SECTION - I

INSTRUCTION TO TENDERERS

1.0 DEFINITION OF TERMS

In the Contract, the following expressions shall, unless the context otherwise requires, have the meanings, hereby respectively assigned to them.

The **'Contract'** means the Documents duly signed by both the Parties, forming formal Agreement executed between Power & Electricity Department, Govt. of Mizoram, Aizawl and the Tenderer.

'Contract Price' shall mean the total sum of financial involvement named in or calculated in accordance with the provisions of the Contract Price.

'Equipment/Materials' shall mean and include all Machinery, Apparatus, Materials etc to be provided/supplied under the Contract by the Tenderer

'F.O.T Price' shall mean the cost of equipment up to destinations as specified in the Contract. The cost should include all Taxes (Central, States etc) Duties, Freight, Insurance, any other Taxes and Charges up to destination.

'General Conditions' shall mean these General Conditions of Contract.
'Month' shall mean a Calendar Month.

'Owner' means the Power & Electricity Department, Govt. of Mizoram, Aizawl.

'Project' refers to that mentioned under the headings of the Tender Specifications.

'Purchaser' shall mean the Engineer-in-Chief, Power & Electricity Department, Govt. of Mizoram, Aizawl.

'Purchaser's Representatives' shall mean any Person or Consulting Firm appointed and remunerated by the Purchaser to Supervise, Inspect, Test and Examine Workmanship on the Survey, Supply and erection works.

'The Tenderer' shall mean the Tenderer whose Bid has been accepted by the Purchaser and shall include the Tenderer's Executors, Administrators, Successors and permitted assigns approved by Engineer-in-Chief, Power & Electricity Department, Mizoram, Aizawl.
'The Engineer/Engineer in charge' shall mean the Engineer appointed by the Purchaser/Owner for the purpose of this Contract.

'Specification' shall mean the specification annexed to or issued with the General Conditions and shall include the Schedules and Drawings attached thereto as well as samples and patterns, if any.

'Ton' or **'Tonne'** used in these specifications shall mean Metric Ton, unless otherwise specified.

'Plant' is any integral part of the works, which has mechanical, electrical, electronic or chemical or biological functions.

'Contract Documents' shall mean the following documents which shall be deemed to form an integral part of this Contract.

i) Contract Agreement, Instructions to Tenderers and all conditions of contract.
ii) Tenderer's proposal including the letters or clarifications there to between the Tenderer and the Purchaser prior to award of Contract and
iii) Equipment Specifications and Drawings. In the event of any conflict between the above mentioned documents, the Contract Agreement shall prevail.

'Works' means the materials and equipments to be supplied and the work to be executed as defined and set out in the specifications and includes all extra Work, Additions, Deletions, Substitutions and Variations ordered by the Engineer in accordance with the provisions of the Contract.

"Tenderer' means the Person, Firm or Corporation tendering for the works and His/Its Executors or Administrators or Successors or Assigns.

'Site' means the land on, under, in or through which the works are to be executed or carried out or such lands as may be agreed between the Owner and the Tenderer as being reasonable and necessary for the carrying out of the work.

'Sub Contractors' used here refer to a Party or Parties having a direct contract with the Tenderer and to whom any part of the Contract has been sublet by the Tenderer with the consent in writing of the Engineer-in-Chief.

'Labourer' shall mean all categories of labour engaged by the Tenderer, his Sub-Tenderers and his piece workers for work in connection with the execution of the work covered by the specifications. All these labourers will be deemed to be employed primarily by the Tenderer.

'Fiscal Year' shall mean a year beginning on 1st April and ending on 31st March in the succeeding year.

'Security Deposit' shall mean all deposits whether in Government Securities, Fixed Deposit Receipts or Bank Guarantees from Nationalized Banks of India, amounts deducted from interim payments or in any other form as specified by the Purchaser pledged to the Owner for due performance of the Contract and shall be adjusted in case of compensations or penalties and which may stand for future either in part or whole as the situation demands.

Letter of Intent means the letter from the Engineer-in-Chief conveying his intention to accept the Bid subject to reservations as may have been stated therein.

Letter of Award/Instruction to Commence means the letter from the Engineer-in-Chief notifying the formal acceptance of the Bid subject to the terms and conditions finally arrived at after conduction/negotiation (if any).

'Manufacturer' used herein refers to the party proposing to design, fabricate and manufacture as specified complete or in part.

'Authorised Representative' of the Owner shall mean any Authorised Officer of the Owner from the level of Junior Engineer and above.

2.0 Qualifying Requirement

Qualification of a Tenderer will be based on meeting the minimum criteria specified in Part-A below regarding the Tenderer's technical and financial position as demonstrated by the Tenderer's responses in Application. The Tenderer shall also be required to furnish the information specified in Part-B.

The prospective bidders shall also satisfy all the conditions mentioned below as (i) and (ii)

(i) The firm or at least one member of the Joint Venture/Associates must have work in hands in the North-East for Civil and Electro Mechanical works involving construction of at least one Small Hydel Project of 4 MW capacity in any part of the North-East in the last three years. Work experience in Small Hydel Projects in Mizoram will be an advantage.

(ii) The firm must have manufactured, supplied and erected successfully at least one Pelton Turbine Project of capacity not less than 4 MW to any Govt./Public Sector organization in the North-East in the last 3 years. Necessary certificate from the client in this respect should be submitted. In case of intended Joint Venture/Associates this condition shall be satisfied by at least one member of the proposed Joint Venture/Associates entity.

Documentary evidence in respect of all conditions of 2(i) to 2(ii) is to be submitted along with the tender.

The Owner may assess the capacity and capability of the Tenderer in Qualification Stage, to successfully execute the scope of work covered under the package within stipulated completion period. This assessment shall include (i) Document verification (ii) Visit to manufacturing plant of the Tenderer (iii) Details of works executed, works in hand, anticipated in future & balance capacity available for the present scope of work (iv) Details of plant and machinery, manufacturing/testing facilities, safety equipments, manpower and financial resources (v) Details of quality system in place (vi) past experience and performance (vii) Customer feedback (viii) Banker's feedback etc.

P&E Department reserves the right to waive minor deviations if they do not materially affect the capability of the Tenderer to perform the contract.

2.1 PART-A

2.1.1 Technical Experience:

The Tenderer shall have completed design, manufacture, test at works, supply, delivery at site, erection, testing at site and commissioning of the Electro-Mechanical equipments of Hydroelectric Project(s) within the last seven (7) years as on date of NIT as per the following details:

a) **Three similar completed** works, each of value not less than **Rs. 623.0 lakhs.**

or

b) **Two similar completed** works, each of value not less than **Rs. 934.0 lakhs.**

or

c) **One similar completed** work, of value not less than **Rs. 1245.0 lakhs.**

The completion of the work(s) should have been completed prior to the date of opening of bid. Documentary evidence in respect of the above will be required with the technical Bid.

2.1.2 Financial position:

Minimum Average Annual Turnover **(MAAT)** for best three years out of last five of the firm should be **1556.50 Lacs**

2.2 PART-B

2.2.1 The Tenderer shall provide evidence satisfactory to the Owner of their capability and adequacy of resources to carry out the Contract effectively. Accordingly, bids shall include the following information:

(a) Copies of original documents defining the constitutions or legal status, place of registration and principal place of business; written power of attorney of the signatory of the "Applicant" to commit the plant.

(b) Firm's credentials including its past experience in executing similar type or works and also the list of ongoing projects.

(c) List of plant, machinery, manufacturing and testing facilities

(d) List of manpower with qualification and designations

(e) Quality assurance system with designated quality officer and Nos. of safety officer with PPE (personal protective equipment)

(f) Photographs showing similar works completed up to date.

2.3 The Tenderer shall also furnish following documents/details with its 'Application ':

(i) A certificate from banker indicating various fund based/non fund based limits sanctioned to the Tenderer and the extent of utilization as on date. Such certificate should have been issued not earlier than three months prior to the date

of submission of 'Application'. Wherever necessary P&E Dept. may make queries with the Tenderer's bankers;

(ii) The complete annual reports together with Audited statement of accounts of the company for last five years preceding the date of submission of the 'Application'.

2.4 Tenderers are required to furnish the list and value of such contracts executed/being executed/awarded till date with completion schedule and actual time of completion supported by documentary evidence e.g. Copy of Agreement/Letter of Award, Payment Certificate, Completion Certificates, copy of profit and loss account and Balance Sheet for the best three financial years out of last five financial years duly certified by Chartered Accountants (statutory auditors in case of limited/private limited company), Banker's Solvency Certificate ,Partnership deed / Affidavit as applicable , based on which it can be ascertained that the Tenderer meets the qualifying Requirements. All the documents are to be submitted along with the bid as per instructions given in the Special conditions of Contract.

2.5 Notwithstanding anything stated above, P&E Dept. reserves the right to assess the Tenderer's capability and capacity to perform the contract should the circumstances warrant such assessment necessary in its overall interest.

2.6 It is imperative/must for each Tenderer to satisfy himself completely of all local conditions and assess any problems relating to the means of access to the site. right of way shall be the joint responsibility of successful Tenderer and the department. a Tenderer shall be deemed to have full knowledge of the site (whether he inspects or not) once they submit the bid.

3.0 Earnest Money

The Tenderer shall have to furnish Earnest Money for Rs. 25 lakh (Rupees Twenty Five Lakhs) only in the form of Bank Guarantee Bond as per the standard form at Appendix-III (enclosed) from a nationalized bank pledged in favour of the Engineer-in-Chief, Power & Electricity Department in a separate cover super-scribing the Tender Specification, Number and Date of opening failing which the Tender will not be opened. Tribal Tenderers are allowed to submit Earnest Money for half the above amount. Manufacturers registered with NSIC, DGT&D and also SSI unit under Government of Mizoram is exempted for payment of Earnest Money provided Registration Certificate is enclosed.

4.0 Validity

Tender should be kept valid for a period of 365(three hundred sixty five) Calendar days from the date of opening of Tenders. Validity less than 365 (three hundred sixty five) days will be liable for rejection.

5.0 Examination of the Documents

The Tenderer shall examine General Conditions of Contract and Specifications to satisfy himself about all the Terms & Conditions and circumstances affecting the Contract Price. He shall quote price(s) according to his own views on these matters and understand that no additional allowances except as otherwise provided therein will be levied. The Purchaser shall not be responsible for any misunderstanding or incorrect information obtained by the Tenderer other than information given to the Tenderer in writing by the Purchaser. The Tenderer shall give his/her signature with seal in each and every page of the Tender Document as an indication of his/her acceptance of the Terms and Conditions of the Tender.

In the Tender, no overwriting is allowed. Dated initial should be given by the Tenderer to all corrections, if any, and the Seal stamped on each. Rates should be quoted both in figures and in words as far as practicable.

5.1 Non-Tribal Tenderers should submit the following alongwith their Tenders:

1) Authorised Dealer must submit an Authorised Dealership Certificate issued by Manufacturers.
2) ISI/BIS Certificate.
3) Documents showing past experience.

5.2 Tribal Tenderers should submit :

1) House Tax Payee Certificate
2) Authorised Dealer must submit an Authorised Dealership Certificate issued by Manufacturers.
3) ISI/BIS Certificate.
4) Documents showing past experience.

6.0 Patent Rights, etc

The Tenderer shall indemnify the Purchaser against all Claims, Actions, Suits and Proceedings for the infringement or alleged infringement of any patent design or copy right protected either in the Country of origin or in India by the use of any equipment supplied by the Tenderer, but such indemnity shall not cover any use of equipment other than for the purpose indicated by or reasonably to be inferred from the specifications.

7.0 Reservation

The Owner reserves the right to accept or reject, partly or wholly, or all the tenders without assigning any reason thereof. Further, the Owner is not bound to select the lowest Tenderer to execute the work. Tenderers who do not accept General Conditions will be automatically rejected.

8.0 Variations - Additions and Omission

i) The Tenderer shall not modify the materials and equipment except directed in writing by the Purchaser.

ii) The Purchaser shall have the right to alter, amend, omit or otherwise vary the equipment by notice in writing to the Tenderer. The Tenderer shall carry out such variations except when said variations result on cost excess of 15% of the Contract Price, in which case the approval of the Purchaser shall be obtained. The amount of such variations shall be determined in accordance with the rate specified in the Contract so far as they may apply and where such rates are not available. These will be mutually agreed between the Purchaser and the Tenderer.

iii) If the Purchaser shall make variations in any part of the materials and equipment, a reasonable notice shall be given in writing to the Tenderer. In such cases where equipment has already been manufactured or is under manufacture, the Purchaser may consider payment of additional sum to the Tenderer. If in the opinion of the Tenderer such variation is likely to prevent or prejudice the Tenderer from fulfilling any of his obligations under the contract, he shall notify the Purchaser thereof in writing and the Purchaser shall decide whether or not the variation shall be carried out.

SECTION - II

GENERAL CONDITIONS OF CONTRACT

1.0 Scope of the Work

The work is design, manufacture, test at works, supply, delivery at site, erection, testing at site and commissioning of the Electro-Mechanical equipments and 3.3/33kV Step-up Substation of 2x2MW, Kawlbem Small Hydroelectric Project.

2.0 Manner of Execution

The Project will be executed on turnkey basis.

3.0 Price

Firm rates for materials should be quoted FOT Destination. Rate should be inclusive of all taxes, duties, insurance, freight, handling charges, etc. For erection, firm rates should be quoted inclusive of all taxes.

4.0 Terms of Payment

a) For Manufacture, Supply and Delivery of Plants and Equipments:

i) 10% of the cost of manufacture, supply and delivery of Electro-Mechanical equipments shall be paid as advanced submission of B.G of equivalent amount

ii) Balance 80% of each consignment/cognizable shall be paid on submission of the following documents through a schedule bank:

- Invoice showing Contract number, goods' description, quantity, unit price and total amount etc.
- Railway receipt/L.R
- Inspection certificate

iii) Balance 10% of the cost of manufacture, supply and delivery of Electro-Mechanical equipments shall be paid after satisfactory commissioning of the units against submission of B.G of equivalent amount.

iv) For spare items, 100% of price inclusive of all taxes & duties shall be paid after delivery of materials at site in full and good conditions.

b) For Erection, Testing and Commissioning of Plants and Equipments:

i) 10% of the contract price of erection shall be paid as initial mobilization advance.

ii) 25% of the contract price of erection shall be paid after satisfactory placement of equipments in position.

iii) 40% of the contract price of erection shall be paid on the basis of R.A. Bills to be raised against final alignment/assembly.

iv) 15% of the contract price of erection shall be paid on mechanical/hydraulic testing of the equipments.

v) Balance 10% shall be paid only after successful commissioning of units against submission of B.G of equivalent amount.

5.0 Mode of Payment

Payments shall be made promptly by the Owner within 30 (thirty) days of receipt of the Tenderer's invoice, complete in all respects and supported by the requisite documents and fulfillment of stipulated conditions, if any. All the payment shall be released to the Contractor directly.

All invoices under the Contract shall be raised by the Tenderer on "the Owner" and all payments shall be made to the Contractor by the Owner.

6.0 Target Date of Completion

The work should be completed in all respect by dt. _____ and shall be implemented strictly in time with the help of detailed PERT/CPM, which the Tenderer should submit along with the tender documents.

7.0 Extension of Time

If the supply of equipment or erection work is delayed due to any reasons, the Tenderer shall without delay give notice to the Purchaser in writing of his claim for an extension of time within 30 days of Scheduled Date of Delivery/Completion. The Purchaser on receipt of such notice may agree to extend the Contract Completion Date as may be reasonable but with Liquidated Damages. However, in the case of Force Majeure or in any such cases beyond the control of the Tenderer and are accepted as such by the Purchaser, the Completion Date may be extended without Liquidated Damages.

8.0 Defect Liability Period

"Defect Liability Period" means 12 calendar months from the date of successful commissioning of the Project by the Owner.

The Contract shall not be considered completed until a Defects Liability Certificate shall have been signed by the Engineer-in-Charge and delivered to the Contractor stating the date on which the Contractor shall have completed his obligations to execute and complete the Works and remedy any defects there in to the Engineer's satisfaction. The Defects Liability Certificate shall be given by the Engineer within 28 days after the expiration of the Defects Liability Period, or, if different defects liability periods shall become applicable to different sections or parts of the Permanent Works, the expiration of the latest such period, or as soon thereafter as any works instructed, pursuant to relevant clauses of this Chapter have been completed to the satisfaction of the Engineer-in-Charge.

Notwithstanding the issue of the Defects Liability Certificate, the Tenderer and the Owner shall remain liable for the fulfillment of any obligation incurred under the provisions of the Contract prior to the issue of the Defects Liability Certificate which remains unperformed at the time

such Defect Liability Certificate is issued and for the purposes of determining the nature and extent of any such obligation, the Contract shall be deemed to remain in force between the parties.

If it appears to the Engineer or his Representative at any time during construction or reconstructions or prior to the expiry of the Defects Liability Period, as specified or 12 (twelve) calendar months from the certified date of final completion of entire work covered under the Contract, that any work has been executed with unsound, imperfect, or unskilled workmanship or that any materials or articles provided by the Tenderer for execution of the work are unsound or of a quality inferior to that contracted for, or otherwise not in accordance with the Contract or that any defect, shrinkage or other faults in the work arising out of defective or improper materials or workmanship, the Tenderer shall upon receipt of a notice in writing on that behalf from the Engineer, forthwith rectify or remove or reconstruct the works so specified in whole or in part as the case may be and/or remove that material/articles so specified and provide other proper and suitable materials at his own expense.

If the power house has to be shut down due to reasons attributable to Tenderer before the end of Defect Liability Period, the Tenderer has to compensate the Owner by giving the cost of deemed generation for the duration of power house shut down at the generation cost to be fixed by the appropriate authority.

9.0 Completion of the work

The work shall be completed to the entire satisfaction of the Engineer and in accordance with the time mentioned in the Contract. As soon as the work under the Contract is substantially completed as a whole, the Tenderer shall give notice of such substantial completion to the Engineer along with an understanding to complete any outstanding work during the Defects Liability Period. The Engineer, within 30 days or receipt of such notice, shall inspect the work and shall satisfy himself that the Work(s) has been substantially completed in accordance with the provisions of the Contract and then issue to the Contractor a Certificate of Completion indicating the date of completion. Should the Engineer notice that there are defects in the works or the works are not considered to be substantially completed, he shall issue a notice in writing to the Tenderer to rectify/replace the defective work or any part there of or complete the work, as the case may be, within such time as may be notified and after the Tenderer has complied with as aforesaid and gives notice of completion, the Engineer shall inspect the work and issue the Completion Certificate in the same manner as the aforesaid.

No Certificate of Completion shall be issued and no work shall be considered to be completed unless the Tenderer shall have removed from the work site and/or premises all his belongings/temporary arrangements made/brought by him for the purpose of execution of the work and cleared the site and/or premises in all respects and made the whole of the site and/or premises fit for immediate occupation/use to the satisfaction of the Engineer. If the Tenderer fails to comply with the above mentioned requirements on or before the date of completion of the work, the Engineer may, as he thinks fit, at the risk and cost of the Tenderer, fulfill such

requirements and remove/dispose off the Tenderer's belongings/temporary arrangements as aforesaid and the Tenderer shall have no claim in this respect except for any sum realized by the sale of the Tenderer's belongings/temporary arrangements, less the cost of fulfilling the said requirements and any other amount that may be due from the Tenderer, should the expenditure on the aforesaid account exceed the amount by sale of such Tenderer's belongings/ temporary arrangements then the Tenderer shall, on the demand of the Engineer, pay the amount of such excess expenditure.

10.0 Taking over

i) The work shall be taken over from the Tenderer by the Owner after he successfully commissioned the Project and after running with overload equivalent to full load of each unit for 700hrs to the satisfaction of the Owner's Engineer.

(ii) The issuance of a Taking over Certificate shall in no way relieve the Tenderer of his responsibility for the satisfactory operation of the equipment in terms of the specifications.

11.0 Insurance of Equipment

The materials and equipment shall be fully insured by the Tenderer against damage, lost, pilferage etc in transit. Insurance Document should be sent along with evidence of dispatch.

12.0 Replacement

If the materials/equipments or any portion thereof is damaged or lost before taking over of the work by the Owner, the replacement of such materials/equipment shall be effected by the Tenderer within a specified time to avoid unnecessary delay in the commissioning of the materials and equipment. The replacement of materials/equipment damaged shall be made free of cost by the Tenderer.

13.0 Rejection

In the event that any portion of the works carried out by the Tenderer is found below standard or otherwise not in conformity with the requirements of the Contract Specifications, the Purchaser shall request the Tenderer in writing to rectify the same. The Tenderer on receipt of such notification shall rectify the work free of cost to the Purchaser. If the Tenderer fails to do so, the Purchaser may:

a) at its option replace or rectify such defective work and recover the extra cost so involved from the Tenderer plus 15% of the defective work.

b) terminate the Contract.

14.0 Inspection & Testing During Manufacture

i) The Purchaser's representative shall be entitled at all reasonable times during manufacture to inspect, examine and test on the Tenderer's premises the material, manpower and workmanship of all equipment to be supplied under this Contract by the Tenderer and if

part of the said equipment is being manufactured on other premise, the Tenderer shall obtain for the Purchaser's representative permission to, inspect, examine, and test as if the equipment were being manufactured on the Tenderer's premises. Such inspection, examination and testing shall not release the Tenderer from his obligations under this Contract.

ii) The Tenderer shall give the Purchaser's Representative thirty (30) days notice in writing of the date and the place at which the materials and equipment will be ready for testing.

iii) Inspection and Testing will be at the cost of Tenderer including providing assistance for labour, materials, electricity, fuel and instrument as may be required or as may be reasonably demanded by the Purchaser's Representative to carry out such tests efficiently.

iv) When the equipment has passed the specified tests, the Purchaser's Representative shall furnish a Certificate to his effect in writing to the Tenderer. The Tenderer shall provide reasonable copies of the Test Certificates to the Purchaser.

15.0 Guarantee

The Tenderer shall provide cover of Guarantee to the materials and equipment supplied for a period of 12 (twelve) months from the date of commissioning of the materials/equipments. During the period of Guarantee the Tenderer shall remedy, at his expense, all defects in design, materials and workmanship that may develop under normal use of the materials and equipment upon written notice from the Purchaser who shall indicate in what respect the equipment is fault. The provision of this Clause including the cost of transport shall be implemented within the period specified by the Purchaser at the Tenderer's expense.

16.0 Force Majeure

The term **'Force Majeure'** shall herein mean Riots (other than among the Tenderers Employees), Civil Commotion (to the extent not Insurable), War (whether declared or not), Invasion, Act of Foreign Enemies, Hostilities, Civil War, Rebellion, Revolution, Insurrection, Military or Usurped Power, Damage from Aircraft, Nuclear Fission, such as Earthquake (above 7 Magnitude on Richter Scale), Lightning, Unprecedented Floods, Fires not caused by Tenderer's negligence and other such causes over which the Tenderer has no control and are accepted as such by the Purchaser, whose decision shall be final and binding.

In the event of either party being rendered unable by Force Majeure to perform any obligation required to be performed by them under this Contract, the relative obligation of the Party effected by such Force majeure shall be treated as suspended for the period during which such Force Majeure cause lasts, provided the Party alleging that it has been rendered unable as aforesaid, thereby shall notify within 10 days of the alleged beginning and ending thereof giving full particulars and satisfactory evidence in support of such cause. The Purchaser shall verify the facts and grant such extension or as the case may be as fact justify.

17.0 Payment due from the Tenderer

All cost and damages for which the Tenderer is liable to the Purchaser including a recovery of advance will be deducted by the Purchaser from any money due to the Tenderer under the Contract.

If for any unavoidable reasons, payment is delayed, the Tenderer shall neither charge any interest for the delay in payment nor the Tenderer shall stop the contract work on account of this.

18.0 Performance Bond or Bank Guarantee for Security

At the time of signing the Contract, the Tenderer shall provide the Purchaser with Security Deposit for a Performance Bond or a Performance Bank Guarantee for an amount of 5% (five percent) of the total accepted value of the works. This Bond or Guarantee will be released at the end of the Guarantee Period and on written request by the Tenderer. Form of Bank Guarantee attached.

19.0 Delay in Completion

If the Tenderer shall fail to complete the work within the time specified in the Contract Agreement or extension of time without Liquidated Damage, the Purchaser shall recover from the Tenderer as liquidated damages a sum of one half of one percent (0.5 %) of the Balance Contract Value, for each Month (30 days) of delay from the expiry of Scheduled Date of Completion. The total Liquidated Damages shall not exceed 10% (ten percent) of the Contract Price.

20.0 Tenderer's Default & Liability

i) The Purchaser may upon written notice of default to the Tenderer terminate the Contract in circumstances detailed here under:
   a) If in the judgement of the Purchaser, the Tenderer fails to complete the work within the time specified in the contract agreement or within the period for which extension has been granted by the Purchaser to the Tenderer.
   b) If in the judgement of the Purchaser, the Tenderer fails to comply with any of the other provisions of the Contract.

ii) In the event the Purchaser terminates the Contract in whole or in parts as provided in Clause 21.0, the Purchaser reserves the right to purchase upon such terms and in such a manner as he may deem appropriate, materials and equipment similar to that terminated and the Tenderer will be liable to the Purchaser for any additional costs for delay as defined in Clause 21.0 of the General Conditions until such reasonable time as may be required for the final supply of equipment.

iii) If the Contract is terminated as provided in Clause 16.0 the Purchaser in addition to any other rights provided in this Article may require the Tenderer to transfer title and deliver to

the Purchaser under any of the following cases in the manner and as directed by the Purchaser:

a) Any completed materials and equipment
b) Such partially completed materials and equipment, Drawings, Information and Contract Rights {hereinafter called Manufacturing Material} as the Tenderer has specifically produced or acquired for the performance of the contract as terminated. The purchaser shall pay to the Tenderer the Contract Price for completed materials and equipment delivered to and accepted by the Purchaser and for manufacturing material delivered and accepted.

iv) In the event the Purchaser does not terminate the Contract as provided in Clause 16.0 the Tenderer shall continue the performance of the Contract, in which case he shall be liable to the Purchaser for liquidated damages for delay as set out in Clause 14.0 until the equipment is accepted.

21.0 Termination of the Contract

i) If the Tenderer finds it impracticable to continue operation or if owing to Force Majeure reasons or to any cause beyond his control, the Purchaser finds it impossible to continue operation then prompt notification in writing shall be given by the party affected to the other.

ii) If the delay or difficulties so caused cannot be expected to cease or become avoidable or if in operations cannot be resumed within 6(six) months then either parties shall have the rights to terminate the Contract upon 10(ten) days written notice to the other. In the event of such termination of the Contract, payment to the Tenderer will be made as follows :

a) The Tenderer shall be paid for all materials and equipment approved by the Purchaser's representative and for any other legitimate expenses due to him.

b) If the Purchaser Terminates the Contract owing to Force Majeure or due to any cause beyond his control, the Tenderer shall additionally be paid for any work done during the said 6 (six) months period including any financial commitment made for the proper performance of the Contract and which are not reasonably defrayed by payments under (a) above.

c) The Purchaser shall also release all Bond and Guarantees at its disposal except in cases where the total amount for payment made to the Tenderer exceeds the final amount due to him in which case the Tenderer shall refund the excess amount within 60(sixty) days after termination and the Purchaser thereafter shall release all Bonds and Guarantees. Should the Tenderer fail to refund the amounts received in excess within the said period, such amounts shall be deducted from the Bonds or Guarantee provided.

iii) On Termination of the Contract for any cause the Tenderer shall see to the orderly suspension and termination of operations, with due consideration to the interest of the Purchaser with respect to completion, safeguarding or storing of equipment produced for the performance of the contract and the salvage and resale thereof.

22.0 The Engineer shall, on such Termination of the Contract, have Powers

i) To take possession of the site of Work under the Contract as well as the Land/Premises allotted to the Tenderer for his preliminary, enabling and Works and

ii) To take possession of any Materials, Constructional Plant, Equipment, Implements, Stores, Structures etc thereon.

The Engineer shall also have powers to carry out the incomplete Work by any means or through any other Agency or by himself at the risk and cost of the Tenderer. In such a case, the value of the Work done through such agencies shall be credited to the Tenderer at his Contract prices and the Tenderer shall pay the excess amount, if any incurred in completing the Work as aforesaid as stipulated herein.

22.1 On termination of the Contract in full or in part, the Engineer may direct that a part or whole of such Plant, Equipment and Materials, Structures be removed from the site of the Work as well as from the land/premises allotted to the Tenderer for his preliminary, enabling and ancillary Works, within a stipulated period. If the Tenderer shall fail to do so within the period specified in a notice in writing by the Engineer, the Engineer may cause them to be sold, the net proceeds of such sale to the credit of which shall be released after completion of Works and settlement of amounts under the Contract.

22.2 If the expenses incurred or to be incurred by the Department for carrying out and completing the incomplete Work or part of the same, as certified by the Engineer, are in excess of the value of the Work credited/to be credited to the Tenderer, the difference shall be paid by the Tenderer to the Department. If the Tenderer fails to pay such an amount, as aforesaid, within thirty days of receipt of notice in writing from the Engineer, the Engineer shall be empowered to recover such amount from any sums due to the Tenderer on any account under this or any other Contract or from his Security Deposit or otherwise.

22.3 Also, the Engineer shall have the right to sale any or all of the Tenderer's unused materials, constructional plant, equipment, implements, temporary building/structures etc. and apply the proceeds of sale thereof towards the satisfaction of any sums due from the Tenderer under the Contract and if thereafter there maybe any balance outstanding from the Tenderer, the Engineer shall have powers to recover the same in accordance with the provisions of the Contract.

22.4 All decisions/actions of the Engineer under this clause as aforesaid shall be conclusive and binding on the Tenderer.

24.0 Bankruptcy

If the Tenderer shall become Bankrupt or have a receiving order made against him or compound with his Creditors, or being a Corporation commence to be wound up, not being a voluntary winding up for the purpose only of amalgamation or reconstruction, or carry on its business under a receiver for the benefit of its Creditors or any of them the Purchaser shall be at liberty:-

a) to Terminate the Contract forthwith by notice in writing to the Tenderer or to be liquidator or receiver or to any person in whom the Contract may become vested and to act in the manner provided in Clause 20.0 as though the last mentioned notice has been the notice referred to in such Article and the materials and equipment has been taken out of the Tenderer's hand.

b) to give such liquidator, receiver, or other person the option of carrying out the contract subject to his providing a guarantee for the due and faithful performance of the contract upto an amount to be determined by the Purchaser.

25.0 Contingent Fees

The Tenderer warrants that he has not employed any person to solicit or secure the contract upon any agreement for a Commission, Percentage, Brokerage or Contingent Fee, broach of this warranty shall give the Purchaser the right to cancel the Contract or to take any other measure as the Purchaser may deem fit. The warranty does not apply to commissions payable by the Tenderer to Established/Commercial or Selling Agent for the purpose of securing business.

26.0 Non-Assignment

The Tenderer shall not assign or transfer the contract or any part thereof without the prior approval of the Purchaser.

27.0 Certificate not to Affect Rights of the Purchaser of the Tenderer

The issuance of any certificate by the Purchaser or any extension of time granted by the Purchaser shall not prejudice the rights of the Purchaser in terms of the contract nor will this relieve the Tenderer of his obligations for due performance of the Contract.

28.0 Settlement of disputes

i) Except as otherwise specifically provided in the Contract, all disputes concerning question of fact arising under the Contract shall be decided by the Purchaser subject to a written appeal by the Tenderer to the Purchaser, these decisions shall be final to the Parties hereto.

ii) Any disputes or differences including those considered as such by only one of the Parties arising out of or in connection with this Contract shall be to the extent possible settled amicably between the Parties. If amicable settlement cannot be reached then all disputes issues shall be settled by Arbitration.

