic, tropicalised type and be mounted in suitable dust proof and shock-absorbing casings. 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. Electro-magnetic relays shall have a transparent cover with appropriate seals.

The protection relays shall be equipped with all necessary auxiliaries such as tripping unit, time relay, external resetting device (hand reset flag with seal-in operation). The relays shall provide easy access for testing and setting purpose.

Pre-warming alarms shall be initiated as early as possible before the protection system trips, in order to enable the operators to take precautions. 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 protection and auxiliary relays shall be grouped and mounted on plug-in modules or stationary-mounted on swing frame with separate plugs and sockets to feature easy replacement testing. The construction shall be sturdy and such that all parts are easily accessible for adjustment. Relays installed in switchboards shall be arranged in compartments separated from the switchgear.

Besides the mechanical-operated flag type indicator, all relays shall have sufficient contacts and / or auxiliary relay contacts to perform all the tripping, inter-tripping, interlocking, indication and alarm function required. Suitable nos. of spare contacts shall be provided for later use. The contacts shall be silver plated or of the seal-in type with the main contacts adjustable. The relay contact rating shall be for the specified standard voltage and for 200% of the nominal passing current. The relay coil shall be able to operate properly at voltage variations of -25% to +15%.

Relays shall be capable of at least one million operations without any defect.

Testing of the individual relays shall either be effected by stationary-mounted or portable testing devices.

* 1. **Cables**
     1. **General**

The Tenderer shall provide the relevant design and engineering of the relevant cable systems and prepare the cable installation drawings with cable routing, connection diagrams, and cable lists, details etc.

All cable and accessories shall be suitable for installation under site conditions (e.g. aggressive soil conditions, etc.).

The Tenderer shall select the most suitable cable routes and raceways ensuring a minimum of interference with other installations.

The maximum continuous current carrying capacity of each individual cable type and cross-section used shall be determined, taking into account site conditions. The resulting load reduction factors are subject to the approval of the Engineer. The conductor cross-section of each cable shall be adequate for carrying the fault currents determined by the relevant short-circuit protection device when operating under the specified load conditions, without deterioration of the dielectric properties. All the above data and their calculation including the short-circuit calculations, shall from part of the documents to be supplied by the Tenderer and same shall be approved by Engineer. All cables shall be designed to cope with a voltage drop of 3% maximum. Maximum temperature to be attained by the Tenderer or any part of the cables when in service at site under the climate conditions as indicated in specifications shall not exceed the limits as per the latest issue of relevant applicable standard.

The polyvinyl-chloride (PVC) used for conductor insulation and cable sheathing shall be of the highest quality, heat resisting type.

The cross-linked polyethylene (XLPE) used for insulation of cables shall be of the dry cured type.

Cable conductors shall be of annealed, high conductivity copper conductors laid up and rendered smooth and free from defects likely to injure the insulations. Under no circumstances mid-joints of cable will be accepted.

The identity of the manufacturer shall be provided by embossing the outer sheath with “name of Manufacturer – year of manufacture”.

* + 1. **Power Cables**

The LV power cables shall be of the extruded solid dielectric insulated type; HV power cables of 12kV shall be of the cross-linked polyethylene insulated cables shall be capable of continuous operation at a highest system voltage as specified with a maximum conductor temperature of 90°C, and a maximum temperature under fault conditions of 250°C.

All conductors shall have coloured insulation according to the phase colours or, alternatively coloured plastic sleeves can be used at all cable terminations.

* + 1. **Control Cables**

The control cables shall be of the multicore or standards, PVC insulated type withstanding without deterioration the conditions prevailing at the individual locations of installation. Cables for analogue signals shall have a common screen of metal tape, cores shall be twisted to pairs.

Within control and electronic circuits, the minimum cross-sections shall be adequate for the design of the plant.

Multicore cables with more than 7 cores shall have approx 20% spare cores for future use.

Multi-conductor cables shall be number-coded and / or colour – coded or identified by other suitable means.

The colour-coding or other identification system shall be shown on the circuit / connection diagrams.

* + 1. **Cable Laying**

As appropriate for the various locations the cables shall be installed in cable, raceways, conduit – or tray systems, cable trenches, etc. or directly laid in the ground. Relevant enclosed drawings shall be followed.

Cables running inside buildings or concrete trenches shall be laid on trays. The trays shall be of adequate strength and size to carrying the specified number of cables, providing approx.25% spare capacity. The design of such trays shall include a safety factor to avoid permanent distortion when supporting erection staff during cable installation. The trays shall be of suitable aluminium alloys or hot-dip galvanized steel standard materials.

In chemically-endangered areas all trays, supports, ladders, etc., shall be of hot-dip galvanized steel elements. Cable trays shall normally be of the ladder type consisting of bars with rings, evenly spaced (max. 500 mm) according to requirements. Perforated, covered metal trays shall be used. All trays hall be rigidly fixed on supporting steel structures, masonry or galvanized racks. Cable trays arranged one above the other shall be at least 300 mm apart in case of power cable and 200 mm in case of control cables.

Cables laid on trays or racks shall be properly fixed or clamped. Supports and racks shall be arranged to facilitate removal or replacement of cables.

Cables branched from general raceways and directed to the relevant plant shall be suitably protected where required over entire length by e.g. galvanized steel conduits sealed at their ends against ingress of water. Conduits shall be fixed on steel structure, brickwork or be embedded in concrete floors or walls according to field requirements.

Conduits embedded in concrete or block work shall be of suitable rigid PVC type. Cables laid outdoors, across roads in concrete or foundations shall run in hard PVC plastic pipes buried in the ground in a depth not less than 600 mm or embedded in concrete foundations at suitable depth.

The cross-section area of such ducts shall be utilized to 50% only. Pipe ducts shall terminate in concrete manholes before entering buildings. Manholes and pull-pits shall be provided where required to facilitate cable installation.

Cable on brick walls or similar civil structures can be laid in conduits (painted galvanized steel conduits within the reach of persons or erection / maintenance devices, PVC conduits in other areas) or in prefabricated installation channels made of galvanized steel metal or plastic.

Unarmoured cables shall be properly protected against mechanical damage when leaving ducts or covered trench works and the like.

Fire-partitions shall be provided when cables are passing through different fire zones or when entering cubicles and panels.

Cable passages into buildings shall be sealed fire and water proof.

Accessible cable galleries shall have fire-barriers at suitable spacings including normally open fire doors, which are closed automatically in case of fire.

The Tenderer shall provide in due course all required information on cable ducts, trenches, manholes, block-outs, foundations, etc. which shall constructed by the Civil Tenderer.

Minor civil works like slotting or chiseling shall be included in this Contract. A distance of approx. 30 cm shall be kept to other services.

Power and control cables shall be adequately spaced. Generally power and control cables shall run on separate trays. However at same location these cables may run in same tray and shall be adequately spaced.

The Tenderer shall be responsible for any damage caused by him to the buildings, and shall be responsible also for making good finishing any cable liable to carry unbalanced currents.

The pulling, and fixing and terminating of cables shall be strictly in accordance with the manufacturer’s instruction, using the recommended tools and appliances.

The following shall be applicable for cable installation in trenches:

* Cable trench covers shall be removed in sections, according to the progress of work.
* Removed covers shall be stored in such a way that they do not create a hazard to people or traffic at site.
* Cables laying in open trenches for more than two weeks shall be protected against sun radiation.
* Open trenches shall be properly secured by red warning tapes both sides along the trench.
* Any cover, cable or cable tray having been damaged during installation shall be replaced by the Tenderer.
* Cable trenches shall be cleaned from dirt, sand, etc. before closing.
* Trench shall be closed as soon as possible.
  + 1. **Cables conduits through concrete blocks**

The interconnection of cables between power house and switchyard shall be done through cable trenches. However, tenderer may quite cable conduits through concrete blocks as an alternative for interconnection of cables between power house and switchyard. Relevant drawings may be referred to.

* + 1. **Cable Terminations**

For all termination of wires and cables, the insulation shall be neatly stripped without nicking the strands of the conductors. Cable lugs for power cables shall be of adequate size. Cable glands or clamps shall be fitted in all cases to prevent stressed on conductors or terminals. It is important that the sealing compound and sleeving used in terminations is selected to suit the service conditions under which the cable is to operate.

No terminations will be accepted if the insulation readings, 24 hours after making off, are less than 200 megohms using a standard 500 or 1000 V “Megger” (MV and HV cables only).

Some slack cable in a loop or other suitable form is to be allowed at a convenient place in the runs where required.

* 1. **Oil and Compound**
     1. **Insulating Oil and Compound**

The first filling of insulating oil and / or compound shall be supplied for any plant provided under this Contract requiring filling.

Oil and compound shall comply with the latest approved appropriate Standards and shall be delivered in strong, hermetically sealed new drums.

Where drums are stored on Site in the open air, they shall be kept in a horizontal position.

* + 1. **Oil or Compound Filled Chambers**

All joints or oil or compound filled chambers, other than those which have to be broken, are to be welded, and care is to be taken to ensure that the chambers are oil-tight. Defective welded joints shall not be caulked but can be re-welded subject to the written approval of the Engineer.

Suitable provision shall be made for the expansion of the filling medium in all oil or compound filled chambers and the chambers shall be designed to avoid the trapping of air or gases during the filling process.

All wiring in the vicinity of oil-filled chambers shall be insulated with oil-resisting insulation of approved quality.

* + 1. **Oil Level Indicators**

Oil level indicators of approved design shall be fitted to all oil containers.

The indicators shall be marked with the normal level clearly visible from normal access levels and shall be easily removable for cleaning.

* 1. **Labels and Plates**
     1. **General**

Labels and data plates shall be provided in accordance with applicable standards and as detailed hereunder.

The proposed material of the labels, size, exact label lettering and proposals for the arrangement of the labels shall be submitted to the Engineer for approval.

* + 1. **Plant Labels and Instruction Plates**

Labels written in the Contract language shall be provided for all instruments, relays, control switches, push-buttons, indication lights, breakers, etc. In case of instruments, instrument switches and control switches, where the function is indicated on the device, no label is required. The label shall be fixed close to the devices in such a way that easy identification is possible. Fixing on the dial glass of instruments will not be accepted. The working shall conform to the working used in engineering documents.

Each separate construction unit (cubicle, panel, desk, box, etc.) shall be identified by its plant identification number. Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible. The overall designation of each unit shall be given in the Contract language and – if required also in a selected local language. These labels shall be made of anodized aluminium with black engraved inscriptions, arranged at the top section of the units. Manufacturers trade labels shall – if desired – appear in the bottom section of the units.

All plant inside cubicles, panels, boxes, etc., shall be properly labeled with their item number. The number shall be the same as indicated in the pertaining documents (wiring diagrams, plant list, etc.)

Instruction plates in the Contract and selected local language, the sequence diagrams or instructions for maintenance shall be fitted on the inside of the front door of the electrical switchboard.

* + 1. **Warning Labels**

Warning labels shall be made of synthetic resin with letters engraved in the Contract and selected local language, where required in particular cases.

For indoor circuit – breakers, starters, etc., transparent plastic material with suitably contrasting colours and engraved lettering would be acceptable.

Details are stated in the Particular Technical Specifications or will be fixed at a later date.

* + 1. **Labels for Conduits, etc.**

The material shall be non-corrosive and the description be done with 4 mm high letter/figures.

* + 1. **Labels for Cables**

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Engineer, non-corrosive labels detailing identification numbers of the cable, voltage, and conductor size.

The cable identification numbers shall comply with those of the cable list.

All cables in cable pits and at the entry to buildings shall be labeled utilizing the aforementioned type of label.

* + 1. **Rating Plates**

Plant (machines, transformers, etc.) rating plates and other technical data/informative plates shall either be of the enameled type or be of stainless steel suitably protected after engraving with a transparent paint.

* + 1. **Single-Line Diagrams**

Each switchgear room shall be furnished with a durable copy of the final as built single-line diagram detailing all electrical data and denominations, separate for each individual switchgear / distribution board / MCC, placed under glass and frame / wall mounted at an approved location.

The same applied to the Station Single – Line Diagram one copy of which shall be arranged in the control room (s).

* 1. **Key System for Electric Boards**

Key interlocked switches shall be provided with Yale or other approved locks for locking in the neutral position. Similar locks shall be provided for selector switches for locking the switches in any of the positions.

1. **INSTRUMENTATION AND CONTROL EQUIPMENT**
   1. **Design Criteria** 
      1. **General**

Section 5 “Electrical Plant”, shall be considered for I & C equipment as far as applicable. Special reference is made to cabling, wiring and labeling.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The plant shall be pre-assembled to the highest extent in the Tenderer’s or Sub-Tenderer’s workshop, e.g., shop welding of thermometer wells and other connections, wiring of boards, desks, etc., including internal wiring and installation of devices shall be carried out. Fragile instruments shall be removed transportation to site.

All components shall be suitable for continuous operation under site conditions.

Materials for instrumentation and control equipment including piping material which is exposed to the measured media shall be selected accordingly.

All components shall be compatible with other electrical, electronic and mechanical plant.

All instrumentation and control functions shall be shown on the piping and instrumentation diagrams. The symbols to be used shall be in accordance with IS/ISO Standard. The identification system (tag numbers) shall be in accordance with the plant identification system and is subject to approval by the Engineer. All measurements and alarms shall be listed in a measuring list of a standard from subject to Approval by the Engineer. For remote controls, a schedule of interlocks shall be provided. The features of automatic controls shall be shown in block diagrams.

