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Date: ________________
Issued By: ________________

IRRIGATION DEPTT- GOVERNMAENT OF SINDH PROJECT

CONSTRUCTION OF

NEW 2X2.5MW HFO GTG OPEN CYCLE POWER PROJECT AT NABISAR – THAR DISTT – PROVANCE OF SINDH

EPC/ TURNKEY CONTRACT ON LUMP-SUM FIXED PRICE BASIS

BIDDING DOCUMENT (VOLUME-II)
SPECIFICATION – TECHNICAL PROVISION

EMPLOYER'S REQUIREMENTS FOR CIVIL, MECHANICAL & ELECTRICAL WORKS

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CONSULTANT

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IRRIGATION DEPARTMENT

GOVERNMENT OF SINDH

NABISAR POWER PROJECT

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GENERAL REQUIREMENTS

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CHAPTER 1

GENERAL REQUIREMENTS

1.1. General

Volume-II of the Tender Documents contains Employer general requirements and Minimum standards of design, materials & workmanship of the work with respect to all Mechanical, Electrical and Civil Works of the Power House to be constructed on EPC/Turnkey basis. In case of any conflict between provisions of Chapters 1, 2, 3, 4, 5, and 6, the later shall take precedence.

In case, employer have requested any work item for more than one technical options or EPC contractor have offered alternate options, this will be reviewed / discussed by owner's engineer and will be agreed with EPC contractor on techno-commercial merit bases.

Chapter 1 of this Volume includes some of the general responsibilities for execution of the Work, which are in addition to the requirements provided in the Conditions of Contract, Volume-I.

1.2. Background and Project Objectives

a) Background

Government of Sindh is in installation process of 2 X 660 MW Coal Fired Plants at Thar under Thar Coal Authority and have advised Irrigation dep't to support these mega projects by supplying the required quantity of essential cooling water for these projects. In the absence of enough cooling water, various costly equipment of plants could be at risk and liable to damage by overheating.

Irrigation department have decided to treat the saline water which is the only available major source of water in the surrounding area. The saline water cannot be used as such for the intended purpose.

In order to treat the required quantity of water in acceptable quality as input to main coal plants, Irrigation department have got Government approval as under.

1. Set Up a Pre Filtration Plant with a capacity of 80 cusec feet which will consume approximately one (01) MW.

2. Set up an RO based Water Treatment Plant with an intake capacity of 70 cusec with a treated water output of 35 cusec feet. This will consume approximately Nine (9) MW.

3. Irrigation department will need to run these both, pre filtration and RO Water Treatment Plant on nonstop bases except essential

maintenance down time and for that purpose, needs approximately Ten (10) MW un-interruptible power connection.

4. Based on the requirement of 10 MW essential uninterruptable continuous duty source, Irrigation department have sought Government Approval to install a total 10 MW capacity HFO power plant at Nabisar.

5. To supplement any partial outage of 10 MW plat, owner have a 5 MW back up priority connection from Wapda. Wapda and Nabisar power plant generation will be synchronized on an 11 KV bus so that any deficiency due to the outage of any unit, Wapda feed can coop the essential load.

6. In its first phase, it's planned to install on urgent bases a 5 MW HFO based power plant at Nabisar and go for the next 5 MW to complete total 10 MW by time it's required.

7. HFO based power plant is feasible because of lowest fuel cost among available fuels or that can be transported easily to site. Please note there is no other fuel source available at site or nearby, like a natural gas pipe line or other source that can be used. Transporting LNG from Karachi and using at site, will for sure cost much more in comparison to the cheap and high BTU per unit of Heavy Fuel Oil.

8. HFO plant is viable and will recover the cost in few years as estimated and in-line practice with other consumers who have captive power plants.

9. In order to cut the operating cost, it is planned to have solar power source installed for plant periphery and building essential lighting.

10. In future, irrigation department may upgrade this plant to combined cycle and produce additional 5 MW at very low capital and almost negligible running cost.

11. Nabisar PP will help uplifting of local population both technically and economically through training on new technology and employment opportunities and will act towards future development of Thar / Sindh.

b). Project Objectives.

This EPC contract is to Engineer Detailed Design, Procure, Construct, Test, Commission and Hand-over of a complete in each respect with Civil Structured Building the main plant & Balance Of Plant including but not limited to ,
Brand New 2X2.5 MW Tri Fuel operation, Fuel Transfer ability at any load, Tuned for for distillate start / HFO run Combustion Turbine Generator units,

Equipped with a suitable air inlet Filter to stop dust ingress keeping in view of Nabisar site data of frequent wind / dust storms. Air inlet must take care of high ambient temperature by incorporating arrangements similar to Evap Cooling or any latest state of the art / effective & efficient in practice technology concept.

Unit will have a High Efficiency turbine driven multistage Compressor, Turning Gear, starting motor, accurate & reliable Fuel Flow Divider, Main, standby, Emergency Oil Pumps, Lift Oil System, distillate start, HFO Run multi combustor, air cooled multi stage turbine and air or water cooled separately exited multiple Electric Generator- operated in Open Cycle,

Main GTG plant is meant to feed uninterrupted power to owner RO/Pre-filter plants facility with a 5 MW Wapda Priority Connection as incomer back up to feed partial load in case of outage of any GTG. Main plant to be synchronized at Owner's 11 KV Main Bus per Electrical SLD, Vendor to review SLD critically and may table a better configuration that can be discussed and finalized.

Main Plant and BOP to include Oil Cooled step up / step down / isolation transformers per vendor plan, matching Switch Gear & fool proof Interlocks, Fuel Oil Treatment Plant, Water Treatment Plant if required, Tank Farm Area, Met Tower (optional), Fuel & Water Test Labs.

(Fuel and Potable Water from RO plant will be supplied by the owner,)

Compressor be equipped with On Line Water Wash and the Turbine Exhaust system with Continuous Emission Monitoring System besides other associated BOP systems.

Generator GCB and other electrical distribution systems be with Necessary sub-station, Switch Gear, and Protection. Interconnections to be with Electromechanical Fool Proof Synchronizing, Plant Safety be provided by feeding essential load with a sufficient capacity Black Start Diesel Engine through a load sequencer.

Units be provided with Redundant Normal and Emergency Cooling equipment / System, Normal and Essential Power Distribution Systems, Fire Detection & Fire Fighting Systems, Excitation and GTG Control Systems, PECC, Main Control Room, Waste Management Systems, Fuel Management & Consumption Audit System, CCTV, Key Control and

Access Control systems be provided as described elsewhere in this document.

Plant Building be equipped with Dehumidifying and Air-conditioned Systems,

Plant and BOP be provided with, including all compatible process links and economically matching electro-mechanical connecting hardware with long life, anticorrosion coating,

Including Earthling transformers, resonant grounding system, arc suppression system, indoor, outdoor, emergency lighting, egress lighting with necessary protection,

Including indoor and outdoor lighting, lighting protection system & egress lighting on central battery bank, Including all above but not limited to what else is required per vendor specific proposal, to become integral part of plant at Nabisar on EPC Turnkey basis.

Each GTG to pass reliability test of uninterruptable 15 days run while overall plant / BOP to pass Combined Reliability Run of one month continuous operation before hand-over to operator (Engro),

Owner are targeting an economical set up with overall high electrical efficiency, high reliability, low heat rate and low maintenance factor resulting maximum possible number of operating hours between planned outages. Contractor shall declare these numbers as guaranteed parameters of the plant and prove these during performance test just before hand-over/take-over by Engro.

EPC Contract is on a Fixed Price Lump Sum Basis including but not limited to any and all expenses, costs taxes, levies, etc. The Contract Amount shall be deemed to include but not limited to any and all expenses, costs, taxes, levies etc.

Following are the plant operating states need be implemented in a fool proof and errorless manner.