29.0 Arbitration

i) If at any time, any question, disputes or difference whatsoever shall arise between the Tenderer and the Purchaser upon or in relation to or in connection with this Contract, either of the Parties may give to the other notice in writing of the existence of such a question dispute or difference and the same shall be referred to two Arbitrators, one to be nominated by the Purchaser and the other to be nominated by the Tenderer or in case of such arbitration not agreeing, then to an Umpire to be appointed by the Arbitrator in writing, before proceeding with the reference and the decision of the Arbitrator or in the event of their not agreeing of the Umpire appointed by them, shall be final and binding on the Parties and the provision of the Indian Arbitration and Conciliation Act, 1996 and of the Rules there under and any statutory modifications thereof shall be deemed to apply and be incorporated in this Contract. Such a notice of the existence of any question, dispute or difference in connection with this contract shall be served by either party within 90 days of the issue of the Taking Over Certificate by the Purchaser, failing which all rights and claims under this Contract shall be deemed to have been forfeited and absolutely barred.

ii) Upon every or any such reference, the cost of and incidental to the reference and award respectively, shall be at discretion of the Arbitrators or in the event of their not agreeing of the Umpire appointed by them who, may determine the amount thereof or direct the same to be fixed as between solicitor and client, or as between Party, and Party shall direct by whom and to whom and in what manner the same shall be borne and paid.

iii) The work under this Contract shall, if reasonably possible, continue during arbitration proceedings, and no payments due from or payable by the Purchaser shall be withheld on account of such proceedings except to the extent which may be in dispute.

30.0 Jurisdiction

No legal proceedings shall be taken to enforce any claim and no suit rising out of any conflict shall be instituted except in a court of competent jurisdiction located within **MIZORAM**.

31.0 Language and Measure

All Documents pertaining to the Contract including Specifications, Schedule, Notice, Correspondence, Operating and Maintenance Instructions, Drawings, or any other writings shall be in English Language. The Metric System of measurement shall be used exclusively in this Contract.

32.0 Correspondence

i) Any notice to the Tenderer under terms of the Contract shall be served by registered mail or by hand at the Tenderer's principal place of business.

ii) Any notice to the Purchaser shall be served at the Purchaser's Principal office in the same manner.

33.0 Consignee and Paying Authority

Name of Work	Paying Authority	Consignee
Design, manufacture, test at works, supply, delivery at site, erection, testing at site and commissioning of the Electro-Mechanical equipments and 3.3/33kV Step-up Substation of 2x2MW, Kawlbem Small Hydel Project.		

34.0 Legal Addresses of the Parties

The addresses of the Parties to the Contract are as follows :

Purchaser : The Superintending Engineer,
Project Circle-II
Power & Electricity Department
Govt. of Mizoram, Aizawl.

Tenderer : _____

SECTION - III

GENERAL TECHNICAL SPECIFICATIONS

0 GENERAL INFORMATION

0.1 General

The Contractor shall strictly observe this General Technical Specification in conjunction with the Particular Technical Specifications. The contractor 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 Contractor 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.

0.2 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 this, the Contractor shall prepare detailed design, construction and installation drawings as well as calculations, material specifications, operating and maintenance instructions etc. The Contractor 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 Contractor 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.

0.3 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 Contractor 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 Organizations for Standardization) Standards. If relevant BIS, IEC and ISO standards are not available in any cases then the Contractor 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 Contractor of the plant shall give a list of national standards not complying with IEC standards to be used.

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

The Contractor 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.

0.4 Design Improvements

The Purchaser or the Contractor 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 Contractor should however, note that changes proposed by him will have to be supported 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 Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

0.5 Quality Assurance Programme

To ensure that the equipment and/or services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-Contractor's premises or at the work site of the Purchaser or at any other place of Work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such

activities at all points necessary. Such programme shall be outlined by the Contractor and shall be finally accepted and approved by the Purchaser after the discussion before finalization of the Contract. A quality assurance programme of the Contractor shall generally cover the following:

a) His organizational structure for the management and implementation of the proposed quality assurance programme.
b) Documentation control system.
c) Qualification data for Contractor's key personnel.
d) 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.
e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control
f) 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.
g) To identify the list of subcontractor.
h) A detailed PERT/CPM network showing all the activities of the work is mandatory.
i) Inspection and test procedure both for manufacture and field activities.
j) Control of calibration and testing of measuring and field activities.
k) System for indication and appraisal of inspection status.
l) System for quality audits.
m) System for authorizing release of manufactured product to the Purchaser.
n) System for maintenance of records.
o) System for handling storage and delivery.
p) 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 Contractor shall be required to submit the following Quality Assurance Documents at the time of dispatch of the Equipment.

a) All Non-Destructive Test procedures, stress relief and weld repair procedure actually used during fabrication and reports including radiography interpretation reports.
b) Welder qualification certificates (Boiler quality).
c) Welder's identification list, listing welder's and welding operator's qualification procedure and welding identification symbols.
d) Raw Material test report as specified by the specification and or agreed to in the Quality Assurance Plan.
e) 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.
f) Factory test results for testing required as per applicable standards referred in the specifications.

0.6 Design Co-ordination

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

0.7 Design Co-ordination Meeting

The Contractor will be called upon to attend design co-ordination meetings with the Purchaser and their Consultants during the currency of the Contract. The Contractor 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.

0.8 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.

0.9 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
- Transportation to the Site
- Loading & un-loading
- Intermediate storage
- Storage and handling at site
- Erection, testing and commissioning
- Train run operation
- Performance guarantees test
- Removal of erection equipment and clearing of Site
- Interdependence with work of other contractors.

The Contractor 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 Contractor shall suitably co-ordinate his operations at the Site with those of other contractors.

1 TECHNICAL DOCUMENTS

1.1 General

Contractor 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 Contractor to the Engineer within the periods, and in a number and quality as specified. The engineer reserves the right to request the Contractor for additional documents as may be required for proper understanding and definition of constructional, operational, co-ordination or other matters.

The Contractor shall co-operate with other Contractors 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 Contractor 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 Contractor's responsibility. The Contractor shall not be relieved of his responsibility and guarantee after drawing and computations have been approved by the Engineer.

The Contractor without the written authorization of the Engineer shall not sublet the preparation of drawings, computations or other technical documents. In such a case the Contractor 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 Contractor's drawings shall bar a serial number corresponding to a drawing classification plan to be agreed by the Contractor 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.

1.2 Drawings

The drawings should be in line with the model Single Line Diagram as shown on Annexure-VIII, any deviation which, should be clearly mentioned.

1.2.1 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 Contractor 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.

1.2.2 Foundation Drawings

If a piece of plant requires its own foundation or needs a special area for installation, the Contractor 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.

1.2.3 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.

1.2.4 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.

1.2.5 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 Contractor 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.

1.2.6 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.

1.3 Diagrams

1.3.1 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.

1.3.2 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 number, 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.

1.3.3 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.

1.3.4 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.

1.3.5 Logic Diagrams

The Logic or Functional Diagrams shall be used for representation of 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 (AND, OR, NOR, NAND, STORAGE, etc.) shall be used for processing and combining binary signals.

1.3.6 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).

1.3.7 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

1.3.8 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.

1.4 Specifications

1.4.1 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.

1.5 Lists and Schedule

1.5.1 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

1.5.2 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 m^3/sec

- Shut off head of pump
- No. of pump impeller / material or impeller

1.5.3 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.

1.5.4 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.

1.5.5 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

1.5.6 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

1.5.7 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

1.5.8 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

1.5.9 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 / Contractor / Subcontractor)
- 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.

1.5.10 Site Test Schedule

Scope as in 1.5.9. above – as applicable.

1.5.11 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.

1.5.12 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

1.5.13 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.

1.5.14 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).

1.6 Calculations

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

1.6.1 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 $S_A(3)$ and current $J_A(3)$
- Peak asymmetrical short-circuit current $J_S(3)$
- Sustained short-circuit current $J_K(rms)$ (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 J_E as determined by the earthing resistance R_E
- Maximum contact voltage as determined by the values as stated above.

1.6.2 Voltage Drop Calculations

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

1.6.3 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

1.6.4 Generator Earthing System Calculation

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

1.6.5 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.

1.6.6 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

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

1.7 Operation and Maintenance Manuals

1.7.1 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
(I.)	Operating Instructions
(II.)	Part A – Mechanical Plant, Part B – Electrical Plant
(III.)	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
Connections to external systems (electricity, water, etc.).
Instructions for operating personnel including periodic tests, check-points, and 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 Subcontractors 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 form 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 contractors.

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:

a) Current (preventive) maintenance indicating inspection periods, routine clearing and lubricating procedures, safety checks, adjustments, etc.
b) 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.

1.7.2 Performance

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

Furthermore, the Engineer may required the Contractor to adapt drawings (single line, wiring, terminal diagrams, etc.) to drawing of another contractor 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 Contractor 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.

1.7.3 Revisions and Supplements

The completeness of the manual shall be checked during installation, testing, commissioning and trial operation jointly by the Contractor 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 Contractor shall supply immediately the necessary supplements and corrections. This shall be handled in the following manner:

<u>Deletions</u>

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

<u>Corrections, Revisions, Replacements</u>

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.

<u>Insertions, Supplements</u>

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 Contractor 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 Contractor.

1.8 Installation Manual

The Contractor 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.

1.9 Commissioning Manual, Commissioning Report

The Contractor 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 Contractor 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.

1.10 Progress Report

During erection the Contractor shall, before the tenth (10^{th}) 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 Contractor'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.

2 SPARE PARTS AND TOOLS

2.1 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 Contractor in present of the Engineer.

Acceptance of any spare parts will not take place before the Contractor 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 Contractor shall label and conveniently store all spare parts in racks provided by him in ready to use manner before handing over to the Purchaser.

2.1.1 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.

2.1.2 Recommended Spare Parts

If any additional spare parts are recommended by the Contractor, 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.

2.2 Mandatory Tools and Appliances

Contractors shall supply all mandatory tools & appliances as specified in particular technical specification and schedule of requirement. Contractor 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.

2.3 Recommended Special Tools and Equipments

The Contractor 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.

3 DESIGN AND MANUFACTURE

3.1 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, manufactured, 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 shall 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 Contractor 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 Contractor 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.

3.2 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 Contractor when dimensioning the main parts of the plant shall be submitted to the Engineer at his request.

3.3 Standardization 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 contractor to use uniform types or make of plant and materials. The Contractor 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.

3.4 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 these and other additional tests shall be borne by the Contractor.

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.

3.5 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.

3.6 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.

3.7 Identification Plates

3.7.1 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.

3.7.2 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.

3.7.3 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.

3.7.4 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.

3.8 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 contractor & 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.

3.9 Workmanship

3.9.1 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 Contractor at the request of the Engineer.

3.9.2 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.

3.9.3 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.

3.9.4 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.

3.10 Welding and Heat Treatment

3.10.1 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 Contractor'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.

3.10.2 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 Contractor 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 Contractor 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 Contractor 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 Contractor 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.

3.10.3 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.

3.10.4 Welding Work

The standard of welding works shall be in accordance with relevant Indian Standard ciety). In addition, the Contractor 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.

3.11 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 at point of welding	Other than low hydrogen welding electrode IS 226	Low hydrogen welding electro or sub-merges arc

	Steel or IS 2062	welding IS 226 steel or IS 2062 steel
Upto 20 mm for incl. IS 226 and upto 25 mm incl. for IS 2062	None	None
Over 20 mm for IS 226 and over 25 mm for IS 1062 upto 40 mm incl.	100 Deg. C	20 Deg. C
Over 40 mm to 63 mm included.	120 Deg. C	100 Deg. C

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.

3.11.1 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.

3.11.2 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 Contractor.

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.

3.11.3 Inspection of Welds

3.11.3.1 Visual 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.

3.11.4 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.

3.11.5 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.

3.12 Corrosion Protection

3.12.1 Scope of Work

The Contractor'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.

3.12.2 Painting Materials

The Contractor 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 Contractor 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 Contractor 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 Contractor 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.

3.12.3 Painting Systems

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

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

3.12.4 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-dyeing 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).

3.12.5 Execution of Painting

The Contractor 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 Contractor 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 Contractor 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 Contractor 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 Contractor 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.

3.12.6 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 m^2, one area of 10 m^2 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 Contractor 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.

3.12.7 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.
<u>Galvanizing of hardware:</u>

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.

3.13 Metal Work, Floor Load

3.13.1 Embedded Metal Work

The Contractor 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 Contractor 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 Contractor shall be responsible for the adequacy and accuracy of the location of al embedded components supplied by him whether installed by him 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 Contractor, but al leveling and adjusting of plant on foundations shall be carried out by the Contractor.

The grouting will be carried out by the Civil Contractor under the supervision of the Contractor and the mix and grouting pressure shall be approved by the Contractor. The Contractor 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.

3.13.2 Miscellaneous Metalwork

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Contractor 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 Contractor. 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 Contractor.

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 Contractor. 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 Contractor 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.

4.3 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.

4.4 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 Contractors to use certain types of lubricants, oil, etc. The contractor 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.

4.5 Piping, Fittings, valves and Gates

4.5.1 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. Suitable venting systems shall be provided where required.

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.

4.5.2 Piping, Fittings

Steel pipes of a diameter <100 mm shall be mild steel. Steel pipes larger then 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 Contractor 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 Contractor. 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. Mitred 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.

4.5.3 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 and diameters larger than DN 100 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 C.I.

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.

4.5.4 Oil Piping

Piping of a diameter <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 Contractor's workshop. They shall be welded except at terminal point and as necessary for erection and future dismantling. The Contractor 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.

4.6 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.

4.7 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.

4.8 Compressed Air Systems

The provisions for safety of the entire compressed air system shall conform to internationally accepted standards. The standards proposed by the Contractor 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.

4.9 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%.

5 ELECTRICAL PLANT

5.1 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 Contractor's or Sub-Contractor'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 Contractor.

Unless otherwise agreed, ratings of main electrical plant (in feeds, bus-ties) as selected or proposed by the Contractor, 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 Contractor 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.

5.2 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.

5.3 Colour Code

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

5.4 Electric Motors

5.4.1 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.

5.4.2 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-load and full-load shall not exceed 10% of non-load speed.

5.4.3 Starting

AC motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite bus bar 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 bus bars, 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.

5.4.4 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.

5.4.5 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 re-cooled 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.

5.4.6 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 re-greasing, oil change etc. depends on the operation time of the motors.

5.4.7 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 motor side-coupling which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

5.4.8 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.

5.4.9 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 maximum temperature contact shall be derived either thermostatically or electronically giving alarm and / or trip the associated motor starter.

5.4.10 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.

5.4.11 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 Contractor.

Routine Tests:

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

Site Tests:

- Measurement of insulation resistance

- Measurement of polarization Index.

5.5 L V Switchgears, Cubicles and Panels

5.5.1 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 bus bars 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 bus bars) 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 lying 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 Contractor 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.

5.5.2 Switchgear / MCC 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 bus bars 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 padlock 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:

- HRC fuses with auxiliary contacts and load-break switch, or

- Fused load break switch, or
- Circuit breaker with instantaneous over current protection
- Starter combination
- Adjustable thermal overload and phase failure protection

Moulded case circuit breakers and miniature circuit breakers can be used if they are 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 contractors 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 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.

5.5.3 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 contractor 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.

5.5.4 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:

A) Terminals for power circuit (one group)
B) Terminals with short-circuit facilities for current transformer circuits (one group).
C) 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.

5.5.5 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.

5.6 Auxiliary Plant

5.6.1 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.

5.6.2 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.

5.6.3 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 Contractor 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 Contractor 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.

5.6.4 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 Contractor 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.

5.6.5 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.

5.7 Cables

5.7.1 General

The Contractor 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 Contractor 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 Contractor 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 contractor 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”.

5.7.2 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.

5.7.3 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.

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

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 Contractor 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 Contractor.
- Cable trenches shall be cleaned from dirt, sand, etc. before closing.
- Trench shall be closed as soon as possible.

5.7.5 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.

5.7.6 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.

5.8 Oil and Compound

5.8.1 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.

5.8.2 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.

5.8.3 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.

5.9 Labels and Plates

5.9.1 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.

5.9.2 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.

5.9.3 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.

5.9.4 Labels for Conduits, etc.

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

5.9.5 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.

5.9.6 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.

5.9.7 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).

5.10 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.

6 INSTRUMENTATION AND CONTROL EQUIPMENT

6.1 Design Criteria

6.1.1 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 Contractor's or Sub-Contractor'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.

6.1.2 Standards

If the Contractor 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.

6.1.3 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.

6.1.4 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

6.2 Tests

The single components and pre-erected assemblies shall undergo functional and routine tests in the Contractor's or Sub-Contractor'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.

6.3 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.

6.3.1 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.

6.3.2 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 will 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.

6.3.3 Pressure Measurement

Pressure gauges shall be shock and vibration-proof (preferably by filling with glycerin) 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 $\pm$ 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/cm^2.

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.

6.3.4 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 $\pm$ 1.0% of the total measuring range. Level switches shall be of packless construction; there shall be a minimum of moving parts.

6.3.5 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.

6.3.6 Position Measurements

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

6.3.7 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.

6.4 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.

6.4.1 Alarm Annunciation System

The alarm equipment shall operate from a 220V DC 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:

a) 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.
b) 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.

6.5 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.

6.6 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, 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.

7 TRANSPORT AND INSTALLATION

7.1 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 Contractor. 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 followed. 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 Contractor'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 Contractor's expense.

7.2 Packing and Transportation

7.2.1 Packing and Marking

The Contractor 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 Contractor'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 Contractor 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.

7.2.2 Shipping Marks

The Contractor 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:	

7.2.3 Packing Lists

The Contractor 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 Contractor 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.

7.3 Equipment Handling and Storage

7.3.1 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 Contractor 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 Contractor 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.

7.3.2 Storage Area and Warehouses

The Engineer will designate areas where the Contractor may store parts of the plant. The Contractor 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 Contractor 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 Contractor 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 Contractor after completion of the work. In case, the Contractor 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 Contractor 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 Contractor at the Contractor's cost.

The Contractor 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.

8 SITE INSTALLATION AND ERECTION

8.1 Preparation of Site Installation Works

Prior to commencement of installation, the Contractor 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.

8.2 Reference Points

The Engineer will provide major centre lines and datum levels only. The Contractor shall be responsible for transferring those required to carry out the Works. The Contractor 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 Contractor 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 Contractor's setting-out. The Contractor 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 Contractor's work or as permanent survey marks will be under the care of the Contractor 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 Contractor's expense.

The Contractor 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 Contractor of his responsibility for its correctness.

8.3 Installation Work

8.3.1 General

All transportation and handling of the plant from the place of storage to the place of installation shall be carried out by the Contractor. 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 Contractor 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 Contractor 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 Contractor 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.

8.3.2 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 Contractor for the site installation work must strictly observe the following standards:

- Indian Electricity Rules, 1956
- 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.

8.3.3 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 Contractor 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 Contractor 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.

8.3.4 Temporary Bracing

The Contractor 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 should be 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.

8.3.5 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.

8.4 Particular Requirements for Switchyard Installation and Erection Works

8.4.1 Erection of Structures

The Contractor shall arrange his own erection plant and equipment, tools and tackles. Scaffolding, etc. and any other accessories and ancillaries required for the work.

The Contractor shall arrange transport with necessary tools and tackles for loading, unloading, handling and transportation of fabricated steel to the erection site and erection thereof.

Handling and Transportation of Steel:

All galvanized steel members including stub angles shall be handled and transported to work at Site by the Contractor with care to avoid bending of members and damage to galvanized surfaces.

Stability of Structure:

The Contractor shall be responsible for the stability of the structure at all stages of its erection at Site and shall take all necessary measures by additions of temporary bracing and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operation. Guying and bracing shall be done in such a way that it does not interfere with the movement or working of other agencies working in the area.

The unit rate of finished steel work shall include provisions of such temporary bracing and their removal. Such temporary bracing shall neither be included in the measurement not any extra rate shall be payable. Such temporary bracing used shall be the properly of the Contractor and may be removed by his at the end of the job from the Site of work.

Sequence of Erection:

The Contractor shall give the detailed sequence of the erection in accordance with the project scheduling of the various structures and their methods of temporary support by means of cleats, bolts, and nuts, temporary bracing etc. The Contractor shall take up the erection work only after same has been approved by the Engineer.

The Contractor shall stack the fabricated steel members in separate piles member wise and structure wise. These shall be stacked clear off the ground with their heels upward in order to avoid entrapping of water between the angle sections.

Switchyard structures shall be erected by member assembly or any other standard method without ever stressing any member on foundations at least after 4 days of casting but a gap of 28 days shall be preferred. The structure shall be erected in the best workman like manner.

The Contractor shall be entirely responsible for correct erection for all the structures as per the approved drawings and their correct setting on the alignment finally approved by the Engineer. The structure must be truly vertical after erection, the permitted tolerance in verticality being 1 in 360 of the tower height. No straining will be permitted to make the towers vertical.

A reasonable amount of drifting as permissible in IS 5613, Part 2, Section 2, 1985 shall be allowed in assembling, but remaining for correction of mismatched holes due to shop errors shall not be permitted.

All errors and omissions in erection of structures shall be corrected by the Contractor at no additional cost to the Purchaser. Any structure damaged during erection due to incomplete bolting, improper guying or any other reasons shall be replied/replaced by the Contractor as directed by the Purchaser.

Assembly:

The method followed for the erection of structure shall ensure the points mentioned below:

a) Straining of the members should not be permitted for bringing them into position. It may, however, be necessary to match hole positions at joints and to facilitate this, tummy bars more than 450 mm long may be used.
b) Before starting erection of an upper section, the lower section shall be completely braced and all bolts provided in accordance with approved drawings.
c) All plan diagonals relevant to a section of structure shall be placed in position before assembly of upper section is taken up.
d) The bolt positions in assembled structure shall be as per IS 5613, Part 2, Section 2, 1985.
e) Columns shall be fitted with danger plate and anti-climbing device (if required) as described.
f) All the blank holes, if any left, after complete erections of the structure are to be fitted up by bolts and nuts of correct size.

Tightening and Punching of Bolts and Nuts:

All nuts shall be tightened properly using correct size spanners. Before tightening, it shall be ensured that filler washers and plates are placed in relevant gaps between members and bolts of proper size and length are inserted and one spring washers shall be placed under the outer nuts. The tightening shall progressively be carried out from the top downward, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at three positions on the diameter to ensure that the nuts are not

loosened in course of time. If during tightening, a nut is found to be slipping or running over the bolt threads the bolt together with the nut shall be replaced.

8.4.2 Modifications, Rectifications and Re-Erection

If the dismantling, modifications, rectification, addition, etc. is necessitated due to any mismatch/discrepancy in the fabrication drawing prepared by the Contractor or in fabrication, the Contractor shall be held responsible for the same despite the fact that such drawing might have been approved by the Engineer. In such cases, nothing extra shall be payable to the Contractor towards carrying out such modification, rectification, addition, dismantling testing, transportation and any other allied activity.

In case, it is found that certain erection marks as already detailed and approved in fabrication drawings require addition, alternation and modification, the same shall be done on the written orders of the Purchaser or his authorized representative.

The work of re-erection include carriage of modified erection marked members from fabrication shop to erection site, lifting of the same to the required position, aligning, erection in position inclusive of bolts and touch up pointing etc. complete to the satisfaction of the Purchaser.

The quoted price shall include all these operation.

8.4.3 Foundation Bolts

Foundation bolts for bus structure and elsewhere shall be embedded in first stage concrete while foundations cost. The bolts may be provided in pipe sleeves permitting adjustments in the proper alignment of these bolts to match holes in the structure basis. The final adjustment of these bolts and their grouting and provision of shiner for correct erection of structure is to be included in the unit rate of items of structural steel.

The Contractor shall be responsible for the correct alignment and leveling of all steel works on Site to ensure that the columns/towers and structures are plumb.

Before erection of columns/towers/structures on the foundations, the tip surface of base concrete shall be thoroughly cleaned with wire brushed and by chipping to remove all laitance and loose material and shall be chipped with chisel to ensure proper bond between the ground and foundation concrete. The Contractor shall also be responsible for bringing the top of concrete to the desired level by chipping. In case foundation as cast in lower than the desired level. The Contractor shall make up the difference by providing additional pack plates and shims without any extra payment for any such work or materials.

No steel structures shall be put on foundation unless such foundations have been certified fit for erection of steel by the Purchaser. Adequate number of air release holes and inspection holes shall be provided in the base plate.

Foundation bolts for the structures shall be supplied by the Contractor.

8.4.4 Stub Setting Templates

Stub setting templates shall be supplied by the successful Tenderer for all types of columns. The stub templates shall be supplied black but given two coats of red oxide paint in the shop before dispatch of material.

8.4.5 Stub Setting

Stub for columns and lightening mast, wherever shown and provided in approved fabrication drawings, shall be set in such a manner that the distance between the stubs and their alignment and slope shall be exactly as shown in the fabrication drawings. The procedure for setting stub at Site shall be as per the details given in the manual on transmission line towers. Technical reports No.9 of CBIP, Chapter 6, Appendix A.

8.4.6 Grouting

The method of grouting the column/structure bases shall be subject to the approval of the Engineer and shall be such as to ensure a complete uniformity of Contract over the whole area of the column/structure base. The Contractor shall be fully responsible for grouting operations.

9 INSPECTION AND TESTS

9.1 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.

9.2 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. In case that the test certificates are older than ten years the Contractor shall carry out the specified type tests at his own costs.

Contractor shall have to do all the routine tests, acceptance tests & site tests required as per technical specification and Indian Standards / International Standards.

Contractor 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, Contractor 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.

9.3 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 Contractor shall send unpriced copies of such orders in triplicate to the Engineer.

Where the Contractor 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.

9.3.1 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.

9.3.2 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 Contractor, Sub-contractor or other contractors.

9.3.3 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.

9.3.4 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.

9.3.4.1 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 rapped 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.

9.3.4.2 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.

9.3.4.3 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.

9.3.5 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.

9.3.6 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 Contractor, as agreed by the Engineer.

Before testing the Contractor 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.

9.3.7 Electrical Tests

Electrical plant shall be tested in accordance with applicable Standards and agreed test programs and procedures.

9.3.8 Model Tests

Model tests for certain parts of the work or plant shall be carried out as specified.

9.3.9 Test Reports

Contractor 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.

9.4 Site Inspection and Tests

During erection, commissioning and Test Service Period operation the Contractor 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 borne by the Contractor. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Contractor for the entire duration of the tests. The Contractor 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.

<u>Commissioning and Test Service Period</u>

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 Contractor. 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 Contractor 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 Contractor.

9.4.1 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 Contractor.

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 Contractor 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 Contractor.
- 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 Contractor's responsibility, this part of the acceptance shall be stated in the "Certificate" and be postponed for a mutually agreed period.

10 CIVIL SITE WORK

10.1 Scope of Work of the Civil Works Contractor

- All concrete work, including reinforcement and formwork, 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 Contractor 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 Contractor and approved by the Engineer.
- Adequate safety covers and protective measures against injury or damage to the Contractor's employees and equipment and to the works due to any operations of the civil contractor.
- Piping, fittings, etc., required for Power House Surface drainage (through gravity) up to the drainage sump.

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 Contractor.

The supplier of plant & equipments shall co-ordinate as regards the following Civil Works :-

a) Foundation of Switchyard Gantry Columns, Bus Post Insulator Support Structures, Lighting / Lightning Masts
b) Foundation of Sub-station equipments
c) Cable trench between Powerhouse and Switchyard
d) Cable trenches along with covers and cable trenches crossing roads/rail track as per the drawing.
e) Drainage pit
f) Foundation of Sub-station bay marshalling boxes and marshalling boxes/control cubicles of the equipments.
g) Foundations for lighting materials
h) Civil works required for foundation and fire protection works of Generator transformers / Station service transformers

i) Drainage System
j) Fencing
k) Roads in the plant
l) Switch room in the 132kV switchyard
m) Spreading of meal (Stone-aggregates) of size 400 mm down.

10.2 Checking of Equipment after Grouting

The Contractor 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 Contractor shall maintain such pre and post grout records of alignment details, in a manner acceptable to the Engineer.

1 SYMBOLS AND ABBREVIATIONS

1.1 Length, area and volume

µm	micron = m · 10^{-6}
mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare
m^3	cubic meter
l	liter
rad	radian

1.2 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/s^2	meters per second squared (acceleration)
m^3/s	cubic meters per second
Hz	hertz (periods per second)

1.3 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 · 10^3
kg/m^3	kilograms per cubic meter
t/m^3	ton per cubic meter
N	newton
N/m^2	newton per square meter
N/mm^2	newton per square millimeter
Bar	bar = N/m^2 · 10^5
Pa	pascal = $1N/m^2$
MPa	megapascal – Pa · 10^6

atm	standard atmosphere 101325 Pa
J	Joule
kJ	kilojoule = J · 10^3

1.4 Electrical Units

A	ampere
V	volt
kVA	kilovolt ampere
kWh	kilowatt hour
W	watt = 1 J/s
kW	kilowatt = W · 10^3
MW	megawatt = W · 10^6
A.C.	alternating current
D.C.	direct current
HV	high voltage (cables)
LV	low voltage

1.5 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

2 SPECIFIC PROJECT CHARACTERISTICS

2.1 Site Operating Conditions

Altitude of site above sea level	m	Power House (Turbine floor)	
	m	Switchyard	
Maximum outdoor ambient	°C 40		

shade temperature for design purposes			
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.

2.2 Standard Voltages

Rated voltage	kV	132	3.3	33	0.415
Highest system voltage	kV	145	3.6	36	0.440
Rated short time withstand current	KA	31.5	32	5	40
Neutral earthing transformer		solid	solid		solid
System frequency	Hz	50		±3%	
Supply voltage for auxiliary plant	AC		415/240 v ± 10% PE/N		
Supply voltage for indications, alarms and supervisory equip. etc.	DC		110		+10/-15%

The stated values for medium and high voltages are rated / highest voltages for plant according to IEC 71-1

2.3 Motor Voltages and Power Ratings

The service voltages and corresponding power ratings for electric motors to be used in the Project shall be as follows:

Motors up to 50 kW	
Service voltage:	3-phase, AC, 415/240 V
Mode of starting:	Direct-on-line (2.5 x IN MAX) or Star Delta Starter
Motors up to 0.75 kW	
Service voltage:	Single-phase, AC 240 V
Mode of starting:	Condenser
Motors intended to work on the DC system	
Service voltage:	110 DC
Mode of starting;	Resistor

2.4 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
	Neutral	M	Blue
Protective earthed	Neutral	PE/N	Green
Earth		E	Gray

2.5 Colour Coding for Mimic Diagrams

Mimic diagrams to be arranged on switchgear cubicles, control panels / desks etc., shall be colour coded as follows:

3.3 kV	Blue
33 kV	Red
415 V	White
110 DC	Green

Note: Colours given above shall be finally agreed upon during detailed design.

2.6 Minimum Sub-Station Clearances

The minimum Sub-station and Switchyard clearances shall be as follows:

	kV	132	33	6.6
Phase to earth	mm	1300	320	100
Phase to phase	mm	1500	350	150

3 REQUIRED DOCUMENTS FOR ELEC. & MECH. PLANT/INSTALLATIONS

3.1 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.

3.2 Principal Requirements

The following documents shall be supplied individually or as a whole for equipment / installations wherever applicable.