Shielded cables shall be provided for the control and supervisory equipment where required.

* + 1. **Standards**

If the Tenderer intends to apply Standards and Regulations other than those specified, he shall provide the Engineer with two (2) sets of such documents, which shall be complete, unabridged and written in the Contract Language.

* + 1. **Sizes of Indicators, Recorders, etc.**

The meters, instruments and recorders shall be standard size, to be selected to guarantee unique appearance of switchgears, control panels, control desks etc. The front glasses shall be of the anti-glare type. The scale shall be 90° or 240° type.

|  |  |
| --- | --- |
| Indicators  on local control panels,  MV and LV switchgears | 72 x 72 mm or  144 x 72 mm |
| Indicators  on vertical sections of control  desk in control room  and on rectifier or converter panels | 96 x 48 mm or  96 x 96 mm |
| Indicators  on control panels is control room  when incorporated in mimic diagrams | 72 x 72 mm or  144 x 72 mm or  144 x 144 mm or  96 x 48 mm |
| Recorders | 144 x 144 mm (for line and 6-point recorders)  288 x 288 mm (for 12-point recorders) |
| Pressure gauges and other dial type  instruments (local) | Preferably 160 mm diameter |

The control switches, adjusters, etc., on the panels and desks shall harmonize with the utilized indicator sizes.

* + 1. **Special Local Conditions**

If the prevailing local conditions require special measures, the following shall be observed for the I & C equipment:

* All local indicators shall be of stainless steel.
* All copper pipes shall be protected with an external plastic sheath.
* All external bolts and screws shall be of non-corrosive material.
* All secondary shut-off valves, balancing and drain / blow-off valves shall be of the non-corrosive type.
* All metallic instrument piping shall be protected with corrosion protecting painting, or shall be of non-corrosive materials.
* All I & C equipment exposed to sun shall be protected against direct sun radiation. This can be done by protection casings, sun shields, etc.
* All multi-core I & C cables installed outside the buildings shall be completely protected by means of closed cable trays, flexible conduits, etc. the individual cables from the terminal boxes to the instruments shall be protected as far as practicable.
* All I & C equipment shall be rated for tropical environmental conditions and shall be certified by the manufacturer.

**Measuring Systems**

Only electric measuring signals of 4 – 20 mA shall be transmitted to the control room. The output signal of transmitters shall be 4 – 20 mA and linear over the whole measuring range.

The components shall quickly respond to any changes of the measured magnitudes. Measuring ranges of indicators, transducers, etc., shall be selected in such a way that the rated value of the measured magnitude covers approx. 75% of the range.

All local instruments shall, as far as practicable, be mounted vibration free to allow good reading. Wherever required, damping elements shall be used.

Corresponding systems shall be grouped together in local panels.

All local indicating instruments and test connections shall be included in the respective plant as integrated parts. The scope of local indicating instruments and test connections shall enable the operator to properly survey the plant, and shall also allow to adequate carry out all acceptance and other tests.

The binary sensors shall be fused separately and supplied with 24 V DC

* 1. **Tests**

The single components and pre-erected assemblies shall undergo functional and routine tests in the Tenderer’s or Sub-Tenderer’s workshop. The ready mounted control and supervisory system shall undergo functional tests on Site prior to commissioning of the power plant.

Calibration tests shall be made on all important pressure gauges and other instruments as required by the Engineer.

* 1. **Measuring Systems**

Only electric measuring signals of 4 – 20 mA shall be transmitted to the control room. The output signal of transmitters shall be 4 – 20 mA and linear over the whole measuring range.

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Corresponding systems shall be grouped together in local panels.

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The binary sensors shall be fused separately and supplied with 24 V DC.

* + 1. **Flow Measurements**

Flow meters shall be of electromagnetic type with high vacuum and abrasion resistance interior.

One NO and one NC snap action contacts shall be provided for maximum and minimum values. Error limit shall be less than 5% of the measured value.

The design and arrangement of tapping points, piping and valves shall be in accordance with relevant Indian Standards / VDI / VDE 3512.

* + 1. **Temperature Measurements**

All wells for capillary type thermometers, resistance temperature sensors and thermocouples shall be of the weld-in type. Wells for thermometers and temperature sensors of the screw-in type shall be restricted to measuring points for lubrication oil, and to such measuring points where welding is not suitable, e.g., at cast-iron parts. Shop-welded thermometer wells be covered by screw caps for protection during transportation and erection.

Resistance thermometers and thermocouples shall be equipped with waterproof connection heads. Thermometer arrangements shall be such that the connection heads do not become warmer than 80°C, and the measuring inserts are easily exchangeable.

The temperature sensors shall be selected in such a way to minimize the number of different spare inserts.

Resistance thermometers shall generally be of type Pt 100. Double resistance thermometers (with two resistors in one insert) should be avoided.

Temperature to be recorded shall be measured by means of resistance thermometers or thermocouples which can directly be connected to the recorders.

The use of dial-type contact thermometers shall be restricted to bearing metal, cooling water and oil temperature measuring. In all other cases, thermocouples or resistance thermometers and electric contact modules (monitors) shall be used. Glass thermometers or similar will not be accepted as contact thermometers.

* + 1. **Pressure Measurement**

Pressure gauges shall be shock and vibration-proof (preferably by filling with glycerine) and shall be equipped with toothed wheels and toothed segments of the machined type. They shall completely be made of stainless steel.

Higher than rated pressure shall not deteriorate the pressure gauge or affect its calibration. The pressure gauges shall be equipped with a radial connecting stud, to allow the mounting on a gauge holder.

Pressure gauges with potentiometers will not be accepted for use as a pressure transmitter.

The error for pressure transmitters shall be limited to + 0.5%.

Pressure gauges and transmitters for inflammable liquids shall have filled systems and the filing liquid shall be separated from the inflammable liquid by means of adequate isolating membranes.

Each gauge, pressure switch and transmitter for absolute or differential pressure shall be equipped with a pressure gauge isolating valve including a test connection of the screwed type M20 x 1.5 mm so that such device can be removed without any disturbance of the plant operation.

Pressure gauges and transmitters for pressure of 10 bar and above, shall not be directly mounted on the pressure tapping point. They shall be mounted apart from the tapping point on gauge holders or gauge boards. Whenever possible, pressure gauges and transmitters shall be group wise combined on racks or consoles.

Pressure gauges for high pressures shall be equipped with a relieve valve for safety reasons in case of leaks (with a rubber reverse flow check).

In case of flowing substances, the measuring point shall be selected in locations of undisturbed flow.

If the press is pulsating, the devices concerned shall be connected via flexible tubes or other pulse-absorbing means.

The design and arrangement of tapping points, piping and valves shall be in accordance with relevant Indian Standards / VDI / VDE 3512.

The scales shall have a diameter of 150 mm with black letters and figures on a white ground. The calibration shall be in kg/cm2.

The high and low pressure connections of differential pressure gauges shall be marked accordingly.

All casings shall be dust and watertight and be made of stainless steel.

* + 1. **Level Measurements**

The liquid level measurements in reservoirs and tanks with atmospheric pressure shall be made by means of pressure transmitter of mercuryless-type, by displacement-type transmitters or float-disc-transmitters. The errors shall not exceed + 1.0% of the total measuring range. Level switches shall be of packless construction; there shall be a minimum of moving parts.

* + 1. **Electrical Measurement**

All Electrical instruments shall be of flush mounted design, dust and moisture-proof. AC Ammeters and Voltmeters shall have moving iron system of not less than 1.5 accuracy class for connection to the secondary side of instrument transformers. DC measuring instruments shall have moving coil systems of the same accuracy. Wattmeters shall have electro-dynamic measuring mechanisms or alternatively a moving coil mechanism if fed by transmitters. Wattmeters shall be suitable for unbalanced system.

All indicating instruments shall generally withstand without damage a continuous overload of 20% referred 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. All instrument and apparatus shall be rear connected, and the enclosures shall be earthed. Means shall be provided for zero adjustment of instruments without dismantling.

All voltage circuits to instruments shall be protected by fuses in the unearthed phases of the circuit installed as close as practicable to the instrument transformer terminals or where instruments are direct-connected as close as practicable to the main connection. All power factor indicators shall have the star point of their current coils brought out to a separate terminal which shall be connected to the star point of the current transformer secondary windings.

When more than one measured value is indicated on the same instrument, a measuring point selector switch shall be provided next to the instrument and shall be engraved with a legend specifying each selected measuring point.

All instruments shall be of the flush mounting type and shall be fitted with non-reflecting glass and shall comply in every respect with the requirements of IEC 51. Except for instruments employed for plant performance tests all instruments shall have an accuracy class of 1.5.

Scales shall be arranged in such a way that the normal working indications is between 50-75% of full scale reading permitting an accurate reading. CT connected Ammeters provided of indication of motor currents shall be provided with suppressed overload scales of 2 times full scale the dials of such Ammeters shall include a red mark to indicate the full load current of the motor.

Where directly connected Ammeters are provided for indication f motor currents they shall be supplied with overload scales indicting up to six times full load current. The dials of such Ammeters shall include a red mark to indicate the full load current of the motor.

Instruments scales shall be submitted for approval by the Engineer. All instruments mounted on the same panel shall be of same style and appearance.

Transmitter connected Ammeters shall have 90° or 240° circular scales calibrated 0-120%. The rated motor current shall correspond to 100% scale indication.

Energy meters shall be of the induction disc type with limits of error according to IEC 170. The casings shall be dust and moisture-proof and shall fit into the boards to permit reading without opening the corresponding front door. Disc and cyclometers of the drum-type shall be clearly visible through a window in the casing and the cyclometer shall be able to record for a minimum of 2.500 hours. Meters shall be suitable for unbalanced systems.

* + 1. **Position Measurements**

Position transmitters of the potentiometer type will not be accepted. Inductive or capacitive type shall be provided.

* + 1. **Contact Devices**

Contacts of level switches, pressure switches, limit switches, and of all other devices shall be of the snap action type (SPDT). Contact devices for interlocking systems shall be separate, i.e., contact devices serving commonly for interlocking and other purposes will not be accepted.

* 1. **Alarm Systems**

The alarm system shall provide all alarms required for a safe and reliable operation of the plant. Alarms shall be initiated locally, in the control room, individual or grouped as required. All alarms shall be recorded on the event recorder.

* + 1. **Alarm Annunciation System**

The alarm equipment shall operate from a 24V DC and 240V AC supply and shall give audible and visual warning when any alarm or trip condition occurs, including fleeting alarms. “Accept”, “Reset” and “Lamp Test” push-buttons shall be fitted to each set of alarm equipment.

The following systems shall be applicable:

1. Upon occurrence of an alarm a horn or buzzer shall sound, and a pertinent window shall be illuminated with flashing light. The horn shall be cancelled by pressing a push-button. The flashing light shall be acknowledged by pressing and acknowledgement push-button. Upon pressing this button, the flashing light shall pass over to steady light. When alarm contacts reset to normal, the light shall flash slowly until and acknowledgement push-button has been pressed.
2. The incidence of the first alarm shall initiate a continuously sounding bell and the flashing of the appropriate illuminated annunciator. The bell shall be silenced and the flashing of the annunciator changed to a steady illumination on the operation of the “Accept” bush-button. The alarm shall remain operated until the initiating contacts have restored or until the “Reset” button is operated, whichever is later.

When several alarms occur before the “Accept” button is operated the illumination of the annunciator of the first alarm shall flash and the annunciators of the subsequent alarms shall have steady illumination. Any alarm which occurs after the operation of the “Accept” push-button and before the first alarm condition has been cleared shall be as for a first up alarm.

Operation of the “Lamp Test” push-button shall illuminate all alarm annunciator lamps on that set of alarm equipment. Operation of the lamp test facility shall not operate any alarm sequence.

The alarm equipment shall incorporate and electrically separate pair of contacts for each individual alarm annunciator module which closes on the occurrence of an alarm and remains closed until the alarm is cleared. These contacts are for the remote indication of alarms.

The alarm annunciators shall have individual illuminated windows with the alarm conditions engraved on the front face. The individual annunciators shall be grouped to form multiway alarm units flush-mounted in the cubicle fronts. 20% spare alarm annunciators shall be supplied for each set of alarm equipment to allow for further alarms.

Buzzers (Chimes, Horns, Bells as appropriate) shall be installed in suitable locations and shall be arranged to sound whenever the main audible alarm is energized.

All fusing and miniature circuit-breakers shall be incorporated in the alarm system so that any and each miniature circuit breaker trip will be announced. These alarms shall group wise be collected and be combined to group alarms. The group alarms shall be connected in such a way the identification of an announced fault within the respective group is easy.

Motor trips and circuit-breaker trips shall be announced with flashing lights via the indicating lamp of the control station. Acknowledgement of this flashing light shall be effected by operating the control push-buttons. Apart from the flashing light of the indicating lamp, such trips shall also be announced audibly by means of the horn and visually group alarms on the alarm annunciators.

Means shall be provided for testing all alarm and indicating lamps at desk, panel and local panels.

* 1. **Logic Controls and Interlockings**

The open loop control and interlocking systems shall comprise all controls of motors, circuit-breakers, disconnecting switches, motorized valves, dampers, solenoids, etc., including all process interlocking to properly control the plant and protect the equipment.