Site Scenario #	Main Plant Units	GTG-1/2 Operating Status	WAPDA BACK UP Status	BLACK START Status	Auto Action
1	GTG-1/2	Operating at FSNL	Available and 11 KV Mains Energized	Ready Shut Down State	GTG-1/2 Synchronize one after one on 11 KV Main with WAPDA
2	GTG-1/2	Both or one Tripped	Available and 11 KV Mains Energized	Ready Shut Down State	WAPDA Supplies 5 MW back Up Load - Load sharing to be indicated in Control Room and locally
3	GTG-1/2	Both or One available and on FSNL	Not Available	In Operation and feed GTG Essential Load through a load sequencer	BS synchronized using Ref Bus. GTG-1/2 Synchronize one after one on 11 KV Main with BS DG to receive incoming WAPDA synchronizing automatic or manual as selected.
4	GTG-1/2	One Unit Operating and connected at 11 KV Mains	WAPDA Resumes, not synchronized on 11 KV Mains	Back on Auto Standby Mode	GTG-1/2 synchronized using Ref Bus. WAPDA be synchronized as incomer back up available,
5	GTG-1/2	Both Units Operating and Synchronized at 11 KV Mains	Available and synchronized at 11 KV mains	Auto-Standby Mode	Demonstrate Operator actions to test various scenarios of switch-in/out
6	GTG-1/2 in Outage	Unavailable	On / Off Frequently	Feeding Essential Load through a load sequencer	Advise optimum action how to synch WAPDA and how to share the load

Note – BS DG be synchronized at 400 Volt bus to feed all downstream load including essential load.

1.3. EPC/TURNKEY MAIN WORKS.

The EPC/Turnkey work includes design and construction of all Civil Works, Procurement, Installation, Erection, Testing and Commissioning of all Electrical and Mechanical Works, equipment, services and ancillary. Maintenance training of operatives all as detailed in the Tender documents.

The power house will comprise of the following main works but not limited to,

(1) All civil works of the power house including Main Plant and Balance Of Plant,
(2) Tri Fuel Capability Distillate Start, HFO Run Multi Stage High Efficiency turbine driven multi stage Compressor , Electric Arc Ignitor multi stage, air cooled high efficiency Combustion Turbine and multi pole separately excited Generator .
(3) Electrical Starting Motor and Turning Gear.
(4) Fuel Flow Divider, Oil Cooling, Lift Oil & Associated Stand Alone Skids.
(5) Suitably sized Generator Circuit Breaker and Generator Step Up / Step Down / Isolation Transformer with appropriate Switch Gear / Fool Proof Electro-Mechanical Interlocks and protective relaying.
(6) Fool Proof Synchronizing System to owner 11 KV mains per Electrical SLD. Suitably sized Black Start and associated control be provided for feeding essential load in case of both GTGs trip for any reason and owner 5 MW WAPDA 11 KV back up fails.
(7) HV and LV panels and substation. With provision to prohibit rat / cat / snake / lizard entry.
(8) PECC / Excitation/ DCS / PLC/SCADA system for auto control, monitoring and data processing. (Local and Main Controls to be opted best among various EPC options).
(9) Inlet Air and Exhaust Duct System.
(10) Continuous Emission Monitoring System.
(11) Tank Farm, Distillate and FOTP System, Fuel Management Systems, Waste / sludge handling, Incinerator and oily waste handling systems and Met Tower as an option.
(12) Internal and external illumination including Solar PV fed emergency lighting subject Solar option be proved better.
(13) Overhead gantry crane suitable to lift Generator Field & Unit Rotors.
(14) Dehumidifiers and Air Conditioning System. Fire Fighting, PA, CCTV, CMMS and Security systems. Visitors Entry Control. Car Park, Stores and Labs.
(15) Any other work to complete the project objective in main plant / BOP.
(16) Outer development including landscaping
(17) Biometry control for staff Entry, Met Tower, Telemetry and Key Control System.
(18) Mains Failure / Auto Start Options.
(19) HT/LT Fire Retardant power and Control cables (with de-rating control) ,
(20) Any other task per vendor / contractor’s scheme,

1.4. Works to be executed on “EPC/Turnkey” basis

The Contract is for the engineering designs, supply and execution of civil, mechanical and electrical works of the power station on “EPC/Turnkey (Engineering, Procurement, Construction, Commissioning) Turnkey” basis as stated in the Contract.

The electrical and mechanical works include complete designs, anti-

corrosive, antiaging manufacture of plant through its designed life and equipment testing at manufacture's works, painting and full tropicalization, packing, freight and port handling including making all arrangements for clearance of imported goods, preparation of bill of entries and all other documents for port clearance, issue of import permits etc. and assessment of duty and taxes. The Contract also includes payment of wharfage, demurrage, octroi, clearance charges, toll and all local/government duties, taxes and charges, insurance costs, taking charge at the port of delivery or at local manufacturer's/supplier's works, loading, transportation, handling at various stages, unloading, safe storage, erection, testing, site painting, commissioning, testing and operation complete in all respects of the plant and machinery for providing a safest power generating station of the highest possible operative standard, maximum electro-mechanical efficiency with maximum possible number of operating hours between the planned outages, least possible heat rate, minimum maintenance factor & lowest possible emission levels - as per Contract Specification including all other items not specifically mentioned but necessary for the satisfactory performance of the Work.
The Contract includes all costs related to the execution of the Work including provision of all skilled and unskilled labour, supervision, training of Employer's operation and maintenance personnel. Production of drawings and O&M manuals as required under the Contract.

1.5. Units of Measurement

All designs, drawings, specifications and manuals shall use SI (Kg m s) units and all measurements, dimensions and performance data shall be quoted in these units.

1.6. Language of Usage

All drawings, instructions, signs, notices, name-plates etc. for use in the operation and maintenance of the completed Works shall be in English.

Warning signs shall be in Urdu and English.

1.7. Operational Capacity of Power Plant

The new Power Plant shall be rated 2X2.5 MW net at site conditions with output delivered at owner provided 11 KV mains 3 phase 50 CPS and shall take from cold start to full load maximum five minutes while synchronized in Auto maintaining the designed drop and terminal voltage at 0.8 PF.

Plant should provide approx. 38% electrical efficiency and least possible heat rate, low emission levels within limit and lowest practical maintenance factor.

1.8. Plant Design

The whole of the Plant and machinery shall be designed and constructed to the high level / latest IEC / ISO /IEEE / ASTM / NEMA / ACI / EPA standards / Internationally accepted prudent Power Station practices.

A manufacturer's standard design may be used for a Plant item where such a design is not available and it is equal to and compatible with that required by the Specifications.

The Plant shall be new, of sound workmanship and robust design, and of a grade and quality suitable for the duty concerned and for the climatic conditions at Site.

The Plant shall be designed to provide adequate protection against the attack of vermin and dust and to minimize fire risk and consequential damage.

All parts which can be worn or damaged by dust, moisture and humidity shall have anti-corrosion coating and be totally enclosed in dust proof housings.

All equipment's shall operate in a perfect balance, without excessive vibration and with minimum of noise. Any balance shots need be applied will raise a concern.

All similar items of the Plant and their components together with spare parts shall be made from the same material and shall be fully interchangeable.

As a provision for the future expansion, contractor to consider following upcoming phases of the project.

Phase - 2. Addition of another 2X2.5 MW HFO GTG Open Cycle complete with BOP. This will result a total 10 MW in open cycle.

Phase – 3. Addition of 5 MW from Combined Cycle of above 4 CTGs.

Contractor is requested to keep the plant layout such that future provisions become an integral set up as it was built 15 MW CC HFO plant. Future provision be marked on drawings.

1.9. Regulations and Standard Specifications

Except where otherwise specified all materials and workmanship shall comply with current international standards provided that these standards are not less stringent than the equivalent British Standards or Codes of Practice or provided that they comply with the requirements of the International Organization for Standardization (ISO) or the International Electro-technical Commission (IEC), as appropriate.

For the purpose of inspection or testing, the Contractor shall make available to the Employer copies of relevant standards.

The electrical installation shall comply with all relevant statutory regulations and standards at the current date of Tender, unless, otherwise indicated within this Specification. Electrical installations shall where relevant be in accordance with the IEE Regulation for Electrical Installations, latest edition.

1.10. Project Management

The Contractor shall be responsible for administration of the Project from award of Contract through design, manufacture, F A T / works testing, delivery of plant to the site, installation, testing and commissioning to one month final taking-over run. For this purpose he shall nominate a Project Manager (PM) who shall be fully responsible for and undertake the administration. EPC Contractor will hand over the entire plant to SECMC after final one month combined reliability uninterruptable run performed after individual units 15 days reliability run. All the three uninterruptable reliability runs need be witnessed and accepted by owner engineer. Test protocols will be submitted by contractor for review of owner along with bid documents or well before tests are planned. Plant performance curves, heat rate, efficiency, Full Load Rejection, over speed / under speed, cold start to full load and all scenarios of plant operation / auto-manual synchronization be checked as practical - prior, during or after reliability runs.