3.2.1 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

3.2.2 Foundation Drawings

For any equipment requiring a foundation or other civil provisions	A

3.2.3 General Arrangement Drawings

For the whole plant and for individual area / buildings / rooms / trenches	A

3.2.4 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

3.2.5 Load Evaluations

For all medium and low voltage levels (AC and DC)	A

3.2.6 List of Plant Identification Numbers

List of Plant Identification Numbers	I

3.2.7 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

3.2.8 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

3.3 Specific Documents for Electrical Plant and Installations

3.3.1 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

3.3.2 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

3.3.3 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

3.3.4 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

3.3.5 Batteries

Specifications including capacity calculation	A
Dimension drawing for individual cells & for complete batteries incl.rack	

3.3.6 Battery Charges

Specification including capacity calculation	A
Arrangement drawing	A
Dimension drawing	A
Circuit diagram	I
Block diagram	I
Logic diagram	A

3.3.7 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

3.3.8 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

3.3.9 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

3.4 Specific Documents for Mechanical Plant and Installations

3.5 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

3.5.1 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 Spiral casing Distributor assembly Regulating ring Guide vanes Guide vane bushings 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 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

3.5.2 Governors and Accessories

Specifications	A
Dimension drawings	A
Design drawings:	
Electronic governor head	A
Pressure oil unit	A
Air/oil accumulator	A
Electro-hydraulic actuator	A
Hydraulic amplifier	A
Speed sensor arrangement	A
For turbine control:	
Schematic diagram	A
Block diagram	A
Circuit diagram	A
Loading drawings	A
Drawings for erection / handling facilities	A
Foundation drawings	A

3.5.3 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	A
Base plates and anchoring components	A
Valve rotor	A
Trunnions and bearings	A
Valve seals	A
Operating mechanism	A
Servomotors	A
Dismantling and expansion joint	A
Upstream connection pipe	A
Maintenance seal bypass line	A
Dewatering line	A
Manhole	A
Spherical valve assembly	A
Oil pressure unit with air / oil accumulator	A
Air inlet / outlet valve	A
For main inlet butterfly valve control:	
Arrangement drawing	A
Schematic diagram	A
Circuit diagram	A
Sequence chart of control functions	A
Drawings for erection / handling facilities	A

3.5.4 Pumps and Filters

Specifications alongwith calculation for pump size selection	A
Outline drawings	A
Bill of materials	A
Design drawings:	
Pump impeller	A
Pump casing	A
Pump wearing rings	A
Pump shaft & coupling	A
Pump shaft seal filter casing	A
Pump shaft seal	A
Filter casing	A
Cross-section of pump & filter assemblies	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

3.5.5 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

3.5.6 Oil Purification Equipment

Specification	A
Component list(s)	A
Outline drawings:	
Oil treatment unit including purifier, dehumidifier and degasser	A
Oil transfer pumps	A
Control diagram	A

3.5.7 Piping and Valves

Specifications	A
Component lists with material specification	A
Dimensional drawings	A
Arrangement and pipe routing drawings for:	

Cooling water system	A
Drainage and dewatering systems	A
Compressed air systems	A
Oil systems	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	

3.5.8 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

3.5.9 Cranes and Accessories

Specifications alongwith calculation for motor / brake selection, girder design etc.	A
Outline drawings	A
Design drawings:	
Runway	A
Crane bridge	A
Trolley with hoist	A
Bridge drive	A
Hook	A
Operator's cabin	A
For crane controls:	
Circuit diagrams	A
Instrument lists	A
Loading drawings	A
Drawings for erection / handling facilities	A
Foundation drawings	A
Calculations	A

SECTION - IV

PARTICULAR TECHNICAL SPECIFICATIONS

1.0 HORIZONTAL FRANCIS 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 numbers of Horizontal Francis hydraulic turbines and associated auxiliary and ancillary equipment, main inlet valve, equipment for auxiliary systems such as compressed air, Cooling water, draft tube dewatering, station drainage, centralized grease lubrication system, oil, water and air piping with valves and fittings, instrumentation, Controls and safety devices(as required): speed increasing gear box (if required): spares for five year operation of the plant, special tools etc.

The scope of supply shall include all parts, accessories, 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 shall be of the Horizontal shaft Francis suitable for coupling directly to horizontal shaft synchronous generator of nominal rating of 2MW each. The direction of rotation shall be clock-wise when viewed from drive end.

The detailed of the hydraulic system of the generating units and basic data for design of turbines are given in Table – 1 below:-

Table-I

1	Weir Full reservoir level (FRL)	870.0m
2	Weir intake level	861.0m
3	Forebay full reservoir level (FRL)	854.7m EL
4	Forebay minimum drawn down level (MDDL)	851.15m EL
5	Tail water level	657.25m EL (maximum) 656.25m EL (minimum)
6.	Rated net head (design head)	193.0m
7.	Diameter of Penstock	900.0mm (main), 700mm (branch)
8.	Number of penstock	1 main, 2 branches
9.	Length of penstock	480.0m

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 guide vane 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 gate 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 is the 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 K_1=0.4, K_2=0.3 and K_3=0.3

1.3.5 RECTIFICATION TO MEET GUARANTEES

The contractor 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 contractor thereafter within a period of 4 months or mutually agreed period as stated above.

1.4 CAVITATION GUARANTEES

The tenderer shall guarantee the runner against excessive pitting caused by cavitations for 18 months from the date of commissioning or 8000 hours of operation, whichever is more. If the 18 months of guarantee period expires before completion of 8000 hours of operation, the guarantee shall apply to the actual hours of operation proportionately.

Excessive pitting shall be defined as the removal of metal from the runner of a weight of W= 0.15 D2 per 1000 hours of operation, where, D = Discharge diameter of the runner and W = weight in Kg.

In case of cavitations pitting exceeding the guarantee, the turbine supplier shall, at his cost, take corrective measures such as modification of design, finish, replacement, repair, etc., and the turbine after modification, etc. shall be subject to cavitations guarantee as for the original equipment. In determining whether or not excessive pitting has occurred metal removal by erosion, corrosion or by the presence of injurious elements in water, etc., shall be excluded.

1.5 CRITICAL AND PLANT SIGMA

Values of critical sigma as determined from cavitations model tests as per IEC 193A shall be given in the forms of curves for different heads of operation. Plant sigma curves as recommended by the manufacturer shall also be plotted on it clearly to show the safety margin available.

1.6 SPEED RISE AND RUNAWAY SPEED

The moment of inertia of the unit and the normal wicket gate closing time and runner blade angle 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.

1.7 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.

1.8 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.

1.9 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.

1.10 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 contractor 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 contractor has already performed model tests on homologous models, the purchaser may, at his discretion, permit the contractor 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 guide vane openings to determine machine characteristics including regimes of safe operations, zones

of cavitation and vibration, etc. The phenomenon of cavitation and vibration, particularly at lesser guide vane openings shall be specially investigated. These tests shall include determination of capacity, cavitation limits, hydraulic thrust, runaway speed, wicket gate torque relationship, etc., and such other details as covered in IEC 193 and 193A. Prototype efficiencies shall be derived from model tests by Moody's step-up formula as contained in IEC 193 for Francis turbines. Model tests shall simulate all possible normal operating conditions of the prototype for entire range of forebay/reservoir and tailrace levels. 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.

1.11 GENERAL ARRANGEMENT AND CONSTRUCTION

The turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus. 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. All equipments in the turbine pit shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, ladders, hand rails, chequered plates, platforms, etc., required in the turbine pit shall be provided by the contractor.

1.11.1 Runner

The runner shall be of 13/4 chromium-nickel stainless steel. 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 runner will be a one-piece construction. The runner will have adequate number of blades 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. For runner of diameter more than 1000 mm, renewable wearing rings shall be provided.

1.11.2 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.

1.11.3 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. 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.

1.11.4 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 contractor.

1.11.5 Spiral Casing and Speed Ring

The spiral casing shall be fabricated from welded steel plate/mild steel plates and shall have suitable sections for ease of shipment and to be within transport limitation. The spiral case shall be designed to withstand maximum water pressure including water hammer and shall be complete with anchors, supports, sole plates, turn buckles, hold-down rods, all types of clamps, etc. The speed ring shall be low alloy cast steel or of welded plate steel and shall be in suitable number of sections. The assembled stay ring shall be suitable for welding on to the casing.

1.11.6 Draft Tube

Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The draft tube cone shall have machined flange for bolting with the runner chamber. Drain box and drain pipes for dewatering the draft tube (if applicable) shall be included in the scope of supply. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation-free operations of the machines.

1.11.7 Guide Vanes

The guide vanes shall be made from stainless steel. Sleeves of stainless steel at the bearing and sealing surfaces shall be provided, if required. The guide vane bushes shall be of the self lubricating type with protective seals or shall be suitable for grease lubrication. In case of grease lubrication, arrangement for manual and automatic grease lubrication to all bushes shall be made.

1.11.8 Operating Mechanism

The operating mechanism shall have ample strength to withstand the maximum load that can be imposed on it by the most severe operating condition. All working points with relative motion shall be bronze bushed, grease lubricated/ self lubricated. Means shall be provided for adjusting the position of the individual guide vanes to ensure close contact with adjacent guide vane in the closed position. Each guide vane shall be individually connected to the regulating ring through suitable levers and links. Shear/ breaking link or some other suitable arrangements shall be provided on each guide vane to protect guide vane and to provide alarm on foreign body getting wedged between guide vanes. The regulating ring shall be fabricated from welded steel plates. It shall be supported on the outer casing of top/side cover on bronze strips with provision for grease/ self-lubrication.

1.11.9 Guide Vane Servomotor

The guide vane shall be operated by two double acting oil operated servomotors of adequate capacity. The servomotors shall be capable of moving guide vanes 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.

1.11.10 Top Cover/ Side Cover

The top/side cover shall be of cast steel or welded plate construction. Suitable stainless steel labyrinth rings or similar sealing arrangements shall be provided in the covers.

1.11.11 Turbine Platform, Walkways, Handrails Etc

Necessary platforms, walkways, handrails, chequered plates, ladders, etc., complete with supporting steel structure, shall be supplied.

1.12 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.

1.13 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.

1.14 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.

1.15 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 high pressure system shall also be used to supply low pressure air requirements for generator brakes, inflatable seals and the centralized grease system, if required. Suitable outlet connections shall be provided for the above purpose and pressure reducers wherever necessary shall be supplied by the turbine contractor to meet the turbine requirements. For generator

brakes, pressure reducer, and air-lines will be arranged by the turbine contractor. The compressors and receivers shall have necessary fittings, mountings, safety devices, etc.

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.

1.16 DEWATERING AND DRAINAGE SYSTEM

Complete equipment for the draft tube dewatering system common for all the units and the station drainage system shall be supplied by the contractor. The equipment for each of the dewatering and the drainage system shall include two motor driven dewatering pumps, necessary piping fittings/gate valve/non-return valves/float switches, controls, accessories etc.

1.17 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.

1.18 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.

1.19 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 contractor.

1.20 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 contractor along with the turbines. The unit prices of the spares shall be indicated as per enclosed Table –D and additional spares if considered necessary by the Engineer in charge shall be provided by the contractor within the overall contract price. Over and above those listed in Table – 'D' and list provided by contractor.

1.21 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.

1.22 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 contractor.

1.23 COMMISSIONING TESTS

The contractor 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.

1.24 ERECTION

The contractor shall depute experts in erection, testing and commissioning of turbines, governors and associated equipments for erection, testing and commissioning of these.

1.25 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 cavitations 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, and 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 (MW)	2MW
iv)	Rated MVA	2.5 MVA
v)	Power factor	0.8 lagging
vi)	Frequency	50 Hz
vii)	No. of phase	3
viii)	Rated terminal voltage between the phases	3.3 kV
ix)	Range of voltage with which rated output must be available	$\pm$ 10 percent
x)	Range of frequency variation	$\pm$ 3 percent (48.5 Hz – 51.5.Hz)
xi)	Rated speed	1500 rpm
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 unit GD^2	Not less than 1
xvi)	Stator-winding connection	Star (Y)

xvii)	Ratio of quadrature axis sub transient reactance to direct axis sub transient reactance $x^n q/x^n d$	Less than 1.25
xviii)	Generator earthing through a distribution transformer	Star point earthed
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 (30^0C)

(a) Stator winding: 60^0 C
(b) Rotor winding: 60^0C
Stator Core: 55^0C

The maximum temperature rise when the generator is delivering maximum output corresponding to continuous overload capacity for conditions stated above shall not exceed 60^0C 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.

2.8.1.2 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 20-25^{0}C. 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 5^{0}C above the surrounding temperature. Necessary thermostat is 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 25^{0}C.

2.9 FIRE PROTECTION FOR GENERATOR (OPTIONAL)

An automatic carbon dioxide fire protection system complete with CO2 cylinders, ring headers, discharge nozzles, temperature 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 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

5.12.1 General

The excitation system of static type consisting of high performance fully controlled solid state converter bridge, dry type excitation transformer of suitable capacity, static voltage regulator, field breaker, field flashing unit, field discharge resistor, etc., conforming to acceptable relevant international standards may be supplied. The excitation shall be completely described in the tender.

Brushless excitation system or self-excited self-regulated excitation may also be offered.

2.12.2 Generator Field Discharge Equipment

A totally enclosed field air circuit breaker, draw out type, complete with auxiliary contacts, capable of breaking, without generating dangerous overvoltage, the maximum field current that can occur under conditions of normal operation or when interrupting the transient D. C. component of the field current due to a three-phase fault at generator terminals, shall be furnished with each set of excitation equipment. The field circuit breaker shall be suitable for both manual and electrical operation. Alternatively, an A. C. circuit breaker on the secondary side of the rectifier transformer instead of D. C. field circuit breaker may be offered.

The field circuit breaker discharge contacts, discharge resistors, or other equipment shall be mounted together to form a self-supporting assembly of the excitation control equipment of each generator. A suitable hinged door, locking handle, inspection windows, foundation bolts etc., shall be provided with each excitation cubicle.

2.12.3 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 over speed. 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.

2.13 LINE TERMINAL AND NEUTRAL GROUNDING CUBICLES

The generator suppliers shall supply 1 no. terminal cubicle for each machine housing surge capacitor, potential transformers, current transformers, lightning arresters, cable boxes, etc., as given in the enclosed drawing. The cubicle shall be complete with necessary tappings for excitation system, etc. The rating of the CTs for AVR shall be decided by the supplier taking into account the requirements of AVR.

The generator supplier shall neutral grounding cubicle one for each machine housing single phase distribution transformer, secondary loading resistor, current transformer, cable boxes, etc., as shown enclosed drawing.

The cubicles shall be sheet suitably compartmentalized with doors and shall be furnished complete with base mounting arrangement, foundation bolts, etc. The internal illumination for cubicles shall be provided with guarded lamps with on/off switches. Copper/Aluminum conductors of appropriate size shall be used for bus bars and connections in the cubicles. The bus bar and main connecting conductors shall be suitably insulated to make them compatible with generator temperature rise and insulation. The support insulators for the bus connection will be provided as necessary. GI earth bus of adequate cross section will be provided in the cubicle.

2.14 POTENTIAL TRANSFORMERS

The potential transformers will be single phase, epoxy cast, dry type units. Potential transformer will be protected on primary and secondary side by current limiting fuses. The PT shall conform to IS:3156. The potential transformers shall berate as given in the drawing.

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)

In case the generators are provided with static excitation system with excitation transformers, high set instantaneous over-current relay (50) IDMT and over-current relay (51) would be provided in the tapping for excitation transformer for protection of excitation transformers.

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 flow current. The arrestors shall conform to IS:3070 (latest edition)Part-I. The nominal discharge current of lightning arrestor shall not be less than 10KA.

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 unit rates shall be quoted for the spares. The tenderer shall also 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 contractor)
(g) Wave form
(h) Determination of characteristic:
(i) Reactance – 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.
(h) Routine tests on static excitation equipment.

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 contractor 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 contractor.

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.

3. TRANSFORMERS

3.1 SCOPE

The scope of work includes design, detailed engineering, manufacture of equipment, testing at works, assembly at manufacturer's works before dispatch, packing transportation, loading, unloading, supply and delivery F.O.R. destination, storage at site, erection, inspection, testing and commissioning of 2x2.5MVA, 3.3/33kV step up, 1x250kVA, 33/0.415kV station service and 1x250 kVA, 3.3/0.415kV station auxiliary(colony) transformers including preliminary acceptance tests and performance guarantee.

3.2 CODES AND STANDARDS

Codes of Practice and Standards shall be the latest editions including all applicable official amendments & revisions as on date of opening of bid.

3.3 SERVICE CONDITIONS

The equipment to be supplied under this specification will be installed outdoor at an altitude below 2000 meters and shall be suitable for satisfactory operation under the site conditions as described in Project Details.

3.4 GENERATOR- TRANSFORMERS

3.4.1 TRANSFORMER RATINGS/CHARACTERISTICS

The ratings/characteristics of the transformers shall be as below:

Sl. No.	Particulars	Ratings/Characteristics
1.	Continuous KVA rating	2500
2	Type	Oil immersed
3	Frequency	50 Hz + 3%
4	No. of Phases	Three
5	Maximum voltage on H.V. side	36 kV (r.m.s.) / 12
6	Maximum voltage on L.V. side	3.6 kV (r.m.s.) / .416 kV
7	Vector group	Y n d 11
8	Connections i. H.V. windings ii. L.V. windings	Star, neutral solidly earthed Delta
9	Off-load taps on H.V. side (for H.V. variation)	. (+) 2.5% to (-) 7.5% in steps of 2.5%
10	Suitability of bushings	L.V. side suitable for cable box/connections. H.V. side : condenser bushings
11	Type of cooling	ON

3.4.2 DESIGN AND CONSTRUCTION

i The transformer shall be 3-phase, oil immersed with core type of construction, tank mounted radiators, and suitable for outdoor service as step-up transformer. Adequate Ceramic ball/spacers shall be provided in the core/winding for circulation of oil so as to ensure proper cooling. All apparatus shall be designed to ensure satisfactory operation under such sudden variations of load, frequency and voltage as may be met-with under system working conditions including those due to short circuits. To minimize the eddy current losses in the windings, CTC shall be used wherever required. Similarly, for minimizing the stray losses, magnetic shield in yoke, magnetic shunt in tank walls, bushing turrets, clamps, flitch plates etc. shall be provided, wherever required. The design value of eddy current losses and stray losses shall be indicated by the manufacturer as a % of load losses.

ii. All materials used in the manufacture of the transformers shall conform to Codes and Standards as above.

iii. Design of all outdoor apparatus, including bushing insulators with their mountings shall ensure that no pockets be formed wherein collection of water can take place.

iv. Corresponding parts, which are liable for replacement, shall be interchangeable.

3.4.3 TEMPERATURE RISE, OVER-LOAD CAPACITY & CONTINUOUS RATING

i. Each transformer shall be capable of operating continuously on any tap at normal rating under service conditions given in Clause 6.6.1 without exceeding following temperature rises, over maximum ambient temperature of 45^0C:

a. 50^0C in winding (by resistance)

b. 45^0C in oil (by thermometer)

c. The temp. of hot spot in the winding not to exceed 90^0C when calculated over max. annual weighted average temp. of 40 ^{0}C &105 ^{0}C at worst ambient of 45 ^{0}C.

ii. Transformer shall be capable of delivering rated current at an applied voltage up to + 10% of rated voltage without exceeding the temperature limit.

iii. The limits of temperature rise mentioned above and over-load capacity as per IEC-354 (1993) shall be satisfied by the manufacturer by carrying out the heat run test at the lowest negative tap. This test shall be carried out by feeding the following losses : -

(Total max. losses at 75 deg. C at highest current tap) x 1.1

iv. Safe over-load capacity of the transformer and the duration of over-load for ON cooling under maximum temperature conditions without any damage to the winding or harmful effects on the insulation shall be as per IEC 354 and shall be clearly stated in the tender.

v. The transformers shall be operable without exceeding temperature rises, winding gradients and hot spot at any particular tapping at the rated MVA for ±10% of the voltage corresponding to that tapping.

3.4.4 TAP CHANGER

The range of transformer taps shall be as per serial no. 9 of table under clause 3.4.1. OFF - circuit tap changer having local manual control and with following features shall be provided:

i. Designed for sustained over current of not less than 150% of rated current of the winding.

ii. It shall not occupy any intermediate position between clearly marked tap positions.
iii. It shall be capable of repeated operation and withstanding S.C. forces.
iv. It shall have integral handle with pad-locking facility at every tap position.
v. The tap charger shall have tap position indicator.

3.4.5 CORE

i. Working flux density under rated voltage shall not exceed 1.55 Tesla at normal voltage, frequency and voltage ratio. Over fluxing shall be as per relevant standards.
ii. Tenders with higher flux density than specified shall not be considered.
iii. The core shall be built up with thin laminations of high grade, non-ageing, low loss, high permeability, cold rolled super grain oriented silicon steel, known as HIBIMOH or low loss CRGO silicon steel of maximum 0.27 mm or low lamination thickness specially suitable for transformer cores.
iv. The laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore original magnetic properties of material after cutting and punching operation. The laminations shall be treated after cutting etc. to remove all burrs and checked during stage inspection. These shall be coated with baked enamel insulation coating. The insulation shall be inert to the action of hot transformer oil and be perfectly adhesive. Paper and varnish insulation shall not be accepted. Particulars of proposed insulation shall be stated in the tender.
v. The core shall be rigidly clamped and/or bolted to ensure adequate mechanical strength and to prevent vibrations during operation. The bolts used in the assembly of the core shall be suitably insulated and the clamping structure should be so constructed that the eddy currents will be minimum.
vi. The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthing clamping structure and the production of flux components at right angles to the plane of the lamination which may cause local heating.
vii. Number of steps in the limb and yoke shall be matching and dimensionally identical to minimize the effect of cross-fluxing and for better mechanical strength.
viii. The core shall be provided with lugs suitable for lifting complete core and coil assembly of transformer and be fixed in the tank so that its shifting will not occur when the transformer is moved or when a short circuit occurs.
ix. Every care shall be exercised in selection treatment and handling of core steel to ensure that the laminations are flat and that finally assembled core is free from distortions.
x. Supporting frame of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.
xi. Oil ducts, where necessary, should be formed across the plane of the lamination and be given a suitable slope to assist oil circulation. The overall design of core and winding should ensure free flow of oil without obstruction.
xii. Frame work and clamping arrangement shall be earthed by connecting to the tank body through a copper strip. Yoke bolt area should be compensated if bolts are used for fastening of the core. Also, flitch plate area will not be counted in core area.

xiii. The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV (RMS) for one (1) minute.

xiv. Core and winding shall be capable of withstanding shocks during transport, installation, service etc. and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

xv. All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

xvi. CRGO used shall be procured from reputed vendor.

xvii. The tenderer shall indicate the maximum flux density allowable continuously, as well as for time intervals of 1 minute and 5 secs. and the limit of flux density at which core material used by them saturates.

xviii. The name of the core material must be mentioned in the tender. The successful tenderer shall be required to furnish magnetization curves of the core material/design calculations and such other data/documents deemed fit by the purchaser for being satisfied that flux density is as desired.

xix. Purchaser may inspect the built-up core for verification of flux density for= which all facilities shall be provided. Core may also be inspected during horizontal assembly, built up assembly.

NOTES:

i. The above flux density has been specified to meet with the over fluxing of the core due to temporary over voltage of the order of 31% for 1 min., 44% for 5 sec. that may appear in abnormal conditions such as those following sudden loss of large loads/ tripping of Generator-breaker.

ii. Yoke bolt area and flitch plate areas shall not be counted in the net core area, if these are provided for fastening of core.

iii. The design of limb and yoke shall be so coordinated that there is no cross fluxing at the joints.

3.4.6 WINDINGS

i. The conductor used for the winding shall consist of solid drawn high conductivity electrolytic grade copper free from scale and burrs.

ii. In case of copper strip, the corners shall be rounded-off to eliminate risk of injury to internal insulation during winding & other operations. No strip Conductor wound on edge should have width, exceeding six times its thickness.

iii. All permanent current carrying joints in the windings and leads shall be welded or brazed. Preference shall be given to a winding with a continuous conductor. The windings shall be pre-shrunk during manufacture so as to avoid any chances of any further shrinkage taking place during service. Provision shall be made so that it will be possible to take up this shrinkage by means of adjustable clamping screws and end rings in case of occurrence of shrinkage.

iv. The voltage between adjacent coils shall be kept as low as consistent with the given design.

v. The windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the windings can be made readily without special equipment.

vi. The coils shall be supported between adjacent sections by insulation used in the assembly of the windings.

vii. The windings shall be arranged so as to ensure free circulation of oil and to reduce hot spots in the windings.

viii. All threaded connections shall be provided with locking facilities. All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used wherever practicable.

ix. The winding shall be designed to reduce the out of balance forces in the transformer to a minimum at all voltage ratios.

x. The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and winding shall be dried and suitably impregnated before removal from the treating tanks.

xi. The insulation of the coils shall be treated suitably to develop full electrical strength of the windings and for this, hot oil vacuum impregnation process shall be used for improving the electrical and thermal properties of insulating paper.

xii. All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be adversely affected under the operating conditions.

xiii. The conductors shall preferably be CTC, transposed at sufficient intervals in order to minimize eddy current and equalize the distribution of current and temperature along the winding.

xiv. Windings shall preferably be made in dust proof condition.

xv. Tappings shall be so arranged as to preserve the magnetic balance of transformer at all voltage ratios. Tapping winding shall be provided separately from the main HV winding.

xvi. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

xvii. Inter-coil and inter-turn insulation shall be designed to ensure that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

xviii. The insulation of transformer windings and connections shall be free from insulating compound which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inert in transformer oil during service.

xix. The windings shall be braced to withstand shocks due to rough handling and forces due to short circuits, switching or other transients.

3.4.6.1 Reinforced Insulation

At each end of HV winding an electrostatic shield and/or cap & ring shall be provided so as to increase the ratio of the electrostatic capacity between turns as compared with the electrostatic capacity of the high voltage winding to earth and to the low voltage winding. HV winding shall preferably be interleaved.

3.4.6.2 Current Density

The design of the transformers shall ensure that the current density of the HV windings at the lowest tap does not exceed 250 A/cm^2, and that of the LV windings 200 A/cm^2.

3.4.7 INSULATION LEVEL

3.4.7.1 The insulating material to be used shall be of class "F" as specified in the latest relevant standards.

3.4.7.2 The dielectric strength of winding insulation and of the bushings shall conform to values given in IS: 2026/1981 part-III amended up to date except for the changes made in this specification.

6.4.7.3 The impulse test and power frequency test voltage shall be as per the relevant IS/Standards followed.

6.4.7.4 Short Circuit Strength and Provision of Separate Tapping Coil for Regulation

Transformers shall be designed and constructed to withstand without damage the thermal and dynamic effects on external short circuits for 5 seconds under conditions specified in IS: 2026 (Part-I)- 1977. The transformers shall be provided with separate tapping coil to limit the short circuit forces.

The position of the tapping coil shall be so arranged that at extreme negative tap, the percentage regulation is less than at normal tap. The bidders shall submit test certificates of short circuit test, if already done on the offered design and rating. However, the thermal and dynamic ability to withstand short-circuit forces shall be demonstrated by calculations.

3.4.8 IMPORTANT TECHNICAL PARTICULARS

Important technical particulars of the transformers to be guaranteed by the tenderers shall be as per formats given in the concerned section.

3.4.9 TOLERANCES

Various tolerances on technical parameters shall be as under :-

i. Impedances:

Maximum tolerance allowed on impedances at all taps shall be as per IS:2026 (Latest edition).

ii. Overload

Transformers shall be tested for over-load conditions as specified in latest edition of IEC-354/1993 , which shall be read with IEC-76/1993.

iii. Weights

No negative tolerance shall be allowed on Weight of Copper, Weight of CRGO & Weight of Oil etc.

iv. Losses

No positive tolerance shall be allowed on guaranteed No load losses, Load Losses and Auxiliary Losses individually at rated voltage, current, principal tap & 75^0C temp.

v. Temperature Rise Test

No positive tolerance shall be allowed on Temperature Rise of Oil, Windings, Winding Temperature Gradients & Hot-Spot Temperature than the Guaranteed Values.

3.4.10 COOLING

Transformers shall have ON type of cooling. Radiators shall be of pressed steel, tank mounted, bolted type. Bolted, gasket and flanged connections shall be used for connecting the radiators to the tank. Radiators shall be designed to withstand the pressure conditions specified for the tank and shall be designed so as to be accessible for cleaning and painting to prevent accumulation of water on the outer surfaces.

Radiator shall be provided with:

i. Top and bottom shut-off valves and blanking plates.
ii. Bottom drain plug, top filling plug and air release plug.
iii. Lifting lugs.

Valves and connections shall have following features:

i. Sluice type valves with hand wheels.
ii. Clear indication of open and closed positions.
iii. Provided with blanking plates and screwed plugs.

Insulating Oil

i. Sufficient insulating oil of NAPTHENIC TYPE (Made from NAPTHENIC CRUDE) conforming to BS: 148/IEC:296 class-I/IV shall be supplied for first filling of each transformer.
ii. An extra quantity of transformer oil equal to 10% of the total quantity of oil shall also be supplied.
iii. If the transformer is to be supplied gas filled, particular attention shall be paid to deliver the oil at site free from moisture and of uniform quality throughout in non-returnable epoxy coated steel drums.
iv. The quantity of oil for first filling of each transformer shall be stated in tender along with manufacturer of the oil to be supplied.
v. Use of inhibitors in oil shall not be resorted to.

3.4.11 SUPPRESSION OF HARMONICS

The transformer shall be designed with particular attention to suppression of harmonic voltages especially the 3^{rd} and 5^{th} harmonics. Percentage of harmonics at normal voltage and at maximum system voltage shall be stated in the tender.

3.4.12 TRANSFORMER TANK

The transformer tank and cover shall be oil tight and fabricated from good commercial grade low carbon steel of adequate thickness. The weld procedure and performance shall be in line with ASME BPV-9 /IS:2062. The tank and the cover shall be of welded construction. All seams

shall be welded and where practicable they shall be double welded. The tank shall be designed and constructed for vacuum filling of oil and be capable of withstanding without leakage or distortion continuous internal gas pressure of 0.7 atmospheres with oil at operating level. The tank cover shall be bolted with the lower position of the tank and the transformer design shall make it possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails. .

Where the design of the tank is such that the bottom plate will be in direct contact with the surface of the foundations, the bottom plate thickness shall not be less than 20mm.

Man holes/inspection covers with welded flange and bolted covers shall be provided on the tank cover. The inspection covers shall be of sufficient size to afford easy access to the lower ends of bushings, terminals etc.

All bolted connections to the tank and connections between sections of the tank shall be provided with suitable flanges, with properly spaced bolts and suitable oil tight gasket which shall give satisfactory service under operating conditions.

The thickness of M.S plate for bottom, sides and top of the tank shall be adequate as per CBIP recommendations.

The main body including tap changing compartments, radiators and coolers shall be capable of withstanding full vacuum of 760mm of mercury when empty of oil.

The design of tank, its shape, proportions, weight of material and construction shall be such as to best facilitate oil circulation and to ensure against transmission or magnification of noise or vibration, which might be injurious or objectionable.

The transformer tank along with radiators and other accessories shall be tested for vacuum and pressure test as per CBIP recommendations.
Suitable guides shall be provided for positioning the various parts during assembly or dismantlement. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

Lifting eyes or lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantlement. In addition, the transformer tank shall be provided with lifting lugs and bosses properly secured to the sides of the tank for lifting the transformer by using hydraulic or screw jacks.

As far as possible, the transformer tank and its accessories shall be designed without pockets so that gasses may not collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main explosion pipe. The vent pipes shall have a minimum inside diameter of 15mm except for short branch pipes which may have 6mm minimum inside diameter.

The tank cover shall be provided with pockets one for mercury in glass thermometers and two pockets for the bulbs of oil and winding temperature indicators. Minimum depth of the thermometer pockets shall be 10'' from top oil level. Protection shall be provided where necessary, for each capillary tube. The thermometer pockets shall be fitted with a captive screwed top to prevent ingress of water. The pockets shall be located in the position of maximum oil temperature at CMR and it shall be possible to remove the instrument bulbs without lowering the oil in the transformer tank.

Each transformer tank shall be fitted with the following valves/plugs with standard screw connections for external piping:

i. One filter-cum-oil drain valve with plug or blanking flange (size 80mm/ 100mm/ dia) and so placed as to completely drain the oil of the transformer.
ii. One no. top filter valve of size 50mm near the top of the tank diagonally opposite to filter-cum-drain valve.
iii. At least two nos. 15 mm dia air release plugs suitably located on top of cover.
iv. One pressure relief valve/device to operate at a pressure below the test pressure for the tank.
v. Suitable no. of jacking bolts shall be provided on tank cover and inspection covers.

The design of the tank, the lifting lugs and bosses shall be such that the complete transformer assembly filled with oil can be lifted with the use of these lugs without any damage or distortion.

All bolts and nuts used in connection with tank and fittings shall be galvanized/Zinc plated & passivated.

The tank shall be provided with suitable lugs for the purpose of grounding with mild steel flat.