* 1. **Auxiliary Power**

The Auxiliary power supply for control and protection systems shall be derived from the specified systems at standard voltage levels.

Where required, control and protection systems shall have duplicate in feeders with appropriate protection and change-over devices.

Great care shall be taken in the general design of the power supply to minimize the risk of failure and damages and to facilitate the detection of faults.

The closed control loops shall be individually protected.

For protection miniature circuit breakers with auxiliary alarm contacts shall be provide. The alarm shall be indicated by an alarm lamp in each cubicle and as a group alarm in the control room.

For each distribution bus, a voltage supervision with alarm in the control room shall be provided.

In order to facilitate interconnecting network design, all components of the control system shall have a common reference, isolated from earth. This will allow the first accidental earthing of a circuit without disturbance; if this earth fault is repaired prior the second one occurs. For this reason, an insulation monitoring system shall be provided measuring the total resistance of the circuits against earth.

In addition, an earth fault detection system shall be provided for fault location. Insulation monitoring as well as fault location detection shall be automatically performed continuously during plant operation without interfering the control signals.

In case of power supply failure, it is necessary that all final control elements automatically switch to a failsafe condition, and the control loops transfer automatically to manual mode with necessary annunciation.

When the power supply returns, the systems shall remain in the latter mode.

1. **TRANSPORT AND INSTALLATION**
   1. **Scope of Work and General Requirements**

Shipping, transportation, loading, un-loading, insurance during transportation (Marine & Inland) storage and erection, commissioning, site testing and trial-run shall be performed by or under the responsible direction of the Tenderer. An appropriate period for transportation shall be considered.

The Engineer will do the general co-ordination of storage and erection work as well as the civil engineering work on site.

The delivery dates, transportation and erection periods and for all other associated activities indicated in the Contract Documents shall be strictly adhered to. Changes, which are unavoidable or necessary, will be regulated in accordance with the stipulations laid down in the General Conditions of Contract.

From the time of manufacturing until commissioning all parts of the plant shall be protected and insured at the Tenderer’s expense against loss and damage of any kind. Parts, which are damaged during transport, storage, erection or trial operation, shall be replaced at the Tenderer’s expense.

* 1. **Packing and Transportation**
     1. **Packing and Marking**

The Tenderer shall prepare all plant, devices and materials for shipment to protect them from damage in transit, and shall be responsible for and make good all damages due to improper preparations, loading or shipment.

After the workshop assemble and prior to dismantling for shipment to the Site, all items of machinery and plant shall be carefully marked to facilitate site erection. Wherever applicable, these markings shall be punched or painted so they are clearly visible.

Dismantling shall be done into convenient sections, so that the weights and sizes are suitable for transport to Site and for handling on the Site under the special conditions of the Project.

All individual pieces shall be marked with the correct designation shown on the Tenderer’s detailed drawings and other documents (packing, lists, spare part lists, in Operating and Maintenance Instructions, etc.).

Each piece, separately shipped, or smaller parts packed within the same case or box, shall be legibly, marked to show the unit to which it is a part and match-marked to show its relative position in the unit.

Unit marks and match-marks shall be done preferably by punching the marks into the metal before painting, galvanizing etc., and shall be clearly legible after painting, galvanizing, etc. In labeling, the Tenderer shall endeavor to use as few designations as possible, and each part of identical size and detail shall have the same designation, regardless of its final position in the plant.

All parts of the plant shall be packed at the place of manufacture; the packing shall be suitable for shipment by sea and for all special requirements of the transportation to Site. Where necessary, double packing shall be used in order to prevent damage and corrosion during intermediate storage.

All identical members shall be packed together, if reasonably possible, in a form convenient for shipment and handling.

Small items shall be packed in boxes and large items shall be protected where necessary, by timber, straw and sacking. Drums shall be used for electric cables, steel ropes, steel wire and similar materials. All bolts, nuts, washers, etc., shall be packed in containers. Each container shall include only bolts, nuts or washers of identical size.

All parts shall be suitable protected against corrosion, water, sand, heat, atmospheric conditions, shocks, impact, vibrations, etc.

All electrical parts shall be carefully protected from damage by sand, moisture, heat or humid atmospheric conditions by packing them in high pressure polyethylene foil. Where parts may be affected by vibration, they shall be carefully protected and packed to ensure that no damage will occur while they are being transported and handled.

Spare parts shall be packed separately and designated as specified and shall be delivered properly and adequately packed for several years’ storage. All packing costs shall be included in the scope of Work.

* + 1. **Shipping Marks**

The Tenderer shall mark all containers with the implementing document number pertinent to the shipment. Each shipping container shall also be clearly marked on at least two sides as follows:

|  |  |
| --- | --- |
| Consignee: | To be decided during placement of L.O.I. |
| Contract No.: |
| Port of Destination: |
| Item number (if applicable) Package number, in sequence and quantity per package: |
| Description of Works: |
| Net and gross weight, volume: |

* + 1. **Packing Lists**

The Tenderer shall provide the Purchaser with one (1) original and two (2) copies of all shipping documents and relevant packing lists of each shipment of equipment items after the same has been shipped. One copy (1) of the packing list shall be sent to the Purchaser’s Representative. All packing lists shall contain the name of the Tenderer or supplier and shall show the complete markings on each packed box or crate that has been shipped. Separate packing lists shall be prepared for each and all shipments made. One copy of the packing list shall be placed inside each box or crate, and one copy inserted in a weatherproof envelope affixed to the outside of each box or crate.

* 1. **Equipment Handling and Storage**
     1. **General**

All equipment shall be handled very carefully to prevent any damage or loss. Wires, chains, ropes slings etc. used for handling of the equipments shall be appropriately protected by sleeves or other means to prevent damage to the equipment.

The equipment stored shall be properly protected damage either to the equipment or to the floor where they are stored. The equipment from the storage shall be moved to the actual location at appropriate time so as to minimize risk of damage of such equipment at site.

The Tenderer shall provide means for all unloading and reloading for all consignments of plant, both during transport to Site and on the Site. Consignments shall be unloaded immediately on arrival at Site. The Tenderer is required to take the necessary steps in order to provide the carriage, special supporting structures for heavy loads, etc.

All large parts of the plant shall be brought, as far as possible and practicable, directly to their final place of erection.

* + 1. **Storage Area and Warehouses**

The Engineer will designate areas where the Tenderer may store parts of the plant. The Tenderer shall, at his own expense, render such areas suitable for the respective purposes.

The required space for the storage facilities will be provided suitably leveled and compacted on the Site.

The warehouses shall be weatherproof, with good ventilation and solid floors. The floors of the warehouses and storage areas shall be designed to carry the loads imposed on them by the stored parts. The following parts shall be stored inside enclosed warehouses:

* Electrical parts with electrical devices attached, electric motors and excitation equipment
* Instruments, welding material and equipment, bolts, pins, packing, tools, insulation materials A
* All small parts and parts of the plant which already have been finally painted.

All electrical panels, control gears, motors and such other devices shall be properly dried by heating before they are put into storage. If panels equipped with anti-condensation heaters will be stored over longer period of time (more than one month), the Tenderer shall assure that the heaters are energized.

Motor bearing slip-rings, commutators and other exposed parts shall be protected against moisture ingress and corrosion during storage and motors shall periodically rotated to prevent corrosion due to prolonged storage.

If large parts are stored in the open air, they shall be provided with weather resistant and fire-resistant covers. Electrical parts, which are not packed in heavy-duty polyethylene foil and those so packed, but whose packing has been damaged, shall be kept in suitable place from the moment of storage to the moment of installation.

All insulation materials which will be taken from the warehouse for installation and which are stored temporarily in the powerhouse shall be protected from weather or humidity.

The consumable and other supplies likely to deteriorate due to storage must be thoroughly protected and stored in a suitable manner to prevent damage or deterioration in quality by storage.

The Tenderer shall ensure that all the packing materials, and protection devices used for the equipment during transit and storage are removed before the equipment are installed. The packing materials and protection devices shall remain the property of the Purchaser and shall be handed over to him by the Tenderer after completion of the work. In case, the Tenderer fails to return the packing materials and protection devices, the Purchaser shall have the discretion to deduct from the contract price at a reasonable amount on this account.

If the materials belonging to the Tenderer are stored in areas other than those earmarked for him, the Engineer will have the right to get it moved to the areas earmarked for the Tenderer at the Tenderer’s cost.

The Tenderer shall maintain an accurate and exhaustive record that details out the list of all equipment received by him for the purpose of erection and keep such record open for inspection of the Engineer at any time.

1. **SITE INSTALLATION AND ERECTION**
   1. **Preparation of Site Installation Works**

Prior to commencement of installation, the Tenderer shall closely inspect the Site and all the foundations and structures on which parts of the plant supplied under this Contract will be installed; he shall check that the foundations conform to the installation drawings.

The result of this check shall be reported to the Engineer in due time to allow any errors to be corrected before the commencement of erection. All parts of the plant shall be cleaned carefully of all contamination such as dust, sand, rust, mill scale and other dirt prior to installation.

* 1. **Reference Points**

The Engineer will provide major centre lines and datum levels only. The Tenderer shall be responsible for transferring those required to carry out the Works. The Tenderer shall employ a competent surveyor for setting-out of all datum lines including the constant checking and maintenance of the setting-out until the completion of his works.

The Tenderer shall provide all necessary pegs, profiled templates and centre lines and shall establish all such permanent markings and recovery marks as may be required by the Engineer for checking the Tenderer’s setting-out. The Tenderer shall be responsible for rectifying, at his own cost, all work rejected by the Engineer due to errors in setting- out.

All bench marks, kerb marks, pegs and signals on the surface, alignment pins and the like put in by the Engineer for the purpose of checking the Tenderer’s work or as permanent survey marks will be under the care of the Tenderer during the period of the Contract. He shall, at his own expense, take all proper and reasonable care and precautions to preserve and maintain them in their true position where such marks are within or adjacent to his work area. In the event of their being disturbed or obliterated by any cause whatsoever, they may, if so, determined by the Purchaser, be replaced by the Engineer at the Tenderer’s expense.

The Tenderer shall be responsible for the true and proper staking-out of the works and levels of reference given by the Engineer in writing, for the correctness of the positions, levels, dimensions and alignment of all parts of the works and for the provision of all necessary instruments, appliances and labour in connection with this.

The checking of any staking-out or of any line or level by the Engineer or the Engineer’s Representative shall not in any way relieve the Tenderer of his responsibility for its correctness.

* 1. **Installation Work**
     1. **General**

All transportation and handling of the plant from the place of storage to the place of installation shall be carried out by the Tenderer. He shall also provide all hoisting equipment, staging and scaffolding, winches and wire ropes, slings, tackles and all other appliances and temporary materials. The erection staging and scaffolding shall be provided with coverings and barriers and shall guarantee safe working conditions.

The Tenderer shall comply with all applicable and approved safety regulations while carrying out the works at Site and with all reasonable requirements of the Engineer. This stipulation shall in no way release the Tenderer from any obligation concerning his liability for accidents and damage. He shall be responsible for adequate protection of persons, plant and materials against injuries and damages resulting from his operations.

The plant or parts to be installed shall not be over-stressed during the process of installation.

The Tenderer shall be responsible that the installation of all plants is properly executed to the correct lines and levels and in accordance with the manufacturer’s instructions and the Contract requirements.

The alignment of the plant shall be done exactly; the tolerances indicated by the Manufacturers or in the drawings shall be kept.

Setting of parts to be aligned shall be performed by means of fine measuring instruments. All erection clearances and settings shall be given to the Engineer. After alignment, the parts shall be held firmly in position by means of set pins, fitted bolts, etc.

* + 1. **Standards**

The procedure followed and precautions taken and the equipments and materials furnished / used in the installation work shall in general conform to the applicable Indian and International Standards. The Tenderer for the site installation work must strictly observe the following standards:

* The Electricity Act, 2003
* Indian Electrical Code
* Indian Boiler Regulation and all other applicable statutory rules and regulations fr pressure vessels.
* Indian Factories Act.
* Standard of the National Fire Protection Association (USA)
* Or any other standard or acts – not specifically mentioned but required for the safe, smooth and successful erection.
  + 1. **Embedded Parts**

Anchor bolts, base plates, anchor rails etc. to be embedded in the first stage concrete shall be delivered in due time with instructions and / or templates to facilitate the bringing in of such parts into the Civil Works.

All parts to be embedded in concrete shall be set accurately in position and shall be supported rigidly to prevent displacement during the placing of concrete. Adjusting screws and bolts shall be drawn tight and secure adequately. Steel wedges shall be secured by welding. Wooden wedges shall not be used.

The Tenderer shall verify carefully the position of all parts to be embedded before concrete is poured. All important measurements and dimensions shall be recorded. Copies of these records shall be given to the Engineer for checking and approval before items are built-in to the works.

The Tenderer shall be responsible for the supervision of the building-in work. He shall state the allowable concreting or grouting rates and ant required sequence for pouring in the different places. After concreting, the control measurements shall be verified again, indicated in the above-mentioned records and submitted to the Engineer.

* + 1. **Temporary Bracing**

The Tenderer shall provide all necessary anchors and braces to ensure the alignment and stability of the parts to be installed. All temporary anchors and bracings shall take care of all dead load, wind load, seismic and erection stresses, e.g., during concreting, and shall remain in place until they can be removed without endangering the stability of the plant.