The PM shall be a manager with not less than 20 years of experience of construction management at least 5 years of which is in a management position on works of a similar nature and complexity as required for this project.

Specific responsibilities of the PM shall be:

a. Representation on behalf of the Contractor or the Consortium of Contractors in all discussions and matters relating to Work.

b. Coordination and monitoring Contract progress and submitting monthly progress reports.

c. Attending periodical and/or monthly meetings called by the Employer and giving full account of the Contract progress, program of Work and Site related problems

d. Coordination and programming of all building works, installation of plant, site tests and takeover trials including coordination of various sub- contractors employed by the contractors.

e. Preparation of training programs of Employer’s personnel and coordination of their training activities.

1.11. Water and Fuel Supply for Plant

Water from RO plant and Distillate / HFO from in-land available sources in required quantity will be provided by the owner, Contractor to test the quality and do the needful for further treatment if necessary.

1.12. Permanent Power Supply

The Employer will provide permanent Electric supply from it's back up 5 MW WAPDA substation / 11 KV mains as determined by the Contractor in his EPC/Turnkey Design. The Contractor shall derive power from this substation at 11kV, 3 phase, 50Hz. The electric supply will be available to the Contractor free of cost for construction, tests and commissioning.

The Contractor shall extend his connections to all switch boards at site safely as provided in the Specification for servicing all sections of the Plant including building services to be provided by him under the civil works of the Contract.

1.13. Drawings

a. General

All drawings submitted by the Contractor to the Employer for consent shall be on ISO standard size sheets with a maximum size of A1 unless otherwise agreed. Every drawing shall have a title box in the bottom right corner showing:-

(1) Employer's Name
(2) Title of the project
(3) Title of Contract
(4) Contractor's Name
(5) Title of Work Location
(6) Title of Drawing
(7) Drawing Number
(8) Date
(9) Designer
(10) Signature of Contractor to the effect that the drawing, whether his own or from any other source has been checked by him before submission to the Employer/ employee representative.

Each drawing shall also have a separate revision box with space for revisions and including revision number, revision date, revision description and revision check.

Drawings shall be drawn to specified scales or to such scales as are appropriate for clearly detailing and conveying the Contractor's proposals. Scales shall generally be 1:2, 1:5, 1:10

or multiples of 10 thereof. The appropriate measuring scales used shall be shown on the drawings.

Drawings shall include cross references where appropriate and key information such as vital levels and dimensions. All plans shall show the 'north' direction.

All drawings submitted by the Contractor shall use the English language and SI units.

Where drawings shall be revised, the revision letter or number shall be incorporated in the title block and the revision shall be clearly indicated on the drawing with the revision letter or number shown in an adjacent triangle.

Original drawings shall be drawn in ink. Prints of drawings shall show dark and fade-proof line work on a light and non-darkening background. Prints shall be on durable paper of good quality and 80 gm/m^2 minimum weight. Reproducible shall be on 75 micron durable plastic film. CAD drawings shall be on DVDs in the latest version of AutoCAD format. Four sets of drawings and documents shall also be supplied in softcopies, DVD ROM.

The drawings comprise of:-

a. Conceptual Drawings

These are drawings issued to the Contractor with the Tender Documents for the purpose of preparing a tender. Such drawings shall be deemed to have been issued for the guidance of the Tenders and shall be referred to for the interpretation of the Contract only where the drawings supplied by the Contractor at the time of tendering and incorporated in the Contract are insufficient.

b. Tender Drawings

The Tender Drawings of all Civil, Mechanical and Electrical Works are to be supplied by the Contractor for the purpose of illustrating his Tender, mainly:

1. A layout of the whole scheme, in appropriate scale.
2. Drawings and technical details of the plant in sufficient detail to illustrate the main items of the plant are sufficient for the intended purpose. Contractors are required to review and come up with complete plan with reference to their particular equipment / technology options.
3. Where Contractors tender proposals are given, Tender Drawings showing features not in compliance with the Specifications, and where such features are not listed in the Contract then the requirements of the Conceptual Drawings will be taken as the basis of the Contract.

c. Approved Drawings

Within 3 months of the Commencement Date, the Contractor shall submit to the Employer, four copies of detailed drawings of all civil, electrical and mechanical works, for approval, as detailed below.

d. Structural detailed Drawings and Computations.

The Power Station building and its components shall be designed to be earthquake resistant.

The drawings shall show sufficient detail and structural design of the associated civil structure, including dimensions of foundations, the detailed dimensions of embedded conduits. Pipes, Steel, channels and sizes of openings in walls etc. Detailed computation sheets for structural design shall also be submitted with the Drawings.

Manufacturing of the Plant shall not begin, nor shall erection of the Plant commence, until the appropriate Approved Drawings are available. The Plant shall be manufactured and erected in accordance with the Approved and Conceptual Drawings.

The approval by the Employer shall constitute only general approval of overall layout of Civil, Mechanical and Electrical works, nevertheless the main responsibility of proper and adequate design and functioning of the entire system of the pumping station shall rest with the contractor.

e. Approved For Construction Drawings

The AFC Drawings shall include but may not be limited to:

(1) General arrangement drawings to illustrate the position of the Plant in relation to the appropriate part of the Work in sufficient detail to show all the principal dimensions, methods of support and other relevant information.

(2) Drawings of the Plant in sufficient details for the Employer to satisfy himself that jointly and severally the items of the plant are suitable for their intended purpose.

(3) Sectional drawings of each major item of the Plant including general arrangement of electrical panels with foundation and cable access details.

(4) Diagrammatic outline and detail drawings of all services to, from and between the various process equipment / elements of the systems / Plant, Not limited to but including main plant and Balance Of Plant, Air Inlet / Exhaust system, Starting, Turning Gear, electric

Ignition, Lube Oil Cooling, Cooling Water, Fire Fighting, PA, CCTV. Access control, Met Instrumentation, Essential and Normal Power Distribution Systems, Plant essential solar lighting, WAPDA back Up, Black Start & Load Sequencing, Transformers, Breakers, MCC, ACBs, OCBs, GCB, Excitation, PECC, Switch Gear and Protective Control, Plant Excitation and Control, Synchronizing, Plant Monitoring, Telemetry, Local and Main Control Room, ,FOTP, WTP, Water Wash, CO2, Over Head Crane etc, pipe work, connections and fittings, electrical single line, Redundancy, Explosion Proof JBs and Panels, Fire Rated and Intrinsically safe devices, Solar Lighting, HVAC, EHS and Safety / Security Systems, and schematic diagrams, Alarm System, cable schedules and site cable layout. Testing Labs, Waste Control and Incinerator, Major Overhaul of main components and laydown areas, Storm Drain Systems, Drinking Water and Utility Water, waste handling, Incinerator, Gents and Ladies rest Rooms etc.

(5) Requirements for incoming supplies, services and details of interface connections in respect of the Plant, particularly where such connections are at the limit of the Contract, including Fuel and potable Water Supplies and incomer back up 11 KV, spares and consumable stores as a minimum but not limited to.

(6) Drawings of the Plant and data in sufficient detail as may be reasonably required by the Employer to satisfy himself as to the stability. Durability and safety of the works and for ascertaining inspection of the Plant during construction that it is in conformity with the Contract.

(7) Installation drawings giving complete dimensions of pedestals, cuts, chases, bolt holes, ducts and other provisions to be made in the civil structures and on Site during the fixing of the Plant including plant active / in-active drain system, chemical waste, and oily waste, sludge etc.

f. Employer’s Drawings

The drawings issued from time to time by the Employer. EPC contractor to review and accept Employer’s issued drawings that are meant to clarify and /or correct problems with the Contractor’s submitted documentation. Employer shall address all such problems through a proper submittal during the review period / and EPC contractor to discuss with owner engineer or return with his review comments or acknowledge as agreed within two working weeks to take it up as a design input, without considering it an addition/change in scope . In case EPC contractor keeps silent, it'll be understood that same has been agreed for implementation. However in case of any wrong adoption / implementation, contractor shall be responsible for correction without any additional charge.

g. As-Built or Record Drawings

The Contractor shall provide As Built or Record Drawings to show the whole of the civil works as constructed and the Plant as installed. They shall be in the form of six (06) sets of full (as drawn) reproducible plus three set of drawings in an electronic format using AUTO-CAD latest version or civil 3D or approved similar. They shall include all such drawings, diagrams and schedules as are necessary for a complete understanding of the work including details of any 'bought-in' items and any items shown as 'blocks' on the main drawings. Information given on Record Drawings shall include tolerances, clearances, Loadings, finishes, materials and ratings. The Contractor shall ensure that the consented to Drawings are marked up to show the condition of the civil Works as constructed and the Plant as installed and two copies of such marked up prints shall be submitted to the Employer for consent prior to the preparation of Record Drawings and to the start of tests before completion.

h. Record Drawings shall include but not limited to -

1) Process and instrumentation (P&I) diagrams showing in symbolic form the plant and systems for measurement, control and automation Including loop and interface between control panels and separate installations etc.