3.4.13 CONSERVATOR TANK

i. An oil conservator tank preferably air cell type complete with sump, filling hole and drain valve shall be mounted above the radiators and located so as not to obstruct taking of bare connections from the transformer terminals.
ii. The capacity of the conservator tank shall be adequate to meet the requirements of expansion of the total cold oil volume in the transformer and cooling equipment from minimum ambient temperature of minus 5^0C to 115^0C.
iii. The minimum indicated oil level shall be, with the feed pipe from main tank cover, under not less than 15mm depth of oil and the indicated range of oil level shall be from minimum to maximum.
iv. One magnetic type oil level gauge with alarm contacts shall be mounted at a convenient height to be read from ground level. Prismatic oil level gauge shall also be provided.
v. Oil level at 30^0C shall be marked on the gauge.

vi. The conservator tank shall have one oil filling hole with cap at the top and drain valve of appropriate size at the bottom. A shut off valve shall be provided at the conservator to cut off supply to the transformer.

vii. The conservator tank will be designed to withstand strong wind pressure. Adequate stiffeners may be added, if necessary.

viii. Each conservator shall be fitted with a double compartment breather with oil seal in which silica gel is the dehydration agent and designed so that :-

a. The passage of air is through the silica gel.

b. The external atmosphere is not continuously in contact with the silica gal

c. The moisture absorption is indicated by change in colour of the tinned crystals and can be observed from distance.

d. All breathers shall be mounted at approximately 1400 mm above ground level.

e. The breather should be made of superior quality see-through material and should consist of two compartments placed in parallel.

f. The conservator shall be of air cell type, if possible, having provision for rubberized air cell so that air does not come in contact with oil in the conservator.

3.4.14 OFF-CIRCUIT TAP-CHANGER

Each transformer shall be provided with an off - circuit tap changing switch suitable for varying its effective ratio of transformation whilst the transformer is de-energized and without producing phase displacement. The off - circuit switch handle will be provided with a locking arrangement along with tap position indicator, thus enabling the switch to be locked in position. A warning plate, indicating that switch shall be operated only when the transformer is de-energized, shall be fitted.

3.4.15 ELECTRICAL CLEARANCES

The electrical clearance in air between live conducting parts and live conducting parts to each structure shall be as per the relevant IS/Standards followed.

3.4.16 FITTINGS AND ACCESSORIES

Each transformer shall be complete with the following fittings and accessories:

i. One 150 mm (6'') dial type indicating thermometer (OTI) of robust pattern mounted on the side of the transformer at a convenient height to read the temperature in the hottest part of oil and fitted with alarm and trip contacts.

ii. 1 No., 150 mm dial type winding hot spot temperature indicator (WTI) placed in HV/LV winding, as described below:

It shall be indicating type responsive to the combination of top oil temperature and winding current calibrated to follow the hottest spot temperature of transformer winding. The device shall have an additional pointer to register the highest temperature reached. Winding temperature indicator should have two sets of contacts. Contacts of the WTI shall be used for trip and alarm purpose, wiring of which will go to the main control and relay panel of the transformer (external control cables from the Marshalling kiosk to the Control & Relay panel are covered in separate section.)

iii. One explosion vent on transformer tank cover.
iv. Inspection covers with jacking bolts in the top cover plates of the tank.
v. One filter - cum - oil drain valve with plug or blanking flange size 80mm.
vi. One filter valve at top of transformer tank size 50mm.
vii. One double float gas/oil surge detecting (Buchholz) relay in the pipe connecting the conservator with tank, complete with alarm/tripping contacts to detect accumulation of gas and sudden rise of oil pressure, complete with two shut - off valves on conservator side as well as tank side and a coupling to permit easy removal without lowering flanges/oil level in the main tank. The size of shut - off valve shall be 80mm.
viii. Two grounding terminals on breadth side of tank
ix. Skids and pulling eyes on both sides.
x. One Marshalling box housing dial type thermometers for winding and oil temperature indicators.
xi. Thermometer pockets for mercury in glass thermometer of minimum 25 cm depth from top level.
xii. A set of universal type bi-metallic multi-bolt double grooved conductor clamps for HV side capable of receiving single ACSR conductor (DOG) for bushing of 33 kV side of transformer.
xiii. Suitable bi-metallic flexible connectors for neutral terminals.
xiv. One set of terminal bushings each for HV & LV winding
xv. One set of Neutral bushing(s) with ring type CT of ratio 40/5, 5P15 15 VA for earth fault protection.
xvi. Suitable size bi-directions wheels for rail gauge to suit existing tracks in both directions-4 Nos. along with locking and bolting devices.
xvii. The following plates, marked in English, shall be fixed to the transformer tank at about 1750mm above ground level:
    a. Rating plate bearing date as specified in IS: 2026/1977, it must contain insulation levels of various windings, impedance at normal & extreme taps short circuit duration, WTI ratio besides other information.
    b. Terminal marking plate showing the internal connections & voltage vector relationship of various windings in accordance with IS: 2026: 1977 (Latest Edition).
    c. Diagram plate showing the location and function of all valves and air release cocks or plugs.
xviii. Oil conservator (for main tank) complete as per 6.6.13.
xix. One no. spare pocket on tank cover for thermometer.
xx. Off-circuit tap changer
xxi. De-hydrating breather
xxii. Any other item, which is not included above but is essential for the satisfactory operation of the equipment.

3.4.17 ANTI-EARTHQUAKE CLAMPING DEVICE

A clamping device shall be provided for fixing the transformer to the foundations to prevent transformer movement during earthquake. The contractor shall supply necessary bolts for embedding in the concrete. The arrangement shall be such that the transformer can be fixed to

or unfastened from these bolts as desired. The fixing of transformer to the foundation shall be designed to withstand seismic events to the extent that a static coefficient of 0.3g applied in the direction of least resistance to that of loading will not cause the transformer or clamping device as well as bolts to be over stressed.

3.4.18 EARTHING TERMINALS

Two earthing pads suitable for connecting 50x8mm mild steel flat shall be provided at positions close to the two diagonally opposite bottom corner of tank. These grounding terminals shall be suitable for bolted connection. Two earthing thermals shall also be provided on marshalling box and any other equipment mounted separately.

3.4.19 UNDER CARRIAGE

The transformer shall be supported on a strong structural steel base equipped with forged steel or cast steel, single flanged, bi-directional wheels suitable for moving the transformer completely filled with oil. Jacking pads shall be provided to make it possible to change the direction of wheel through 90 degree when the transformer is lifted on jacks and permit movement of the transformer both in the longitudinal and transverse direction. Track gauge in both longitudinal and transverse direction shall match with the existing track at power house switchyard site. Means shall be provided for locking the swivel movement in position parallel to and at right angles to longitudinal axis of the tank.

Pulling eyes and skids shall be provided to facilitate moving of the transformer. These shall be suitably braced in the vertical direction to avoid bending when the pull has a vertical component.

3.4.20 BUSHING INSULATORS AND TERMINALS

i. Transformer shall be fitted with bushing insulators as follows :-
   a. HV Bushings: 36 kV
   b. LV Bushings: 3.6 kV
   c. HVN Bushings: 36 kV

ii. Bushing shall be suitable for 25 times rated current for 5 seconds.

iii. Short time current withstand capability of bushing shall be 17.5 kA for 3 seconds for HV bushing and 40 kA for LV bushing.

iv. The electrical characteristics of bushings shall be in accordance with IS:3347 and IS:2029.

v. All bushings shall be equipped with suitable terminals of approved type and, size and all external current carrying surfaces shall be adequately silver plated. All ends as well as all tappings on the windings shall be brought to terminals. Bushings which pass through the cover shall be removable without disturbing the transformer cover.

vi. The bushings shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushings of various voltages and between bushings and grounded parts.

vii. Bushings of identical voltage shall be interchangeable. The insulating class of the high voltage neutral bushings shall be properly co-ordinated with the insulation class of neutral of the high voltage winding.

viii. Clamps and fittings shall be galvanized.

ix. Each bushing shall be so co-ordinated with the transformer insulation that all flash covers will occur outside the tank. All bushings shall have puncture strength greater than dry flash over value. Any stress shield shall be considered as integral part of bushing assembly. Only condenser type bushing shall be accepted.

x. Neutral bushings shall be provided as required for earthing of neutral point along with ring type of CT ratio 40/5, 5P15, 15 VA.

3.4.21 CENTRE OF GRAVITY

The center of gravity of the assembled transformer shall be low and as near the vertical center line as possible. The transformer shall be stable with or without oil, if the center of gravity is eccentric relative to track either with or without oil, its location shall be shown on the outline drawings.

3.4.22 JOINTS, GASKETS AND VALVES

i. All gasket used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber. The material used should not deteriorate under the action of hot oil.

ii. All valves up to and including 100 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clockwise when facing the hand wheel. Means shall be provided for padlocking the valves in the open and closed position. Every valve shall be provided with flanges having machined faces. The drilling of valves flanges shall comply with the requirement of IS: 2026/IS: 3639.

3.4.23 CLEANING AND PAINTING

All corrodible parts and surfaces shall be of such material and shall be provided with such protective finish that no part of the installed equipment is injuriously affected by atmospheric conditions.

The whole of the exposed portion except bright parts shall be thoroughly cleaned by sand blasting and painted with two primary coats of approved rust resisting paint in dark admiralty grey colour. Inside surface shall be clean, smooth, free from voids and of best construction. The nature of coatings, provided inside, shall be specified and it shall be ensured that it does not react with transformer oil or deteriorates its electrical/chemical properties. Some paint suitable for primary and secondary coats shall also be supplied to cover the damage to paint work which may be experienced during transportation.

3.4.24 MARSHALLING KIOSK

Made of sheet steel of minimum 3mm thickness, vermin proof, well ventilated and weather proof marshalling box of a suitable construction shall be provided for the transformer ancillary apparatus. Wiring up to marshalling box shall be with PVC/SWA, PVC copper cable 660/1100 volts grade IS certified/marked.

The marshalling box shall accommodate the following equipment: -

a. Temperature indicators.
b. Terminal board and glands for incoming and outgoing cables.

The temperature indicators shall be so mounted that the dials are not more than 1600 mm from the ground level and the door(s) of the compartment(s) shall be provided with glass window of adequate size to prevent internal condensation. An approved type of metal clad heater with thermostat shall be provided, controlled by water tight single pole iron clad rotary switch mounted on outside of the box. The ventilation louvers, suitably padded with felt, shall also be provided.

All outgoing connections from the transformer viz.: Buchholz relay, temperature indicators, level indicators, etc. shall be wired to marshalling kiosk.

All incoming cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and associated compartments shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

3.4.25 CONTROL CONNECTION, INSTRUMENT WIRING, TERMINAL BOARDS & FUSES

All wiring connections, terminal boards, fuses and lines shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation. There shall be no possibility of oil entering connection boxes used for cables and wiring. When 415 volts connections are taken through junction boxes of marshalling boxes, they shall be adequately screened and 415 volts danger notice must be affixed to the outside of junction boxes or marshalling boxes. All wiring shall be with stranded copper of 1100 volts grade and 4.00 sq. mm for CT leads and not less than 2.5 Sq.mm for other connections. All wiring cables shall be ISI-marked/certified and in accordance with the relevant ISS.

All wires on panels and all multicore cables shall have ferrules bearing same number at both ends. Same ferrule numbers shall not be used on wires in different circuits, on the same panels. Ferrules shall be of white insulating material and be provided with glossy finish to prevent adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil. Wiring shall, in general be accommodated on sides of the box and wires for each circuit shall be separately grouped.

Back of panel wiring shall be arranged so that access to the connecting stems of relays another apparatus is not impeded. All the cables and capillary types of OTI and WTI etc are to be wired properly on cable trays with the help of suitable cleats upto the marshalling box. The cable trays shall be kept minimum 100 mm away from the tank body to avoid excessive heating of cables/wires.

Wires shall not be joined or tied between terminal points. Wherever possible, all circuits in which the voltage exceeds 125 V shall be kept physically separated from the remaining wiring.
The function of each circuit shall be marked on the associated terminal boards.
Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of copper wire.
No live metal part shall be exposed at the back of terminals boards.
All fuses shall be of cartridge type and links shall be labeled.
All wiring diagrams for control panels shall preferably be drawn as viewed from the back.
The overall design of wiring shall be such that various wires and ends of the same wire can be traced easily and there is convenience to access the terminations and ferrule number shallbe readable with convenience.

3.4.26 DRAWINGS

The tenderer shall submit with his tender, one set of dimensional drawings of the equipment offered, along with illustrated and descriptive literature for scrutiny. The successful bidder after the award of the contract shall supply four copies of the following drawings documents within 30 days after the receipt of purchase order, which will describe the equipment in detail for approval by the Purchaser.

i. Detailed outline General Arrangement drawing showing plan, front elevation, side elevation with all fittings and accessories etc. Following information must be specifically included on this drawing:
   a. Make of transformer oil.
   b. Electrical clearances, minimum as well as actual.
   c. The no. of radiator elements, width, thickness of sheet & height of each radiator.
   d. A sketch showing detailed procedure for dismantling.
   e. Thickness of transformer tank bottom, side & top plates.
   f. Type, shade, shade no. and thickness of transformer paints.
   g. Roller, rail gauge sketch.
   h. Weight of oil; bare copper windings, core, un-tanking mass, transportation mass and dimension etc.
ii. Detailed drawing of bushing, showing plan & elevation, terminal details, mounting details, make and type, number, incorporating electrical characteristics, description of various parts, total creepage/protected creepage distance, weight of oil, total weight of bushing, dimensions, short time rating etc.
iii. Transportation sketch showing dimensions and weights of the heaviest package and the shipping arrangements of the transformer.
iv. Rating and diagram plate.

NOTE: Bushing CT's for WTI's are to be provided on HV side.

v. Detailed structural drawings for the transformer tank, under carriage, conservator, radiators, supporting structures for cooling fans etc.
vi. Dimensional drawings of multi bolt bimetallic connectors for line ends and flexible connectors for the neutral ends.
vii. Roller Stopper arrangement drawing.

3.4.27 ADDITIONAL DRAWINGS

Following drawings shall be supplied for reference and record in addition to the above listed drawings.

i. Large scale drawing of high and low voltage windings of transformer showing the nature and arrangement of insulation and terminal end connections.
ii. Drawing showing sectional view of the HV and LV windings when viewed from top.
iii. Detailed drawings of conservator and pressure relief device (explosion vent) mounted in position.
iv. Foundation plan of the transformer including auxiliary equipment.
v. Any other drawing considered necessary by the Purchaser.
vi. A schedule showing the requirement of set of spare gaskets.

3.4.28 INSTRUCTION MANUALS

The successful tenderer shall be required to supply 6 (six) sets of instruction manuals per transformer, each properly bound in hard cover. Each set shall consist of the following:-

i. All the approved drawings listed above.
ii. Erection, Operation & Maintenance manual for transformer and pamphlets for all spare parts e.g. OIL, WTI, Off- load tap-changer Buchholz relay, Silica-gel breather / Pressure relief valve.
iii. Instructions for dehydration, if any.
iv. Precautions prior to vacuum application, if any.
v. Any other information/data/documents/instructions considered necessary by the manufacturer for efficient functioning of the transformer.

3.4.29 GUARANTEED DATA AND OTHER PARTICULARS

Guaranteed data and other technical particulars of the transformers offered shall be furnished by the tenderer in accordance of this specification for all the transformers.

3.4.30 PLACE OF MANUFACTURE, TESTING AND INSPECTION

The tenderer shall state in his tender, the place (s) of manufacture, testing and inspection of various portions of the work included in the tender. The place of manufacturing shall not be allowed to be changed at a later stage.

The purchaser or his duly authorized representative shall have access to the manufacturer's works at any time during working hours for the purpose of inspecting the manufacture & testing of materials, equipment and completed plant and the supplier shall provide necessary facilities for inspection.

3.4.31 INSPECTION AND TESTING

The successful tenderer shall submit complete set of drawings as already brought out in this specification within 30 days from the receipt of purchase order. The suppliers will furnish schedule of manufacturing of the transformer along with the drawing. Purchaser can inspect the

raw material, manufacturing process at sub-supplier's works for which advance intimation of manufacturing activities shall be given.

i. Radiators

Radiators shall be routine/type tested at supplier works as per relevant standards.

ii. Routine Testing

All routine tests shall be carried out on each transformer as per IS- 2026/ IEC-76 & IEC- 354

iii. Type testing

The following type tests and T/F withstand capacity beyond name plate as per IEC-354 shall be carried out as per IEC-76/IEC- 354 & IS- 2026 on the transformers :-

a. Temp. Rise Test with 2x50% radiators only.

b. Impulse Voltage withstand test on all the three phases with chopped impulse.

3.4.32 FOUNDATIONS AND FIXINGS

All plant and equipment shall be provided with a complete set of foundation bolts, washers, nuts, plates and other fixtures as may be required and these shall be supplied by the supplier. These fittings shall be fixed by the purchaser in the foundations, unless otherwise specified. All foundations, bolts, fixtures etc. shall be supplied as soon as possible after the contract drawings have been approved.

3.4.33 PACKING, DESPATCH AND DELIVERY

The supplier shall be responsible for suitable packing of all equipment and marking of the consignments so as to avoid any damage during transit, storage and to ensure correct dispatch to the destination. Damages to equipment/material in transit due to improper packing shall be to supplier’s account. All parts requiring protection from moisture shall be especially packed to prevent ingress of moisture. No parts of any kind shall be packed inside other larger parts. Heavy parts shall be so mounted that there is no difficulty in attaching slings etc. for unloading at destination.

All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with contract number and shall have packing list enclosed, showing the parts contained therein.

In case the transformers are dispatched gas filled and oil for first filling is dispatched separately, sufficient quantity of gas in NON RETURANABLE Cylinders shall be supplied to maintain the pressure of the gas in the tank at site before it is filled with oil.

3.4.34 TOOLS

The transformers shall be supplied with a set of special tools, if considered necessary for assembling and dismantling of transformer. The details of the tools etc. included in the offer shall be given.

3.4.35 SPARES

All the spare parts of the equipments shall be interchangeable and shall be of same material and workmanship as the corresponding parts furnished with main equipment. Unit prices of any additional spares considered necessary may be indicated separately. The F.O.R. destination prices shall be mentioned clearly against each item given above. Further, voltage & current rating of each spare bushing should be clearly indicated and should be same as that of bushing provided on the transformers.

3.4.36 DRYING-OUT AND ERECTION

The transformer shall be dried-out by an appropriate method at the manufacturer's works and so arranged for transportation and storage that it may be put into service without further drying out at site. For any subsequent drying out which may be necessary at site the manufacturer shall give details of the method recommended for using the same.

The transformer shall be designed to withstand pressure and vacuum tests as specified by CBIP specification for power and distribution transformers :-

a. Vacuum as per CBIP manual to be applied to tank and cooling equipment when empty of oil.
b. Pressure of 1 kg/cm2 mercury applied to tank and cooling equipment when empty of oil.
c. Pressure of 0.5 kg/cm2 to be applied at conservator on fully assembled transformer when full of oil.

Clear instructions shall be given in the maintenance manual regarding special precautionary measures e.g. stucking up of tap changer barrier or tank cover which must be taken before applying the specified vacuum treatments. The maximum vacuum which the complete transformer filled with oil, can safely withstand without any special precautionary measures being taken shall also be stated in the maintenance manual.

The bushings shall be capable of withstanding vacuum operation when drying out the transformer.

3.50 STATION SERVICE TRANSFORMER

The Station Service Transformer shall be Indoor, cast resin type to be installed inside the Power House. The main requirements are as given below:

Rated Power	250 kVA
Number required	1(one)
Type	Three-phase, two winding dry cast resin type
Type of installation	Indoor
Frequency	50Hz
Cooling medium	AN
Rated voltage:	
a) High voltage winding	3.3kV

b) Low voltage winding	0.415kV	
Highest system voltage:		
a) High voltage	3.6	
b) Low voltage	1.1	
Method of system earthing:		
a) Low voltage	Solidly earthed	
Type of tap changer	Off-load	
Range of tapping full capacity on HV side in eight (8) equal steps of 1.25% each	-5% to +5% in steps of 1.25%	
Neutral terminal to be brought out	on HV winding	
Percentage impedance at 75˚C	5%	
Insulation level:	HV	LV
a) One minute power frequency withstand test voltage kV (peak)	20	3
b) Impulse withstand test voltage kV (peak)	40	-
Max. fault level kA (rms)	25	-
Winding connection	Delta	Star
Vector group	Dy11	
Type of cooling	AN	
Neutral earthing	LV neutral shall be solidly earthed through a CT with copper bar mounted over insulators fixed to the side of the transformer tank	
Terminal details:		
a) HV phase terminals	Shall have detachable Cable Box for XLPE cable termination of suitable size.	
b) LV Phase terminals	Cable box with disconnecting chamber with necessary glands, lugs and fixing arrangement XLPE cable shall be provided.	

STANDARDS, SPECIFICATIONS AND CODES OF PRACTICE

1. POWER TRANSFORMERS

IS: 1367 Hot dip galvanized cooling on threaded fasteners.
IS: 1866 Code of practice for maintenance of insulating oil.
IS: 2026 Specification for Power Transformers
IS: 2705 Current transformers
IS: 3347 Dimensions of porcelain transformer bushings for use in lightly Polluted Atmospheres
IS: 3637 Gas operated relays
IS: 3639 Fitting & accessories for Power Transformers
IS: 6600 Guide for loading of oil immersed transformers
IS: 9434 Guide for sampling and analysis of free and dissolved gas in oil filled Atmosphere.
IS: 10028 Code of practice for selection, installation and maintenance of transformer
IS: 12371 Technical requirements for single action telescopic tipping cylinders for agriculture trailers
IEEE: 32 IEEE standard requirement terminology and test procedure for neutral Grounding device.
CBIP: Manual of Transformer.

Equipment complying with other internationally accepted standards such as IEEE, IEC, BS, USA, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case the Bidder shall clearly indicate:

i. The standards adopted,
ii. The bidder shall clearly bring out salient features for comparison with the standards listed under serial 1 above.
iii. Furnish a copy (in English) of the relevant standards adopted (along with the latest revision of standard and copies of all official amendments and revisions in force as on date of opening of bid).

4.0 33 kV SWITCHYARD EQUIPMENT/WORKS

4.1 SCOPE

Design, detailed engineering, manufacture of equipment, shop testing, packing, transportation, loading & unloading, delivery, storage at site handling, erection, pre-commissioning tests and commissioning of the following equipment/system including preliminary acceptance test and performance guarantee for the following 33 kV switchyard equipment of the powerhouse.

1. Isolators
2. Circuit Breakers
3. Lightning Arrestors
4. Potential Transformers
5. Current Transformers
6. Bus Bars & Bus Connections
7. Grounding/Earthing
8. Lighting of switchyard
9. Lightning Protection System for power house and switchyard
10. Structures
11. Fencing
12. Any other equipment necessary to complete the job

4.2 CODES OF PRACTICE

All Codes of Practices and Standards shall be the latest editions including all applicable official Amendments & Revision as on date of opening of bid.

4.3 ISOLATORS

4.3.1 Application

These are to be used for:

i. Breaker isolation/connection on no load
ii. Line connection/isolation/ on no load

4.3.2 Type and Construction

i. Triple pole gang operated suitable for outdoor installation in open yard under the specified site conditions.
ii. Common actuating mechanism for all three poles.
iii. Motor operated from Remote/local and also manually operable.
iv. Interchangeable single pole units
v. Switch blades shall be of copper and of one solid piece construction.
vi. Adequate Inter-phase clearance and mounting height.
vii. Speed of operation during opening or closing shall ensure minimum arcing.
viii. 33 kV isolator shall be horizontal double break type mounted on structure.

4.3.3 TECHNICAL PARTICULARS

i. Nominal system voltage : 33 kV

ii. Highest system voltage : 36 kV
iii. Rated frequency : 50 Hz
iv. Type : Outdoor station type, double break, triple pole double throw with turn and twist mechanism, with earth switch (on feeder isolator only)
v. Continuous current rating : 630 A
vi. Short time rating 1 sec : 750 MVA
vii. Rated peak withstand current : 17.5 kA Peak
viii. Insulation level of
   a. Impulse withstand voltage : 170 kV (1.2/50 micro sec.)
   b. Between poles to earth : 195 kV Across Isolating distance
   c. One min. power freq. Withstand : 70 kV voltage (both dry & wet)
   d. Between poles to earth : 80 kV Across Isolating distance
ix. Min. creepage distance : 2.54 cm/kV
x. Operating mechanism : Gang operated, Auto and manual/motorized
xi. Termination : ACSR conductor both sides
xii. Earthing switch : Mechanically inter-locked with isolator. Rating of earthing Switch same as that of isolator
xiii. Auxiliary contacts : 3 NO + 3 NC
xiv. Installation : Pole structure with padlocking facility
xv. Interlocks :
   a. With upstream circuit breaker/isolator
   b. Mechanical interlock with earthing switch for correct sequence of operation
xvi. Control voltage : 110V DC/230 V AC
xvii. Temperature rise above 45° ambient : 50°C

a. Disconnecting blades shall be capable of carrying rated current continuously as well as specified short circuit current for the duration indicated above without causing mechanical damage to any part or temperature rise which may damage the insulation.
b. The switches shall be capable of making on to faults specified and withstanding the dynamic stress involved.
c. The isolator shall be suitable for interrupting small inductive and capacitive currents such as those occurring while disconnecting lines at no load, bus bars or voltage transformers under energized condition.

4.3.4 CONTACTS

i. High pressure self-aligning adjustable type.
ii. Contacts shall be well protected all round by a metal cover to provide not only electrostatic screening but also to prevent coarse dust from entering between the contacts.
iii. Contacts shall be of high grade high conductivity heat resisting copper and silver plated.

4.3.5 OPERATING MECHANISM

i. It shall be suitable for motorized and also manual operation.
ii. Operating mechanism and its controls shall be so designed that under no circumstances the travel of the switch blades is interrupted before it reaches the fully closed or open position.

iii. Provision for padlocking the mechanisms in either the open or closed position shall be provided.

iv. Housing for the operating mechanism and its control shall be of sheet steel, weather and dust proof construction, with rubber gaskets conforming to enclosure protection class IP-55.

4.3.6 EARTHING SWITCHES FOR LINE ISOLATORS

i. Disconnecting switches shall be provided with earthing switches on the line side forming integral part.

ii. Rating of earthing switch shall be same as that of the main isolator/disconnecting switch with respect to rated short time current and dynamic peak withstand current.

iii. Earthing blade shall be operated by a separate mechanism on manual and motorized mode but interlocked so that it can be closed only when the main disconnecting switch is open and vice-versa.

4.3.7 INTERLOCKS

i. To be interlocked with associated isolators and circuit breakers through castle key and electrical interlock arrangement.

ii. Earthing switch and isolator interlocking.

iii. For closing of isolators main blades, associated earthing switches shall have to open and it is also to ensure that isolators are not used for on load closing.

iv Final wiring or contact multiplication relay, blocking solenoid etc. shall be provided as per approved logic diagram.

v. Breaker can be closed if associated earthing switches are open and isolators are in closed position.

4.3.8 TERMINAL CONNECTION

Shall be provided with high conductivity terminal connecting suitable for ACSR conductors.

4.4 33 kV CIRCUIT BREAKERS

4.4.1 TYPE

i. Outdoor type Vaccum Circuit Breaker suitable for installation in open yard.

ii. Three identical single pole units linked together for simultaneous operation, complete with supporting frames and tie-rods.

iii. Capable of interrupting small inductive currents caused by switching of unloaded transformers and low capacitive current without causing undue over-voltage.

iv. The circuit breakers are to be supplied complete with their control and relay panels for operation from remote i.e. inside the power house.

4.4.2 TECHNICAL PARTICULARS

i. Nominal system voltage : 33 kV

ii. Highest system voltage : 36 kV

iii. BIL : 170 kV

iv. Power Frequency withstand voltage : 70 kV

v. Rated frequency : 50 Hz
vi. Rated continuous current : 1250 A
vii. Closing mechanism : Electrical spring charging with 230 V AC motor and local manual closing.
a. Closing coil/tripping coil (2 nos.) : 48 V DC
b. No. of Poles : 3
viii. Symmetrical short circuit : 750 MVA for 1 sec. withstand capacity
ix. Temperature rise : Not to exceed 50oC above ambient temp. of 45oC.
x. Operating duty : 0-3 min. CO-3 min.-CO.
xi. Dead time of breaker : Adjustable between 0.3 sec. to 15 sec.
xii. System neutral : Solidly Earthed
xiii. Min. creeping distance : 900 mm
xiv. Control supply voltage : 110 V DC
xv. Auxiliary, contacts with each : 6NO+6NC circuit breaker Interchangeable at site
xvi. Accessories
a. ON/OFF/TRIP : Mechanical as well as Electrical
b. Emergency tripping mechanism : Mechanical
c. Termination suitable with : ACSR Conductor connectors
d. Anti-pumping operation : To be provided
e. Spring charge indicator : To be provided

4.4.3 OPERATING MECHANISM

i. Electrically / Manually operated mechanism. Breaker shall be provided with trip free mechanism.
ii. It shall be suitable for remote operation / control from the control room.
iii. The operating mechanism shall be of spring charging type by electrical control under normal conditions. The mechanism shall be trip free electrically and mechanically.
iv. The motor for spring charging shall be suitable for operation on 230 V AC supply and shall have overload protection.
v. A local control switch with locking arrangement shall be provided for each breaker for local operating i.e. tripping and closing during maintenance, test etc.
vi. Local/remote selector switch and Trip/Normal/Close control switch shall be provided in the mechanism cabinet.
vii. An operation counter for each breaker shall be provided.
viii. Cabinet for operating mechanism and its accessories shall be as per relevant standards with padlocking facility. Cabinet shall be simplex type, all equipment mounted on front side and wiring on back in proper wire ways.
ix. Panel illumination and anti-condensation heater shall be provided in the local and remote control panel with MCB and thermostat.
x. Closing circuit to operate satisfactorily from 85% to 110% of the rated control voltage and tripping from 50% to 110% of the rated voltage.

4.4 33 kV LIGHTNING ARRESTORS

4.5.1 TYPE

i. Station class, 10 kA, heavy duty, non-linear resistance, metal oxide type gapless lightning arrestor for 33 kV system.
ii. Self-supporting type in single pole assembly.
iii. Suitable for pedestal mounting.
iv. Outdoor type suitable for installation in open yard.
v. Shall be designed to provide maximum protection against lightning and switching surges.

4.5.2 TECHNICAL PARTICULARS

i. Nominal system voltage : 33 kV
ii. Highest system voltage (rms) : 36 kV
iii. Rated arrestor voltage (rms) : 30 kV
iv. Continuous operating voltage (rms) : 24 kV
v. Frequency : 50 Hz
vi. Power frequency with stand test voltage : 70 kV
vii. Impulse voltage (peak) : 170 kV
viii. System neutral connection : Solidly earthed
ix. Nominal discharge current for 8/20 micro sec. : 10 kA (peak)
x. Long duration discharge class as per IEC-99-4 : 3/2
xi. Maximum residual voltage at nominal : 100 kVP (peak) discharge current of 8/20 micro sec wave
xii. Maximum steep current impulse : 110 kV (peak) (1/20 micro sec.) residual voltage at nominal discharge current
xiii. Arrester Housing
  a. One minute power frequency : 70 kV withstand voltage (rms)
  b. Lighting impulse withstand voltage : 170 kV (peak)
xiv. Prospective Symm. Fault current for : 40 kA pressure relief test (rms)
xv. Disconnecting device : Disconnecting devices as per IS: 3070 (Part-II) shall be connected in series with ground lead.
xv. Minimum creepage distance of : 900 porclain housing (mm)

4.6 POTENTIAL TRANSFORMERS

4.6.1 TYPE

i. 33 kV outdoor type
ii. Epoxy moulded dry type for 33 kV sealed type self cooled
iii. Single phase design
iv. Independently mounted
v. Suitable for operation on 33 kV kV, 3 phase, 50 Hz AC systems

4.6.2 TECHNICAL PARTICULARS

i. Standard : IS-3156 (1992)
ii. Nominal system voltage : 33 kV
iii. Highest system voltage : 36 kV
iv. Rated frequency : 50 Hz

v. System neutral earthing : Solidity earthed
vi. Number of secondary : One
vii. Voltage ratio : 33kV/ $\sqrt{3}$ /110V/ $\sqrt{3}$
viii. Class of insulation : F
ix. Insulation level :
   a. One minute power : 70 kV Frequency withstand Voltage (wet and dry)
   b. Impulse withstand voltage : 170 kV
x. For rating/other details : Refer single line diagram
xi. Temperature rise : As per IS 3156 Part- I/1992
xii. Limits of voltage error & phase : As per IS 3156 Part displacements I/1992
xiii. Accuracy & burden etc. : As required

4.6.3 WINDING CONNECTION

i. Any three single phase units shall be suitable for three phase connection in star/star formation on three phase system.
ii. The positive, negative and zero sequence impedances shall all be equal.
iii. Secondary winding to be used for metering.