Temporary bracing and attachments shall be fixed and removed in such a way as to prevent damage occurring to the base metal to which they are attached. Projecting welds remaining after this operation shall be ground flush. Tears in the base metal shall be filled with weld and ground flush after completion of work and the surface restored to proper condition by grinding and repainting.

Welding, torch-cutting and drilling work on the plant to be erected shall only be carried out with the approval of the Engineer.

* + 1. **General Notes on Workmanship**

Special care shall be taken not to damage surfaces of galvanized or specially treated plant during erection. Care shall be taken to prevent or remove any rust streaks or foreign matters deposited on galvanized or otherwise finished surfaces during storage or transport or after installation.

Glass parts of other parts which can easily be damaged shall be provided with suitable protective sheaths or coverings during installation.

Machined or bare metal surfaces that are not painted shall be protected during transportation, storage and erection by a suitable anti-corrosion film.

All portable power tools shall preferably be operated pneumatically.

Special tools which are supplied for maintenance and repair can be used for installation. They are to be handed over at the end of the installation work in good condition in accordance with the Engineer’s instruction.

After erection, the works shall be finally painted; it shall be done as far as applicable in accordance with the painting specification, and any damaged paint-work be restored.

1. **INSPECTIONS AND TESTS**
   1. **General**

In addition to the provisions established in the Conditions of Contract regarding general procedure of inspections and tests, terms and definitions, and time schedule for inspections and tests the following stipulations shall apply.

Engineer reserves the right to ask for the valid calibration certificate for any instrument to be used for testing or may get the instrument tested by any independent agency.

* 1. **Type Tests / Routine Tests / Acceptance Tests / Site Tests**

For the specified type tests certificates for the same equipment type, not older than ten years from the date of signing the Contract, shall be submitted for approval by the Purchaser. Incase that the test certificates are older than ten years the Tenderer shall carry out the specified type tests at his own costs.

Tenderer shall have to do all the routine tests, acceptance tests & site tests required as per technical specification and Indian Standards / International Standards.

Tenderer shall have the access to the required facilities as stated in the relevant standards to carry out the tests on the various equipments.

In case, Tenderer does not have the facility to carry out any of the test and intends to carry out the same at some other agency those testing agencies shall be got approved by the Engineer.

* 1. **Workshop Inspection and Tests**

As far as practicable, quality of materials, workmanship and performance of all items of the work and plant to be furnished under this Contract shall be inspected at the places of manufacture.

When placing orders for material and plant with Sub-suppliers, the Tenderer shall send unpriced copies of such orders in triplicate to the Engineer.

Where the Tenderer desires to use stock material, not manufactured specifically for the work, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted. Tests on these materials can be waived.

Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time. Any painting work as well as transport to the Site of the plant shall not be started before the approval of the Engineer has been obtained.

* + 1. **Material Tests**

Unless otherwise specified, the quality of materials shall be verified generally by:

|  |  |
| --- | --- |
| Chemical analysis |  |
| Mechanical tests | (yield point, tensile strength, elongations, notch impact strength, etc.) |
| Welding tests | (welding procedure, welding material, welding tensile strength, welding bend test, welding reversed bend test, etc.) |
| Non-destructive tests | (x-rays, ultrasonic, magnaflux, liquid penetration inspection, etc.) |
| Electrical tests | (voltage, losses, tan delta, insulation, magnetic properties, etc.) |

Certified mill test reports of plates will be acceptable when these comply with the requirement for “Reports of Inspections and Tests” as stated in the Special Conditions. Test specimen and samples for analysis shall be plainly marked to indicate the materials they represent.

Castings and forgings shall be tested in the rough state in order to detect flaws in good time thus avoiding delays. Magnetic particle inspection of important castings shall over the whole surface of the casting. After partial machining, further tests can be conducted.

Load tests on crane hooks, steel wire ropes, chains, etc, shall be considered as material tests.

* + 1. **Checking of Dimensions**

The dimensions, especially clearances and fits, (ISO 286) which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:

* Runout and roundness tolerances of shafts. Rotors, pistons, etc., to be measured on single parts as well as (wherever possible) on the assembled components.
* Fits and clearances of bearings, runners, rotors, servomotor pistons, valves, guiding, distributing and actual actuating elements, etc.
* Accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, water passages in hydraulic machinery, valves, etc.
* Profiles of turbine runners, pump impellers, etc. to be checked by means of templates
* Dimensions of coupling of connections for assembly with other deliveries from the Tenderer, Sub-Tenderer or other Tenderers.
  + 1. **Workshop Assembly**

In addition to the quality and production control tests. The following shop assembly work and tests shall be made to check measurements, fitting and functioning.

Plant to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the Specification, that the delivery is complete, and that no work remains to be done at Site which reasonably can or should be done in the shop.

Where applicable, each item of the plant shall be assembled completely prior to painting.

Field joints shall be temporarily connected.

All parts shall be properly match marked, identified and doweled where practicable, to facilitate correct and quick field assembly and alignment. Where necessary, suitable dowels shall be provided for insertion after field assembly and drilling. The holes for any fitted bolt shall be accurately reamed.

During workshop assembly all instruments, control devices and piping shall be fitted.

If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Engineer. Faulty parts or plant shall by no means be delivered.

* + 1. **Pressure and Leakage Tests**

All parts subject to internal or external pressure or containing any liquids of gases temporarily or permanently during operation shall be tested prior to painting. As far as practicable, these tests shall be done in the shop but can be repeated at Site.

Parts exposed during operation to hydraulic pressure, to gas pressure or to any liquid without pressure, shall be treated distinctively.

In addition to the Specifications, the applicable and approved standards and official regulations shall be observed. If any liquid is used for the test that may cause corrosion, all plant and piping shall be thoroughly cleaned immediately after the test.

As far as practicable and required, the influences of temperatures and temperature differences to which the part will expose during operation shall be considered in the execution of the tests.

Leaks and defects can be repaired if permitted by the applicable standard and approved by the Engineer. If defects are found, the Engineer may reject the defective parts, or permit welding repairs with stress relieving, radiographic examination and additional pressure tests.

* + - 1. **Parts Exposed to Hydraulic Pressure**

Unless otherwise specified or required, the following shall apply: the hydraulic pressure tests shall be carried out using the liquid to be used during operation or a liquid with less viscosity.

The hydraulic test pressure shall be 1.5 times the maximum operating pressure and shall be maintained for a period of two hours or longer if required by the applicable standards. Afterwards the test pressure shall be reduced to the operating pressure.

The welded seams of large parts which are not subjected to any heat treatment during or after welding shall be wrapped with a 500 g hammer during the pressure decrease or treated otherwise to obtain the required effect of stress relief.

Finally, the test pressure mentioned above shall be maintained for ten (10) minutes. Leakages appearing at seals, joints, etc., shall be measured and stated in the test report, together with the relevant pressures.

* + - 1. **Parts Exposed to Gas Pressure**

Parts which will be subjected to gas pressure during operation for example the turbine governor pressure tanks, pressure air tanks and others, shall be inspected and tested according to the official regulations with the respect to design, construction, fittings, etc.

The pressure test shall be executed by applying the test pressure in accordance with the relevant standards and specifications.

* + - 1. **Parts Exposed to Liquid without Over-Pressure**

Parts which shall not be closed and which are exposed to only small pressures of any liquid during operation e.g. bearing housings, oil containers, etc. shall be subjected to a tightness test with a suitable liquid of low viscosity. The testing-period shall not be more than 10 hours, unless otherwise agreed.

* + 1. **Functional Tests**

Functional tests shall be defined as tests of the function of assemblies, subassemblies or parts of the plant under no load conditions. Functional tests shall be performed on all plant prior to the execution of operational tests.

* + 1. **Operational Tests**

As far as practicable operational test shall be carried out on all plant, simulating operating conditions.

Parts to be delivered by sub-suppliers shall be tested either at the premises of the sub-supplier or of the Tenderer, as agreed by the Engineer.

Before testing the Tenderer shall submit a notice containing full information on the tests with detailed tables or graphs on the latest edition of the characteristic values of the plant to be tested and on the test facilities and equipment.

Testing of the electrical plant shall be performed in accordance with applicable Standards; they shall include but not be limited to tests for heating, loading, overloading, losses.

Operational tests of lifting equipment and other machinery shall include tests under nominal load and 125% of nominal load unless otherwise specified.

* + 1. **Electrical Tests**

Electrical plant shall be tested in accordance with applicable Standards and agreed test programs and procedures.

* + 1. **Model Tests**

Model tests for certain parts of the work or plant shall be carried out as specified.

* + 1. **Test Reports**

Tenderer shall have to furnish all the test reports of tests performed on materials, equipments & plants etc. during various stages such as manufacturing, shop assembly etc.

* 1. **Site Inspection and Tests**

During erection, commissioning and Test Service Period operation the Tenderer shall perform at suitable interval all inspections and tests in the presence of the Engineer in order to prove the orderly execution of the works in accordance with the Contract.

Unless otherwise specified, all costs for testing at Site and of the works and charges associated with it shall be born by the Tenderer. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Tenderer for the entire duration of the tests. The Tenderer shall delegate his experts to perform the tests at site.

The procedure of inspections and test at Site, notice to the Engineer, report, commissioning trail runs and acceptance tests shall be finalized as per the General Condition of Contract.

Commissioning and Test Service Period

Immediately upon completion of commissioning of a part or section or the Plant which can operate as an independent unit a “Certificate of Suitability for Operation” shall be issued by the Engineer.

This document shall be signed by an authorized representative of the Purchaser, the Engineer and the Tenderer. On completion of Test Service Period this certificate becomes null and void.

This certificate shall state:

* the supplier of the plant concerned
* the quantity and type of plant concerned
* the conditions of commissioning
* the names of the participants
* the date of commencement of Test Service Period
* the list of minor defects, if any

During the operation in Test Service Periods the Tenderer shall make familiar the Purchaser’s personnel with the properties, the operation and maintenance of the plant and its auxiliaries to such extent that thereafter the duties can be assigned to the Purchaser’s trained personnel.

If any defect of irregularities affecting the safety or reliability of the plant, should arise during the Test Service Period, the Test Service Period shall be interrupted and started again after such defects or irregularities have been corrected by the Tenderer.

* + 1. **Acceptance**

The testing of any part of section of the Plant which can operate as an independent unit, shall be performed in accordance with the standards and regulations laid down in the “Particular Technical Specifications” and following the test procedure agreed upon between Engineer and Tenderer.

Immediately upon completion of any such testing of a part of section of the permanent Plant a “Protocol of Acceptance” which shall be deemed to be the Test Certificate required by Conditions of Contract shall be issued by the Engineer.

This document shall be signed by an authorized representative of the Purchaser, the Engineer and the Tenderer and shall form an integral part of the later “Taking-Over Certificate”.

This “Certificate” shall state:

* The date of testing
* The quantity and type of plant concerned
* Statement of all minor defects and/or irregularities, which have to be corrected by the Tenderer.
* Confirmation that the guaranteed date have been proven
* Confirmation that all contractual documents have been submitted
* Confirmation that the Purchaser’s personnel have been familiarized with the plant and that they will be able to operate and maintain the plant.

If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Tenderer’s responsibility, this part of the acceptance shall be stated in the “Certificate” and be postponed for a mutually agreed period.

1. **CIVIL SITE WORK**
   1. **Scope of Work of the Civil Works Tenderer**

* All concrete work, including reinforcement and formwork, casting foundation of M/C i.e. turbine, generator, panels etc. and all grouting required for filling in, around and under the various parts of the works to be embedded in concrete.
* All necessary excavation and backfilling required for installing the plant in its final position, unless otherwise stated in the Particular Technical Specifications.
* Building in of all required parts into the first stage concrete. The readiness of such parts shall be communicated to the Engineer and they shall be delivered in due time by the Tenderer unless otherwise specified or agreed in the Contract.
* Providing and grouting the block outs for all anchoring and foundation bolts needed to support and fix the plant in its final positions.
* All protective measures. E.g. pumping, etc. to keep the various parts of the plant and the erection site free from accumulated water during the time of erection.
* Provision of cable and ducts, trenches, block-outs, etc., in accordance with the drawings supplied by the Tenderer and approved by the Engineer.
* Adequate safety covers and protective measures against injury or damage to the Tenderer’s employees and equipment and to the works due to any operations of the civil Tenderer.
* Piping, fittings, etc., required for Power House Surface drainage (through gravity) up to the drainage sump.
* Earthwork for foundations, tail race, cable trench etc.

If chequered plates or other covered provided under the civil works required special care for fitting to plant and installations, such work (Cutting, Matching, Welding of supports, etc.) shall be performed by the Tenderer.

* 1. **Checking of Equipment after Grouting**

The Tenderer shall check and verify the leveling and alignment of machinery as applicable before and after grout is done and to ensure that no displacement had taken place during grouting. The values recorded prior to grouting shall be used during such post grouting check-up and verifications. The Tenderer shall maintain such pre and post grout records of alignment details, in a manner acceptable to the Engineer.