2) General arrangement of drawings and sectional views, fully dimensioned and showing in detail all items of plant and ancillary equipment to be provided under the Contract.

3) Dimensional assembly and erection drawings of each item of Plant.

4) Foundation drawing showing foundation requirement for Plant and loads thereon. This shall include all holes, chases and other requirements to building structure required for the installation of the Plant including concealed power and control cables / duct banks.

5) Working drawings of all engineering systems requiring electrical, and process/or mechanical connections. Showing the units of equipment in the

proposed position for installation and the details of attachment and connections required, with locations referred to each other and to the structure. E&IC, system Single Lines and loop diagrams for each system of Main Plant / BOP / BMS / Auxiliary Systems.

6) Diagrams of connections for each type of electrical equipment together with a comprehensive wiring diagram showing all connections between the various items of the equipment and the safety devices (the terminal lettering shall correspond to the terminal marking to be used on the equipment).

7) Laydown areas for spares, tool kits, removed parts, oil, chemicals etc during planned shut down for major overhaul each equipment with access and approach of mobile crane, fork lifter and overhead crane be shown for most difficult overhauling activities..

8) Working drawings for protection and air-conditioning systems and for water supply, drainage, waste water, storm water and firefighting systems.

9) Plans of conduits, station pipe work and valves indicating manual and remote control devices.

10) Fabrication drawings for station metal work, including platforms, floor plates and frames, hand railings etc.

11) Diagrams showing flow paths and circuits and piezometric levels corresponding to average and maximum flow rates accompanied by proof of computations.

12) Complete and detailed schedules listing all items of plant and ancillary equipment to be supplied by the Contractor.

13) Civil works drawings (liaison, markup and correction to the civil contractor design as necessary to facilitate the integration of the M & E and civil systems).

14) Any additional drawings required to cover other elements not listed above.

All items of electrical equipment constituting an operating system and any mechanical units involved therein or necessary for the functioning of such system shall be submitted to the Employer concurrently and shall include clear diagrams showing circuit functioning and necessary details for field erection.

1.14. Bid submissions

1.14.1. Design brief

a) General

Clause 7.1 of Material & Workmanship defines the scope of work. The Employer requires that each bidder be prepared to define in detail, the elements of his offer during the tendering process. This shall be done through a design brief covering all elements to be designed by Contractor. Through this brief the contractor shall provide evidence that consideration has been given to all other items. The design brief is to be supported by drawings and are intended to represent the type and quality of information required to evaluate the bids and to highlight;

(1) Design parameters and methodology
(2) Design criteria of the project and its components parts.

1.14.2. Construction Specifications

All designs, equipment materials and construction methodology not completely detailed in referenced or proposed documents or design criteria shall conform to acceptable industrial practice. During the evaluation period, the Employer may request to submit Construction Specifications for the purpose of clarifying and defining the bid. The format of the Specifications shall be as follows:

a. General
b. Detail Description
c. Related Works
d. Reference Specifications
e. Submittals
f. Design Requirements

1.14.3. Contractor staff qualification

All staff must be proficient in the English language.
The Project Manager, Project Design Manager, Quality Assurance Manager and Project Design Engineer should be graduates of recognized colleges and as a minimum with the following skill,

a. **Skill set for startup personnel:**
   Startup manager: experienced in starting plants.
   Electrical startup engineers: experienced in testing transformers, switchgear, motor control centers, and motors. Able to calibrate electrical protection relays and meters.
b. **Mechanical startup engineers**: experienced in flushing systems, running equipment, and operating the plant.

Instrumentation startup engineers: experienced in calibrating instruments, performing loop checks through the distributed control system, communicating between programmable logic controllers and the distributed control system.

Operators: experienced in operating the plant from the control room, and supervising the shift

The Bidders shall submit with their Bids the name of the nominees for each of the designated positions together with detailed resumes of their experience and qualifications.

1.15. Detailed design submission

1.15.1. Design Programme

The Contractor shall submit to the Employer a Design Programme showing the order and procedure in which he proposes to carry out the Design and Engineering services with a schedule of submission of all design documents and all drawings for completing the Works within 28 days after the "Notice to Commence", and also to match with the Work Programme (Sub-Clause 8.3 of

the Conditions of Contract). Such Design Programme shall be subject to review and revision by the Contractor in Consultation with the Employer in order to achieve completion of the Works with-in the time for completion.

The number of copies of the report and other documents to be submitted to the Employer by the Contractor is specified in Sub-Clause 2.8.

1.15.2. Detailed design submission

The Contractor shall carry out structural analysis of the structures and its foundations to confirm the stability under site specific seismic loads.

Detailed reinforcement drawings and bar bending schedules shall be prepared for all concrete structures. Where the structural design for earthquake loading relies in ductile behavior of structural elements then anchorage, splicing of bars and shear provision shall comply with current earthquake detailing practice.

The design works shall cover determining the Fuel Treatment Quality for long term operational efficiency and safety in the approach to through all Fuel conveyance elements. Fuel Management System must cater for its efficient consumption for maximum power output with allowable emission levels and least possible heat rate. Necessary water injection be considered for Emission Control and not for power augmentation.

EPC contractor to submit detailed design documentation & drawings for all disciplines of the projects without exception and without fail for an early review, comments and implementation.

Within 2 (two) months of commencement date and prior to beginning any construction work, the Contractor shall submit to Employer for consent a Detailed Project Report (DPR). The DPR shall define all finished structural dimensions and / or performance characteristic of all elements of the project except those dependent on subsurface geotechnical conditions. Geotechnical investigation report be enclosed. The bidder however shall ensure that the estimates are based on the Contractor's own confirmatory investigations and / or interpretations. The results and interpretations of the geotechnical investigations shall be presented in the DPR.

The DPR should include at least the following:

1.15.2.1. The result and interpretations of the geotechnical investigations (including construction materials.)
1.15.2.2. The results and interpretations of the Metrological investigations considering plant data at ISO conditions and means to bridge the gap.
1.15.2.3. The results and interpretations of topographic surveys.
1.15.2.4. The geotechnical, Site Climatic Conditions and structural design including design standards, criteria and calculations.
1.15.2.5. Drawings to a detail sufficient to show all significant structural and plant features.
1.15.2.6. Justifications supported by calculations and drawings.
1.15.2.7. Details of specifications to be adopted.
1.15.2.8. Quality Control and Inspection (RFI) plan for construction stage. Punch List and Warranty Management during defect liability period.
1.15.2.9. Key Control, LOTO and EHS / Fire Safety, Security Assurance Plan
1.15.2.10. Vendor Engineering Support during Construction / Commissioning and after take over. During PUP maintenance. Contacts and cost of TA services over next 10 years.
1.15.2.11. Supply of Plant Operational Consumables, Spares, Serialized Parts and parts refurbishment plan including qualified services shops location and cost of refurbishment over next 10 years.
1.15.2.12. Provision of potential Fuel Conversion, Up-Rate and Life Extension Services, TIL / PAC services set up for Nabisar Power Project.
1.15.2.13. Supply of substitute parts in case any part is becomes obsolete in future.
1.15.2.14. Especial Tools and specific procedures for any possible maintenance scenario. CMMS and Call Up cards system for preventive maintenance.
1.15.2.15. Back Up and reload demonstration of Control systems and all software used in plant including intelligent controllers, PLCs, SCADA, Stand Alone Skids Switch Gear, Protective Relays / Panels and BMS.
1.15.2.16. Proposal connecting emergency and plant periphery lighting on Solar PV system installed on plant roof.