4.6.4 LIMITS OF TEMPERATURE RISE

i. Limits of temperature rise specified in technical particulars shall correspond to 1.2 times the rated primary voltage applied continuously at rated frequency and at rated burden connected to both the secondary windings simultaneously.
ii.. Temperature rise when 1.5 times the rated primary voltage is applied for 30 seconds after achieving stable thermal conditions followed by application of 1.2 times the rated voltage continuously, shall not exceed by more than 10°C rom the values specified above.

4.6.5 TERMINAL ARRANGEMENT

i. Bi-metallic (Cu/Al) terminal connector shall be suitable for ACSR conductors.
ii. Suitable earth terminal connector to be supplied for connections to earth.
iii. Secondary terminals to be housed in weather and dust proof cabinet with provision for terminating PVC insulated, armoured and PVC sheathed control cables.

4.7 CURRENT TRANSFORMERS

4.7.1 TYPE

33 kV outdoor type

4.7.2 TECHNICAL PARTICULARS

i. Standard : IS-2705 (1992)
ii. Nominal system voltage : 33 kV
iii. Highest system voltage : 36 kV
iv. CT Ratio : As per requirement.
v. Rated frequency : 50 Hz

vi. System neutral earthing : Solidly earthed
vii. Short time thermal current rating for : 25 kA 1 sec. duration
viii. Class of insulation : F
ix. Insulation level :
a. Peak impulse withstand voltage : 170 kV
b. Rated one minute power frequency : 70 kV wet and dry withstand voltage
x. Terminal : Suitable for ACSR conductor
xi. Marshalling kisok : IP-55 enclosure xii. For rating, ratio, class of accuracy and : As required and shown in Annexure

4.8 BUSBARS AND BUSBAR CONNECTIONS

4.8.1 TECHNICAL PARTICULARS

i. Nominal system voltage : 33 kV
ii. Nominal current rating : 800 A
iii. Bus conductor : ACSR "DOG"
iv. Short time rating : 750 MVA (17.5 kA) for 3 (three) seconds

4.8.2 CLEARANCE

The net clearance in air of bus bars, jumpers etc. shall not be less than that given in CBIP manual.

9.8.3 ACSR CONDUCTOR

i. Construction
a. Conforming to IS 398 (Part-III)-1996
b. Aluminum wire made from at least 99.5% pure electrolytic aluminum rods of EC grade with copper content less than 0.04%.
c. Steel wires uniformly coated with electrolytic high grade 99.95% pure zinc.
d. Steel strand hot dip galvanized with minimum coating of 250 gm/sq.m.
e. No joints permitted in the individual aluminum strands and steel core of the conductor.
f. No Joints permitted in bus bar and jumpers conductor.

4.8.4 TECHNICAL PARTICULARS

1. Wire diameter Aluminum (mm)/Steel (mm): 6/4.72 7/1.57
2. Sectional area of aluminum (sq.mm): 103.6
3. Total sectional area (sq.mm): 119.45
4. Overall diameter (mm): 14.15
5. Approximate weight (kg/km): 394
6. Maximum calculated D.C. resistance at 20°C (ohms/km): 0.2745
7. Ultimate tensile strength (kN): 32.99
8. Final modulus of elasticity (Kg/Sq.m): 0.735x106 Kg/cm2
9. Coefficient of linear expansion x 10^{-6} per °C: 19.53

4.8.5 Hardwares

The bolted tension fittings complete with U-bolts arcing horns etc. shall be provided suitable for 33kV bus bar. Clamps and connectors for connecting ACSR conductor shall be made of alloy casting.

Bi-metallic connectors shall be used for connecting equipment terminals made of copper or brass. Bolts, nuts and washers for connectors shall be made of mild steel and electro-galvanized and passivated to make them corrosion resistant conforming to requirements of BS 1706.

4.8.6 INSULATORS

The insulators shall conform to the relevant latest IS standards (IS 2544, 731, 1248) and made of hard porcelain. Creepage distance shall be adequate for polluted outdoor atmosphere. Glazing of the insulator shall be uniform brown color, free from blisters, burns and other similar defects.

The insulators shall have technical particular as detailed below:
i. Type: Post/Disc/Pin
ii. Nominal system voltage kV (rms): 33
iii. Highest system voltage kV (rms): 36
iv. Wet power frequency one minute 70 withstand voltage kV (rms)
v. Power frequency puncture kV (rms) 1.3 times the actual voltage dry flash over voltage
vi. Impulse withstand voltage kV(peak): 170
vii. Creepage distance in mm (minimum): 580
viii. Minimum failing load: 10 kN (45 kN for disc insulators)

4.9 GROUNDING / EARTHING OF SWITCHYARD

Earthing system of the S/yard and power station shall be designed as per IS: 3043 and IEEE: 80. Earthing system network/earthmat shall be interconnected mesh of mild steel rods buried in ground in the switchyard area and/or earthing electrode type earthing system for the power house area as may be most suited to the existing power house. All off-site areas shall be interconnected together by minimum two parallel conductors. The contractor shall furnish the detailed design and calculations for Owner's approval. Contractor shall obtain all necessary statutory approvals for the system. The grounding resistance of the grounding system for power house and switchyard together shall not be more than 0.5 Ohms. The step and touch potentials shall be within safe limits. The earthing system of the power station and switchyard shall be joined together.

The grounding and lightning protection shall include complete grounding of PH and switchyard area including the equipment, earthing of all steel structures & bodies of all equipment.

The equipment/work shall have following features:
i. All earthing connections shall be sufficient to carry the fault current for 1 sec.
ii. Soldered joints shall not be used. All joints shall be made pressure type fitting or welded.
iii. The earth resistance of yard shall be not be more than that indicated above.

iv. Touch and step potential shall be maintained in a safe value by grounding mat in accordance with IEEE-80 for a fault current for 1 sec.
v. Fencing around the yard shall be earthed separately.
vi. Earth electrodes shall have facilities for measurements of resistance and watering during dry season.
vii. Earth mat shall be extended 150 cm beyond fencing.
viii. All structures and buildings shall be provided with lightning protection as per IS-2309.
ix. Complete earthing of transformer neutrals, L.A. earthing of all steel structures, earthing of bodies of all equipment etc.
x. Any other item/work required for efficient completion of work.

4.10 SWITCHYARD STRUCTURES ETC.

Galvanized main and auxiliary structures for the equipment to be installed in the switchyard shall be provided along with other material e.g. conductors, clamp and connectors, insulators and hardware etc. complete as required.

4.11 LIGHTNING PROTECTION

The lightning protection system shall be designed as per IS: 2309. It shall cover all buildings and structures in the plant, and switchyard areas. It shall comprise horizontal/vertical air terminations, down conductors, test links and earth connections to the station earthing grid. All conductors shall be of minimum 25x6 mm size and shall be of galvanized steel only.

The down conductors of lightning protection system shall have a test joint at about 1500 mm above ground level. Each down conductor shall be connected to a 40 mm dia, 3 m long mild steel earth electrode as well as station earthing grid.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cables, and shall not be connected above ground level to other earthing conductors. All joints in the down conductors shall be of welded type.

Pulsar system for lightning shall not be accepted.

Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths as per IEEE: 142.

4.12 PAINTING AND FINISHING

The colour code for the electrical equipment shall be as follows:

Sl.No.	Item	Colour	Paint Shade No. (as per IS:5,1991)
1	Transformer	Dark admiralty grey	632
2	Outdoor equipment	Dark admiralty grey	632

3	Outdoor structures, bolts, nuts etc.	Galvanised	--
4	H.T. Switchgear panels	Light gray	631
5	L.T. board etc.	Light admiralty grey	697
6	Panels, Dist. Boards etc	. Light admiralty grey	697
7	Junction Boxes	Light grey	631
8	Earthing	Bus Greas	--

The painting shall be, as per relevant IS. It shall be ensured that there will be no rusting, no peeling-off of the paint. The painting shall be long lasting type. The contractor shall ensure sufficient spare supply of paint for any touch-up required later on.

4.13 FENCING

The 33kV / 11kV switchyard shall be secured by surrounding it with 2 meters high M.S. pale fencing consisting of 2.3 m long 50 x 50 x 6 mm M.S. angle upright supports and two numbers 40 x 40 x 5 mm M.S. angle runners. The supports shall be spaced at 3 m interval and 75 mm vide pale strips shall be fixed on runners through G.I. bolts/nuts/washers at a clear spacing of 75 mm. The corner upright shall be supported with similar angle struts. The supports and struts shall be properly grouted.

CODES OF PRACTICES AND STANDARDS

IS-3231 Electrical relays for power system protections
IS- 1248 Indicating Instruments
IS-722 Energy meters, control switches (LV switching devices for control and Auxiliary Circuits)
IS-2705 Current transformers
IS-3156 Voltage transformers
IS-4237 General requirements for Switchgear and control gear
IEC-157 for voltage not exceeding 1 kV
IS-375 Marking and arrangements for switchgear busbars, main connection and auxiliary wiring
IS-8686 Specification for static protective relays
IS: 1248 Specification for direct acting electrical indicating instruments
IS: 2516 Specification for alternating current circuit breakers (Part I&II) IEC 529 Classification of degrees of protection provided by enclosure (IP code)

5.0 DC AND UNITERRUPTED POWER SUPPLY

5.1 Scope

This specification covers the design, manufacture, assembly, shop testing at manufacturer's works before dispatch, supply and delivery at Site, erection and commissioning of 110V DC Battery, Battery charging equipment, DC Distribution Board and accessories.

The scope of supply shall include all parts, accessories, spares, etc., which are necessary for construction, operation and maintenance of complete equipment even through these are not individually and specially stated or enumerated. Corresponding parts of all the equipments and the spares shall be of same material, dimensions, workmanship and finish and shall be interchangeable. All the materials and workmanship shall be of suitable commercial quality as have proven successful in their respective uses in similar services and under similar conditions.

5.2 Auxiliary Supply

DC charging equipment s shall be suitable for operation on 415 V, 3 phases, 4 wires, 50 Hz supply. The supply voltage and frequency may vary as follows:

AC Voltage	+10, 15%
Frequency	$\pm$ 3%
Voltage and Frequency	any combination of above.

5.3 General Description of DC System

1(one) set of 110 V lead acid type storage batteries it means 250 Ah at 10 h, as required for meeting the continuous and short time DC current requirements of 2 nos. of 2.5 MW generating unit auxiliaries, including 33 kV Switchyard, HV and LV switchgears, control and protection including computer supply, emergency lighting, as well as field flashing for unit starting under emergency conditions.

The charging equipment for each battery shall comprise one set of float charger and boost cum float charger units.

A DC distribution board connected to battery/battery charging equipment shall be provided with a number of outgoing feeders to supply the DC power requirement of generating units, circuit breaker operations, emergency lighting and various control panel DC circuits.

An AC supply panel is provided to control the AC supply to battery charging equipment, normal cum emergency lighting, etc. AC supply panel shall be fed through MCCB of adequate rating.

5.3.1 Details of Batteries

5.3.2 Design consideration

The battery shall normally remain under floating condition at 118 to 120 V with float charger unit supplying the normal continuous load. However, the battery shall be capable of supplying

the following combination of loads under emergency conditions without any assistance from the charger and without its terminal voltage falling below 99 V (90% of rated voltage).

i) Continuous load 45 Amps for 3 Hours
ii) Emergency lighting 15 Amps for 1 Hour
iii) Intermittent load 50 Amps for 1 Min.
iv) Other loads of 15 Amp for 20 Mins.

The battery shall be capable of meeting field flashing requirements of the Static Excitation System of the generator if called for. If the AH capacity of the battery as assessed by the tenderer, on the basis of the duties indicated above, are different from the one mentioned above, the tenderer may quote separate prices for such battery in addition to the specified herein.

The Contractor shall submit power balance calculations which shall indicate the DC power consumption at every 15 minutes, of the complete Plant, as well as, load / time diagrams and discharge curves over the specified or required by the equipment discharge time, whichever is longer.

The capacity of the battery has been calculated as 250 Ah at 10 h discharge rate.

The number of cells and the cell capacity of each battery, even after 15 years of operation, shall be such as required to ensure the safe stopping of the Plant under emergency conditions, i.e. without using any AC source from the Unit Auxiliaries Transformers, or the Diesel Generator Set in an ambient temperature varying between + 10°C and + 40°C.

5.3.3 Construction Details

5.3.3.1 Battery

The battery shall be made of stationary type lead acid cells with high discharge performance type tubular plates manufactured to conform to latest issue of IS 1651 and IEC 622.

5.3.3.2 Containers

The containers for the cells shall be of impervious, moulded transparent plastic/glass material having heat resisting, high strength, non-reacting and low inflammable properties. The containers shall be mounted on insulator block. The containers shall be of robust construction and free from flaws, bubbles or foreign matter. The size of the containers shall be such that sufficient sediment space shall be available and the battery shall not require cleaning during its normal life.

5.3.3.3 Plates

The positive and negative plates shall conform to latest issue of IS 1651 for stationary cells and batteries of lead acid type and shall be fixed on the top of the containers, handing type.

5.3.3.4 Separators

The separators shall be of acid resistant synthetic material conforming to latest issue of IS 6071. These shall maintain the electrical insulation between the plates and shall allow electrolyte to permeate freely. These shall be free from defects such as cracks, pin holes etc.

5.3.3.5 Electrolyte

The electrolyte shall be prepared from the battery grade sulphuric acid conforming to latest issue of IS 266 and shall have a specific gravity of 1.2 at 27^0 C. The requisite quantity of electrolyte with additional 10% extra shall be dispatched in non-returnable containers.

Sufficient quantity of distilled water conforming to latest issue of IS 1069 shall be supplied to correct the level of electrolyte.

5.3.3.6 Plate Group Bar with Terminal

The plate group bar with terminal shall conform to latest issue of IS 1651. The positive and negative terminals shall be clearly marked for easy identification.

5.3.3.7 Buffers/Springs

Suitable buffers/springs shall be provided in the cell to keep the end plates in position. These shall have adequate length and strength.

5.3.3.8 Markings

Acid level line shall be permanently and indelibly marked around on all the containers.
The following information shall be indelibly marked on outside of each cell/battery:

i) Manufacturer's name and / or trade mark
ii) Country and year manufacture
iii) Normal rating of the cell
iv) Cell number

5.4 Installation of Batteries

The battery sets shall be installed on wooden racks in a separate battery room provided with induced ventilation. The tenderer shall offer the racks and mounting insulator, etc.

The cells shall be arranged on the racks, in a two-tier arrangement with two rows of cells on each tier. The racks shall be coated with acid resisting and flameproof coating. These shall be designed and arranged in such a way that easy handling of the cells is possible while in operation.

The tenderer shall indicate and provide the proposed arrangement of the battery and include the arrangement for fixing and mounting of interbank, inter-row, inter cell and bus-off connectors, etc.

The tenderer shall examine the adequacy of the space for installing batteries. Connectors: Bare tinned copper connectors shall be employed for inter-cell, inter row and inter tier connectors.

However, the tee-off connections from the battery unit shall be made with acid resisting cable of suitable size. The tenderer shall provide the suitable terminal box for the purpose.

The connectors shall preferably be of bolted type and the bolts and nuts shall be of similar materials as that of connectors and the same shall be provided with corrosion resistant coating.

The connectors shall be of sufficient cross-section to withstand all the working conditions including one-minute discharge rate as well as short circuit condition.

All the electrical installation within the battery room including lighting fixtures, local switches, power outlets, etc. shall be of the explosion-proof type. Moreover the fans, which draw the air from the battery room, shall be of the explosion-proof type, as well.

The Contractor shall supply all required accessories such as thermometers, densimeter, funnels, anti-corrosive agents or paste, as well as, the initial filling.

A lockable fused load break switch shall protect each battery. This shall be installed inside a totally enclosed box with hinged door (protection class IP55), which will be located close to the battery room.

5.5 Charging Equipment

5.5.1 Design Consideration

Each Battery shall comprise of one set of float and boost cum float charger units as charging equipment. The chargers shall be of adequate capacity to meet the trickle and boost charging requirements of the batter. In the float-charging mode, the charger shall be capable of supplying the continuous DC load of the power station so as to keep the battery floating in a fully charged condition. In case of failure of AC mains, the batteries shall alone meet the continuous and emergency power requirements of the power station resulting in rapid discharge. After the battery has discharged to a considerable extent resulting in voltage per cell falling to 1.85 V the battery would need recharging in a short period by setting the charger in boost charging mode. In addition to boost charging the battery, the charger in the boost charging mode shall be capable of simultaneously supplying the continuous DC load of the station at required voltage.

Each of the float and boost cum float charger units in the charger set shall have 3-phase, full wave, full control thyristor controlled Rectifier Bridge. The incoming supply to the three phase thyristor-bridge of the float and boost cum float charger units shall be though separate three phase double wound transformers. The triggering of the thyristor shall be controlled by AVR units, which would automatically correct the error between the output and reference signals by adjusting the firing angle of the thyristor. The tenderer may offer AVR/rectifier Bridge with integrated/digital circuit technology to achieve the specified performance of the charging units.

When the battery requires "Boost charging" the rectifier shall be capable to provide the adequate output voltage. "Boost voltage" shall be performed with the batteries disconnected from the associated switchgear.

5.5.2 Type and Ratings

The rating of float and boost cum float charger units shall be as under:

A) Float Charger Unit

a) Input supply: 415 V, 3 phase, 50 Hz

b) DC output: 110V DC Float charger unit shall be capable of supplying ungrounded 45 A capacity, low ripple (ripple content to be less than 1%) DC to supply the continuous DC load in addition to float charge a battery of 110V, 250 Ah capacity between an approximate voltage range of 2.15 to 2.2 V per cell. Contractor shall check the above-mentioned current rating as per system requirement during detailed engineering and furnish calculations for approval.

B) Boost cum Float Charger Unit

The rating of the boost cum float charger unit shall be as follows:

a) Input supply: 415 V, 3 Phase, 50 Hz

b) DC output: 100 A DC at 110V DC. The boost cum float charger unit shall be capable of supplying at 90 to 160 V a maximum charging current with voltage per cell carrying from 1.55 to 2.9 V for boost charging a battery of 250 Ah capacity, in addition to supplying the continuous DC load of the station at 110 V DC. Contractor shall check the above-mentioned current rating as per system requirement during detailed engineering and furnish calculations for approval.

5.5.3 Design Details of Chargers

The chargers shall be of solid state, thyristor-controlled rectifier with 3 phases, full wave full control bridge circuit having low ripple factor direct current output. The ripple content shall not exceed 1%.

The transformers used shall be suitable for operation with 3 phase, 415 V, 50 Hz, AC supply and shall be air-cooled and dry type.

The transformer for float charger and boost charger units shall have tapings from $\pm$ 2.5% to $\pm$10% on the input side.

The chargers shall have Auto and Manual modes for regulating DC output voltage.

In auto mode, the regulating system of float charger shall float the battery between 118 V – 120 V and hold the voltage nearly flat from zero to full load but with definite drooping characteristics at load greater than full load, so that such loads are transferred to the battery. The automatic voltage regulating system shall have built in limiting features which will

automatically bring down the output voltage when output current exceeds the full load current of the float charge. The regulating system shall maintain constant DC Voltage within ±1% of the set value with an AC voltage variation of +10, -15% and frequency variation of ±5%. The AVR should be suitable for setting the DC output voltage within ±20% of 100 V in steps of 2.5%. It shall be ensured that in case of failure of float charger, during the battery healthy condition, the boost charger shall automatically change over to float charger mode to supply the DC load.

The boost charger shall have arrangement for regulating DC output voltage so as to maintain the constant charging current. During boost charging since the battery shall be connected to the boost charger at a higher voltage, it shall be ensured that the load connected to the battery is not subjected to higher voltage by reducing the number of cells or any other means. The full details of the scheme offered to meet the above specified requirement shall be furnished.

The maximum temperature attained by any part of float and boost cum float chargers when in service at Site under continuous full load conditions shall not exceed the permissible limits fixed by relevant standards and as corrected to Site conditions.

5.5.4 Charger Panels

Charger panels shall be rigid, self-supporting structure completely assembled, totally enclosed, cubicle type construction made out of structural steel members with sheet steel coverings. The panel shall have hinged front and back with concealed type hinged locks and latches. The panel shall have adequate cross-ventilation arrangement, to avoid any undue rise in temperature. All equipment and wiring used in the panel shall be tropicalised, dust and vermin-proof. The degree of protection provided for the panel shall be IP42 as per IS13947. Necessary terminals for grounding the panel with two distinct and separate earthing shall be provided.

Necessary primer and finishing coats of light grey paint shall be given to the panel. All external cables connected to the charger shall be arranged for bottom entry and suitable glands shall be provided for the cables.

Each charger panel shall incorporate necessary controls, indications, interlocks, protective devices and timing features to ensure trouble free operation. Provision shall be made with necessary contacts/relays for annunciation in the event of alternating current power failure to the charger and automatic shut down of charger by over current device. Annunciation shall be prevented when the charger is manually shut down or when AC power supply is momentarily interrupted for adjustable period of 1 to 5 seconds.

The float and boost charging rates shall both be adjustable from the front of the charger control panel. Each charger shall be protected against any damage from over-load currents and shall be so designed that it an continuously deliver at least rated current output without operation of the protective over-load device from abnormal conditions f low battery voltage down to 88 V (80% of the rated voltage). Necessary selector switches for “Float charging mode and Boost Charging mode” shall be provided. These shall be of “make before break type”.

All indicating instruments shall be square type in size 96 x 96 mm suitable for flush mounting conforming to latest issue of IS 1248.

The float/boost charger panels shall have the following instruments relays, control switches and other accessories:

i) 425 V Triple pole AC circuit breakers of suitable capacity with over load and short circuit release and contacts for ON/OFF indication and annunciation.
ii) ON/OFF switch or push buttons for the air circuit breaker/contactor.
iii) Pilot lamps to indicate AC mains "ON" condition.
iv) Double wound impregnated, natural air-cooled, 3 phase main transformer with taps range of ± 10% in steps of 2.5% of 415 V rated voltage.
v) Booster Transformer.
vi)Ballast chokes to limit the variations with charging current due to fluctuation in the supply voltage.
vii) Mode Selector Switch.
viii) 0-500 V range flush-mounted AC voltmeter with voltage selector switch and protected by MCB.
ix) Constant potential controller to stabilize the DC voltage within ± 1% of the set value with an AC voltage variation of +10, -15% of the set value with simultaneous load variation of 0-110%.
x) Auto/manual switch to operate the regulator manually in case of failure of automatic potential controller.
xi) Raise/lower push buttons for manual operation of the voltage regulator
xii) 3 Phase, full wave full control bridge rectifier circuit.
xiii) 0-175 V flush mounted DC voltmeter with ±2% Full Scale Indication (FS) accuracy.
xiv) DC ammeter to suit the charger output flush type within ± 2% Full Scale … (FSD) accuracy.
xv) Double pole moulded case circuit breaker of suitable capacity with over load and short circuit release and with contacts for annunciation.
xvi) Interlocking contactor to prevent the load getting connected to high voltage at the time of boost charging.
xvii) Blocking diode.
xviii) Compression type cable gland of suitable sizes for PVC unarmoured Aluminum conductor cable entering from the bottom for the AC and DC supply and also suitable cable supports for the above cables inside the panel
xx) AC failure alarm relay with signaling contacts
xxi) DC Earth Fault relay with signaling contacts
xxii) DC under voltage relay with signaling contacts

5.6 Distribution Panel

5.6.1 Type and Ratings

The DC Distribution panels shall be freestanding, self-supporting cubicle type with front and back hinged doors. It shall have three sections, namely the section for incoming connections

from the battery and the chargers, the main distribution section and section for emergency lighting system.

The rating of DC bus bars, incoming and outgoing feeders on main distribution boards shall be as follows:

i) Bus Bars: 400 A continuous current rating with suitable short circuit capacity to meet the short-circuit power supply requirement from battery and charger but in no case less than 20 kA.

ii) Incoming feeders (2 nos.): 200 A DC continuous current, 20 kA breaking current capacity double pole molded case circuit breakers.

iii) Outgoing feeders: double pole MCCB as per system requirement. The Contractor shall submit required calculations for feeder ratings as well as selected above ratings.

The rating of the 240V AC bus bars for UPS shall be as follows:

i) Bus Bars: 240 V, AC, 40 kA short time current capacity Phase and Neutral Bus

ii) Incoming AC feeder: 240 V, AC, 2 pole, 40 kA breaking current capacity of MCCB's

iii) Outgoing feeder: as per requirement of computers in the plant

iv) Inverter: single phase, 240 V, AC 15 kVA capacity

5.6.2 Design and Construction

The panels shall be totally enclosed and shall have adequate cross-ventilation arrangement to avoid any undue rise in temperature. All equipment and wiring shall be tropicalised, dust and vermin-proof. The degree of protection provide for the panel shall be IP42 as per IS13947. Necessary terminals for grounding the panels with two distinct and separate earthing shall be provided.

All external cable connection to the panels shall be arranged for bottom entry. Suitable cable glands and supports shall be provided for PVC insulated unarmored cables.

The panel shall be so designed as to permit extension in either direction and shall be complete with all accessories, including fixtures, supporting frame channels, foundation bolts, etc. for securing the panels to the floor. Space heaters to operate from the 240 V AC supply shall be provided. The panel shall match with that of charger panels and shall be given necessary primer and finishing coats of light grey paint.

The incoming and the outgoing feeders shall be controlled by moulded case circuit breakers. The breakers shall be trip free type. All the breakers shall be provided with instantaneous and thermal over load releases. The breakers shall be suitable for manual operation. The breakers shall be draw-out type removable from front without disturbing the electrical connections. The breakers shall be provided with "ON" and "OFF" indicating lamps. The making and breaking capacity of the breakers shall be stated by the tenderer.

The emergency lighting board shall be normally supplied with single phase. 20 V AC, supply and the illumination lamps in the power house connected to the feeders on emergency lighting board shall be switched on from AC source. Failure of AC supply will automatically trip the AC contactor and switch on AC inverter contactor. On restoration of normal AC the inverter supply will be automatically tripped and normal AC supply to emergency lighting bus will be automatically resumed. The change over switch contactors, inverter, signal lamps etc. shall be mounted in the panel.

The DC bus shall be provided with an insulation-checking device comprising of a selector switch (for checking insulation of the positive and negative bus) push button, potentiometers with centre earthed a voltmeter and a voltage relay for annunciation. The device will measure the insulation of each pole in kOhm/MOhm and also indicate the voltage of each pole with respect to the earthing point. Alternatively the tenderer may quote the standard device normally used to detect earth fault and measure the insulation of each pole of the DC bus.

Dc under voltage relays shall be connected to initiate alarm whenever the bus voltage falls below 99 V.

At least 10% spare terminals shall be provided in the terminal blocks. The interior of the panel shall be provided with AC lighting and spare AC plug socket for maintenance test, etc.

All wiring shall be properly supported and cleared. Both ends of the wiring shall have numbered ferrules for proper identification.

5.7 AC Supply Panel

5.7.1 Type and Rating

AC supply panel shall be freestanding, self-supporting cubicle type with front and back hinged doors. The AC supply panel shall be located in the control room alongside of the chargers and DC distribution panels and shall have matching shape and appearance. The panels shall have 415 V AC, 3 phase and neutral bus bars. Each AC panel shall be connected to one station service board section 200 A, 40 kA breaking capacity draw out MCCB's.

The rating of the bus bars, incoming and outgoing feeders of the AC panel shall be as follows:

i) Busbars: 200 A continuous current, 40 kA short time withstand current
ii) Incoming feeders: 1 no, 415 V AC, three pole, 100 A, 40 kA MCCB's
iii) Outgoing feeders: 5 nos, 415 V AC, 40 kA, braking current capacity MCCB's

5.7.2 Design and Construction

The panel shall be totally enclosed and shall have adequate cross ventilation arrangement to avoid any undue rise in temperature. All equipment and wiring shall be tropicalised, dust proof and vermin proof. The degree of protection provided for the panel shall be IP42 as per IS 13947. Necessary terminals for grounding the panels with two distinct and separate earthing shall be provided.

All external cable connection to the panels shall be arranged for bottom entry. Suitable cable glands and supports shall be provided for unarmored cables.

The panel shall be so designed so as to permit extension in either direction and shall be complete with all accessories including fixtures, supporting frame channels, foundations bolts, etc. for securing the panels to the floor. Space heaters to operate from the 240 V AC supply shall be provided.

The incoming and outgoing feeders shall be controlled through manually operated moulded case breaker. The breaker shall be provided with instantaneous and thermal over load releases. The breakers shall be trip free. The breakers shall be draw out type removable from the front without disturbing the electrical connections. The breakers shall be provided with ON and OFF indicating lamps.

5.8 Installations

The DC distribution boards and AC supply panels shall be installed in the same row as the charger panel in the control room and therefore these should match.

5.9 Detection of Abnormalities and Faults

The DC system shall have provision for detection of following faults and initiation of audio-visual alarms to indicate occurrence of any of the following faults. The DC system shall also be provided with a continuous earth-leakage indicating scheme suitable for operation with an earth fault on either pole. The abnormal operating conditions/faults are as listed below:-

a) Over voltage on DC bus
b) Under voltage on DC bus
c) Current limits in float and boost cum float chargers
d) Float charger failure
e) Boost cum float charger failure
f) AC supply failure
g) Earth leakage
h) Float output DC MCCB Trip
i) Boost output DC MCCB Trip
j) Controller card defective

5.10 Tests

The Contractor shall provide type and routine test reports as per relevant Indian Standards or other standards for the equipment covered by the specifications and detailed below. All test reports shall be submitted and shall be got approved from the Employer before dispatch of equipment in case of tests to be carried out in manufacturer's works.

Each cell and the complete battery shall be subjected to the following acceptance tests in accordance with IS 1651, as given below in presence of the Employer's representative.

i) Test for capacities of individual cells and the complete battery.
ii) Dimensional checking of plates
iii) Visual Inspection
iv) Endurance Test
v) Ampere-hour and watt-hour efficiency test

The Contractor shall furnish the details and testing facility available at his work.

The acceptance tests shall also be carried out at the discretion of the Engineer on batteries or each cell after installation at Site. Certified copies of the test report for the following type tests as stipulated in the IS shall be supplied.

i) Test for retention of charge
ii) Specific gravity of a charged cell

The charger panels and switchgear shall be assembled at the manufacturers works with all apparatus, instruments and meters connected and various components shall be tested in accordance with the latest issue of IS 3136, IS 13947, IS 8623 and other relevant Indian Standards in presence of Employer's representative. Other tests as may be necessary shall also be carried out. Manufacturer's type test certificates shall be furnished along with the tender.

The following tests on chargers shall be carried out.

Routine Tests:

i) DC voltage/current characteristics
ii) High voltage tests
iii) AC measurement
iv) Reverse leakage
v) Visual inspection
vi) Operation of auxiliary devices

Tests on Switch Boards (AC supply panel, DC distribution emergency lighting board).

Routine Tests:

i) Mechanical operation test
ii) High voltage test
iii) Test for variation of calibration of releases
iv) Millivolt drop tests
v) Visual inspection

The inverter shall be subjected to routine and acceptance tests as per relevant standard.

All test reports shall be submitted and got approved by the Engineer before dispatch of equipment.

6.0 EOT CRANE FOR POWERHOUSE

6.1 Scope

This specification covers for the design manufacture, shop assembly, shop testing before dispatch, supply, delivery at site, unloading, erection, testing and commissioning of one indoor, electric overhead travelling crane. The crane shall be equipped with a main hoist of tentatively 15 Tonnes capacity and an auxiliary hoist of 5 Tonnes capacity. Cranes shall be complete with motors for all motions of the crane, the hoist control gears, power and control cables, runway rails along with plates, clamps etc. runway conductor with mounting brackets, collectors, insulators, etc.

The Contractor is responsible to coordinate the finally required lifting capacity of the main hoist with the generator/step up transformer design. The lifting capacity shall be confirmed in the bid.

6.2 Requirements

6.2.1 General Requirements

The general arrangement of the crane shall be as described in the specification at various places. The EOT crane is required to handle major assemblies and sub-assemblies of generating units, power transformers and other power house equipments during loading, unloading, erection, repair, assembly, reassembly and maintenance.

6.2.2 Performance requirements

The crane shall be capable of raising, lowering holding and transporting its rated load without any damage to or excessive deflection of any crane component.