1. **SYMBOLS AND ABBREVIATIONS**
   1. **Length, area and volume**

µm micron = m · 10-6

mm millimeter

cm centimeter

m meter

km kilometer

mm2 square millimeter

cm2 square centimeter

m2 square meter

km2 square kilometer

ha hectare

m3 cubic meter

l liter

rad radian

* 1. **Time and time derived units**

s second

min minute

h hour

d day

mm/s millimeters per second

m/s meters per second

km/h kilometers per hour

m/s2 meters per second squared (acceleration)

m3/s cubic meters per second

Hz hertz (periods per second)

* 1. **Mass, force and derived units**

kg kilogram

g gram = kg · 10-3

mg milligram = kg · 10-6

mg/1 milligrams per liter

t ton = kg · 103

kg/m3 kilograms per cubic meter

t/m3 ton per cubic meter

N newton

N/m2 newton per square meter

N/mm2 newton per square millimeter

Bar bar = N/m2 · 105

Pa pascal = 1N/m2

MPa megapascal – Pa · 106

atm standard atmosphere 101325 Pa

J Joule

kJ kilojoule = J · 103

* 1. **Electrical Units**

A ampere

V volt

kVA kilovolt ampere

kWh kilowatt hour

W watt = 1 J/s

kW kilowatt = W · 103

MW megawatt = W · 106

A.C. alternating current

D.C. direct current

HV high voltage (cables)

LV low voltage

* 1. **Other symbols and abbreviations**

approx. approximately

bhp brake horse power

dia. or diam. diameter

fig. figure

hp horsepower

horiz. horizontal

HT high tensile (steel)

max. maximum

min. minimum

no. number (units) as in 6 no.

No. number (order) as in No.6

temp. temperature

°C degrees Celcius

vert. vertical

vol. volume

wt weight

% per cent

M.F.L maximum flood level

H.W.L high water level

M.O.L minimum operation level

M.C.C Motor Control Center

PN nominal pressure

DN nominal diameter

1. **SPECIFIC PROJECT CHARACTERISTICS**
   1. **Site Operating Conditions**

|  |  |  |  |
| --- | --- | --- | --- |
| Altitude of site above sea level | m | Power House (Turbine floor) |  |
|  | m | Switchyard |  |
| Maximum outdoor ambient shade temperature for design purposes | °C 40 |  |  |
| Maximum outdoor ambient temperatures | °C 40 |  |  |
| Relative humidity | \_\_\_\_\_ | Powerhouse |  |
| Earthquakes: |  |  |  |
| Seismic loads shall be considered in accordance with relevant BIS for earthquake. | | |  |

The following values of design Basic Earthquake (DBE) shall be taken into account:

* Horizontal DBE : .15g
* Vertical DBE : .075g
* All the plant included in the supply shall be able to operate during a DBE or resume operation after a DBE without requiring any inspection or adjustment.

A DBE shall not trigger off a shutdown of the generating units. All components or sensors whose function is to control load rejections or emergency shutdowns, shall be insensitive to the DBE or shall be provided with mountings or supports to protect them from the effect of the DBE.

In a more specific way the IEEE recommendations shall be applied to electrical plant.

* 1. **Standard Voltages**

|  |  |  |  |
| --- | --- | --- | --- |
| Rated voltage | kV | 0.415 | 11 |
| Highest system voltage | kV | 0.440 | 12 |
| Rated short time withstand current | kA | 40 | 25 |
| Neutral earthing transformer |  | solid |  |
| System frequency | Hz |  |  |
| Supply voltage for auxiliary plant | AC | 415/240V +10% PE/N | 415/240V +10% PE/N |
| Supply voltage for indications, alarms and supervisory equip. etc. | DC | +10/-15% | +10/-15% |

The stated values for medium and high voltages are rated / highest voltages for plant according to IEC 71-1

* 1. **Colour Coding for Electrical Connections**

Live parts of electrical connections shall be colour coded as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Conductor Designation** | **Coding Alphanumeric** | **Symbol** | **Colour** |
| AC network | Phase 1 | L1 | Red |
| Phase 2 | L2 | Yellow |
| Phase 3 | L3 | Blue |
| Neutral | N | Black |
| DC network | Positive | L+ | White |
| Negative | L- | Black |
| Earth |  | E | Green |

1. **REQUIRED DOCUMENTS FOR ELEC. & MECH. PLANT/INSTALLATIONS**
   1. **General**

The following documents for the electrical and mechanical plant shall be supplied to the Engineer for approval (marked A) or for information (marked I).

For identical items being supplied several times such documents shall be submitted once only.

* 1. **Principal Requirements**

The following documents shall be supplied individually or as a whole for equipment / installations wherever applicable.

* + 1. **Loading Drawings**

For all larger pieces requiring special means for transportation, as for example:

|  |  |
| --- | --- |
| Generator stator | I |
| Generator rotor | I |
| Generator transformers | I |
| Switchgear assemblies | I |
| Turbine runner | I |
| Turbine shaft | I |
| Turbine spiral case | I |
| Turbine draft tube liner | I |
| Turbine draft tube liner | I |
| Main inlet butterfly valve | I |

* + 1. **Foundation Drawings**

|  |  |
| --- | --- |
| For any equipment requiring a foundation or other civil provisions | A |

* + 1. **General Arrangement Drawings**

|  |  |
| --- | --- |
| For the whole plant and for individual area / buildings / rooms / trenches | A |

* + 1. **Short – Circuit Calculations**

For the following voltage levels:

|  |  |
| --- | --- |
| HV network |  |
| MV systems (generators system and MV general & unit distribution systems) |  |
| LV unit and general auxiliary systems |  |
| Unit and general DC systems |  |
| All documents | A |

* + 1. **Load Evaluations**

|  |  |
| --- | --- |
| For all medium and low voltage levels (AC and DC) | A |

* + 1. **List of Plant Identification Numbers**

|  |  |
| --- | --- |
| List of Plant Identification Numbers | I |

* + 1. **Basic Documentation**

For any equipment / installation the following basic documents shall be provided:

|  |  |
| --- | --- |
| Specification for rating plates and labels; including list of inscriptions | A |
| Motor lists | I |
| Workshop test schedule | I |
| Site test schedule |  |
| List of tools and appliances | I |
| List of spare parts | I |

* + 1. **Overall Diagrams**

|  |  |
| --- | --- |
| Single-line overall diagram | A |
| Three-phase overall diagram with phase sequence and vector groups | A |
| Unit control diagram | A |
| Unit control sequence diagram | A |
| Control sequence diagram | A |
| Low voltage distribution diagrams:  Compressed air systems  Drainage and dewatering systems  Cooling water system  Oil purification equipment  Ventilation system | A |
| P&I diagrams for the following systems:  Oil systems of bearings, governor, main inlet valve  Compressed air, cooling water, drainage, dewatering and oil purification equipment  Cooling water system | A |

* 1. **Specific Documents for Electrical Plant and Installations**
     1. **Generator and Accessories**

|  |  |
| --- | --- |
| Outline drawings | A |
| Design drawings:  Stator frame with core and winding  Fixing of stator core to frame  Stator winding  Main terminals  Shaft (including calculation of deflection, critical speeds, max. oscillations with and without prime mover)  Rotor hub and spider  Rotor rim  Pole core  Pole winding  Damper winding  Shaft mounted fans  Bearings (with permissible clearances at standstill, drawling, rated and overspeed)  Bearing insulation  Bearing lubrication and cooling  Rotor jacking device  Slip rings including mounting details | I  I  I  A  I  I  I  I  I  I  I  I  I  I  I  I |
| For generator cooling systems:  Dimension drawing | A |
| For auxiliary systems such CO2-equipment, stand-still heating, as applicable:  Arrangement drawing  Dimension drawings  Circuit drawing | A  A  A  I |
| For excitation and de-excitation system:  Arrangement drawing  Dimension drawing  Circuit diagram  Block diagram  Logic diagram  Terminal diagram | A  A  A  A  I |
| Motor list | I |
| List of measurements | I |
| Drawings for erection / handling facilities | I |

* + 1. **Motors**

For large size motors (if not standard product) the items as mentioned above shall be valid as far as applicable.

For standard motors the following shall apply:

|  |  |
| --- | --- |
| Outline drawing | A |
| Motor list | I |

* + 1. **Medium Voltage Installations**

|  |  |
| --- | --- |
| Dimension drawing for complete distribution boards & for each type of feeder | A |
| Single –line diagrams | A |
| Standard circuit diagrams | I |
| Individual circuit diagrams | A |
| Arrangement drawings | A |
|  |  |

* + 1. **Low Voltage Installations**

|  |  |
| --- | --- |
| Dimension drawing for complete distribution boards & for each type of feeder | A |
| Single –line diagrams | A |
| Standard circuit diagrams | I |
| Individual circuit diagrams | A |
| Arrangement drawings | A |

* + 1. **Batteries**

|  |  |
| --- | --- |
| Specifications including capacity calculation | A |
| Dimension drawing for individual cells & for complete batteries incl.rack |  |

* + 1. **Battery Charges**

|  |  |
| --- | --- |
| Specification including capacity calculation | A |
| Arrangement drawing | A |
| Dimension drawing | A |
| Circuit diagram | I |
| Block diagram | I |
| Logic diagram | A |

* + 1. **Electrical Control and Protection Systems**

|  |  |
| --- | --- |
| Arrangement drawing | A |
| Dimension drawing | A |
| Circuit diagram | A |
| Block diagram | I |
| Logic diagram including tripping scheme for protection | A |
| Single-line diagram (protection diagram) | A |
| Protection co-ordination diagrams | I |
| Specifications for protection relays including tripping curves, setting ranges etc. | I |
| Generator earthing system calculation | I |

* + 1. **I & C and Communication Systems**

|  |  |
| --- | --- |
| Dimension drawings | A |
| Arrangement drawings | A |
| Block diagrams | I |
| Logic diagrams | A |
| Process diagrams | A |
| Circuit diagrams | A |
| Terminal diagrams | I |
| Final list of control elements | A |
| Description of software | I |
| Installation drawings | A |

* + 1. **Cabling**

For power, instrumentation and control installations:

|  |  |
| --- | --- |
| Specifications including calculation for size selection | A |
| Cable list | I |
| Connection diagrams | I |
| Arrangement drawings (cable routing plans) for buried cables | I |
| Cable tray arrangement drawings | I |
| Cable allocation drawing for trays at different locations / trench path, can be combined with above cable tray arrangement drawings | I |

* 1. **Specific Documents for Mechanical Plant and Installations**
  2. **Documents for all Mechanical Plants as Applicable**

|  |  |
| --- | --- |
| Shop test programs | I |
| Material test certificates | I |
| Shop test reports | I |
| Instrument lists | A |
| Wiring diagrams | I |
| Erection procedures | A |
| Site test procedures | A |
| Commissioning program | A |
| Operating & maintenance manuals | I |
| Program for training of Employer’s personnel | I |
| Site test reports | A |

* + 1. **Turbines and Accessories**

|  |  |
| --- | --- |
| Specification (s) | A |
| Component list(s) | A |
| Critical speed calculation | I |
| Outline drawings | A |
| Neat line drawings | I |
| Foundation drawing | A |
| Foundation load calculations | A |
| Hydraulic transients analysis | A |
| Stress analysis for main components | A |
| Design drawings:  Turbine runner  Turbine shaft  Shaft seal  Couplings  Turbine guide bearing  Head cover  Distributor assembly  Servomotors  Bottom ring  Draft tube lining  Draft tube compressor  Wearing rings, facing plates  Turbine assembly  Pipe routings | A  A  A  A  A  A  A  A  A  A  I  A  A  A |
| Safety self-restoring device drawing | A |
| Overspeed device drawing | A |
| Outline drawing of failure (blockage) indicator cubicle | I |
| Efficiency hill chart | I |
| Hydraulic thrust calculation | A |
| Maximum steady runaway speed calculation | I |
| For turbine cooling system:  Dimensional drawing  Specification | A  A |
| Drawings for erection / handling facilities | A |

* + 1. **Governors and Accessories**

|  |  |
| --- | --- |
| Specifications | A |
| Dimension drawings | A |
| Design drawings:  Electronic governor head  Pressure oil unit  Air/oil accumulator  Electro-hydraulic actuator  Hydraulic amplifier  Speed sensor arrangement | A  A  A  A  A  A |
| For turbine control:  Schematic diagram  Block diagram  Circuit diagram | A  A  A |
| Loading drawings | A |
| Drawings for erection / handling facilities | A |
| Foundation drawings | A |

* + 1. **Main Inlet Butterfly Valve and Accessories**

|  |  |
| --- | --- |
| Specification | A |
| Component lists(s) | A |
| Outline drawings | A |
| Foundation drawings | A |
| Hydraulic transient analysis | A |
| Stress analysis for main components | A |
| Design drawings:  Valve body  Base plates and anchoring components  Valve rotor  Trunnions and bearings  Valve seals  Operating mechanism  Servomotors  Dismantling and expansion joint  Upstream connection pipe  Maintenance seal bypass line  Dewatering line  Manhole  Spherical valve assembly  Oil pressure unit with air / oil accumulator  Air inlet / outlet valve | A  A  A  A  A  A  A  A  A  A  A  A  A  A  A |
| For main inlet butterfly valve control:  Arrangement drawing  Schematic diagram  Circuit diagram  Sequence chart of control functions | A  A  A  A |
| Drawings for erection / handling facilities | A |