1.15.3. Drawings & documents

The contractor shall provide copies of all standard mentioned in this document. Furthermore all standards referred to in the design documents submitted by the EPC contractor shall also be provided to the employer. All standards copies shall be provided. As a part of the Design Documentation,

the Contractor shall provide a complete and clear set of stability check calculations, specifications and drawings of all construction works, service utilities, and materials as well as of his temporary works design.

The Contractor shall successively submit structural design, documents and all project discipline drawings for the review, comment and consent of the Employers in accordance with the schedule of submission of design documents and drawings in the Contractor's Work Programme as stipulated in above. The Employer shall give his consent / Comments on all design and drawings referred to him within 15 days for submissions prepared by the Contractor and submitted to the Employer at Site, and 28 days of the date of receipt in the Employer main design office for submissions prepared by the Contractor and reviewed by the Employer from the main design offices.

1.15.4. Submission Drawings

The details of drawings / documents which will be submitted for the Employer review and consent or for information are as below:

1.15.4.1. Detailed technical specifications wherever necessary.
1.15.4.2. General arrangement and layout drawings of the entire project.
1.15.4.3. Concrete outline drawings.
1.15.4.4. Assembly drawings.
1.15.4.5. Foundation design and treatment drawings.
1.15.4.6. General reinforcement arrangement for structures.
1.15.4.7. All Civil, Mechanical, Electrical and Instrumentation / Control drawings or any other requested by the employer.

As an exclusive responsibility of EPC contractor, drawings in the following category will be submitted only for information and record of the Employer. However employer have the right to review and point out any discrepancies for a joint discussion / correction by the contractor.

a. Detailed Reinforcement drawings.
b. Design Calculations, Civil, Process, Electrical, Mechanical. Protection, I&C or any other requested by the employer,
c. Sub-assembly Drawings, all disciplines.

In case of consent of a submission of drawings / documents by the Employer, one set of drawings / documents will be returned to the Contractor within the stipulated review period, marked “Consented”.

In case the drawings / documents are accepted in principal, but minor comments are made, the drawings / documents will be marked “consented with comments” and the comments shall be explained in a covering letter and
/ or clearly marked in the drawings / documents, which will be returned to the Contractor within the stipulated review period. Further design construction shall proceed, considering the comments. Amended drawings / documents will be submitted after completion of the works.

In case of substantial disagreement with the drawings / documents, these will be marked “returned for review” and will be returned to the Contractor within the stipulated review period with the reasons for disagreement spelt out in detail in the covering letter. Technical discussions shall, if required, be held thereafter without delay to address the concerns of the Employer. The drawings / documents will be reviewed, appropriately revised and resubmitted for information with the response, explanation or action to the comments of the Employer.

1.15.5. Approved drawings for Construction (AFC)

In case consent or comments of the Employer have not been communicated within the stipulated review period then the drawings shall be deemed to have been consented to and the Contractor can then act on them and shall inform the Employer accordingly.

The Contractor shall furnish to the Employer the following number of copies of approved drawings, reports and other technical documents:

- **1.15.5.1.** One transparent copy and 3 paper copies of drawings, which are submitted for information only.
- **1.15.5.2.** One transparent copy, three paper copies A1 size and three paper copies of minimum A-3 size of drawings, which are submitted for consent. One paper copy shall be returned to the Contractor with consent or comments.
- **1.15.5.3.** Consent drawings in sets of two transparent copies and ten paper copies of minimum A-3 size.
- **1.15.5.4.** As-built drawings in sets of one transparent copy, and ten paper copies of minimum A-3 size.
- **1.15.5.5.** Report and other documents in five copies and approved manual in ten copies for Employer’s reference and records.
- **1.15.5.6.** Progress reports in five copies.

1.15.6. Amendment / revision of drawings

No comment, amendment or revision to a report or design or its redesign made or requested by the Employer which is for reasons caused by an error or mistake by the Contractor or is deemed necessary for the proper fulfillment of the Scope of the Works defined in the Contract shall not be grounds for additional time or payment. Any request of the Employer that can be shown to be a requirement outside of the scope of the Works of the Contractor shall be formally notified as such by the Contractor within 7 (Seven) working days and the Employer will decide whether such additional work will be required. If outside the scope of the works and required by the Owner this shall imply that such additional works shall constitute a Variation. Formal notice for such request not received formally by the employer means that contractor agrees to execute the same within the scope of EPC contract awarded on lump sum fixed price.

1.15.7. Defect

If either the Contractor or the Employer become aware of an error or defect of a technical nature in a document which was prepared for use in executing the Works, which has any effect on the execution of the Works and needs to be clarified, prompt notice shall be given to the other party of such error or defect, if errors are found in the documents produced by the Contractor, the documents and the Works shall be corrected at the Contractor's cost, not-withstanding any consent by the Employer.

Employer can serve such a notice till the end of stipulated warranty period, that's one year after final acceptance and take over of the complete project by the employer operator, Engro.

The Contractor is responsible to liaise and co-ordinate his design with that of the different disciplines and subcontractors / suppliers, including incorporating the interface requirements,

1.15.8. Consent or approval

Consent or approval of the Employer to any or all of Contractor's documents, programme, schedules, designs and drawings etc. shall not relieve the Contractor of design and construction responsibilities / liability or obligations to complete and commission the Works as per provisions of the Contract.

1.16. Transport for the Employer

The Contractor shall provide new approved vehicles as listed in the Schedule of Prices, for the use of the Employer and his staff.
Vehicles shall be equipped with First Aid Kit, spare water and double fuel tanks, roof rack and be suitable for rough / tough use considering the site location. Kerb weight and tyre pressures shall be

stated on each vehicle and the vehicles shall conform in all respects to the regulations of the appropriator registration authority.
The Contractor shall provide competent drivers trained First Aid Provider, to the approval of the Employer for the vehicles used on site. The Contractor shall provide all fuel, lubricants, etc and shall license, insure (as detailed below), servicer and maintain the vehicles in a roadworthy state. The Contractor shall be obliged to have ready access to spare parts appropriate to the number, type and duty of the vehicles supplied. If in the opinion of the Employer the Contractor should default in this respect and deprive the Employer of use of vehicle(s) made unserviceable by normal use in the conditions and demands of the Site, the Contractor shall provide suitable alternative transport to the approval of the Employer. If the Contractor fails to provide this service the Employer shall be entitled to withhold the issue of a Payment Certificate until the service is resumed.

Insurance for vehicles must be comprehensive and include:

a. Cover for the Employer and his staff driving the vehicle;

b. Usage on the business of the Employer and his staff and for social document and pleasure purposes; and

c. Liability to third parties (including passengers whether the Employer, his staff or others) for an unlimited indemnity in respect of death or personal injury and for the maximum indemnity reasonably obtainable in respect of loss, destruction or damage to property.

The vehicles shall be handed over to the Employer at the end of the Defects Liability Period or earlier if ordered by the Employer and transferred in the name of the Employer.

For a site movement of Employer Supervision staff, for inspection of Contractor’s works or in connection with the works, the Contractor shall make available suitable transport as required. No direct payment shall be made for this and the cost thereof is deemed to be included in the contract price.

1.17. Telephones

The Contractor shall provide following communication facilities for the sole use of the Employer and his staff.

The Contractor shall introduce e communication facilities as much as possible for the business calls and e faxes etc.
A call-in conference call facility be set in place to ease out the communication and cut the direct calling cost. Internet services be set in place at site and residence with land line service provider or via separate dish antenna.

In discussion with contractor, few landline telephone shall be provided in the site office of Employer and one Fax machine of approved make. The Contractor shall bear the cost of installation, instruments and payment of telephone bills regularly to keep telephone in service continuously until the end of Defects Liability Period. The Contractor shall maintain the Fax machine with provision of all consumables until the end of Defects Liability Period.

One completion of work, the telephone and Fax machine will be the property of the Employer and will be handed over to him.

1.18. Health and Safety

The Contractor shall provide for the health and safety of its employers, any employees of Employer and any other persons who are at any time directly or indirectly effected by the performance of the Work by an application of a suitable or acceptable health and safety policy that ensures attention to the safety of work sites, to safe methods of working, to the suitability of personnel by training or placement and by adequate supervision.