The following tolerances shall be maintained in the operation of the crane:

i) Smooth control of movement with hook carrying rated load:

a)	Main hoist vertical movement	1.0 mm
b)	Auxiliary hoist vertical movement	2.0 mm
c)	Bridge travel	5.0 mm
d)	Trolley travel	5.0 mm

ii) The motor speed not to exceed 105% of the synchronous speed while lowering the rated load

iii) The vertical deflection of the main girders caused by the rated load plus all dead loads not to exceed 1/1000 of the crane span.

6.2.3 Design Requirements

All parts of the crane and runway rails shall be designed to sustain the loads and the combinations of load as per IS : 3177.

Design criteria shall be:

a.	Crane structure	according to FEM class A3, or equivalent BIS
b.	Crane mechanism	according to FEM class A3, or equivalent BIS

6.2.4 Material requirements and workmanship

Materials and workmanship shall conform to an comply with the latest edition of internationally accepted standards such as BIS, CMAA, DIN, FEM, ASTM, IEC, British Standards, etc. and are subject to acceptance by the Employer. The Contractor shall indicate in the Tender, the standards to which the materials, components, workmanship etc. would conform.

Bronze and stainless steel bolts and nuts shall be used in all cases where component parts are subject to frequent adjustments or removal, such as stuffing box, adjustment bolts, adjustable bearings etc.

6.2.5 Safety requirements

In the design of crane all safety regulations as applicable with factory acts, Indian Electricity Rules etc. shall be taken into consideration and provided for.

6.3 Type, parameters and performance requirements

The crane shall be of indoor, electrically driven, cage operated, single trolley, double girder, overhead travelling type. The crane shall have a main hoist of capacity 15 Tonnes and an auxiliary hoist of 5 Tonnes. The hoists shall be mounted on a trolley, which shall facilitate cross travel of hooks and hoists. The crane shall run on runway rails along the entire length of the powerhouse. The bridge of other crane shall be carried on adequate number of wheels, but numbering not less than eight, mounted in trucks designed to distribute the load equally on the truck beams and wheels and also to allow the wheels to adjust themselves to irregularities of the rails. The crane shall have at least two driving wheels. Power shall be supplied from conductors mounted at a convenient height along the run of powerhouse.

Suitable platforms shall be provided for access to bridge trucks and a walkway of ample width shall be attached to the outside of each bridge girder.

6.4 Crane Details

6.4.1 General

All mechanical equipment and structural shall be simple and substantial in design and shall enable erection, inspection, adjustment, painting and disassembly. All fastenings shall be adequate to hold the parts in place under all conditions of service. Keys, splines or pins shall transmit all shaft loads. The transmission of loads by press fits only shall not be accepted.

Wherever practicable, machinery shall be mounted on self-contained frames or bedplates or on rigid structural steel supports. In the design of all affected parts, suitable allowance shall be made for forces arising out of collision between bumpers and track stops.

6.4.2 Structure

6.4.2.1 Bridge

The bridge shall consist of two girders supported on end trucks. The girders shall be designed to safely carry the full rated load without undue vertical or lateral deflection or vibrations. The girders shall be of the box type construction. Stiffening ribs etc. shall reinforce the box section girders. Steel stop shall be welded near the end of each girder to engage bumpers on the trolley to prevent it from leaving bridge.

The rails for the trolley shall be supported on the girders and shall be held in position by rail clips. The clips shall be locked in position to prevent the rails from creeping.

6.4.2.2 Trolley

The trolley shall consist of a welded frame of structural steel sections adequately braced to withstand vertical, lateral and torsional strains and properly machined to receive the hoisting drums, wheels, axles and motors for hoisting and cross travel. The trolley wheels and winding drums shall have heavy duty roller bearings. Bearing caps shall be provided with fittings for pressure lubrication. On the bottom of the trolley frame on each side shall be two spring buffers to engage stops at each end of the bridge.

6.4.2.3 End Carriages (Trucks)

The end carriage (trucks) shall be constructed of cast steel, structural steel or sections of plates, welded, riveted or bolted together and shall be of box type with openings at each end for receiving the truck wheels, each truck shall be fitted with double flanged rail wheels with roller bearings running on suitable axles, wheel fracture props, buffer etc. for easy maintenance. The size of journals shall be ample to carry the rated capacity load at specific speed without excessive heating during continuous operation. All trucks shall be provided with suitable track sweeps at each end of trucks so as to be effective in both directions of travel. Safety lugs shall be provided which shall extend below the top of rail on both sides to prevent the trucks from leaving the rails. Lugs shall be provided on the truck frames to permit a drop of not more than 25 mm in case of broken axle. Wheel assembly shall be arranged such that replacement of a wheel can be achieved from the side without undue difficulties. The wheelbase shall not be less than 1/6 (one sixth) f the crane span and shall be reckoned as the distance between the centres of outer wheels. The end trucks shall be designed to contact and stops and the contact faces shall be fitted with spring buffers. The end stops shall be provided and they shall be designed such that they contact the face of the end truck and not the wheel. The stops shall be attached at each end of runway rails.

6.4.2.4 Wheels and Axles

The bridge shall be carried on sufficient number of wheels on each side. The wheels may be equalized in pairs or may be equalized individually, if necessary. All wheels shall be double flanged with threads machined or ground to size and shall be of chilled wheel cast iron. The composition of wheel shall be stated in the guaranteed technical particulars. The wheels shall be turned or ground to true and uniform diameter concentric with bore. The wheels shall be heat-treated. The tread width shall have proper clearance for the railhead and shall be of sufficient size to withstand maximum static and rolling loads. The truck axles shall be made of forged

carbon or alloy steel and shall be accurately turned, ground and polished at the wheels. All axles shall be forced into the wheels at a suitable pressure and the driving wheels shall be keyed to the axles in addition to the forced fit. The Journal boxes of all the truck wheels shall be drip proof and shall be provided with self-lubricating bronze bearing accurately machined to seats in the truck bodies and correctly bored for the axle fit or may be provided with roller bearing with high pressure grease lubrication. All bridge trucks bearings shall be interchangeable. Wheels bearings and journals shall be easily removable from the truck bodies.

6.4.2.5 Runway Rails

Two runway rails for the bridge travel shall be designed and supplied by the contractor. The rails shall extend to the full length of the power house and the service bay as shown in the drawings. The trolley rails shall also be the same as the bridge rails. The rails for bridge travel shall be laid on the crane beam and shall be fixed to the crane beam by means of anchor bolts etc. The contractor shall supply all the materials required for fixing the bridge rails.

6.4.2.6 Operator's Cage

The operator's cage shall be structural steel frame and shall be of the open type fire proof and suitable for indoor service. The cage shall be suspended from the outside girders of the crane and braced to the crane so as not to sway, swing or shake. The cage shall have ample space for containing the control equipment and for performing all crane operations and maintenance.

The cage shall be so designed that it shall afford the driver an unrestricted view of the working area. The floor of the cage shall be made of steel plate connected securely to the frame and covered with rubber matting. Suitable raising shall be provided for all open sides. A foot operated rotary alarm gong at least 300 mm in diameter shall be provided in the cage. A ladder shall be provided for access from the cage to the crane bridge walkway.

6.4.2.7 Walkways and Ladders

Ladders, platforms, walkways, hand holds, etc. necessary to give safe access to and movement in the cage, bridge drive and trolley drive mechanisms and all other components of the crane needing inspection, maintenance and repair shall be provided. The walkways shall be of steel chequered plate with minimum width of 750 mm extending to the entire length of the bridge preferably at the same elevation as the bridge and attached to the outside of each girder. The steel ladders and stairs shall have nonslip treads not less than 600 mm wide between the sides and shall preferably slope forward. 1100 mm high hand rails with an intermediate rail shall be provided for enclosing completely walkways, platforms, stairs/ladders etc. Two plates on each side edge for a height of about 100 mm shall be provided for all pen edges of walkway.

6.4.3 Mechanical Details

6.4.3.1 Bridge Travel Mechanism

Longitudinal travel of the crane shall be affected in such a manner that equal speed is ensured at each end truck by means of either one motor mounted near the centre of the bridge girders or by two motors at each end of the bridge. The motor shall drive the bridge wheel through a

totally enclosed helical gear box. Shaft couplings shall be of the safety flange type and shall be shrunk into place with taper flush keys and accurately faced and trued. The motion shall be free from vibration, rocking etc. under all conditions of operation and the crane structure shall not have any tendency to get out of line. Foot brakes of the mechanically or hydraulically actuated type, operated from the cage of crane shall be provided in addition to automatic electro mechanical brakes. Each foot brake shall have capacity 1-1/2 (one and half) times the full load torque of the bridge travel motors(s) and shall be designed so as to be secured in position. It shall be possible to remove the motor armature without dismantling the brake.

6.4.3.2 Trolley Travel Mechanism

The trolley shall be powered by a motor mounted on trolley frame and connected through gearing and shafting to at least one wheel on each side of trolley. The drive mechanism shall ensure steady motion free from vibration and rocking. An automatic mechanical brake capable of bringing the motion of fully loaded trolley safely to rest in the shortest possible time with least possible shock shall be provided. In addition thrustor brake shall also be provided.

6.4.3.3 Hoisting Machinery

The trolley shall be equipped with main hoist and an auxiliary hoist mounted on trolley framework. The hoists shall be driven by suitable motors and gears to obtain the required hoisting speed. Each hoist shall be provided with brakes and retarding devices as stated elsewhere. The winding drums shall have machined grooves to receive the full hoisting rope without overlapping and the drum shall be of such size that there will be not more than one layer of rope on the drum when the rope is in fully wound position and its length shall be such that each lead off rope has a minimum of two full turns when position and its length shall be such that each lead off rope has a minimum of two full turns when the hook is in its lowest position and one spare groove for each rope lead off the drum when the hook is at the highest position. The drum shall be designed to withstand the maximum compressive stresses and local bending stresses in the drum at the groove when the rope is wound on. The lifting tackles shall consist of a safety lower block and hook, necessary sheaves, flexible steel wire rope etc. The lower block shall be a heavy steel housing to support the sheaves and hook. The swiveling hooks shall be mounted on ball thrust bearings and protective skirt shall be provided to enclose the bearings. The main hook shall be of the Ramshorn type and the auxiliary hook shall be shank type plain hook conforming to approved relevant standards. The sheaves shall be made of cast iron, cast steel or mild steel and shall be machine grooved to a depth of not less than 1.5 (one and one half) times the diameter of the rope. The groove shall be finished smooth and shall be free from surface defects likely to injure the rope. The sheaves shall be provided with guards to retain rope in grooves and other requirements of sheaves shall be as per approved relevant standards. The hoisting rope shall be flexible plough steel wire type with fiber core and internal lubricant. The factor of safety of the hoisting ropes shall not be less than 5(five). The rope system shall be equalized and arrangements entailing reverse bends shall be avoided as far as possible.

6.4.3.4 Gears

All gears in power operated motion shall be machine out conforming to internationally accepted standards. The gear trains shall be in totally enclosed oil tight fear cases with welded seams. An inspection cover on the top of the gear case shall be provided for quick and easy inspection of fears and for adding oil in the case. Adequate breathing and drainage facilities shall be provided on all gear cases. Means for clear and correct indication in the oil level in gear cases shall be provided. All gears not enclosed in gear case shall be properly guarded. The pitch line shall be described on all the gears and pinions to facilitate erection. All gears shall be of cast or wrought steel and shall be designed for the specified crane duty. Spur and helical gears shall be used for speed reduction.

6.4.3.5 Bearings

The bearings shall be of the roller, ball sleeve type with removable bronze linings preferably flanged at both ends. The shaft bearings shall be placed as close as possible to the pints of loading. Unless otherwise specified herein, bearings on revolving shaft shall be of the divided type so that each shaft may be removed from the crane with its pinions and gears in position. In all cases where divided bronze bearings are used, the bearing caps shall be dowelled or secured with not less than two turned bolts, the holes for which shall be reamed to a close fit unless the caps are recessed into the base. Cap screws shall not be used for this purpose. This requirement will not apply where roller or ball bearings are involved. All bearings shall be designed so as to be replaceable easily. Bushings at the ends of shafts shall be sealed by an approved method so as to be drip proof if oil lubrication is used. In case of grease lubrication, open ends of bushings shall be sealed with approved grease retainers.

6.4.3.6 Lubrication

Provision shall be made for lubricating all bearings including ball and roller bearings by a pressure gun bottom and all lubrication nipples shall be readily accessible. Ball and roller bearings shall be packed with grease during initial assembly. Where access to a bearing (e.g. end carriage wheels) for lubricating purpose is difficult, provision shall be made for remote lubrication through copper or brass piping of ample size. Gear trains, sleeve bearings etc. shall be provided with oil lubrication. Gear trains shall be run in oil baths. High pressure grease guns shall be supplied with the crane and the crane shall be handed over completely lubricated with approved oils and grease in the presence of Employer's maintenance crew. The contractor shall furnish the details of the lubricants such as the quantities and specifications etc. to enable Employer to procure the lubricants for stock. The contractor shall supply a lubricating chart indicating points to be lubricated and frequency of lubrication.

6.4.3.7 Drip Pan and Covers

All bearings and gear cases shall be made oil tight. Suitable drip pans shall be provided to collect oil and grease, which may drip from bearings, gear cases and other components of the crane in case drip proof arrangement is not possible. Means for cleaning the drip pans shall be available. Dust covers shall be provided where necessary to protect sliding and rotating pairs and to prevent dust from mixing with the lubricant.

6.4.3.8 Bumpers

Spring bumpers shall be attached to the bridge trucks and the trolley. The bridge shall have four bumpers one at each corner arranged to meet the crane stops squarely. The trolley shall have two spring bumpers on each side placed to meet the track stops squarely at the end of the stops. The bumpers shall consist of suitable springs, steel cylinders, rams, etc. and shall be fastened to the trucks and the trolley and shall be capable of bringing the crane and the trolley to a gradual stop when travelling at rated speed in either direction, when the power supply is off and thus eliminate excessive stresses and damage to any part of the crane.

6.4.3.9 Holding Clamps

As a safeguard against movement of the crane off the rail during an earthquake, suitable provision to contain the movement of crane shall be made. Clamps to keep the crane in a locked condition while not in operation shall be supplied.

6.5 Electrical Equipments

6.5.1 General

Electrical requirements for motors, controllers, resistors, braking, limit switches, protective equipment, isolating switches, cable wiring, earthling and other conductors, etc. shall be in accordance with IS 3177 – 1999. The power supply for the electrical system shall be 415 V, 3-phase, 4 wire, 50 Hz AC. The supply for crane control and lighting system shall be 240 V AC, 50 Hz and shall be obtained through individual 415/240 V transformers. All electrical equipments shall be suitably designed and constructed for operation under tropical conditions. Allowable temperature rise of the equipment shall be as prescribed in the Indian Standards or the corresponding International Standards and shall be based on ambient temperature of 40°C. The Tenderer shall state in his Tender the make and type of electrical equipment, which he proposes to furnish so that this could be confirmed by the Employer. Controllers, levers and other operating mechanism shall be marked plainly and permanently. The location of all operating mechanism and electrical devices shall be subject to the approval of the Engineer.

6.5.2 Motors

All the motors shall be of ample capacity for the duties and speeds specified and shall conform to IS 325 (latest) or equivalent. The motors shall also meet the requirements as specified in IS 3177 (latest) or equivalent. Motors shall be suitable for revering, frequent accelerating and mechanical braking. The rating of motors for all motions shall be 40% CDF with minimum 150 (one hundred & fifty) starts and stops per hour. All motors shall be suitable for operation at 415 V, 50 Hz, 3 phase, 3-wire system. The motors for inching (creep speed) operation shall be squirrel cage type.

Continuous operation under the following supply conditions:

a) Voltage variation - +10%, -15%
b) Frequency variation - $\pm$ 3%
c) Combined voltage frequency variation (absolute sum)

The breakdown torque of the motors shall not be less than 225% of full load torque with rated voltage and frequency applied. The bearings shall have ample strength to withstand the heavy shocks and variations to which they will be subjected. Motors shall be provided with class B insulation and shall be the rated (for trolley motors 30 m meter locating and for creep motors continuous rating). Under the specified service conditions, the temperature rise shall not exceed 75 deg. C over the ambient temperature of 45 deg. C when measured by resistance method. Full technical particulars of each motor including the value of the locked motor current, breakdown torque etc. shall be given in the Tender. All electrical works shall conform to Indian Electricity Act 1910 and Indian Electricity Rules 1956, wherever applicable. Motors of 30 kW and above shall be provided with space heaters operating at 240 V and motors below 30 kW shall be provided with arrangement of winding heating at 24 V. The motors offered shall be TEFC type and of reputed make.

The motors shall also fulfill the following requirements:

a) The motor ratings at the given ambient temperature shall be at least 15% above the load demand of the driver equipment at the design duty point or 5% above the maximum power requirements of the driver equipment whichever is higher. The rating shall be such that the motors shall not be overloaded at any operating point of driver equipment from zero to full load.
b) The motors shall be provided with IP 55 enclosures as per IS 4691.

6.5.3 Brakes

Main hoist, auxiliary hoist and trolley travel shall be spring set. The electrical operating parts shall consist of AC or CC (in case of DC solenoids, suitable rectifier unit shall be supplied by the Contractor) solenoid switch shall release the brake on energisation. Interruption or failure of electric power supply shall apply all brakes immediately. The bridge travel brake shall be of mechanical or hydraulic type, foot operated from the cage. The brake pedals shall have a non-slip surface and it shall be possible to apply the foot brake with a force not exceeding 40 kg. The breaking system shall incorporate a parking feature to hold the crane immobile when the power is off. In addition electro hydraulic thruster brakes shall be provided for all motions except the long travel for which the brakes shall be mechanical or hydraulic. All brakes shall have adequate capacity. The brakes for hoisting when applied shall cut the motion and sustain the load up to the test load at any position of the lift. Provision shall be made to control with safety the lowering of any load up to the test load. Brakes in other motions shall be capable of bringing the relevant motions of the fully loaded crane safely to rest in the shortest possible time with least possible shock and shall arrest the motion under all other service conditions.

The various brakes shall be designed for torque equal to1.5 times the full load torque of motors.

The brake torques may be increased if considered necessary by the manufacturer in order to ensure proper and safe application of the brakes. All electro-magnetic brakes coils shall have continuous rating.

6.5.4 Limit Switches

All limit switches shall have a minimum contact rating of 5A at 240 V AC and shall include the following:

Self reset rotary type limit switch of gear or cam design for the hook block.

1(one) each for main & auxiliary "Hoist" motions.

1(one) each for main & auxiliary "Lowering" motions.

Hand reset gravity type back up unit switch to operate in the event of failure of main unit switch

1 (one) each for main and auxiliary hoist motions.

Self reset type lever operated limited switches with closed contracts shall be provided to operate at the extremities of travel motions as given below or as required.

2(two) for bridge travel motions.

2(two) for trolley travel motions.

All limit switches shall be capable of reset by revering the controller.

The Contractor shall ensure that spring failure within the limit switches do not make them inoperative.

6.5.5 Control, Controllers and Resistors

All motor controls shall be full magnetic reversing type with definite time limit or frequency controlled acceleration devices and instantaneous over current, overload single phasing and under voltage protection. They shall be so designed that it will be possible to limit the vertical movement of the hooks, with full rated load and when starting from complete standstill, to within 1 mm for main hook. All hoist motor controller shall have at least six speed control points in each direction of operation and all other controllers shall have at least four speed control points in either direction of operation. The main hoist and trolley travel shall be provided through inching motor (continuously rated) and planetary gears to give 10% of normal speed of the hoist. Drift point for both direction of travel shall be provided for trolley travel controllers.

The contacts of protective relays of any motors shall be so wired that the operation of any relay will trip the motor primary contactors, thus making it necessary to return all controls to the off position before the motor primary contactors, thus making it necessary to return all controls to the off position before the motor to be started again. The instantaneous relay shall be adjusted between 200 and 300 percent of motor full load current. The power supply from the main collectors shall be protected by a 3 pole, 415 volt AC totally enclosed air circuit breaker equipped with a three time delay direct acting, overload tripping elements and the one shunt trip coil located in the operator's cage. Push buttons shall be provided in the cage for emergency tripping. A double pole switch shall be provided to control and protect the control circuit for each motor and all control circuits shall be fused properly.

An indicating lamp shall be provided to show that the control circuit is healthy. All switches, contactors and relays shall be enclosed in suitable cabinets placed in accessible locations. All control motors shall have master switches with vertical handles. Changes in speed in the lowering direction should be under the direct control of the operator and shall permit him to stop the motor without time delay from any position of the master switches.

All resistors shall have non-breakable, corrosion resisting type and shall have a low temperature co-efficient. The resistors shall be placed in accessible places outside of the cages and in well ventilated non-combustible cabinets which will not emit flame. The general arrangement of the resistors shall be such that a defective bank of elements or part thereof may be easily removed and replaced without having to completely dismantle. Tapping shall be connected by copper rod or strap to an accessible terminal board at the base of each frame. Provision shall be made for making a connection to any grid of each resistor. The resistors shall be of continuous duty for main hoist & auxiliary hoists motors. The resistors for bridge travel and trolley travel shall have at 10 (ten) minute rating.

Each main supply circuit breaker or conductor shall have an interrupting capacity of not less than 40,000 A symmetrical at 415 V. All switches, contactors, primary relays and primary CKTs on controller shall have a thermal capacity of 20,000 A for one second without injury and shall have a rating of at least 660 V. Allowable temperature rises shall be prescribed in the Indian Standards or other equivalent standard and based on an ambient temperature of 40°C.

Each Tenderer shall state in his Tender the make and type of all electrical equipment which he proposes to furnish. All switches, controllers, levels and other operating mechanism shall be marked plainly and permanently. The location of all operating mechanism and electrical devices shall be as per the approval of the Employer.

6.5.6 Master Switch for Operation

Master switch for operation shall be of vertical type lever handle design. Changes in speed in lowering direction should be under the direct control of the operator and shall permit him to stop the motor without time delay from any position of the master switches. A dead man's feature shall be incorporated for switching off power supply in emergency situation.

The following control points (positions) shall be provided in each direct on. Each of the speed points shall be capable of providing continuous operation without overheating, overloading any part of the crane system.

Main hoist	Six (6) minimum
Aux. hoist	Six (6) minimum
Bridge ravels	Four (4) minimum
Trolley travel	Four (4) minimum plus drift point for both direction of trolley travel

The controls shall be designed to limit the vertical movement of the hook with full rated load when starting from complete standstill to within 1 mm for main hook. Sufficient motor torque shall be available to support the load before the brakes are released to avoid the load sug (slight lowering before hoisting).

6.5.7 Power Supply

The power to the crane shall be supplied through a fully shielded conductor and collector system installed at appropriate elevation on the downstream side of the machine hall. The conductor system shall be of sufficiently low impedance and suitable current carrying capacity to permit full operation of the crane at the most distant point from the power infeeds.

The Contractor shall furnish the voltage drop calculations to establish satisfactory operation of the crane operating at rated load.

Red warning light shall be provided at both ends of the runway to indicate that power supply leads are alive.

Metal enclosed isolating switch fuse units shall be provided by the Contractor at 1.5 m above the operating floor level for isolating the power supply leads. All cabling from these isolating switch fuse units onwards shall be in the Contractor's scope.

6.5.8 Cross Wires

Flexible copper wire PVC insulated trailing cable arranged in festoon configuration shall be provided on the bridge & cross wires. The cable shall be suspended on bearings fitted trolleys operating on I-beam of suitable size just outside on the bridge girder.

6.5.9 Power and Control Cables

The Power Cable shall be 1.1 kV grade, heavy duty, stranded conductor, PVC insulated (type –A), extruded PVC sheathed, galvanized steel wire/strip armoured, extruded PVC type ST-I under sheath. The power cable size shall be so chosen, considering the current carrying capacity of connected equipment that the voltage drop shall not exceed 2.5% after taking into account the group derating factor. The control cable shall be 1.1 kV grade, heavy duty stranded copper conductor, PVC insulated type-A, extruded PVVC inner sheathed, galvanized steel wire/strip, extruded PVC (type-ST-1) outer sheathed the cable shall be conforming to relevant IS in gear 20% cores reach control cables shall be kept as span.

6.5.10 Trolley Conductors

The conductors shall be of rigid type. Bare copper wire shall not be acceptable. The minimum clearance between live parts and ground shall be 80 mm. sufficient safety guards shall be provided to avoid any accidental touch with these conductors.

6.5.11 Down Shop Lead Arrangement (Long travel current collecting system)

Down Ship Lead (DSL) arrangement using copper sections with or without shrouding cable arrangement shall be used. Use of shrouded conductors where possible is recommended. DSL arrangement shall as per IS : 3177.

6.5.12 Lighting and Convenience Outlets

The permanent 240 volts lighting system on the crane shall consist of 4 (four) nos. 500 W high bay lighting units to illuminate uniformly the area under crane and 2 (tw0) nos. 60 W lighting units in operator's cage, with a convenience outlet at each end of the bridge and two in operator's cage. The system shall be supplied from 415 V crane power system through a 415 V circuit breaker. One branch circuit system shall be connected to two 60 W lights, each of two branch circuit shall be connected to two to four convenience outlets. The wiring shall be done in accordance with latest Indian Electricity Rules. The 415 V circuit breakers shall be enclosed two pole circuit breakers with an over load tripping element for each pole A 21 V.

6.6 Earthing

The crane structure, motor frames and metal cases of all electrical equipment including metal conduit or cable armoring or ends shall be efficiently bounded to facilitate earthing as per Indian Electricity Rules 1956 and IS 3043-1966.

6.7 Cleaning and Painting

After fabrication, all structural steel and unfinished surface of castings shall be cleaned thoroughly of all mills or foundry scale, rust, dirt, oil, grease and other foreign substances. The cleaning shall be done by metal brush scrapers, chisels or hammers or by sand blasting. Oil and grease shall be removed by wiping with gasoline or benzene.

After cleaning the surfaces shall be given two priming coats of approved rust resistant paint. Surface which will not be accessible after the parts are assembled or erected shall be given additional shop coat. Immediately after cleaning al machine finished parts and surfaces including bolts and nuts shall be well coated with a suitable rust preventive compound. In addition, one coat of finishing paint of approved colour shall be applied over two coats of primer in the shop. All paintings shall be performed in workman like manner and the resulting paint film shall be uniformly thin without runs, or partially covered areas. All joints and crevices will be coated thoroughly. No paint shall be applied on damp or framed surfaces, and material painted under cover in damp or cold weather shall remain under cover until dry. In painting machinery, special care shall be taken that no paint is applied to finished surfaces. The material shall not be loaded for shipment until the paint is thoroughly dry. At no time after the application of paint shall any material be laid on ground. In handling painted material, care shall be taken to avoid scraping or breaking the painted surface. Sufficient quantity totally of paint for giving one coat to equipment after erection at site shall be supplied.

6.8 Inspection, Shop Assembly and Match Markings

Shop tests (to be inspected) shall include chemical and physical tests on castings, X-ray tests on welds and general inspection of al important casting. Test certificates for motors, contactors, circuit breakers, hoist ropes, hooks, etc. shall be required to be furnished.

The cranes shall be completely assembled and operated and load tested in the shop by the motors and controls. The parts of care shall be delivered assembled in as large units as practicable for filed erection and handling. Field connections shall be fitted in the shop and match marked suitably to facilitate field erection. All such match marks shall be clearly legible after the crane is painted. On painted surfaces the match marks shall be placed after the painting is complete. Six copies of all diagrams of such marks for field connections shall be furnished with the crane.

The Employer or his authorized representatives shall have access to the manufacturer's works at all reasonable times for the purpose of witnessing the manufacture, inspection and testing for all components or complete crane.

Any work found defective or which his not in accordance with the approved drawing, standards or contract may be rejected by the inspector.

The particulars of the proposed tests and the procedures for the tests shall be submitted in detail in the proposal clearly indicating the tests offered for witnessing by the Employer. All materials, castings and forging shall be tested quality. Besides other tests certificates crane hook and wire rope tests certificates shall be made available. The certified reports on all these tests shall be submitted to the Employer/consulting Engineers for review. All materials can be dispatched only after test certificate are approved. The approval of the Test Certificates shall be given only if the corresponding drawings and technical particulars of the equipment have been approved by the Employer/engineer.

The crane bridge shall have permanent inscription in English on each side readily legible from operating floor stating manufacturer's name, serial number, the year of manufacture and the safe working load.

6.9 Tests

6.9.1 Test at Manufacturer's Works

All electrical and mechanical equipment shall be tested in accordance with appropriate International or Indian Standard Specification at either the crane maker's or equipment manufacturer's works and test certificates shall be furnished.

The crane shall be tested under load on hoisting and cross traverse motions. Travelling fear may be run light to check shaft and gear alignments.

The Contractor shall clearly list the test that can be performed at his works.

6.9.2 Tests on Site

6.9.2.1 Insulation tests

After erection, but before crane is connected to the supply, insulation of electrical equipment shall be tested by suitable instrument and any defects revealed shall be rectified by the Contractor. The supply voltage required for the insulation resistance test shall be DC with voltage not less than twice the rated voltage.

6.9.2.2 Motions and Approach Distances

The basic parameters like crane clearance shall be verified and the height of list shal be measured.

6.9.2.3 Speeds

The speed load characteristics of the various motions of the crane as offered by the manufacturer shall be verified by the Purchaser at his premises by actual loading such as no load, half load, full load at all notches. Any deviation shall be corrected by the manufacturer.

6.9.2.4 Tests for operation

After the supply has commenced and before the complete crane installation is put into commercial service, tests shall be carried out to prove the following:

i) Satisfactory operation of each controller, switch contractor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavourable conditions.
ii) The correctness of all circuits and interlocks and sequence of operation.
iii) The satisfactory operation of all protective devices.
iv) The satisfactory operation of each motion of the crane.
v) The compliance of the crane with the specified performance requirements and
vi) The tolerance of specified speed at full load shall be within $\pm$ 10%.

6.9.2.5 Deflection Tests

The test shall be carried out with the working load at rest and with the trolley in a central position. The measurement shall not be taken at the first application of the load. The datum line for measuring the deflection should be obtained by placing the crab on the extreme end of the crane span with smaller hook approach. The vertical deflection caused by the safe working load and weight of the crab in central position (without taking into account the impace factor) shall not exceed 1/1000 of the span.

6.9.2.6 Overload Tests

After tests but before the crane is put into service, it shall, with overload relays appropriately set, be tested to lift and sustain a minimum test load of 125 percent of the working load when the load is located at the centre of the span.

During the overload test each motion including bridge travel, in turn, shall be maneuvered in both directions and crane shall sustain the load under full control.The Contractor shall arrange the test load.

7.0 EARTHING AND LIGHTNING PROTECTION SYSTEMS

7.1 Scope of Work

The Contractor shall provide a complete system for potential gradient control and earthing of all installations in the Power House, HV Switchyard, Cable Shaft, including interconnection between power house and switchyard earthing system.

Earthing system in power house area require a special attention with regard to their dimensioning, due to fact that the Power House is completely embedded in strata with a varying specific resistivity, from few tens of ohm-m to few thousand ohm-m.

Since this specific resistivity of the soil is important for calculating of the earthing systems, the successful bidder should wherever possible execute measurements in due time.

Touch and step voltages and transferred potential are to be calculated in accordance to IEEE 80/76.

A lightning protection system for all buildings and outdoor structures including 33kV switchyard shall be also supplied under this Section.

Trench excavation and refilling work for the installation of the earthing systems is under the scope of contractor. The quantity of earthing materials is indicative and may undergo change upward and downward depending upon the actual design and execution by the successful bidders.

The scope shall comprise all required mild steel conductors and earthing rods of individual size, connecting and all kind of fixing materials to form a complete, safe and reliable system. All electrical equipment such as generators, transformers, switchboards, control boards, motor, relay and auxiliary relay boards and all other subsidiary electrical equipment as well as such metal parts of the civil construction or the mechanical equipment, which can carry currents in case of earth faults, shall be connected to such a network.

7.2 Design Features

7.2.1 General

Drawings shall be submitted for the approval of the Engineer giving sufficient information on the earthing system, the earthing of structure-mounted equipment, as well as on methods of measuring the earth resistance.

The complete earthing system shall have a maximum earthing resistance of one (1.0 Ohm at any point of the system.

The termite welding process or clamping connections shall make all interconnections of the earthing grid to equipment and the connections between the earthing grid and the earthing rods.