* + 1. **Pumps and Filters**

|  |  |
| --- | --- |
| Specifications alongwith calculation for pump size selection | A |
| Outline drawings | A |
| Bill of materials | A |
| Design drawings:  Pump impeller  Pump casing  Pump wearing rings  Pump shaft & coupling  Pump shaft seal filter casing  Pump shaft seal  Filter casing  Cross-section of pump & filter assemblies | A  A  A  A  A  A  A  A |
| Pump characteristics diagrams | A |
| Filter characteristics | A |
| Control diagrams | A |
| Sequence chart of control functions for water systems | A |
| Drawings for erection / handling facilities | A |
| Foundation drawings | A |

* + 1. **Compressor**

|  |  |
| --- | --- |
| Specifications | A |
| Outline drawings | A |
| Bill of materials | A |
| Design drawings and cross-section of compressor assemblies | A |
| Air receiver drawings | A |
| Safety valve drawings | A |
| Compressor characteristics diagrams | A |
| Control diagrams | A |
| Instrument list | A |
| Sequence chart of control functions | A |
| Drawings for erection / handling facilities | A |
| Foundation drawings | A |

* + 1. **Oil Purification Equipment**

|  |  |
| --- | --- |
| Specification | A |
| Component list(s) | A |
| Outline drawings:  Oil treatment unit including purifier, dehumidifier and degasser  Oil transfer pumps | A  A |
| Control diagram | A |

* + 1. **Piping and Valves**

|  |  |
| --- | --- |
| Specifications | A |
| Component lists with material specification | A |
| Dimensional drawings | A |
| Arrangement and pipe routing drawings for:  Cooling water system  Drainage and dewatering systems  Compressed air systems  Oil systems | A  A  A  A |
| Procedure for pressure testing at the Site | A |
| Procedure for touch-up painting at the Site | A |
| Drawing for erection / handling facilities | A |
| Foundation drawings | A |
| Evaluation of pressure transients and anchor points loads |  |

* + 1. **Ventilation System**

|  |  |
| --- | --- |
| Heating and cooling load calculation | A |
| Arrangement drawings | A |
| Duct and pipe routing drawings | A |
| Calculation of air distribution and pressure drop | A |

**PARTICULAR TECHNICAL SPECIFICATIONS**

**1. HORIZONTAL TURGO IMPULSE TYPE HYDRAULIC TURBINES, INLET VALVES, GOVERNING EQUIPMENT AND AUXILIARIES**

**1.1 Scope**

This section of the specifications covers the design, manufacture, tests at works, supply, delivery at site, erection, testing at site and commissioning of 2 nos Horizontal Turgo Impulse hydraulic turbines and associated auxiliary and ancillary equipment.

The scope of supply shall include all parts, accessories, and spares etc., which are essential for construction, operation and maintenance of the complete prime mover even though these are not individually or specifically stated or enumerated. Corresponding components, of all the turbines and associated equipment and spares shall be of the same material, dimensions and finish and shall be inter-changeable. The turbine manufacturer shall co-ordinate with the generator supplier so that the generator to be coupled to the turbine is matched in respect of speed, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements.

**1.2 Type and Rating**

The turbine is selected by using scientific methods for selection of turbine which is based on specific speed (Ns), i.e.

Ns = NP/H5/4

where N is the speed of turbine (r.p.m). For direct coupling, the speed of the turbine is assumed to be equal to the speed of the generator (say 1500 r.p.m). P is the power output of turbine (kW) and H is the net head (m). The calculated value is within the specific speed range of Turgo Impulse turbine.

The turbine shall be of the Horizontal shaft Turgo Impulse suitable for coupling directly to horizontal shaft synchronous generator of nominal rating of 50kW each. The direction of rotation shall be clock-wise when viewed from drive end. The rated net head of the turbine shall be **105 m.**

The turbines shall be capable of giving outputs higher than rated outputs to match the overload capability of the generators. Each turbine shall be designed to give a rated output at rated head at generator terminals with nozzle opening of about 80-85 Percent. The turbine shall have adequate capacity commensurate with the 10 % continuous overload capacity of the generators. The turbine would have output higher than the rated output when operating at heads higher than the rated head. The supplier may offer his nearest standard design. The maximum output both at maximum and minimum heads shall be stated in the offer.

The specific speed of the turbine shall be as per the best modern practice and of proven design and operation.

**1.3 OUTPUTS AND EFFICIENCY GUARANTEES AND PENALTIES**

**1.3.1 Output and Efficiency Guarantees**

The rated output of the turbine at rated head shall be stated and guaranteed. The efficiency of the turbine at rated head for 100%, 80% and 60% rated output shall also be guaranteed. These figures shall be applicable for purpose of penalties, rejection limits and bid evaluation as defined in following clauses 1.3.2, 1.3.3 and 1.9. In addition, the output of the turbine at full nozzle opening at net head and rated head shall be stated in the tender.

**1.3.2 Penalties**

**Penalty for Shortfall in Weighted Average Efficiency and Output**

For any shortfall in the tested values of rated output and weighted average efficiency (as determined on the basis described in clause 1.3.4) from the guaranteed values penalty shall be applied at rate of 0.5 (Half) percent of ex-works price of turbine including governing system for every 0.1(one tenth) percent or part thereof by which test figure is less than the corresponding guaranteed figure. The penalties for output and efficiency shall be computed separately and the total amount of penalty shall be the sum of these two. No tolerance shall be permissible over the test figures of rated output. In case of efficiency, tolerance will be allowed as per appropriate IEC test code.

The ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output shall be 10% of the total unit price of turbines and governing system.

**1.3.3 Rejection Limit**

The purchaser has the right to reject the turbine if the test value of either weighted average efficiency or the rated output is less than the corresponding guaranteed value by 2(two) percent or more after allowing tolerance in computation of efficiency.

**1.3.4 Weighted Average Efficiency**

The weighted average efficiency of the prototype turbine shall be determined from the field test or model test values of efficiency at rated head in accordance with the following formula for purpose of penalty and rejection limit and bid evaluation. Tμav =k1 x Tμ100 +k2 xTμ80+ k3 x Tμ60 Where Tμav Weighted average efficiency of the turbine, Tμ100, Tμ80 and Tμ60 are efficiencies of turbine at 100%, 80% and 60% rated output at rated head respectively. The value of K1=0.4, K2=0.3 and K3=0.3

**1.3.5 Rectification to meet guarantees**

The Tenderer shall be given 4 months or mutually agreed time to improve/modify the design of turbine or to carry out rectifications, etc., as may be required so that the guarantees are met in case the tests prove unsuccessful in meeting the guarantees. If the second meeting is also unsuccessful, penalty or rejection of the equipment, as the case may be, shall be applied. However, no delay in the original delivery schedule shall be allowed if the model test results do not meet the guarantees and rectifications are made by the Tenderer thereafter within a period of 4 months or mutually agreed period as stated above.

**1.4 Speed Rise and Runaway Speed**

The moment of inertia of the unit and the normal nozzle closing time shall be so adjusted that the maximum momentary speed rise of the unit shall not exceed 35% and the maximum pressure rise in the penstock shall not exceed 25% of the maximum rated head under any condition of operation. The turbine manufacturer shall coordinate with the generator manufacturer for limiting the speed and pressure rise values. The maximum runaway speed of the unit, both off cam and on- cam, under any combination of head and load conditions shall be stated in the tender. The turbine shall be capable of running safely at maximum runaway speed without any damage to its parts for a period of not less than 15 minutes for every such occurrence, with cooling water supply on.

**1.5 Noise Level**

Maximum noise level resulting from any of the operating conditions shall not exceed 90 db (A) at any place 1.0 m away from operating equipment in the machine hall.

**1.6 Stress and Factor of Safety**

All parts of turbine shall be designed and constructed to safely withstand the maximum stresses during the normal running and runaway and short circuit conditions, out of phase synchronizing and brake application. The maximum unit stresses of the rotating parts shall not exceed two-thirds of the yield point of the material. For other parts, the factor of safety based on yield point shall not be less than 3 at normal conditions. For over-load and short circuit conditions, a factor of safety of 1.5 on yielding point shall be permitted.

**1.7 Bid Evaluation**

In the comparison of the tenders; the equalization on account of differences in the efficiencies of various offers will be made on the basis of weighted average efficiency as calculated by the formula given below: Tμav = K1 x Tμ100 + K2 x Tμ80 + K3 x Tμ60 at rated head. Where Tμav = weighted average efficiency and Tμ100, Tμ80, and Tμ60 are efficiencies at100%, 80% and 60% outputs, respectively, at rated head. The highest figures of weighted average efficiency will be the basis for comparison of prices of turbines with lower efficiencies and will be loaded at the rate of 0.5% of their ex-works prices for each 0.1% difference in weighted average efficiency as compared with the highest weighted average efficiency.

The weighted average efficiency of the turbine will be multiplied by the efficiency of the gear box (if provided) for obtaining overall weighted average efficiency which will be used for bid evaluation.

The basis for selection of the offers shall be the overall economy to the purchaser considering power house civil works, monetized values of efficiencies, prices of matching generator, prices of powerhouse crane required, etc. The speed and setting of the turbine and its design shall be such as to result in the installation of the best generating unit at least cost.

**1.8 Model Test**

The rates for model test as per relevant standards may be quoted separately. The purchaser shall have the option to get the model test performed by the Tenderer at an extra cost after the award of the contract. In that event, the manufacture of any part of prototype turbine shall be started only after the efficiency and other guarantees and requirements of the turbine are established and fulfilled on the basis of model tests. In case the Tenderer has already performed model tests on homologous models, the purchaser may, at his discretion, permit the Tenderer to proceed with the manufacturer after approval by the purchaser of the model test report.

The performance of the model tests either afresh or that had been done earlier shall be as per IEC 193 and 193A in all respects. Hydraulic performance tests shall be made at various nozzle openings to determine machine characteristics including regimes of safe operations, zones of vibration, etc. These tests shall include determination of capacity, hydraulic thrust, runaway speed, nozzle opening output relationship, etc., and such other details as covered in IEC 193 and 193A. Model tests shall simulate all possible normal operating conditions of the prototype for entire range of heads and loads. The tenderer shall clearly mention the time within which the model tests including manufacture of a new model, if required, will be completed. The delivery schedule given by the tenderer shall be reckoned from the date of approval of model tests or model test report or from the time of permission to proceed with the prototype manufacture. If the model test is already available, this shall be submitted within 1(one) month after the award of the contract if required by the purchaser.

**1.9 General Arrangement And Construction**

The turbine shall be of horizontal type Turgo Impulse type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts. The design shall also permit horizontal/vertical\* movement of runner shaft by an amount sufficient for adjustment of bearings and for clearing the joint at the coupling between the turbine and the generator.

**1.9.1 Runner**

The runner shall be of 13/4 chromium-nickel stainless steel having buckets cast integral with the central disc. The composition of the material and the source of runner casting shall be stated in the tender. The runner shall be cast integrally of stainless steel. The shape of the bucket should be such that the jet of water strikes the plane of its runner at an angle of about 200. The runner will be a one-piece construction. The runner will have adequate number of buckets which shall be polished and ground smooth and shall be free from roughness, cracks, high spots, etc. The finished machine and ground runner shall be dynamically balanced in the works before dispatch. The runner shall be either bolted or keyed to the turbine shaft.

**1.9.2 Shaft and Coupling**

The turbine shaft shall be forged carbon steel or alloy steel conforming to IS or other equivalent international standards. Wherever the flanges are integral with the shaft, the same should be conform to American standard ANSI-49.1, 1967. For long larger size shafts, tubular construction of proven design will also be considered. The turbine shaft shall be connected to the runner on one side and to the gear box/flywheel generator shaft on the other side. It shall be of ample size to transmit torque at rated speed without excessive vibration or any distortion.

A renewable and removable sleeve of stainless steel shall be provided wherever the shaft passes through a shaft seal or a gland.

The turbine manufacturer shall co-ordinate and co-operate with the generator manufacturer for proper design and construction. The final alignment of the shaft at site shall be the responsibility of the generator manufacturer.

**1.9.3 Bearings**

The turbine bearings can be:

i) The pad type or sleeve type or Babbitt lined, oil/grease lubricated either self lubrication or forced lubrication type.

ii) Anti-friction ball, roller bearings, oil or grease lubricated.

These bearings shall be guaranteed for a minimum continuous operation of 100,000 (one hundred thousand) hours and the design and performance shall be well proven and established.

The turbine shall be provided with adequate number of bearings. As water flowing through the Turgo runner produces an initial force, it requires thrust bearing on the runner shaft. The bearings shall be designed to withstand operation at maximum runaway conditions with cooling water supply on (if cooling water is provided) for a period of not less than 15 minutes and also for operation at normal speed without cooling water supply for 15 minutes. The bearings shall be provided with a dial type or resistance type thermometer and a pressure gauge with provision for alarm annunciation/shut down on excessive bearing temperatures. The number and type of bearings shall be stated in the tender.

**1.9.4 Shaft Gland**

The shaft gland shall be of the stuffing box/carbon ring type with self-lubricated packing and lantern ring. Any other suitable type of shaft gland will also be considered. The gland shall effectively prevent leakage of water along the shaft under all operating conditions and at standstill and prevent entry of air. In case the location of the gland is below maximum tail water level, an inflatable rubber seal shall be provided for attending the main gland without dewatering the draft tube. A stainless steel sleeve shall be provided on the shaft where it passes through the gland.

Arrangement for providing clean water supply to the gland, if required, shall be made by the Tenderer.