The Contractor shall be under an obligation to take all reasonable safety measures in relation to the type of services undertaken along with all personnel assigned to the Work and perform the Work in such a way as to comply at all times with its obligation and duties under laws, regulation, rules, order and other enactments in force from time to time relating to health and safety matters, including the Employer’s safety requirements.

The Contractor shall in addition observe and follow all guides, codes and recommendations issued or made by the government, professional or trade organization or other official or responsible organization relating to health and safety at work as applicable to the project.

At every site where the work is being performed under this Contract the Contractor will appoint a safety officer who will be responsible for all personnel engaged in the performance of the work under this contract including those of the Contractor’s sub-contractor. The contractor will draw up and ensure compliance with safety regulations commensurate with the hazardous nature of work.

Safety equipment, such as eye wash stations, safety showers, breathing apparatus, respirators, etc. should be ready for use during the system commissioning, as conditions warrant. If the permanent safety equipment is not yet available, temporary equipment can be purchased or rented. Safety signs and warning beacons must be in place, and the workers in the area should be trained in the identification of safety hazards and the remedial actions in case of an incident or

accident. Permits should be used for confined space entry, in order to have the proper equipment for monitoring the safety of the atmosphere in the vessel, and to have the required standby personnel to monitor those in the vessel.
Material Safety and Data Sheets must be available onsite for all the hazardous chemicals used during the startup.
Work permits are used to allow construction personnel to work within the boundaries of a system that has been turned over to startup. Special attention should be placed on “hot work permits,” where any welding, cutting, or grinding will occur.
The safety tagging program (lock out and tag out) is the principle means of preventing injury to personnel or equipment when the systems have been energized.

1.19. Operation and Maintenance Manuals

The Contractor shall compile installation, operating, preventive maintenance, removal, testing and overhauling manuals for the whole of the Work. The Manuals shall be divided into (a) Maintenance Manuals
sub-divided into mechanical, electrical and instrumentation, and (b) Operating manuals divided into locations.

It is emphasized that a collection of standard pamphlets of a general nature unaccompanied by drawings and descriptive matter relating to items of Plant as installed, will not be acceptable. In particular information supplied by subcontractors and manufacturers employed by the Contractor shall be coordinated into the comprehensive manual. Cross-referencing of descriptive matter, drawings and spare part lists must be complete.

The Operation and Maintenance Manuals shall describe the installation as a whole and shall give a step by step procedure for any operation likely to be carried out during the life of each item of Plant, including its erection, commissioning, testing, operation, maintenance, dismantling and repair. Manuals shall identify and cover aspects liable to affect other installations and shall include all health and safety precautions to be taken. For GTGs, need inspection procedures, step by step for CI, HGPI and MI besides replacing compressor blades, Turbine buckets and Unit Rotor as an integral assembly or separately.

Maintenance instructions shall include routine call up cards through CMMS, including data showing lubrication, checking, testing and replacement procedures to be carried out at daily, weekly, monthly and longer intervals to ensure trouble-free operation. Where applicable, fault location charts shall be included to facilitate tracing of the cause of malfunction or breakdown.

A separate section of the Manuals shall be devoted to each size and type of equipment identified / arranged in alphabetic order and be sortable with equipment name / component name / vendor name etc, its operation and shall include all relevant pamphlets, and a list of parts with the procedure for ordering spares. The detailed sections of the Manuals, if necessary, shall contain further maintenance instructions and fault location charts. Subject to the foregoing, the Manuals shall generally comply with the recommendations of BS 4884 Parts 1 and 2 (Technical Manuals - Content and Presentation).

The Contractor may ensure that, as minimum following items are included in the Operation and maintenance Manuals:

a. All health and safety instructions for chemicals and any precautionary measures necessary for ensuring health and safety and avoidance of mishaps. EHS system shall be computerized so to be adopted by owner / plant operator on permanent bases.

b. General description of the scope, purpose and manner of working of each system or apparatus forming part of the Work.

c. Schedule of equipment supplied giving manufacturers name, address, fax number and appropriate Make/Model No /Cat No description of unit and component parts identified on drawings giving ordering reference numbers.

d. Maintenance procedures for regular maintenance and preventive maintenance including frequencies of routine operations, guide to trouble shooting, fault finding charts, procedures for disassembly, repair and reassembly, procedures for removal of transport screws and/or clamps and procedures for alignment, adjustment and checking should be a part of CMMS.

e. Schedules of spare parts, tools and lubricants supplied.

f. Schedules of consumable supplies, packings, together with lubricant application.

g. Schedule of changeover frequencies for duty/standby equipment.

h. Sectional arrangement drawing of major items of equipment with comprehensive instructions for dismantling, cleaning, servicing and replacement of component parts, reassembly including recommended clearances and tolerances.

i. Plant layout drawings showing the “As installed” installation.

j. Process and instrumentation drawings of the "As installed" processes.

k. General arrangement and schematic diagrams of the "As installed" control panels.

l. "As wired" diagrams of all electrical connections between the control panel and installed loads, circuit directories of panel boards and "As installed" color coded wiring diagrams. Cable schedules and connection/termination data for all equipment installations.

m. Operating procedures including step by step instructions for pre-start, starting up including startup following emergency shutdown, normal operation and normal and emergency shutting down of the Plant.

n. Test certificates and performance curves for both works and site tests of both GTGs, Compressors, motors, pumps, Air Intake Filters, Evap Cooling, FOTP, electrical switchboard, transformer, instrumentation, valves and lifting equipment, site tests of pipework, cabling and electrical installations, earthling, lightning protection and other items where appropriate.

o. Records of lightning protection system installation to BS 6654, section 5.

p. Complete software documentation for each programmable piece of equipment. The material to be provided shall include all of the manufacturer's standard published reference materials and user's guides.

q. Instrumentation, control and automation equipment, operating instructions for normal procedures in a step by step format including flow charts, control operations, requests for display or printing of data, performance monitoring, response to alarms or failures, changing of operation parameters, and manual data entry.

r. Description of the plant control philosophy.
s. Schedule of alarms, their initiation and action to be taken.

t. Procedures for calibration of instruments etc.

u. Firefighting procedures and drills.

All drawings incorporated in the manuals shall be presented in such a way that they can easily be referred to whilst reading the associated description in the text copies of all software & shall be provided on DVD.

The Manuals shall be in the English language and each volume shall be numbered in sequence. Pages shall be of A4 size to 150-216 or folded to that size and placed in a loose leaf four ring hard cover binder.

The cover of each volume shall have inscribed on it, the names of the Employer, project and subject matter. A content page shall be included in each volume and index tab pages shall be provided to permit quick reference.

Any additions, alterations or deletions which may be required by the Employer or following the experience gained during the running and maintenance period shall be incorporated in the Manuals without any extra cost to the Employer.

Six final copies shall be submitted in each hard and soft version not later than three months before the due date for final taking over of the Work. Back up download of all software be provided at the end of one month combined reliability run and demonstrated by uploading of main plant MK VI or whatever vendor have loaded, all plant controllers, BSDG, all BMS, FAS and protective relays,

1.20. Commissioning and Reliability Trials

Following completion of FAT, Inspections before shipment, erection of the plant and after each item of the plant has been retested on the site and found to be in working order, water and electricity having been provided as and when available, the Contractor shall conduct 15 days uninterrupted reliability run of each GTG / BSDG, and combined plant reliability run for a minimum of 30 uninterrupted / consecutive days and undertake such adjustments / repairs as are necessary to make it fully operational and compliant with the requirements of the Specifications.
The completeness and complete operation shall be demonstrated to the Employer in conjunction with instructions given in the operation and maintenance manuals. This shall also include such tests and simulations of operating fault conditions as are required to prove the satisfactory operation of all automatic and essential lighting, emergency control systems including frequency, variation trip, Full Load Rejection Test and efficiency / performance test / heat rate test,

recording declared guaranteed perimeters on Compressor, combustion turbine, Generators, AIF efficiency, evap cooler, oil cooler performance, Water / Fuel treatment Quality / Consumption measuring and proving the declared maintenance factor as optimized one. Tests must include the proof of performance data and curves submitted by vendor in bid / catalogs / product broachers.

The Contractor shall operate the plant over its complete operational range and shall prove its safe and satisfactory operation during normal and abnormal operating situations likely to be encountered, and also in various modes of combinations with other power sources operating in parallel.