7.2.2 Potential Gradient Control System

The Contractor shall provide a complete potential gradient control system for the Power House, Transformers yard, Switchgear rooms, Switchyard and all such locations where dangerous surface voltage gradients may occur, including all necessary connections to the plant earthing grid. Prior and during the concreting stage the Contractor shall provide all information in sufficient details to enable the Civil Contractor connecting the reinforcement bars to form and adequate grid.

Within concrete structures (foundation, floors, columns) the Civil Contractor shall provide reinforcement bars of adequate cross section interconnected to a net with permissible mesh dimensions, with at least two connection pieces protruding at diagonal points into the ground floor of buildings. In the caverns several connection pieces with equal distances shall be provided.

The number and the location of this interconnection point shall be determined by the Contractor. The Contractor shall provide drawings showing the mesh dimensions and the extension of the earthing grid formed by the reinforcement bars.

7.2.3 Earthing System

The Contractor shall provide a complete earthing system for all installations of the power plant. The main earthing rod shall be 30.0 mm dia m.s rod and earthing conductor shall be 50x8mm M.S. flat while risers shall be provided with 50X6mm G.S. flat for connections to plants/equipments.

The earthing system shall consist of individual lops with connection to the different equipment to be earthed and with connections to the plant-earthing grid. At certain locations earthing measuring points shall be installed.

Within the Power House and Transformer yard, the switchgear rooms and other rooms or building containing electrical installations, at least one main protective earthing bus shall be provided, approximately 0.3m above floor at the circumference of the building room. This bus having minimum dimensions of 50 x 6 mm shall be connected with the sub-grade earthing system and reinforcement steel. This protective earthing system shall be carried along with the cable trays to reach every electrical consumer in a convenient manner.

The connection straps (minimum 4 pieces) from the reinforcement net to the main protective earthing buses shall be provided with disconnect terminal lugs for measuring, always visible for inspection.

Each electrical device as well as equipment made of conducting material shall be provided with an earthing screw of sufficient diameter or an earthing plate. If several devices form part of a larger unit (such as control cabinets, control boards, metal-clad sub-distribution boards, etc.)

this unit shall be provided with an earthing screw or plate with which the earthing screws or plates of each individual device shall have solid contact.

When control boards, control desks, switchboards, distribution boards, etc., consist of several individual panels, each panel shall be connected to a common earthing bar unless all panels are solidly welded together or other approved means are applied ensuring solid connection. If in this case units of larger extension should be formed (e.g. switchboards), provisions for earthing shall be available at least at both ends.

The low voltage distribution network shall be supplied with protective multiple earthing in which the neutral conductor will be earthed at the transformers and main and sub-distribution boards. The housing of all equipment shall be connected to this protective multiple earthing conductor. In the event of a short circuit between live parts and earth, the resulting resistance of the closed circuit phase conductor and the earthing system shall affect at least an operating current activating the appropriate protective device.

7.2.4 Lightning Protection System

The Main Power House Building shall be provided with a lightning protection system composed of roof and down conductors sufficiently sized, spaced and connected to the main earthing loop or to separate earthing electrodes. Local conditions shall be strictly observed. Lightning protection for interconnecting towers from Power House & Switchyard shall be done through overhead earth wire. 32kV switchyard lightning protection shall be done through earth-wire and if required through Lightening mast.

8 CONTROL AND MONITORING SYSTEM

8.1 Scope

This section covers the design, manufacture, testing at manufacturer's works before dispatch, delivery to the Site, storage till installation/commissioning, software installation, testing and commissioning of the Unit and Station Control System for the 2x2.5 MW generating units and their associated auxiliaries as per the details and conditions described herein and at other relevant sections, wherever applicable.

8.2 Philosophy of Control System

The system shall have distributed Process Control System to achieve better reliability.

The structure of the distributed system shall have the following control levels:

Unit Control System (Local Control for the individual)

This level covers the control/supervision at unit level, i.e. for the overall sequence of operation of machine start-up an shutdown.

- Service Control System

This level covers the control of individual equipments of the Unit / Switchyard and shall be used mainly for testing and maintenance purposes.

The control systems will communicate together via serial buses.

The system shall be designed to permit the station to be operated as follows:

Operation from the Central Control Room (CCR) where the operator shall get information and will have the necessary controls to perform a simple and reliable operation of the

- Generating unit
- Step Up Transformers
- 33kV Switchyards
- Common station auxiliaries / services

The system shall also have back-up operation/local control by, which it shall be possible to operate the station through operation (automatic or manual) of its different functional group as well as through individual drives.

At the unit control level, each local control system shall have its own control mode selector switch. These switches shall have three positions viz. Remote/Local Auto/Local Manual.

Due to Co-relation of all the system, the time resolution of a fault occurring in the plant shall be minimum.

To meet the peak load demands of the system, it is very essential that the availability of the units be ensured. So, there shall be a very fast maintenance and troubleshooting possible in case of fault due to diagnostic built in the software of the computer system.

The control system shall be self-supervising, i.e. the system shall be able to monitor and register the startup/shutdown sequences or any other failures in the control system.

8.3 Modes of Operation of Power Plant

The following operational modes of the generating units are envisaged:

Starting and running mode

Normal stopping, Control action shutdown/emergency shutdown.

All the generating units shall be designed to operate independent of each other.

Broadly, the Control system shall have excellent operational capabilities such as ability maintain high plant efficiency, better load adjusting and plant protection functions, operation monitoring and easy maintenance.

The tenderer shall furnish sequential block diagrams based on the modes of operation of the units stated above. Some of the main considerations for reference of the tenderer are proposed below:

When the unit is started in generating mode, the generator shall be synchronized to the system by Generator circuit breaker. The modules located in the speed governor and voltage regulator shall carry out matching of the incoming generator voltage and frequency with those of the system.

Control Action Shutdown/Emergency Shutdown (depending upon the groups of protection provided for the generating units) of the units shall come into operation by installation of anti-mechanical and electrical protection. The control system supplier shall co-ordinate with the supplier of T/G and electrical protection equipments supplier(s) for the purpose. It shall also be possible to stop the machine by emergency control bush-button from local unit control and station control systems.

The details of operation of the plant in various modes shall be programmed in the unit control and station control systems, otherwise as specified by the supplier.

8.3.1 Sequences

The related sequence diagrams shall be sent for approval to the Engineer.

A) Control action shutdown conditions

a) Generator bottom & thrust bearing temperature very high

b) Generator top bearing temperature very high
c) Turbine bearing temperature very high
d) Generator hot air temperature very high
e) Electrical fault (non-urgent)
f) Rotor temperature very high
g) Stator winding temperature very high
h) Stator core & tooth temperature very high

B) Emergency shutdown conditions

a) Unit over speed
b) Shear pin broken
c) Governor oil pressure very low
d) Generator fire (CO_2 initiated)
e) Governor oil level very high
f) Guide vane failed to close
g) Excitation fault (stage-3)
h) Electrical fault urgent

8.4 Unit Control System

8.4.1 Unit Control Board (UCB)

The Unit Control Board shall be installed nearby each turbine generator unit be divided into the following sections.

- Electronic Governor Section
- Local Control, indication and monitoring sections
- Transducers and relay section
- Alarm and annunciation section

The Unit Control is responsible for the overall sequence of operation, e.g. when the machine is started or shut down (normal and emergency). It takes process criteria as its input and executes a sequence program and issues commands to the Functional Group or Drive Control. It checks for the presence of all the required criteria before it issues a particular command. Also time taken for the execution of the command is monitored and an alarm or trip is generated, if command executions take more than the stipulated time. Indications are provided for status of machine, faults like progression criteria missing, start criteria, protection fault, etc.

8.4.2 Mode of Operation

The Unit Control can be operated in three modes, namely:

- Automatic Mode
- Step-by-Step Mode
- Automatic Inactive Mode

In the Automatic mode, the operator gives the commands only once to start the program. No operator intervention is further needed for normal execution. This is the mode in, which the unit control system normally operates.

Step-by-Step mode is one, which is usually used to execute the program in steps. Every time a step is ready to be executed, the operator has to initiate the step through a push button command. This mode is normally utilized during commissioning and test phases.

In Automatic inactive mode the commands from Unit Control to functional group and drive control are blocked. All the indications including missing criteria display are active. The operator can start the drives by manual commands to the functional gropu or drive control from Unit Control Board.

The unit control system mainly comprises:

- Main inlet valve (Butterfly valve)
- Governing system
- Excitation system
- Electrical and mechanical protection

Butterfly valve (MIV):

The butterfly valve (MIV) will be designed for service, maintenance and emergency closing of penstock.

Governing system:

The electro hydraulic speed governor will provide automatic speed, regulation and turbine control. It will be designed for the following modes of operation:

- No load running (Excited mode)
- Operation on load in generating mode
- Starting in generating mode
- Normal and emergency stopping of the units

Excitation system:

The generator shall be provided with parallel/self excitation system, which is intended to excite the unit in the generating mode.

Electrical and Mechanical Protection:

The main electrical and mechanical protections necessary for generating units shall be provided by the supplier of turbine / generator.

8.4.3 Operation from Unit Control Board (UCB)

It shall be possible to operate the unit in manual mode as well as automatic mode from UCB through selector switch.

A) Manual Operation

For the purpose, the UCB shall be equipped with required control switched/push buttons for manual start/stop of the unit. In the event of the station control computer/unit control computers being out of service, a manual control mode shall operate for each device by using the Push Button control Switches in UCB.

The input, output signals from the I/O Modules shall ensure this operation mode.

The following functions can be achieved with the manual controls:

a) Starting and stopping of the unit in Manual Mode

This mode shall enable the operation with the Push Button Control Switches in UCB and the relay safety interlocks shall avoid dangerous operation. A manual start shall be carried out in the following way:

Before the unit can start to rotate, all necessary auxiliary systems have to be started manually.

When the speed of the turbine/generator unit has reached rated speed, excitation shall be applied by operating the excitation system via Push Button Control Switches in UCB. Synchronization of the unit shall be carried out automatically or initiated manually. When the unit is connected to the network the voltage and the active power shall be adjusted via the above-mentioned Push Button / Control Switches in UCB for the excitation and turbine governing systems.

b) **Fault Annunciation:**

For fault annunciation the same system shall be used as for automatic control.

c) Protection:

All the protective system comprising electrical and mechanical protections shall. be in operation during the manual control.

B) Automatic Operation

Automatic start/stop operation f the units shall be possible from UCB. For this purpose, the process control computer/unit control computer shall perform he sequential control functions, some of which are indicated below:

a) Control and Supervisory Functions

The main control and supervisory functions performed shall include:

- Complete automatic start-stop for turbine operation
- Supervision of all control sequences including all transfer control and emergency shutdown sequences

b) Protection

The function of the protective system shall be in the same in automatic control as in manual control mode.

For each individual protection there shall be an indicating signal connected to the unit control computer. These signals shall be used for initiating a stop sequence, which shall handle the disconnection of the auxiliary systems, etc. during the shutdown of the machine after a trip. The signals shall also be used for the event treat functions on the station control level in the CCR.

c) Indications:

The unit control board panel shall be used for maneuvers and indications in this control mode.

Instruments and position indicators for breakers and isolating switches shall be connected directly to the adaptation equipment. Devices for automatic control functions such as start/stop etc. shall be connected to digital inputs and outputs of the programmable controller.

d) Fault Annunciation

For supervision of the unit an alarm system shall be used. The alarm system shall be based on an electronic controlled signal system. The input signals to the alarm system shall be supplied via interposing relays in the adaptation equipment with one contact for event recording and second contact for collective alarm generation on the mosaic board of the central control room.

e) Operating module for the automatic control sequences

The operating module, which shall be integrated in the unit computer cubicle, shall contain all operation and annunciation facilities required for control of the various programmes and diagnostic functions.

f) Emergency stop and quick shutdown

The emergency stop shall be realized in the following ways:

- units computer (through trip relays)
- from the unit control board (through trip relay).

All signals, which initiate emergency stop of the unit shall be collected by trip relays, for the following purposed.

- For electrical failures (immediate tripping of generator circuit breaker).
- For mechanical failure (first closing wicket gates, unloading, then tripping of generator circuit breaker).

8.4.4 Synchronizing Equipment

An automatic synchronizer in double channel design with frequency and voltage matching and monitoring of manual paralleling (synchro check) shall be provided for each unit. One portable testing device for periodic testing of functions shall be provided for all the two (2) Units. Alternately, the testing function can be integrated in the automatic synchronizer.

8.4.5 Transducers for Electrical Measurements

A microprocessor based transducers unit with serial interface for communication with the process control computer shall be provided. The same unit shall drive all indicating instruments in the UCB. Following functions shall be provided:

a) Current in all 3 phases
b) 6 voltages (phase to phase and phase to ground)
c) Cos-phi, MW, MVar and Hz
d) MWh and MVarh

8.4.6 Electronic Turbine Governor

The electronic turbine governor provided by the turbine manufacturer shall be installed and fully integrated in to the UCB. The turbine governor shall have a serial/suitable interface with the process control computer.

8.4.7 Process Control Computer (Unit Computer)

The process control computer shall be built around a 32-bit microprocessor. System software shall be stored in non-erasable high-speed solid-state memory. Application programs shall be stored in non-erasable memories as well EPROMS. Process control computer shall be provided with redundant CPU. Automatic diagnostic functions and built-in test functions with fault indication LED's shall be provided in order to accomplish an easy and quick fault tracing. Real time clock and calendar shall be provided. Cycle times for different tasks shall be individually selectable in steps from 10 ms up to 30 minutes. The main functions implemented by the computer are briefly indicated below:

- Automatic start/stop sequence
- Communication with station control centre via station bus
- Communication with unit related equipment via field bus and I/O Modules
- Monitoring of unit
- Data acquisition
- Event and alarm handling
- Trend data logging

Data acquisition from generator, turbine, transformers and 33 kV switchyard, etc. shall be realized via distributed I/O Modules with suitable interface.
All trip signals shall be channelled via the programmable trip logic to be furnished as part of the electrical protection cubicle.
Manual start and stop of the unit shall be possible in case the process control computer/unit control computer is out of operation.
Basic interlock shall be hard wired.
Grouped alarms shall be provided on the unit/local control board for equipment that are equipped with local annunciator (excitation, electrical protection, etc.) for other equipment, individual or less grouped alarms shall be provided on the local/unit control board.

1) Automatic start, stop and emergency shutdown sequence

a) The function for automatic start and stop of the generator/turbine unit under all the specified modes of operation shall be built up with a number of sequences, which will bring the unit from one defined operating condition to another, such as synchronized, running but not synchronized and standstill and unloading of the unit (MW, MVar) shall be built into the start/stop sequences as well.

b) Each sequence shall be built up from a number of steps in each step, orders shall be given to different process objects and the next step shall not be activated until the conditions of the previous step have been fulfilled. Each step shall be supervised and if any condition is not fulfilled within a specified time an alarm shall be initiated and the actual step and the fulfilled condition shall be indicated on text display or with individual LED's.

c) Pre-start condition shall be monitored and any missing condition shall be indicated as specified above.

2) Communication with unit related equipment via field bus

a) As specified, the communication with the process should be realized to maximum extent through a bus connection. The manufacturer shall co-ordinate and ensures that all equipment furnished under this contract like excitation systems, turbine governor, temperature monitoring device, etc. are designed to be capable to communicate with the process control computer via field bus.

b) In equipment where a physical concentration f process signals occurs like in the generator terminal cubicle, transformer control cubicle, turbine pit and 33 kV switchyard, etc. if necessary remote I/O units shall be provided and installed. These shall communicate with the process control computer through a field bus as well.

3) Local I/O Units:

Where the process communication can neither be channelled through field bus nor remote I/O units, local I/O elements shall be provided in the unit control board as interface elements to the process control computer. These interface boards as well as the interface boards in the remote I?O units if any shall be capable to process digital, analog and special (Pt 100, etc.) signals from and to the process as required.

4) Supervisory Functions:

a) For a generator/turbine unit the supervision is mainly on signals from limit switch for levels, flows, pressure, temperatures, etc. and limit check measured values such as temperatures and vibrations. The signals shall be supervised and in case of abnormal conditions, an alarm signal shall be given.

b) Calculation of running hours and number of operating cycles shall be included.

5) Event and Alarm Handling:

a) The database for all unit related process signals shall preferably be located in the process control computer. The pre processing of events and alarms like time lagging, definition of how the signal shall be presented, and the decision if a process signal shall be handled as an event or alarm in the control system shall take place in the process control computer. Presentation shall be done in the operator control stations.

b) Feature to monitor analogue signals on passing limit values and the corresponding processing of these limit values shall be provided.

6) Generation of Reports:

Functions to assemble reports from measured and calculated values stored in the process database shall be provided.

Local Manual/Automatic Control:

a) As specified earlier, a manual control facility shall be provided from where the unit can be started and stopped without use of the process control computer. A switching between manual a automatic start/stop sequence shall be possible after completion of each step in the corresponding sequence.

b) The Contractor shall provide all interface modules, annual/auto switch and other elements required for both the manual and automatic mode of operation from the unit control board.

c) For automatic operation from the unit control board, a corresponding operator module shall be installed. This module shall contain push buttons for start/stop and indicators showing the status of the unit and the sequence that is in process. Further, this module shall contain a display that indicates in clear text when the start/stop unfulfilled. Missing pre start condition s are to be indicated as well.

8.5 Specific Requirements

8.5.1 Electromagnetic Compatibility

The equipments specified in this section shall be installed in locations as shown in the drawings enclosed to the tender documents. Based on the shown equipment locations and their relation

to other equipment like 33 kV Switchyard, that knowingly generate electrical interference environment, the manufacturer shall design his equipment such as power supply units, I/O – units, internal electronics and communication part to suit the interference environment in the power plant.

8.5.2 Maintenance and Reliability

The hardware and software of the system shall be configured for maximum availability. To ensure this, the following techniques shall be implemented.

8.5.2.1 High Reliability Design

The designer shall use state of the art components from reliable manufacturers. All sub assemblies shall be tested extensively during design to verify functionality and durability. All software designs shall be thoroughly tested and debugged. Special attention shall be given to fault tolerant design. System software modules and basic application software module shall be used with proven good result on other projects.

8.5.2.2 Maintainability

The system shall be provided with extensive diagnostic features so that a failure can be diagnosed down to the module level giving details of faulty module/card on VDU and printer automatically. The system shall be as modular as practical so that if a particular function is lost, it is isolated, having little or no effect on other modules in the system.

Ease of maintenance and quick diagnosis shall be the primary consideration in the equipment selection.

8.5.2.3 Quality Assurance

A rigorous quality assurance system shall be used in the manufacture of the system. This system shall include testing at the sub assembly and system level. Automated assembly and test equipment shall be used wherever possible to ensure consistent quality. The tenderer shall submit a complete description of his quality assurance programme. The relevant ISO certification for the control systems shall be furnished.

8.5.3 Ambient Conditions

The equipment supplied shall operate and be fully functional in the ambient conditions.

Programming

A function block language with graphic representation shall be used. The resulting programme shall be documented automatically in graphic form.

8.5.4 Cabling

All fibre optics cable and other cables, protective conduits, interface elements and other materials required to realize the communication links (station bus, field bus) shall form part of the scope of supply including erection as well.

No signal amplifiers shall be required for the cable.

8.5.5 Cubicles, Wiring and Cabling

The cubicles shall be of sheet steel construction (thickness not less than 2.0 mm) with neat appearance and painted as per employer's instructions to be given at a later date. The cubicles shall be of protection class 1P40 according to DIN 40050.

The cubicles shall be free standing, equipped with interior lighting, grounding bar, transparent doors, flexible wiring, equipment and cubicle labeling, terminals and cable access from bottom. Doors shall be provided with rubber seals. Mimic diagram shall be provided as per final approved layout drawings. Measuring instruments used shall be of 96 mm x 96 mm size with 240-degree scales and of accuracy class 1.5. Al switches, pushbuttons, indicating lights, etc. shall be of best quality and shall fit nicely into the cubicle front picture.

The manufacturer shall recommend the kind of earthing arrangement required for the cubicles accommodating electronic modules.

The internal wiring to the specified equipment shall be as per relevant IEC/VDE standards. The wiring within the cubicle shall be laid in flame retardant cable ducts according to IEC 331, Part 2.

The tenderer shall define the technical requirements for all the external cabling (shielding, earthing, size, type, etc.) from the interface cubicles, etc. All these cables shall be covered under the scope of these specifications.

Each process computer shall have a suitable system for air circulation and temperature supervision the cubicle. In case of air-circulation system failure/temperature rise, an alarm shall be given.

Each process computer system/cubicle shall be equipped with a fully redundant power supply system including voltage supervision system.

Each cubicle shall receive two independent power supply feeders by means of DC/DC converters and other devices required to transform the incoming voltages to system voltage used in the cubicle shall be delivered and installed in each cubicle. Arrangement shall be made for an un-interrupted functioning of the control system in case either of the redundant supplies gets interrupted.

8.6 Performance

8.6.1 Communication Speed

The system provided shall preferably use a "report by exception" protocol operating at a sufficient data rate to accomplish following performance goals:

a) With 40% of the system inputs changing every "10 seconds, the operator control stations shall be able to be updated from all local control stations in less than a 3 seconds, and update all changes on the VDU display and issue any alarms in less than 4 seconds after changes occur at the local control station.

b) With the reporting level in sub clause 15.7.1 a) above there shall be not more than 3 seconds between the time that the operator actuates a control and the status input associated with the control responds on the VDU, exclusive of the delay time required for the controlled device to respond.

8.6.2 Display Response

With the reporting level above, the time required for a new character based display to be fully presented on the screen after it is called by the operator shall not exceed one (1) second. The maximum time for a pixel resolution trend display to be fully presented on the screen shall not exceed 3 seconds.
Information shall be updated on the screen within 2 seconds after being received by such local control station.

8.6.3 Alarm Performance

With the communication loading above, the system shall be able to accommodate a burst of 50 alarms per second for 5 seconds. The alarms shall be posted to the appropriate alarm summary within 500 milliseconds of being received by the operator control station. All the alarms shall be logged within 2 minutes after the beginning of 5 second burst.

8.6.4 Resolution and Time Synchronization

The resolution in the tagging of events shall be one mill-sec. function shall be provided to generate accurate time Synchronization between all computers in the system.

8.6.5 Data Acquisition System

The data acquisition for systematic data logging and analysis shall be provided. In addition to the vent and alarm record, trend analysis plant optimization, energy reporting etc. shall be possible. The signal lists for the data acquisition system shall be finalized during detail engineering stage. However the same shall be considered as 100 digital signals and 25 analog signals.

8.6.6 Tests

All shop tests shall be carried as per the relevant VDE, IEC recommendations. These tests shall comprise as a minimum:

a) Individual apparatus routine test
b) Dielectric test
c) Visual checks of finish, markings, inscriptions, etc.
d) Full-scale functional test. For this test all equipments specified under this section shall be hooked up together in the same way and with the same elements as will be used later by Site installation. Included in this test shall be all other equipment for one unit, which shall communicate with the control system through bus connections (turbine regulator, excitation system, electrical protections, etc.).

System and application software functions shall be fully verified. All input signals shall be simulated and output signals verified from cubicle input to cubicle output.
The manufacturer shall prepare for owner's approval a detailed test processing and inspection plan/programme for all shop tests. For this purpose, the Employer shall depute two (2) engineers for a period of two weeks.

8.6.7 Site Tests

After installation at Site and after finishing all cabling works, the Contractor shall verify all process signals and process interface. All control commands shall be executed and real process contact and variable shall be checked.

Once all above checks (dry tests) have been realized all system tests shall be repeated with units, 33 kV switchyard, spillway etc. in operation.

8.7 Spare Parts/Service and Programming Units

8.7.1 Mandatory/Recommended Spare parts, Consumables

It is intended to obtain all spare parts required for maintenance during a period of 10 (ten) years. The tenderer shall therefore quote for all the mandatory spare parts. The Employer shall review this list and recommend any additional spare parts separately.

Tenderer shall also submit a list of consumables, required for operation of the control system for a period of ten years.

9.0 POWER CONTROL AND INSTRUMENTATION CABLES

9.1.1 Scope

This section covers the design, manufacture, stop testing at manufacturer's works before dispatch, supply and delivery, laying, testing & termination of power cables for 3.3 kV AC, 415 V AC, 110 V DC with associated cable terminations, joint boxes and accessories.

9.1.2 Types of Cables

All types of cable covered under these technical specifications shall be Fire Retardant Low Smoke type (FRLS)

The cables for 3.3 kV systems shall be unarmored single core aluminium Conductor XLPE conforming to IS 7098.

The cable for 415V AC and 110V DC system shall be single core/multi core, 1100V grade, PVC insulated, PVC sheathed, Aluminium conductor, unarmored type conforming to IS 1554 (Part I).

9.1.3 XLPE Cables

XLPE cable for 3.3kV system shall be 185/500/630 mm^2 (as per requirement) single core unarmored, heavy duty, stranded, Aluminium conductor and shall be provided with semi-conducting conductor shield, XLPE insulation, semi-conducting insulation shield, copper tapped metallic shield and PVC outer sheath conforming IS 7098 (Part II)

The semi-conducting conductor shield shall ensure perfectly smooth profile land avoid stress concentration. The conductor shield shall be extruded in the same operation as the insulation.

The insulation shall be extruded type and manufacturing process shall ensure that insulation is free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method shall give very smooth interface between semi-conducting conductor shield and insulation.

A non-magnetic semi-conducting insulation shield shall be applied over insulation to confine electrical field to the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion process.

A copper tap/wire metallic shield shall be put over non-metallic insulation shield.

An extruded PVC outer sheath shall be applied over metallic shield with suitable additives to prevent attack by rodents and termites.

The cables shall be subject to type, routine and acceptance tests as per applicable standard.

9.1.4 PVC Cables

All single core and multi core PVC cables for low voltage AC and DC system shall conform to IS 1554 (Part I). These cables shall be 1100 V grade, heavy duty, aluminium conductor, heat resistant PVC insulated, colour coded laid up, unarmored, inner and outer extruded PVC sheath. The outer sheath shall be of specially formulated PVC compound having oxygen index, smoke density, acid gas and flame propagation properties as applicable for standards for FRLS cables. Tall the materials used for conductor and insulation shall be new and of requisite quality. Necessary tests during the manufacture shall be conducted in conformity with standards.

9.1.5 Colour Scheme

To facilitate easy identification of phases, colour scheme of red, yellow, blue for phases and black for neutral shall be adopted for power cables.

9.1.6 Jointing Boxes/Jointing Kits

Straight through joints in the run of cables, wherever unavoidable will be made through joint boxes. The tenderer shall, therefore, quote unit rates for suitable jointing boxes for the type and size of cables indicated in the schedule. The design of the jointing boxes must ensure that the actual insulation strength between phases and to earth is greater than that of the associated cable and eliminate any possibility of moisture entering the joint or the compound surrounding the joint.

Provision shall exist for binding the sheaths of the two cables being joined solidly by approved means to ensure the electrical continuity of the sheath from one end of the cable run to other. Full details of the Jointing Boxes and of the Joints including dimensions shall be given.

The Jointing Boxes shall comply in all aspects with the provision of the latest issue of relevant standards.

9.1.7 Cable Termination Kits and Sealing Ends

The tenderer shall quote unit rates for cable terminations of heat shrinkable type for XLPE cables. The termination kits shall be of reputed make only.

Full details, dimensions and drawings of the cable terminations shall be given in the tender.

9.1.8 Jointing and Sealing Material, etc.

The tenderer shall quote unit rates for all hardware, filling compounds, plumbing metal, tapes and other materials required for the making of these joints and terminal connections of the various size of cable given in the schedule of requirements.

Wherever unit rates are quoted, any reduction in price for bulk orders shall also be stated.

9.1.9 Cable Lugs

For termination of PVC cables inside the panels, cable lugs for the type and sizes of cables as given in the schedule of requirements shall be offered as an optional item. The cable lugs shall be made of copper tube electro tinned. Longneck crimping lugs shall be supplied for cables of size 400 mm^2 and above. The contractor shall ensure that no bimetallic action takes place between the Aluminium conductor of the cable and the cable connecting lugs by filling the lugs with suitable compound.

9.1.10 Cable Glands

The cable glands made of brass duly electro tinned in order to avoid corrosion and oxidation of the surface, shall be offered as an optional item. The nipple threads shall be in accordance with IS 1653. Glands shall provide neat, tight, dust and vermin proof termination. Glands shall be provided with rubber ring to hold the cables firmly when check nut is slightly tightened. Glands shall be complete with suitable washers. Glands shall be of reputed make.

9.1.11 Crimping Tool

A crimping tool suitable for manual operation for making joints with lugs for Aluminium conductor unto size of 50 mm2 shall be offered.

A portable hydraulic crimping tool for making compression shale terminal on the cable conductor up to size 630 mm2 also be offered.

9.2 Control and Instrumentation Cables

9.2.1 Scope

This specification covers the design, manufacture, and shop testing at manufacturer's works before dispatch, supply and delivery of control and instrumentation cable.

9.2.2 Types of Cables

All control and instrumentation cables shall be Fire Retardant Low Smoke type (FRLS)

All the control cables shall be copper conductor, HR-PVC insulated, PVC sheathed, unarmored, 1100 V grade. All the material used for conductor and insulation shall be new and of requisite quality. The conductor shall be of high conductivity annealed single conductor copper.

The instrumentations cables in addition to meeting the requirements of control cables shall be provided with electrostatic shielding by aluminium tape and screening by annealed tinned copper wire.

Each cable shall consist of twisted pairs having individual screens, multipairs having an overall screen only or multiple fibres, together with drain wires, fillers, shielding, wire, armor and outer sheath as specified. The metric system shall be adopted throughout.

Maximum loss for fibre optic cables shall not exceed 3 dB/km at 850 nm, 1dB/km at 800 nm.

Bandwidth of fibre optic cables shall be of 160 Mhz·km at 850 nm and 500 Mhz·km at 800 nm

Fibre cables with 8, 12, or 18 multimode fibres (62.5/125 µm) shall be used.

9.2.3 Colour Scheme

To facilitate easy identification of cores, multicore control and instrumentation cables shall be colour coded by using PVC insulation of red, black, yellow, blue and grey colours in accordance with IS 1554 (Part I).

9.2.4 Cable Lugs

Compression type terminals would be offered for control cables as an optional item. These terminals shall be suitable for crimping to the conductor while other end will provide flat surface for better connection. The cable lugs shall be made of copper type electro tinned.

9.2.5 Cable Glands

The cable glands made of brass duly electro tinned shall be offered as an optional item. Glands shall provide neat, tight dust and vermin proof termination. Glands shall be provided with rubber ring to hold the cables firmly when checkout is slightly tightened. Glands shall be complete with suitable washers. Glands shall be of reputed make.

9.2.6 Inspection and Tests

The tenderer shall state in his tender the places of manufacture, testing and inspection of the cables. Authorized representatives of the Purchaser shall have at all reasonable times access to the manufacturer's premises of works to inspect and examine the materials and workmanship during manufacture.

The tenderer shall submit with the tender, a copy of test certificates for the type tests as stipulated in IS 1554 (Part I) and relevant IEC, carried out either in the manufacturer's works or any approved Laboratory.

Before dispatch, sample pieces of the cable shall be subjected to all routine, acceptance and FRLS tests at the manufacturer's works as stipulated in IS 1554 (Part I)/IEC in the present of Purchaser or his representative. The tenderers must clearly indicate the details of testing equipment and other testing facilities available in their works. Offers from tenderers with inadequate testing facilities shall not be considered.

The following FRLS tests are to be conducted:

a) HCL gas evolution test (IEC 754.1)
b) Oxygen Index (ASTM-D-2863)
c) Temperature Index (ASTM-D-2863)
d) Smoke density test (ASTM-D-2863)
e) Flammability tests (IEC 332.1)

Copies of manufacturer's test certificates in quadruplicate shall be submitted to the Purchaser as soon as the tests are completed. The Purchaser reserves to himself the right of having, at his expense, any inspection or tests of a reasonable nature carried out at the Contractor's premises or at Site, in addition to the aforesaid tests and the tests included in the Contract, to satisfy himself that materials comply with the requirements of the specifications. The cost of samples required for such tests shall be borne by the Contractor. All test reports shall be got approved from the Purchaser before dispatch of material by the Contractor.

9.2.7 Packing

All the cables shall be supplied on non-returnable wooden drums with adequate barrel diameter so as to avoid any damage to the cable and to withstand rough handling during transportation and storage. Particulars of the drums on which the cable would be packed for transportation with a dimensioned drawing shall be submitted. Not more than one length shall be wound on one drum.