**1.9.5 Nozzles and Needles**

The discharge of each unit will be regulated by spears moving axially in the nozzles or by means of deflectors. The nozzle mouth ring and the needle tip shall be of 13/4 chromium nickel stainless steel. The needle assembly shall consist of an inlet bend, spear nozzle, spear rod, its guide, spear rod seal etc.

**1.9.6 Needle Servomotor**

Each shall be operated by oil operated servomotors of adequate capacity. The servomotors shall be capable of moving the needles smoothly during full opening and closing in required time. Standard available hydraulic cylinders of approved make, proven design and of suitable material can also be used as a servomotor.

**1.9.7 Jet Deflector**

A suitably designed jet deflector, one for each needle, but operated by a common servomotor through levers and links shall be provided to stop the jet stream from impinging on the runner on load rejection to minimize pressure rise in the Penstock. The deflector shall be of forged steel/cast steel/alloy steel.

**1.9.8 Turbine Platform, Walkways, Handrails Etc**

Necessary platforms, walkways, handrails, chequered plates, ladders, etc., complete with supporting steel structure, shall be supplied.

**1.10 Inlet Valves**

The main inlet valves of the turbines shall be butterfly valve type suitable for Gross Head and discharge required for over load capacity of the turbine / generator and connecting to the proposed penstock. The valve shall be suitable for all operating conditions of transient and maximum water hammer. The valves shall be operated by oil, pressure and closed by oil pressure/counterweight, so that it is capable of being closed under all emergencies. All associated equipments such as servomotors, oil pressure units, counterweights, etc., shall be included in the offer. The valve shall close automatically under normal and emergency shutdown conditions. The valve will be complete with inlet pipe, outlet pipe, with expansion joint, by-pass arrangement if required for equalization of pressure on either side of the valve, etc.

**1.11 Governing Equipment**

Each turbine shall be equipped with suitable electronic governor conforming to IEC No. 308/Hydro – Mechanical Governor complete with all accessories. The governor shall be of proven design capable of maintaining control of speed under all conditions of heads and loads. Such governing system shall be complete with actuator unit comprising speed responsive element, restoring mechanism having adjustable temporary and permanent droop setting, load limiting device, speed level control, etc.

The speed responsive element of the governor can be operated by a toothed wheel mounted on the generating unit shaft with speed pick-ups or its equivalent is normally used as an input to speed sensing device. Standard protections like over speed device, brake control, emergency shut down and alarms, etc., shall be provided in the governing systems. The turbines shall also be equipped with suitable load controlling system for parallel operating with grid.

**1.12 Pressure Oil System**

Oil pressure Units system shall comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit.

Provision for emergency shutdown of the unit without any oil pump running shall be made. Gauges, pressure switches etc., will be provided as may be necessary.

**1.13 Compressed Air Equipment**

A centralized high pressure compressed air system common for all the units, if applicable, shall be provided for charging the governor oil pressure vessels. The system shall comprise two numbers of high pressure compressors of suitable capacity, one of them being a standby, a common air receiver and necessary pipes, fittings, valves, pressure switches, etc. The capacity of the system shall be sufficient to cater to all the generating units. The compressed air system shall be of the automatic start-stop design operating under pressure switches control sensing the pressure in the receiver.

The tenderer may also quote as an alternative for providing necessary equipment and devices including nitrogen filled cylinders requires for pressuring the oil pressure vessels with nitrogen gas.

**1.14 Cooling Water System**

The cooling water for generator air coolers (if applicable) generator and turbine bearing coolers, turbine shaft seal if applicable and for other equipment in the powerhouse needing cooling water shall be provided by tapping the penstock. If a higher pressure is needed at low head conditions, booster pumps to obtain the required pressure shall be provided for each tapping. In case the pressure at the tapping is high, suitable pressure reducer shall be provided. The system shall be complete with required number of duplex strainers, fine mesh filters, flow meters, flow indicators, flow relays, pressure gauges, etc.

**1.15 Turbine Instrumentation, Control and Safety Devices**

Each turbine shall be provided with a complete set of instruments, gauges, controls and safety devices on unit control board, for monitoring the conditions of the unit during normal running and emergencies. These shall permit the unit to be started and brought up to speed at the governor location and control during normal running. The instruments and gauges for the turbines include, inter alia, pressure gauges, level indicators, temperature and flow indicators, position indicator, indicating lamps for status indication etc. These shall be placed near the locations of apparatus or in the UCB or both. The safety devices shall comprise equipment and devices for sensing abnormal operating conditions, for giving visual and audible annunciation and shut down the unit, if required. The items, quantities and location are to suit the requirements for safe and satisfactory operation of the generating units and the auxiliary systems.

All the instruments, indicator, gauges, controls, safety devices, etc., shall be complete with necessary detecting element, auxiliary relays, etc.

**1.16 Special Tools, Slings, Consumables etc.**

All special tools, slings, lifting devices, jacks, turn buckles, foundation plates/ bolts, etc., required for erection of the equipments shall be listed and supplied. First filling of oil and= grease (if applicable) with 10% extra quantity is included in the overall scope shall be and supplied along with equipment. Welding electrodes as required for site welding and paint for finishing coat shall be supplied by the Tenderer.

**1.17 Spares**

The spare parts for the turbine and associated equipment considered necessary for 5 years of operation of the generating units shall be supplied by the Tenderer along with the turbines.

**1.18 Shop Assembly and Tests**

The following assemblies and tests shall be carried out on the turbines and associated equipment at the manufacturer’s works before dispatch in the presence of the purchaser’s representatives if desired by the purchaser and test certificates shall be submitted whether or not the tests were witnessed by the purchaser.

i) One turbine, manufactured first, shall be assembled in the shop to the extent possible.

ii) Static and dynamic balancing of runners.

iii) Hydrostatic testing at 1.5 times the maximum working pressure including water hammer for not less than 15 minutes for the main inlet valve, spiral case, servomotors, etc.

iv) Non-destructive testing of welds.

v) Performance tests for individual auxiliary equipment.

vi) Complete assembly and operational tests of governors.

vii) Assembly of spiral case and draft tube liner.

viii) All motors/pumps/compressors, etc., shall be tested as per relevant Indian or other standards.

**1.19 Field Acceptance Tests**

The turbines shall be tested at site for establishing fulfillment of guarantees in respect of turbine output and efficiencies including weighted average efficiency. The tests shall be carried out as per IEC 41 for Field Acceptance Tests of hydraulic turbines.

The arrangements for these tests will be made, including the testing devices, by the Tenderer.

**1.22 Commissioning Tests**

The Tenderer shall carry out the commissioning tests in accordance with IEC 545. The turbine, after continuous operation during the trial operation of one month, shall be free from problems of leakages, overheating, failure, damage etc. The machine will be handed over to purchaser thereafter. Subject to fulfillment of all other conditions laid down in the contract elsewhere.

**1.21 Erection**

The Tenderer shall depute experts in erection, testing and commissioning of turbines, governors and associated equipments for erection, testing and commissioning of these.

**1.22 Tender Drawings**

The following drawings shall be furnished by the tenderer for vetting and approval:

a) Drawings of the main cross section of the turbine showing the various components, parts/assemblies of the turbine to the extent possible.

b) Layout drawings of the power house showing the overall dimensions and layout of turbines, etc., clearly indicating unit spacing dimensions of spiral casing, draft tube and all important elevations.

c) Schematic drawings of piping system, control system and instrumentation.

d) Physical and schematic drawings and descriptive literature on the governor and governor mechanism.

e) Charts/curve showing performances and cavitation characteristic of the turbine

f) Curve showing areas and velocities at different sections of draft tube.

g) A list of tests to be performed at site on sub-assemblies and equipments.

h) A complete list of equipments auxiliaries, etc. covered in the quotations.

i) Model Test Report

j) Quality Assurance Plan

**2. ALTERNATING CURRENT GENERATORS, EXCITERS, VOLTAGE REGULATORS AND ACCESSORIES**

**2.1 SCOPE**

This section of the specifications covers the design, manufacture, test at works, supply, delivery at site, erection, testing at site and commissioning of 2 nos. Horizontal AC generators complete with excitation system, voltage regulating equipment, neutral grounding and generator terminal equipments including CTs. PTs, (as per protection schemes) surge protection equipment, etc., and auxiliaries such as CO2 generator firefighting equipment (if required), lubrication system (if required), oil, water and air piping with valves and fittings, instrumentation, controls and safety devices (as required), spares for 5 years operation of the plant, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements. The scope of supply shall include all parts, accessories, spares etc., which are essential for construction, operation and maintenance of the complete generator even though these are not individually or specifically stated or enumerated. Corresponding components of all the generators and associated equipments and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

The generator manufacturer shall co-ordinate with the turbine supplier so that the generators to be coupled to the turbine is matched in respect of speed direction of rotation, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements

**2.2 TYPE AND RATING**

The generator shall be designed and manufactured on the basis of following requirement

i) Number required two sets

ii) Type Horizontal shaft, water wheel driven, alternating current synchronous generator

iii) Rated output 50kW

iv) Rated kVA 62.5

v) Power factor 0.8 lagging

vi) Frequency 50 Hz

vii) No. of phase 3

viii) Rated terminal voltage between the phases 0.415 kV

ix) Range of voltage with which rated output + 10 percent must be available

x) Range of frequency variation + 3 percent (48.5 Hz – 51.5.Hz)

xi) Rated speed to be given by manufacturer.

xii) Direction of rotation In accordance with the turbine

xiii) Runaway speed To co-ordinate with turbine manufacture

xiv) Short circuit ratio Not less than 0.8

xv) Moment of inertia at the whole generating Not less than 1

unit GD2

xvi) Stator-winding connection Star (Y)

xvii) Ratio of quadrature axis sub transient Less than 1.25

reactance to direct axis sub transient

reactance xnq/xnd

xviii) Generator earthing through a distribution Star point earthed

transformer

xix) Cooling water temperature 30 degree Celsius

The generator shall be capable of delivering maximum continuous output of 110% of the rated output at rated power factor. The tenderer may offer his nearest standard. The generator will be connected to the turbine directly or through speed increaser which will be supplied by the turbine supplier. All generator terminals shall be brought out of the stator frame for insertion of current transformer for protection, metering and surge protection apparatus. The generator neutral shall be grounded suitably and the generators shall be designed to safely withstand any mechanical/magnetic stresses resulting from either a three phase or a single phase fault.

Each generator shall comply in all respects with the requirement of the latest issue of Indian Standard IS:4722 except where specified otherwise.

**2.3 SPEED RISE AND RUNAWAY SPEED**

The moment of inertia of the generator together with the moment of inertia of the turbine and flywheel (if any) shall be such that the maximum momentary speed rise on full load rejection shall not exceed 35 % of the rated speed. The generator manufacturer shall co-ordinate with the turbine manufacturer to limit the speed rise to this value.

Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at the maximum runaway speed. The runaway speed test shall be considered successfully if after undergoing the test ‘no injury’ is apparent. The runaway speed test may be carried out at site for which the purchaser would provide suitable foundations that will withstand the test.

**2.4 NOISE LEVEL**

The noise level shall not exceed 90 db (A) when measured at a distance of 1m from any component of the generator.

**2.5 INSULATION AND TEMPERATURE RISE**

Insulation shall be provided as follows:

i) Stator winding material corresponding to class F.

ii) Rotor winding material corresponding to class F.

The generator shall be capable of delivering rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding the following values of temperature rise over ambient temperature (30oC)

(a) Stator winding 60o C

(b) Rotor winding 60o C

Stator Core 55o C

The maximum temperature rise when the generator is delivering maximum output corresponding to continuous overload capacity for conditions stated above shall not exceed 60o C for both stator and rotor windings.

**2.6 EFFICIENCY AND OUTPUT GUARANTEES**

Within the limits of temperature rise specified above, the rated continuous output of the generator shall be guaranteed under penalty with a rejection limit of minus 2% for the rated generator terminal conditions. The weighted average efficiency of the generator shall be guaranteed under penalty with a rejection limit of minus 2%. The efficiencies shall be determined by the summation of losses method as specified in latest Indian Standard IS:4889. For any shortfall in the test value of output and weighted average efficiency (as determined below) from the guaranteed figures, the penalty shall be at the rate of 5% of the ex-works value of generator per generator for every 1% by which the test figure is less than the guaranteed figure. The weighted average efficiency = 0.40 x efficiency at full load + 0.30 x efficiency at 80% full load + 0.30 x efficiency at 60% full load. The penalty on account of output and efficiency shall be computed separately and the total amount of penalty shall be the sum of the two. The ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output will be 10% of the total unit price of the generators.

No tolerance shall be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant Indian Standard.

**2.7 BID EVALUATION**

For the purpose of comparison of tenders, the equalization on account of differences in the weighted average efficiencies between various offers will be made on the same basis as indicated for penalties, i.e., the prices of generators with lower efficiencies will be loaded at the rate of 0.5% of x-work price each 0.10% (one tenth) difference in weighted average efficiency as compared with the highest weighted average efficiency.

**2.8 STRUCTURAL DETAILS**

**2.8.1 STATOR**

**2.8.1.1 Stator frame**

Frame shall be fabricated from M.S. plates and to be rigid enough to take the stresses transferred during core assembly. Ventilating ducts of suitable dimensions with wire mesh shall be provided on outer periphery of the frame. The frame shall have its own foundation plate, which shall be fixed with the existing foundation bolts if possible. The bidder shall coordinate with turbine supplier for details of centerline of stator frame to be kept. If necessary, suitable fabricated structure should be provided to fix the generator sole plates with the existing foundations.