Should the Plant not achieve satisfactory, constant and continuous output or requires specialist services of the Contractor during the initial commissioning it will be deemed not to have achieved an acceptable level of reliability and it would require the 30 days period to be restarted.

After satisfactory completion of the initial running period of 30 days as certified by the Employer the Operator – Engro shall continue to operate and maintain the plant to the satisfaction of the Employer.

All consumables, spare parts, replacement components and labour shall be provided by the contractor at his cost during the initial commissioning and reliability trial period. The cost of power, Fuel and water required shall however, be borne by the Employer.

1.21. Inspection and Tests

The Contractor shall be responsible for ensuring that all inspections and tests in connection with, performance, protection quality control or otherwise are properly carried out whether on the Site or elsewhere and that, where necessary, the appropriate remedial measures are taken.

The Employer may require to inspect work being prepared and to witness tests at supplier’s premises. The Contractor shall give the Employer adequate notice of the program of Work and testing at supplier’s premises to enable the Employer to arrange such inspections particularly for GTGs, Black Start and associated switch gear / controls.

The Contractor shall ensure that access to supplier’s premises is available to the Employer and his representatives throughout the Contract period. The Contractor shall at no additional cost provide all facilities and equipment necessary to carry out inspection by the Employers Representative.

Satisfactory testing or inspection of manufactured items or materials before these are delivered to the Site shall not relieve the Contractor of his responsibility to ensure that manufactured items and materials used in the works comply with the Contract and meet its objective when they are incorporated in the Work. Manufactured items and materials delivered to the Site shall be inspected on arrival and any defects shall be notified to the Employer’s Representative. The Contractor shall obtain the consent of the Employer for his proposals for rectification of

the defects, either at Site or at the manufacturer's premises or for replacement of the goods.
Inspections or tests carried out by or on behalf of the Employer shall not relieve the Contractor of his responsibilities in connection with quality control on every aspect of the Work.

Records of on-site testing and inspection shall be kept on approved format. Test results shall be certified by the appropriate responsible member of the Contractor's staff. All test certificates and inspection records (including any from suppliers or other outside testing agencies) shall be clearly identified with the appropriate part of the Work to which they refer.

Test results shall be summarized in tabular form or graphically or both in a way which best illustrates the trends, specific results and specification requirements. Where the tests show that the specified requirements were not achieved, the report shall describe the action which was taken and test be repeated till satisfactory results achieved. .

The Contractor shall keep detailed and up-to-date inventories in an approved form of goods and materials subject to quality control which are on order, delivered, found faulty, and lost during the work or to is surplus to requirements.

1.22. Warranty Period

During the one year or specifically described warranty period (Defect Liability Period) after entire plant take-over the Contractor's responsibilities shall include, at no additional cost in the Contract, but not limited to:

a. Providing skilled maintenance staff and spares in each discipline for the whole of the maintenance warranty period so to rectify the defect without loss of generation hours.

b. Monitoring the performance of the whole of the Works locally and remotely at their engineering office or product services center.

c. Investigating faults in similar equipment under similar conditions.

d. Rectifying faults.

e. Have an agreed arrangement to attend the defects of items having longer warranty period like Industrial Ethernet and other specialized electronic gadgets.

1.22.1 Protection and packing for dispatch

Before dispatch from the place of manufacture, the equipment shall be adequately protected by painting or by other approved means against corrosion and accidental damage for the whole period of transit, storage and erection. The Contractor shall be responsible for the equipment being so packed and/or protected as to ensure that it reaches the site intact and undamaged. All equipment as necessary shall be packed in first quality containers or packing, no second-hand timber shall be used. The equipment shall be packed to withstand rough handling in transit and all packages shall be suitable for several stages of handling via sea or air freight, inland transport and movement on Site and for storage including possible delays in delivery.

Precautions are to be taken to protect shafts and journals where they rest on wooden or other supports likely to contain moisture. At such points impregnated wrapping with anti-rust composition or vapour phase inhibitors are to be used of sufficient strength to resist chaffing and indentation due to movement which is likely to occur in transit.

Lids and internal cross battens of all packing cases are to be fixed by screws and not nail.

Hoop metal bindings of cases are to be sealed where ends meet, and if not of rust proof material, shall to be painted.

Contents of such cases are to be bolted securely or fastened in position with struts or cross battens and not with wood chocks, unless they be fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges on which the batten may rest. Cases are to be opened after packing, to prove that there is no movement of contents.

Where parts are required to be bolted to the sides of the cases, large washers are to be used to distribute the pressure and the timber is to be strengthened by means of a pad.

Waterproof paper and felt linings are to overlap to at least 12mm and the seams secured together in an approved manner, but the enclosure is to be provided with screened openings to obtain ventilation.

The flanges of pipe, sluice valves and fittings shall have their open ends protected by adhesive tape or jointing and then protected by wooden discs secured by means of service bolts (which shall not be used on Site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 Kg.

All relays, instruments, and similar equipment shall be shipped with transport screws and/or clamps, clearly marked and painted red, to prevent movement of moving parts.

Structural steel work, pipes, sluice valves, uncased fittings and metalwork shall be similarly marked. When the dispatch marks cannot be applied satisfactorily to any item they shall be stamped on a metal label attached to the item or part by means of a piece of wire passing through holes at either end of the label and secured so that it lies flat with the item.

GTGs, Black Start DG, Excitation System, Control Panels, Switchgear and all Indoor items such as electric motors, switch and control gear, instruments and panels, skids, machine components are to be 'cocooned' In aluminum or polyethylene sheeting, sealed at the joints and the enclosures provided internally with an approved desiccator.

All items of equipment shall be clearly marked for description and tagged with plant identification codes against the packing list.

All cases, packages etc, shall be clearly marked on the outside with a waterproof material to show the weight, where the weight is bearing and where the slings should be attached.

Cases shall bear the Contractor's name and the name of the Employer and the particular Site. These shall be marked in legible letters, and all markings shall be in red or black paint.

Each crate or package is to contain a packing list in a waterproof envelop and three copies are to be forwarded to the Employer prior to dispatch. All items or material are to be clearly marked for ready identification against the packing list.
The Contractor shall be deemed to include in the Contract Price all materials and packing cases necessary for the safe conveyance and delivery of the equipment.

The Employer may require to inspect and approve the packing before the items are dispatched but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the Contractor for any loss or damage due to faulty packing.

The Contractor shall ensure that during all handling operations adequate care is taken for all uncrated fittings. Nylon slings and timber packing shall be used to ensure that surface finishes of uncrated items are not damaged.

The Contractor shall send advice of dispatch to the Employer, this information is received not less than two weeks before the anticipated delivery of the goods.

1.22.2 Safekeeping and Storage

The Contractor shall be entirely responsible for the security and maintenance of equipment during all periods of storage.

Should it be necessary to place the equipment into on-site store, the Contractor shall be responsible for inspecting all equipment after shipment and prior to storage and he shall arrange for any damaged equipment to be rectified prior to delivery to the Site.

The Contractor shall remove the equipment from off-Site storage or the place of manufacture as the case may be and ship or remove from on- site storage and delivery to the final point of installation

The off-Site and on-Site storage arrangements shall comply with the following minimum requirements.

Category-A: Electrical and instrumentation equipment covered in air Conditioned dust and vermin proof area.

Category-B: Rotating mechanical equipment -covered area.

Category-C: Pipes, valves, steelwork, etc - security sheeting on open hard standing area.

The Contractor shall be responsible for the operation, safe keeping and maintenance of the equipment on Site during and after erection upto the final taking over of the Works.

1.23. Unloading, erection and running of equipment

The Contractor shall at his own expense provide all equipment, tools, meters, gauges, temporary accommodation, all skilled and unskilled labour for the erection of the whole of the equipment and apparatus so that it can be installed completely and left in good working order.

Erection shall include unpacking of plant either on Site or in the on-Site storage for examining damages or defects, notifying such damages and defects to the Employer and taking action, for their repair or replacement with the approval of the Employer. The cost of such repairs or replacements shall be borne by the Contractor.

The Contractor shall provide the services of adequate numbers of competent skilled and experienced erection engineers, for mechanical and for electrical works, trained at the manufacturer's works on the various components of the plant being supplied. The Contractor shall submit the Curriculum Vitae of his erection engineers and senior supervisory staff for the approval of the Employer.

Any special erecting tackle required shall be provided by the Contractor and be left at site after the completion of the Contract.