A layer of waterproof paper shall be applied to the surface of drums and over the outer cable layer. Each drum shall carry the name of the manufacturer, the name of the Purchaser, his address, order number, type, size, length of the cable, net and gross weight duly stenciled there on.

See also General Technical Specification.

9.2.8 Guarantees

The Contractor shall guarantee among other things, the following:

a) Quality and strength of materials required

b) Adequate factors of safety for all parts of the equipment to withstand the mechanical and/or electrical stresses developed therein. These shall be stated in the tender.

c) Suitability of design and workmanship of the equipment for the conditions envisaged in these specifications.

d) The temperature rises and other performance data furnished for the equipment as applicable in accordance with relevant standard.

It must be clearly understood that the Contractor shall be responsible for replacing at Site and free of cost any portion/lot of the cables that may prove faulty or fail by reason by any of the causes (a), (b), or (c) stated above, within the guarantee clause stated at Vol.-I of this specification.

10.0 CONTROL & RELAY PANELS

10.1 SCOPE OF CONTRACT:

The scope of the specification covers design, manufacture, testing/inspection at manufacturer's works before dispatch, forwarding, packing, transportation to site, transit insurance and testing and commissioning at site of Control and Relay Panels for 33 KV switch yard equipments complete with all accessories for efficient and trouble free operation. The specific requirements are furnished in the enclosed technical data sheet.

10.2 SPECIFICATION FOR RELAY & CONTROL PANELS

10.2.1 TYPES OF PANELS

10.2.2 The panels shall be suitable for systems having Main I & Transfer Bus as indicated in Annexure for Particulars of 'Relays' and 'Control & Relay Panels for supply.

10.2.3 The panels shall be duplex, floor mounting and indoor type. The duplex panel shall be walk -in-tunnel type comprising two vertical front rear panel sections connected back on back by framed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external connections. Both ends of the corridor shall be provided with double leaf hinged doors. Doors shall have handles with built in locking facility. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form continuous passage with the sides of the two end panels provided with doors. Separate cable entries shall be provided for the front and rear panels. However, inter connections between front and back panel shall be by means of inter-panels wiring at the top of the panel.

10.3 CONSTRUCTION FEATURES.

10.3.1 Panels shall be completely enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP31 in accordance with relevant Indian standard.

10.3.2 Panels shall be free standing, floor mounting type and shall comprise structural frames enclosed completely with specially selected smooth finished, cold rolled sheet of thickness not less than 3mm for weight bearing members such as base frame, front sheet and door frames, and 2.0mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation.

10.3.4 All doors, removable covers and panels shall be sealed all around with neoprene gaskets or other best quality seals. Ventilation louvers provided shall have dust screens and filters. The screen shall be made of either brass or GI wire mesh.

10.3.5 Metal seals in the form of metal channels properly drilled, shall be furnished by the supplier along with anchor bolts and necessary hardware for mounting the panels. Panels shall have additional rolled channel plinth at the bottom with smooth bearing surface.

10.3.6 Cable entries to the panels shall be from the bottom. The plates of panels shall be fitted with removal glands. The bidder shall supply necessary number of cable glands.

10.4 MOUNTING OF EQUIPMENTS

10.4.1 All equipment on and in the panels shall be mounted and completely wired to the terminal blocks ready for external connection. All equipment on the front and rear panels shall be mounted flush. Terminal markings shall be clearly visible.

10.4.2 The centerlines of switches, push buttons and indicating lamps shall be no less than 750 mm from the bottom of the panel. The centerlines of the other equipment such as meters, relays etc shall not be less than 450 mm from the bottom of the panel.

10.5 INTERNAL WIRING

10.5.1 Panels shall be supplied completely with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and wiring shall be carried out internally. These adjacent inter panel wiring shall be clearly indicated in the drawing furnished by the supplier. In case of transport limitations, when the panels required to be sent separately, provision shall be kept for inter panel wiring amongst the adjacent panels and to be done by the supplier at the site after installation

10.5.2 Wiring shall be carried out with 660-Volt grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of stranded copper conductor used for internal wiring shall be as follows:

(a) All circuits except current transformer circuits: 1.5 sq. mm. per lead.

(b) Current transformer circuit: 2.5 sq. mm. per lead.

10.5.3 Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panel running throughout the entire length of the panels.

10.5.4 Wire terminals shall be made with solder less clamping type of tinned copper lugs, which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected from blocks.

10.5.5 Interconnections to adjacent panels shall be brought out to a separate set of terminals blocks located near the slots or holes meant for taking the interconnecting wires. Arrangement shall permit easy interconnection to adjacent panels at site and wires for this purpose shall be provided by the supplier looped and bunched properly inside the panel.

10.5.6 A laminated copy of total schematics is to be fixed on the inside of door.

10.6 TERMINAL BLOCKS

10.6.1 All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. Terminal blocks shall be of 660 volts grade and have 10 amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Terminal block designs include a white fibre-marking strip with clear plastic/silicon chip on terminal covers. Marking on the terminal strips shall correspond to block and terminal number on the wiring diagram.

10.6.2 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. Current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.

10.6.3 At least 20% spare terminals shall be provided on each panel and these terminals shall be uniformly distributed on all terminal blocks.

10.6.4 There shall be a minimum clearance of 250 mm between first row of terminal blocks and associated cable gland plates. Also, the clearance between two rows of terminal blocks shall be a minimum of 150 mm. A steel strip shall be connected between adjacent terminal block rows at 450-mm intervals for support of incoming cables.

10.6.5 Terminal blocks should be suitable for connecting ring type lugs.

10.6.6 Terminal marking with the "ferrule" to be accomplished in each of the core of the cables near the terminal blocks in accordance with the interconnection diagram.

10.7 PAINTING

10.7.1 All Sheet steelwork shall be phosphated in accordance with IS 6005.

10.7.2 Oil grease, dirt and warp shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

10.7.3 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of 2 (two) coats of ready mixed, stoving type zinc chromate primer. The first coat may be 'flash dried' while the second shall be stoved.

10.7.4 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The owner shall select the exterior colour of the paint at a later date.

10.7.5 Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting.

10.7.6 A small quantity of finishing shall be supplied minor touching up required at site after installation.

10.8 MIMIC DIAGRAM

10.8.1 Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of the control panels.

10.8.2 Mimic diagram shall be made preferably of anodized Aluminium or plastic of approved fast colour materials, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2 mm thick. The width of the mimic bus shall be 10 mm for bus bars and 7 mm for other connections.

10.9 NAME PLATES AND MARKINGS

10.9.1 All equipment mounted on front and rear side as well as equipment mounted inside the panel shall be provided with individual nameplates with equipment designation engraved. Also, on the top of the each panel on front as well as rear side large and bold name plates shall be provided for circuit /feeder designation.

10.9.2 All front mounted equipment shall be also provided at the rear with individual name plates engraved with Tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

10.9.3 Nameplates shall be made of non rusting metal or 3 ply lamicord. Nameplates shall be black with white engraved lettering.

10.10 MISCELLANEOUS ACCESSORIES

10.10.1 A 240 Volts, single-phase plug points shall be provided in the interior of each cubicle with ON-OFF switch for connection of headlamp.

10.10.2 Each panel shall be provided with fluorescent lighting fixtures for the interior illumination of the panel complete with all fittings, i.e. lamp, switch (controlled by panel door)

10.10.3 Each Relay and Control panel shall have provision to receive A.C.. and D.C power supplies required for control, indication, illumination and space heaters etc. There should be adequate arrangement for their isolation and distribution of the circuits and each of the circuits shall be protected by HRC cartridge type fuses mounted on plug in type fuse bases. Fuses shall be adequately rated and equipped with the operational indicators to indicate their " blown off" condition. Fuse carrier base shall have imprints of the fuse rating and voltage. The main input A.C. and D.C. circuits will be protected with miniature circuit breakers.

10.11 EARTHING

10.11.1 All panels shall be equipped with an earth bus securely fixed along with inside base of the panels. The materials and the sizes of the bus bar shall be at least 25X4 mm copper. When several panels are mounted joining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply. Provisions shall be made for extending the earth bus bar to future adjoining panels on either side.

10.11.2 All metallic cases of equipment shall be connected to the earth bus by independent copper wires of size not less than 2.5 sq. mm. Earthing wire shall be connected on terminals with suitable clamp connectors and soldering shall not be permitted.

10.11.3 PT and CT secondary neutrals or common lead shall be earthed at one place only at the terminal blocks, where they enter the panels.

10.12 INSTRUMENTS, METERS AND RECORDERS

10.12.1 GENERAL

10.12.1.1 All instruments, meters and recorders shall be housed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be accurately adjusted and calibrated at works and shall have means of calibration, check and adjustment at site.

10.12.1.2 All these instruments and meters shall be flush mounted type and back connected, suitable for panel mounting.

10.12.2 INDICATING METERS

10.12.2.1 Unless otherwise specified all electrical indicating instruments shall have circular 240 degree Analogue Scale, and with a dial of 96 mm x 96 mm. They shall be suitable for flush mounting. They shall have circular scales and black pointers and black numerals and lettering. Indicating instruments shall have accuracy class of 1.0 or better accuracy as per IS 1248. Current coils of ammeters, watt meter, and VAR meters shall continuously withstand 120% of rated current and 10 times the rated current for 0.5 second. Voltmeter and voltage coil of watt meters and VAR meters shall withstand 200% or rated Voltage for 0.5 seconds without loss of accuracy.

10.12.3 RECORDING METERS (TRIVECTOR METERS)

10.12.3.1 Microprocessor Based static trivector meters shall be of three phase, four-wire suitable for measurement of unbalanced loads in three phase four wire circuits. They shall be flush mounted with back-connected terminals. They shall be provided with a separate three phase, four wire type test blocks for testing of meters without disturbing the CT and PT secondary connections at the bottom of the panels where the meters are mounted. Meter shall conform to relevant IS and of accuracy class of 0.5 and with digital display. The demand period for maximum demand indicators shall be 30 minutes.

10.12.4 STANDARDS APPLICABLE

Unless otherwise specified elsewhere in this specification, the performance & testing of the meters shall conform to the following Indian/International standards with updated and latest amendments/revisions thereof.

S. No	Standard No.	Title
1	IS 13779	AC Static Watt-hour Meters for active energy Class 1 & 2
2	IS 13010	AC Watt Hour Meters, class 0.5,1 & 2
3	IEC 1036-1996	AC Static Watt-hour Meters for active energy Class 1 & 2
4	IS 12063	Specification for degree of protection
5	*CBIP Report No.-88	Specification for AC Static Electrical Energy Meters

***CBIP: Central Board of Irrigation and Power, New Delhi**

10.12.5 SUPPLY SYSTEM

System	:	3-phase 4-wire
System Voltage (V ref)	:	110 volt ph-ph fed through PT
System frequency	:	50 Hz
No. of Phases	:	3
System of Earthing	:	Solidly grounded

10.12.6 POWER FACTOR RANGE

The meter shall be suitable for full power factor range from Zero (lag) to Unity to Zero (lead).

10.12.7 POWER SUPPLY VARIATION

The extreme power supply variation (which an operating meter should withstand without damage and without degradation of its meteorological characteristics when it is subsequently operated under its operating conditions) is as follows.

Voltage : 70% to 120 % of V ref

Frequency : 45 Hz to 55 Hz

The manufacturer can also offer meters which can withstand higher variations.

10.12.8 ACCURACY

The class of accuracy of the meter shall be 1.0.

10.12.9 POWER CONSUMPTION

The active and apparent power consumption on each voltage circuit including power supply of the meter at ref. Voltage, temperature and frequency shall not exceed 1.5 watts/phase and 8VA / phase.(table 9 of IS 13779:1999)

10.12.9.1 The apparent power drawn by each current circuit of the meter shall not exceed 1 VA/phase at basic current, reference frequency and reference temperature. (Table 10 of IS 13779:1999)

10.12.10 SEALING OF METER

Reliable sealing arrangement should be provided to make the meter tamper proof and avoid fiddling or tampering by unauthorized persons.

10.12.11 NAME-PLATE MARKING OF THE METER

The marking on every meter shall be in accordance with relevant clauses of IS 13779/1999.

10.12.12 FACILITIES TO BE PROVIDED WITH THE TRI-VECTOR METER

10.12.13 REMOTE READOUT FACILITY

A) The meter shall be provided with a galvanically isolated optical communication port as per IEC 1107, PACT, ANSI with removable cover and with hardware locking arrangement so that it can be easily connected to a CMRI (Common Meter Reading Instrument) for data transfer or transfer of data through remote metering device such as modem / multiplexer, etc. The optical communication port shall also have sealing provision.

B) The meter also shall have a separate individually sealable RS-485 communication port so that meter data stored in NVM can be communicated on line as well through other communication means.

10.12.14 CALIBRATION AND TEST OUTPUT

1. The meter should have test output accessible from the front and be capable of being monitored with suitable testing equipment. The operation indicator must be visible from the front. Test output device shall be provided in the form of one common LED for KWh, KVARh and KVAh with provision of selecting the parameter being tested. The test output device should have constant pulse rate in terms of pulse/unit energy.

2. The meter shall be tested, calibrated and sealed at works before dispatch.

10.12.15 DISPLAY

1. The meter shall have a minimum 7 digit, 7segment display of back lit liquid crystal display (LCD) or light emission diode display (LED) with another digit for legend. The minimum character height shall be 10 mm. Provision shall be made to read consumption in either whole units or decimal multiples or sub-multiples of one possible to display content of relevant parameters with another digit displaying legend for identification.

2. The meter should have facility of auto display mode where all parameters automatically scroll within the specified time and a manual mode where the parameters can be read by push button operation. In auto display mode each parameter shall on display for 10 seconds. The display "off" period between two cycles shall not exceed 30 seconds. The register should not roll over in between this duration.

3. The meter should have non-volatile memory, so that the registered parameters will not be affected by loss of power. A provision shall be made to read the meter parameters such as MD and consumption, etc., through the meter cover without actually opening the meter box cover.

10.12.16 DISPLAY SEQUENCE

The meter shall display the required parameters in two different modes as follows:

A. Auto Display Mode

- Display test (LCD/LED Segment check)
- Real time & date
- Active energy (KWh) Import/Export
- Reactive energy (kVARh) Import/Export
- Apparent energy (kVAh) Import/Export
- Maximum Demand (kVA) Import/Export
- MD occurrence date and time
- Rising demand with elapsed time
- MD reset count
- Instantaneous average 3 ϕ PF
- Instantaneous frequency
- Phase voltages R,Y,B
- Phase currents R,Y,B

B. Push Button Mode

All above & the following

- Present CT status
- Date and time of last tamper occurrence
- TOD Register [Active energy]
- TOD Register [Apparent energy]
- TOD Register [Apparent MD]

•Cumulative power on hours

C. Read out Parameters with CMRI

All above including following

•Energy registers

•TOD Registers

•Real time calendar clock fail

•History of monthly Energy Flow, Maximum Demand, Average power factor for the last 12 months

10.12.17 MAXIMUM DEMAND REGISTER

1. The maximum demand is to be monitored during each demand interval set with 30 minutes integration and the maximum of these in a month shall be stored. Whenever MD is reset the maximum demand value so registered shall be stored along with date and time. Under the current integration period, the rising demand should be displayed continuously along with the elapsed time. The registered demand and the number of times the MD is reset shall also be displayed and the information stored.

10.12.18 MAXIMUM DEMAND RESET

1. Facility for auto reset of MD at 00.00 hrs of first of every month shall be provided for which minimum 30 years calendar shall be programmed by the manufacturer.

The meter shall display the maximum demand reset count.

10.13 OTHER SALIENT FEATURES

a) **It should be possible to check the healthiness of phase voltages by displaying all the voltages on the meter display.**

b) **The meter should work accurately irrespective of phase sequence of the mains supply**

c)**The meter should remain powered up and functional even when either of the two phases or one phase along with neutral is available to meter.**

d) **The meter should continue to record accurately as per prevailing electrical conditions even if the neutral of the potential supply gets disconnected.**

10.14 RELAYS

10.14.1 GENERAL

10.14.1.1 All relays shall conform to the requirements of IS 3231 or Relays shall be suitable for flush or semi-flush mounting with connectors from rear. Relays shall have dust proof, dull black painted case with transparent covers removable from front.

10.14.1.2 All draw out cases or plug in type modular cases will have proper testing facilities. The testing facilities provided on the relays shall be specifically stated in the bid. Necessary test plug shall be in the supplier's scope of supply and shall be supplied loose. Unless

otherwise specified all auxiliary relays and timers shall be supplied either in non-draw out cases or plug in type modular cases.

10.14.1.3 All A.C. relays shall be suitable for operation at 50 Hz. A.C. Voltage operated relays shall be suitable for 110 volts VT secondary and current operated relays for 1Amp CT secondary. DC auxiliary relays and timers shall be designed for 110 volts/ 220 volts DC and shall operate satisfactorily between 70% and 110% of rated voltage.

10.14.1.4 All Protective relays, auxiliary relays and timers except the lockout relays and interlocking relays shall be provided with self reset type contacts. All protective relays, trap relays and timers shall be provided with externally reset positive action operation indicators provided with proper inscription. All protective relays which do not have built-in hand reset operation indicators shall have additional auxiliary relays with operating indicators for this purpose. Similar separate operating indicators (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholz relays, temperature protection etc.

10.14.1.5 No control relays that shall trip the circuit breaker when the relays are de-energized shall be employed in the circuits.

10.14.1.6 All relays shall withstand a test voltage of 2.5 kV, 50 Hz r.m.s. voltage for one second. In case of static relays the Clause 5.1.8 shall be applicable.

10.14.1.7 Auxiliary seal-in unit provided in the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured and necessity for using series relay shall be furnished.

(i) The operating time of the series seal-in unit shall be sufficiently shorter than that of the trip coil relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

(ii) Seal - in unit shall obtain adequate current for operation when one or more relay operate simultaneously.

(iii) Impedance of the seal-in unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when D.C. supply is minimum.

10.14.1.8 Whenever solid state relays are used the following requirements shall be met with:

a) The printed circuit cards shall be of fibreglass type and the contact shall be gold plated. All connectors with the connector pegs shall be through wire wrapping. All solder Joints on the printed circuit boards shall be encapsulated or covered with varnish.
b) The components shall be loaded by less than half of their rated values. The resistor shall be of carbon composition or metal oxide type and the capacitors shall be plastic film or tantalum type. Stringent measures including shielding of long internal wiring should be taken to make relays immune to voltage spikes.
c) The supplier shall ensure that the terminals of the contacts of the relays are readily brought out for connectors as required in the final approved scheme.
d) DC /DC converter shall be provided in the solid state protective relays wherever necessary in order to provide a stable auxiliary supply for relay operation. Provision of DC cell in the protective relays as relievable stand-by power supplies will however not be acceptable.

10.14.1.9 All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired terminals exclusively for owner's use.

10.15 PROTECTION SCHEME FOR TRANSFORMER, AUXILIARY TRANSFOMER AND LINE

10.15.1 The following protections scheme shall be provided in Control and Relay Panels for Generator Transformer, Station Transformers and 33 KV Transmission lines:

(A) Transformer

Differential Protection for Transformer.

(i) Back up Combined Non Directional Over current & Earth Fault Protection

(ii) Earth Fault Protection for Generator Transformer.

(iii) Restricted Earth fault protection.

(iv) Transformer auxiliary protection like Buchholz, oil temperature, winding temperature etc.

(B) Station Transformer

(i) Combined Non Directional Over current and Earth fault Protection

(C) Bus –Coupler

(i) Combined Non Directional Over current and Earth fault Protection

(D) 33 KV Transmission Line Protection

(i) Combined Non Directional Over current and Earth fault Protection with High Set Element

10.16 ANNUNCIATION SYSTEM

1. The annunciation system shall be of visual and audible type. The Visual annunciation shall be provided by annunciation facia mounted flush on the top row of the front panel. Alarm buzzer or hooter shall provide the audible alarm.
2. The annunciation facia shall be provided with translucent Plastic window for alarm point with minimum size of 35mm X 50 mm. The facia plates shall be engraved in black lettering with respective inscription which will be engraved on each window in not more than three times and the size of the lettering shall not be less than 5mm.
3. Each annunciation window shall be provided with two white LED lamps in parallel to provide safety against lamp failures. The cover plates of the facia windows shall be flush with the panel and shall be capable of easy removal to facilitate easy replacement of lamps.
4. TRIP and NONTRIP facia shall be differentiated. All TRIP facia shall have red colour and all NONTRIP facia shall have white colour.

   Sequence of operation of the annunciator shall be as follows:

SL. No.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1	Normal	open	off	Off
2	Abnormal	close	flushing	on
3	Acknowledge push button pressed	a) close b) open	Steady on Steady on	Off Off

4	Reset push button pressed	a) close b) open	On Off	Off Off
5	Lamp test push button pressed	Open	Steady on	Off

5. Visual and audible annunciation for the failure of DC supply to the annunciator shall also be provided and this annunciation shall operate on 240 volts AC. On failure of power supply to the annunciation system for more than two or three seconds (adjustable setting) a facia shall light up and a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but facia window shall remain steady lighted till the supply to the annunciation is restored. The sound of the audible alarm (bell) provided for this purpose shall be different from the audible alarm provided for annunciation system.
6. A separate voltage check relays shall be provided to monitor the failure of AC supply to the scheme mentioned in Para 5 above. If the failure of supply exists more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation.
7. The annunciation system shall meet the following additional requirements:

a) The annunciation system shall be capable of catering the entire signals simultaneously indicating fault /abnormal conditions of the system plus four spare windows.

b) One self-resetting push button shall be provided on each panel for testing the facia window lamps. Push buttons for testing flasher and audible alarm circuit of annunciation system and for testing the annunciation supply failure monitoring circuits shall also be provided. These testing circuits shall be so connected that even when testing is done it shall not prevent the registering of any new annunciation that may land during the test.

c) One set each of the following push buttons shall be provided on each panel.
   i) Reset push button for annunciation system.
   ii) Accept push button for annunciation system.

d) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milliseconds.

e) Auxiliary relays for annunciation shall have adequate auxiliary potential free contacts for owner's use.

f) The annunciator shall be suitable for operation with normally open fault contacts, which close on fault. For fault contacts which open at fault, it shall be possible at site to change annunciation from 'close to fault' to 'open to fault' and vice versa.

10.17 SWITCHES

1. Control and instrument switches shall be rotary operated " Stay Put" type with plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out. Handles of

different shapes and suitable inscriptions on switches shall be provided as on switch identification.

2. The selection of operating handles for the different types of switches shall be as follows: -
   (a) Breaker and isolator - Pistol grip, black control switches.
   (b) Synchronizing switches-Oval; black, keyed handle.
   (c) Selector switches - Oval or knob; black
   (d) Instrument switches - Round, Knurled, black.
   (e) Protection transfer - Pistol grip; lockable and black switch.

3. The control switch of breaker and isolator shall be of spring return to neutral type.
4. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selector switches shall have make before type contacts so as to prevent open circuit of CT secondary when changing the position of the switch.
5. Synchronizing switches shall be of maintained contact type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be arranged to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.
6. The contacts of all switches shall preferably open and close with snap action. Contacts of switches shall be with coated with pure silver. Spring shall not be used as current carrying parts.

10.18 INDICATING LAMPS

1. Indicating lamps shall be panel-mounting type with rear terminal connections. Lamps shall be of LED type. Lamps shall have translucent lamp covers to diffuse lights; coloured green, red, amber, clear white or blue as specified. The lamp covers shall be of type and of unbreakable materials.

2. Indicating lamps and resistors shall withstand 120% of rated voltage on a continuous basis.

10.19 POSITION INDICATORS

1. Position indicators of 'semaphore' type shall be provided when specified as part of the migrants on panels for indicating the position of circuit breakers, isolators, earthing switches etc.
2. The position indicators shall be such that when the supervised object is in the closed position, the position of the indicators shall take up a position in line with the mimic bus bars and at right angles to them when the object is in the open position. When the supply failure occurs to the indicator, the pointer shall take up an intermediate position to indicate the supply failure. The rating of the indicators shall withstand 120% of rated voltage on a continuous basis.

10.20 TESTS.

1. The supplier shall carryout all tests as per relevant standards as all associated equipment including relays, meters, instruments etc. The supplier shall submit all that reports to owner for approval before dispatching the control and relay panels. The Bidder shall also submit along with the bid type test reports for relays instruments, meters and other devices of the type and class being offered.
2. Control and relay panels shall be subjected to the following tests:
   a) Mechanical operation test.
   b) Verification of degree of protection.
   c) High voltage test (2000 volts for 1 minute)
   d) Electrical control interlock and sequential operation test.
   e) Verification of wiring as per approved schematic.

10.21 TECHNICAL DATA SHEET FOR THE CONTROL PANELS

Features to be provided in various Relay and Control panels are indicated below. Description below are only indicative; the Contractor shall ensure that all items are included in their offer to complete the schemes described in the Specification whether such items are specifically mentioned or not.

A. LINE PANELS

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Panel with Main & Transfer Bus Scheme
	LINE PANEL	1 Set.
1	**Protection and relays:**	
	(a) Combined Non-Directional over current and earth fault scheme	1 Set per Panel
	(b) Trip Transfer scheme to Bus Coupler Breaker	1 No. per Panel
	(c) Trip Circuit Supervision Relay for pre and post closing	Supervision for trip coils : 2 trip coils per breaker
	(d) DC Supply healthy monitoring scheme	1 No.
	(e) AC Supply healthy monitoring scheme	1 No.
	(f) High Speed Trip relay	1 No.
	(h) PT Selection Scheme	Not Applicable
	(i) Auxiliary relay, timer relay scheme	As required
2	**Instruments and meters**	
	(a) Ammeter	3 Nos.
	(b) Voltmeter	1 No.
	(c) MW meter (Centre zero)	1 No.

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Panel with Main & Transfer Bus Scheme
	(d) MVAR meter (Centre zero)	1 No.
	(e) Trivector Meter	1 No. (For export & import)
3	**Controls**	
	Volt meter selector switch	1 No.
	Ammeter selector switch	Nil
	Breaker Control switch	1 No.
	Trip Transfer Switch	1 No.
	Push Button for Trip Circuit healthy lamps	As per design
	Isolator Control Switch	Nil
	Synchronizing switch	1 No.
4	**Annunciation**	
	18 Window facia Annunciator shall be suitably inscribed, marked red, green depending on trip / non trip status	1 No. complete scheme with buzzer etc.
5	**Indication**	
	Indicating Lamps & Semaphores for breaker On & Off status	1set
	Indicating Lamps & Semaphores for each Isolator On & Off status	for each isolator
	Indicating Lamps for line Isolator earth switch On & Off status	1 set
	Indicating Lamps for trip circuit healthy scheme	As per scheme

B. TRANSFORMER PANELS

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Class Generator Transformer Panel with Main & Transfer Bus Scheme for each of the Generator transformer
	Transformer Panel	2 Sets
1	**Protection and relays:**	2 Sets
	(a) Relay for Overall Differential Protection	1 No.

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Class Generator Transformer Panel with Main & Transfer Bus Scheme for each of the Generator transformer
	Transformer Panel	2 Sets
	(b) Relay for Back up Non Directional combined over current & Earth Fault Protection scheme (Electromechanical) for HV Side of the Generator Transformer	1 Set
	(c) Relay for Earth Fault Protection on the neutral side of the Transformer.	1 Set
	(d) Trip Circuit Supervision Relay Scheme for ascertaining pre and post closing healthiness	Supervision for trip coils : 2 trip coils per breaker
	(e) Trip Transfer scheme to Bus Coupler Breaker	1 No.
	(f) DC Supply healthy monitoring scheme	1 No.
	(g) AC Supply healthy monitoring scheme	1 No.
	(h) High Speed Trip relay (HV Side)	1 No.
	(i) High Speed Trip relay (LV Side)	1 No.
	(j) PT Selection Scheme on HV Side (only for substation employing Main-I & Main-II bus bar scheme)	1 No. Complete Bus PT Selection Scheme
	(k) Auxiliary relay, timer relay scheme	As required
2	**Instruments and meters**	
	Ammeter (for HV side)	1 No.
	Voltmeter (for HV side)	1 No.
	MW meter	1 No.
	MVAR meter	1 No.
	Trivector Meter.	1 No. (For export)
3	**Controls**	
	Volt meter selector switch (for HV side)	1 No.
	Ammeter selector switch (for HV side)	1 No.

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Class Generator Transformer Panel with Main & Transfer Bus Scheme for each of the Generator transformer
	Transformer Panel	2 Sets
	Breaker Control switch	1 No.
	Trip Transfer Switch	1 No.
	Push Button for Trip Circuit healthy lamps	As per design
4	**Annunciation**	
	18 Window facia Annunciator shall be suitably inscribed, marked red, green depending on trip / non trip status	1 No. complete scheme with buzzer etc.
5	**Indication**	
	Indicating Lamps & Semaphores for breaker On & Off status	1 set
	Indicating Lamps & Semaphores for each Isolator On & Off status	For each isolator
	Indicating Lamps for trip circuit healthy scheme	As per scheme

C. BUS COUPLER PANEL

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Panel with Main & Transfer Bus
	Bus Coupler Panel	1 Set
1	**Protection and relays:**	
	(a)Combined Non-Directional Over current & earth fault scheme (Electromechanical)	1 Set
	(b) Trip Circuit Supervision Relay Scheme for ascertaining pre and post closing healthiness	Supervision for trip coils : 2 trip coils per breaker
	(c) DC Supply healthy monitoring scheme	1 No.
	(d) AC Supply healthy monitoring scheme	1 No.
	(e) High Speed Trip relay	1 No.
	(f) Auxiliary relay, timer relay scheme	As required
2	**Instruments and meters**	

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Panel with Main & Transfer Bus
	Bus Coupler Panel	1 Set
	Ammeter	1 No.
3	**Controls**	
	Ammeter selector switch	1 No.
	Breaker Control switch	1 No.
	Push Button for Trip Circuit healthy lamps	As per design
	Isolator Control Switch	Nil
	Voltmeter Selector Switch	1 No
4	**Annunciation**	
	18 Window facia Annunciator shall be suitably inscribed, marked red, green depending on trip / non trip status	1 No. complete scheme with buzzer etc.
5	**Indication**	
	Indicating Lamps & Semaphores for breaker On & Off status	1 set
	Indicating Lamps & Semaphores for each Isolator On & Off status	For each isolator
	Indicating Lamps for trip circuit healthy scheme	As per scheme

D. STATION AND COLONY SUPPLY PANEL

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Panel with Main & Transfer Bus Scheme
	No of Panels	1 No.
1	**Protection and relays:**	
	(a) Non-Directional over current and earth fault scheme	1 Set per Panel
	(b) Trip Transfer scheme to Bus Coupler Breaker	1 No. per Panel
	(c) Trip Circuit Supervision Relay for pre and post closing	Supervision for trip coils : 2 trip coils per breaker
	(d) DC Supply healthy monitoring scheme	1 No.
	(e) AC Supply healthy monitoring scheme	1 No.
	(f) High Speed Trip relay	1 No.

SL NO	ITEM	RATINGS AND PARTICULARS
		33 kV Panel with Main & Transfer Bus Scheme
	(h) PT Selection Scheme	Not Applicable
	(i) Auxiliary relay, timer relay scheme	As required
2	**Instruments and meters**	
	(a) Ammeter (for HV side)	1Nos.
	(b) Voltmeter (for HV side)	1 No.
	(c) MW meter (Centre zero)	1 No.
	(d) MVAR meter (Centre zero)	1 No.
	(e) Trivector Meter	1 No. (For export)
3	**Controls**	
	Volt meter selector switch	1 No.
	Ammeter selector switch	1 No.
	Breaker Control switch	1 No.
	Trip Transfer Switch	1 No.
	Push Button for Trip Circuit healthy lamps	As per design
	Isolator Control Switch	Nil
4	**Annunciation**	
	18 Window facia Annunciator shall be suitably inscribed, marked red, green depending on trip / non trip status	1 No. complete scheme with buzzer etc.
5	**Indication**	
	Indicating Lamps & Semaphores for breaker On & Off status	1 set
	Indicating Lamps & Semaphores for each Isolator On & Off status	for each isolator
	Indicating Lamps for line Isolator earth switch On & Off status	1 set
	Indicating Lamps for trip circuit healthy scheme	As per scheme