**Stator core**

Stator core material shall be of high quality Electro technical sheet sheets of grade 50C 270 as per IS 648. Core punching may be in one piece or in segments. Punching shall be degreased cleaned & dried before varnishing. Core plate varnish with class `F’ properties shall be applied and over dried. Both side thickness of the varnish shall be restricted to 6- 7 microns. Insulation resistance shall be measured and recorded. The segments shall be assembled in stator frame with the help of wedges. In case punching are in segments these shall be staggered in alternate layers. The punching shall be pressed between pressing plates welded with fingers as per bidders shop specifications. However, no looseness in core assembly shall be permitted. Bidders shall ensure monolithic stator core frame inside to outside. Assembled core shall be tested for core losses & hot spots if any. Proper record shall be kept for the test procedures & observations. After completion of core loss test, stator slot portion shall be painted with conducting varnish.

**2.8.1.3 Stator Windings**

Windings shall be multi turn with tip to tip class `F’ insulation system, manufactured by VPI system. The copper for elementary conductors shall be ETP as per IS 191. The section shall be rectangular in shape. The self insulation of elementary conductor shall be glass braiding with class `F’ varnish. Other insulation details like liners, packers & slot wedges shall also be of class `F’ material. Over hang portion of the winding on both sides shall be supported on suitable binding rings and lashed properly with packers of suitable thickness to provide adequate rigidity to the overhanging portion against dynamic forces . Three main & 3 neutral terminals shall be brought out.

**2.8.2 ROTOR**

**2.8.2.1 Shaft & Spider**

Generator shaft shall be of forged steel in one piece including extension for mounting the turbine runner. The shaft shall be heat-treated & accurately machined. Spider shall be of fabricated type with central bush to be shrink fitted on the shaft. Suitable arrangements shall be provided to fix the poles on the rotor body. Generator supplier shall coordinate with turbine manufacturer for mounting the turbine runner on the extended portion of the generator shaft and flywheel required for turbine governing. If any additional flywheel is required excluding generator rotor effect, it shall also be mounted on the generator shaft. The high frequency generator shall also be mounted on the generator shaft.

**2.8.2.2 Poles**

The field poles shall be laminated from stamped sheets of suitable thickness, and fixed between iron plates and fitted to the rotor rim/spider/rotor body. The form of pole shoe shall be such that sine wave of voltage at no load performance of the generator is achieved. Field windings shall be made of copper bends on edges. The subsequent turns shall be insulated with pretreated Nomex paper of suitable thickness of class `F’ properties.

The body of the poles shall be isolated with glass insulation. Temperature limits for field windings shall be 60oC which shall ensure the reliability of operation and long life of insulation system. Pole coil connections shall be soldered with suitable grade of material.

**2.8.2.3 Current carrying leads**

Suitable arrangement from diode wheel shall be provided for transferring power from diode wheel to the field poles. The field current shall be fed directly from diode wheel to the rotor winding through cable. The cable /current carrying leads shall be insulated with class `F’ insulating material. The leads shall be secured perfectly for any slippage due to centrifugal forces.

**2.8.2.4 Bearings**

There shall be two bearings one on either side of the generator, the bearing shall be of pedestal type with bearing sleeves in two half. The bearings shall be cooled by circulating oil coolers mounted in the oil bath. Suitable temperature measuring devices viz. RPT&TSD with two contacts shall be provided for measurement of bearing metal temperature. Suitable flow relays in water flows system with alarm & tripping for low water supply shall also be provided. Bidder shall furnish the complete details of bearing being provided along with the offer. The bearing metal temperature rise shall not exceed 20-25oC. The bearing shall be capable to withstand forces due to earthquake of magnitude 0.3g in both the directions.

**2.8.3 Ventilation System**

Cooling system for the generator shall be open ventilating type. Two fans of suitable design shall be provided at both ends of the generator rotor. These fans shall suck the cold air from sides and hot air after cooling stator winding & core shall be exhausted from the ducts provided on the stator frame.

**2.8.4 Heating Of Generator In Stand Still Conditions**

At each end of the generator heating elements of suitable capacity shall be installed to avoid condensation when the unit is under shutdown. The temperature to be maintained shall be 5oC above the surrounding temperature. Necessary thermostat to be provided for auto on/off of the heating elements.

**2.8.5 Bearing Oil Coolers**

Coolers shall be manufactured with cupro-nickel tubes grade Cu Ni 30 as per IS 1545. Adequate surface shall be provided to evacuate the bearing losses. These shall be plugged to the oil bath. Necessary cooling water flow arrangement shall be provided for oil cooling. Oil temperature at full load shall be less than 25oC.

**2.9 FIRE PROTECTION FOR GENERATOR (OPTIONAL)**

An automatic carbon dioxide fire protection system complete with CO2 cylinders, ring headers, discharge nozzles, temp. detectors etc., shall be provided as a common system for all the generators. The temperature detectors shall be of the rate of the rise of temperature type. Automatic control shall be arranged to discharge CO2 into the generator in the event of operation of temperature detector or of the differential relay of the generator (if provided). The system shall be complete with manual operation arrangement to release CO2 and with all necessary pipes, fittings, directional valves, etc.

**2.10 OIL AND GREASE**

The tenderer shall indicate this requirement and give his recommendations with detailed specifications regarding type of oil/grease to be used for lubrication of generator bearings. The oil if used for generator bearing lubrication, etc., shall be identical with that used for the pressure oil system of governor. The generator and turbine manufacturers shall cooperate to ensure that their recommendations regarding oil are identical. The first filling of oil with 20% extra shall be supplied along with the generator

.

**2.11 THE FLYWHEEL**

A separate flywheel of ample dimensions shall be supplied in case the required moment of inertia for limiting the speed rise/runaway speeds in case not available from the generator rotor (through the speed increaser, if envisaged). Necessary provision for receiving the piston of the brake cylinder on application of brakes shall be made in the flywheel.

**2.12 EXCITATION SYSTEM**

**2.12.1 General**

The excitation system shall be of brushless type.

**2.12.2 Automatic Voltage Regulator (If Not Already Included In the Excitation System)**

An automatic voltage regulator, complete with an enclosed master element, voltage adjusting rheostat, contactors, etc., shall be provided with each generator for the automatic control of the generator exciter. The voltage regulator shall be anti-hunting. The voltage regulator shall be capable of maintaining the generator terminal voltage at and pre-set value and at the same time sharing the reactive kVA of the load between the two similar units.

The voltage regulator shall be sensitive to the charge of plus or minus 0.5 (one half)% 0f normal voltage (average of three phases) of the generator when operating under steady load conditions for any load or excitation within operating range and shall initiate corrective action without hunting.

After the initial maximum voltage following any load rejection up to 110 (One hundred and ten)% of rated load, the automatic voltage regulator shall restore the terminal voltage to a value not more than 5(five)% above or below the voltage being held before the load rejection and shall maintain the voltage within these limits throughout the period of generator overspeed. The voltage regulator shall be provided with cross-current compensating devices for parallel operation of generators.

A voltage adjusting rheostat suitable for manual and also for motor operation by remote control shall be furnished with each voltage regulator equipment. The range of the voltage control shall extend from 90 (ninety)% to 110 (One hundred and Ten)% of rated voltage of generator.

**2.15 CURRENT TRANSFORMERS**

The current transformer will be epoxy cast, dry type unit conforming IS:2705. The current transformer shall be designed to withstand the thermal and magnetic stresses resulting from the maximum short circuit current.

The technical requirement and location of the CTs are given in the drawing. The generator suppliers shall supply suitable transformer for the protection scheme and these shall be installed in the neutral grounding and line terminal cubicles.

The current transformers should be suitable for metering and protection.

The following protections are recommended:

i) Three-pole differential relay (87 G)-3 CTs on the neutral of the generator and 3 CTs on the phase.

ii) Over-current and earth fault relay (50/51 and 64)

iii) Rotor earth fault protection single stage ( 64 R)

iv) Stator earth fault protection (64 G)

v) Over voltage protection (59)

vi) Field failure protection (40)

vii Negative phase sequance (46)

viii) Reverse Power Protection (32)

ix) Over speed frequency protections (81)

x) Voltage restrained over current relay (SIV)

**2.16 LIGHTNING ARRESTORS**

The lightning arrestors shall be heavy duty indoor station class non-linear resistor type suitable for repeated operation to limit voltage surges on alternating current power circuits and to interrupt power follow current. The arrestors shall conform to IS:3070 (latest edition)Part-I. The nominal discharge current of lightning arrestor shall not be less than 5KA.

**2.17 SURGE CAPACITORS**

The surge capacitors shall conform to the latest edition of IS:2834 and shall be rated 0.25 microfarad. The capacitors shall be connected in parallel with lightning arrestors and shall be provided with a built-in discharge resistor. The capacitor shall be suitable for indoor mounting.

**2.18 UNIT CONTROL BOARD AND GENERATOR INSTRUMENTATION AND CONTROL**

The generator supplier shall supply all equipment and devices for control, instrumentation and safety relating to the generator. These together with the equipment supplied by the turbine supplier shall constitute a complete and coordinated set of instruments, gauges, and control and safety devices for control of the units during normal running and in emergencies. indicating instruments, gauges, control and safety devices will be mounted on the unit control board to be supplied by the generator supplier. The turbine supplier shall supply necessary loose items for mounting on the unit control board. The generator manufacturer shall fully coordinate with the manufacturer of turbine to ensure a neat and functional arrangement of the cubicles. The generator manufacturer may increase/decrease items according to requirements to suit the type and design and also for proper and satisfactory operation of the units. The alarm and annunciation panel with all necessary annunciation relays, aux relays, alarm bell, terminal bolts etc., and adequate number of alarm annunciation fascia windows for both turbine and generator shall be provided. The generator manufacturer shall fully co-ordinate with the turbine manufacturer in this regard.

**2. 19 SPARES**

The tenderer shall indicate in the tender any additional spares that he would recommend for 5 years’ operation and furnish item wise unit prices for the same.

**2.20 TESTS**

The first generator shall be completely assembled at works and types tests as specified below shall be conducted on the assembled unit and auxiliaries as per the latest edition of IS:4722.

**2.20.1 Type Test on First Generator**

a) Temperature rise test.

b) Dielectric test.

c) Efficiency test.

d) Excess current test.

e) Runaway speed test.

f) Moment of inertia of rotating parts (by mutual agreement between the purchaser and the Tenderer)

g) Wave form

h) Determination of characteristic:

i) Reactances – Synchronous, transient, sub transient, negative phase sequence and zero phase sequence.

ii) Rated current, zero power factor lagging saturation curve.

iii) No load and short circuit saturation curve.

**2.20.2 Routine Tests on all the Generators**

a) High voltage test on stator coils and stator sections and on assembled stator.

b) High voltage test on field coils and poles.

c) Insulation resistance tests.

d) Impedance and voltage test on field coils.

e) Accuracy test for RTDs and dial type thermometers.

f) Hydraulic tests on oil, and air coolers.

**2.20.3 Tests on Exciters and Regulating Equipment (For Rotating Exciters)**

a) High voltage test.

b) Temperature rise test.

c) Measurement of resistances.

d) Measurement of insulation resistance.

e) Regulation test.

f) Commutation test.

g) Excitation response ratio.

**2.20.4 Additional test, if any, as recommended by the supplier.**

**2.20.5 Tests At Site**

Site test for each generator shall include the following:

a) Mechanical run.

b) Measurement of stator and rotor winding insulation resistance.

c) High voltage dielectric test.

d) Measurement of shaft voltage (if applicable)

e) Measurement of stator and rotor winding resistance.

f) Phase sequence test.

g) Load acceptance and rejection test at selected loads from no load to full load.

h) Overall response of machine and excitation system to system voltage changes.

i) Adjustment of AVR.

j) Synchronizing test.

k) Checking and commissioning of various other auxiliary equipment.

**2.20.6 Test on other equipment like CTs, PTs, LAs shall comply with the routine tests, etc., as per relevant standards.**

Test report for all type tests on the generator, CTs, PTs, etc., carried out on similar equipment already supplied shall be furnished for approval.

**2.21 TESTING EQUIPMENT**

A list of field testing equipment along with item-wise rental prices rental prices shall be indicated in the tender.

**2.22 SPECIAL TOOLS**

The Tenderer shall supply a complete set of special tools and other equipment that may be necessary or desirable for operation and maintenance of the generator and auxiliary equipment of his supply. The tenderer shall submit a list of the above and include the price in tender.

Any special reamers or broaches and brazing equipment for all work which must be done in the field, shall be provided by the Tenderer.

**2.23 DRAWINGS**

In addition to the drawings called for, the following drawings and data shall be submitted with the tender.

The drawings containing all the information required for designing the civil works shall be supplied within 60 calendar days of the placement of letter of intent:

i) The general arrangement and overall dimensions of the generators, exciters (where applicable) and bearings, and showing positions of main and neutral terminals.

ii) Description of lubrication system along with drawings.

iii) Physical and schematic drawings of excitation system and AVR along with descriptive literature.

iv) Graphs showing predicted characteristic of the generator.

v) Generator layout drawings showing overall dimensions and layout of all ducts, cables, piping, relative positions of auxiliaries, etc.