The Contractor shall provide adequate protection for the equipment from the time it is delivered to Site until the final taking over of the Works.

When loading, unloading or erection of equipment is undertaken adjacent to structures using a mobile or static crane, the Contractor shall ensure that the maximum superimposed load exerted by such lifting shall not exceed by half of the bearing capacity of the standing surface or $100N/m^2$ on the standing surface whichever is more.

The Contractor shall be responsible for the installation, maintenance, operation and subsequent removal of temporary supplies of electricity, gas and water etc, to all offices and stores used by the Contractor together with that required in connection with the installation of the Work.

The Contractor shall at his own expense during progress of the work and on completion of erection and site tests, remove from the Site all surplus materials supplied by him, including rubbish and shall ensure that the Site is left tidy to the satisfaction of the Employer.

1.24. Plant Delivery and Handling

As per prudent practices and as stated elsewhere in this document.

1.25. Equipment spare parts

The Tenderer shall provide such spare parts for the equipment listed in the approved spare parts schedules which he considers would be kept in stock to cover replacements over a period of 5 years after final taking over of the Work. The spares shall be packed and sealed in individual boxes to preserve the parts against damage and corrosion over long storage periods. Each package shall be clearly identified as to its contents in English.

The priced lists of recommended spare parts for all of the equipment which would be needed shall be evaluated by the Employer operator, Engro. After approval of the prices list the Contractor will proceed with their procurement and supply to the Site.

BSDG/FOTP/Other BOP and GTG / Compressor serialized / CAPs must be declared for their life span and recycle terms after refurbishment at qualified service shops. Contractor will establish a computerized plan where in each planned, un-planned services the replaced parts will be recorded with operating hrs and terms of recycle to track the useable life of such components before discard.
If any component fails before its designed life, vendor will extend his engg support to conduct FOC an RCA and advise future remedy. In case such component fails before life and RCA reveals non of operator reasons, than vendor needs to replenish the same FOC delivered at site inclusive of courier in/out shipment charges.

1.26. Special tools and testing equipment

The Contractor shall supply a complete set of special tools required for major overhaul of plant (CI, HGPI, MI) / BOP equipment and test equipment necessary for maintenance or testing of any part of the Plant to be carried out during the life of the Plant, whether of an electrical, mechanical or any other nature. The Contractor shall include a price list of all special tools and test equipment in his tender.

The tools and test equipment shall not be used for the erection of the Plant and shall be handed over in a new and unused condition expecting that the Employer may call upon the Contractor to prove their effectiveness.
The tools and test equipment shall be boxed separately, in suitable containers marked or labeled with their contents. All cases, containers or other packages shall be designed to facilitate opening and subsequent repacking.

When specified, tools and test equipment for internally sited plant shall be mounted in suitable cabinets with lockable doors. Racks or clips shall be provided for individual items with outline markings and labels showing which tools or equipment are missing. The cabinet shall be wall mounted with best quality finish and appearance.

The Contractor shall supply price lists of all tools and equipment which would be evaluated by the Employer. After approval of the price lists the Contractor will proceed with their procurement and supply to the Site.

1.27. After – Sales Service

The Contractor shall provide full details in the Schedule of Guarantees and proof of particulars of facilities which he will provide for “After-sale service” in the supply or replacement of components / spare parts and skilled maintenance services at Site at any time in future covering all plant and equipment incorporated in the Work besides engg office and product services support.

After completion of the 1 month combined reliability run, the Contractor shall arrange four visits of his technical advisor, each of 7-10 days during planned outages or as desired by the Employer for inspecting the work as part of his "After-sale service". These visits shall continue for five years at no extra cost to the Employer. As a minimum, main plant equipment Internal Boroscope Inspection be performed by the vendor TA. During his each stay at site, transport and lodging will be supplied by the operator FOC.

1.28. Cleaning of Plant

At all stages of manufacture and construction, the Contractor shall ensure that all components which will come into contact with water which is to be used as potable water, are kept in a clean and wholesome state. During storage in the Contractor’s works and at Site all reasonable measures shall be taken to exclude vermin, debris and dirty water. After completion of erection and before commissioning, the pump house FOTP WTP and pipework shall be flushed with clean-water and detergent to remove any debris or foreign matter. Chemical cleaning be done where necessary with proper disposal of chemical waste.

EMPLOYER'S REQUIRMENT FOR MECHANICAL & ELECTRICAL WORKS

CHAPTER 02

MATERIALS & WORKMANSHIP

MECHANICAL & ELECTRICAL PLANT

CHAPTER 2

MATERIALS & WORKMANSHIP
MECHANICAL & ELECTRICAL PLANT

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CHAPTER 2

MATERIALS & WORKMANSHIP
MECHANICAL & ELECTRICAL PLANT

2.1. Introduction

This Chapter of the Specification sets out the minimum standards of materials, workmanship and design to be used by the Contractor for mechanical works. Reference to any specific material or equipment does not necessarily imply that such material or equipment is included in the Work.

All components/parts of the Work shall, unless otherwise specified, comply with the provisions of this Chapter unless overridden by the Employer's Requirements or be subject to the approval of the Employer.

2.2. Reference of Standards

All goods, materials and workmanship shall comply with the requirements of the latest issue (with up to date amendments) of the appropriate standard or standards of the British Standards Institution, IEEE, NEMA or, if none is applicable, with the standards of best practice.

Where standards other than British Standards are proposed by the Contractor in his tender, the acceptance of the tender based on such standards shall only signify the approval to the use of such standards, but shall not make the Employer liable to accept any standard subsequently found inferior to the corresponding British Standard. The Employer shall be empowered to reject any material components and workmanship found to be inferior to the appropriate British Standard and the Contractor shall make good the deficiency at his own expense.

The Contractor may propose at no extra cost to the Employer the use of any alternative relevantly authoritative and internationally recognized reference of standard which shall be no less exacting than the corresponding standard quoted in the Specification. The Contractor shall demonstrate to the Employer that the alternative standard is suitable and equivalent to the specified standard as well as provide proof of previous successful use.

2.3. Abbreviations for references of standard

The following abbreviations where used in the specification refer to standard; codes of practice and other publications published by the organizations listed below:

ACI	:	American Concrete Institute
ANSI	:	American National Standard Institute
API	:	American Petroleum Institute
ASA	:	American Standard Association
ASCE	:	American Society of Civil Engineers

ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
AWS	:	American Welding Society
AWWA	:	American Water Works Association
BS	:	British Standard Institute
CP	:	British Standard Institution (Code of Practice)
DIN	:	German Industrial Standard
HMSO	:	Her Majesty's Stationary Office
IEE	:	The Institute of Electrical Engineers
IEC	:	International Electro-technical Commission
I Mech E	:	The Institute of Mechanical Engineers
ISO	:	International Organization for Standardization
JIS	:	Japanese Industrial Standard
NEMA	:	National Electrical Manufacturers Association
SI	:	International System of Units
SIS	:	Swedish Standard Commission

2.4. Plant design and life

The plant as a whole shall be new, of sound workmanship, robustly designed for a long reliable operating life and shall be capable of 24 hours per day continuous operation for prolonged periods and with minimum maintenance required. Particular attention shall be given to temperature changes, the stability of paint finish for high temperatures, the rating, electrical machinery, thermal overload services, cooling systems and the choice of lubricants for possible high and prolonged operation at high ambient temperature.

The plant shall be designed to provide easy and safe access and replacement of component parts which are subject to wear, without the need to replace whole units except for consumable items. No part subject to wear shall have a life of less than five years from new to replacement or repair. Where major dismantling is unavoidable to replace a part, the life of such part shall not be less than ten years.

Component parts shall be designed to be manufactured to strict limits of accuracy and to be interchangeable with parts of similar plant.

Design features shall include the protection of Plant against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Plant shall operate without undue vibration and parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service. Materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause which may have a detrimental effect upon the performance or life of the Work. All materials in contact with water shall be impervious to it and not impart taste, odor and toxicity or otherwise be harmful to health or adversely affect the quality of water conveyed.

Manually operated plant located outside a building or structure shall be vandal-proof in addition to any other requirement in the Specification in respect of security.

Outdoor equipment shall be weatherproof and designed to exclude dust and to prevent the collection of water at any point. Metal-to-metal joints will not be permitted and all external bolts or screw shall be provided with blind tapped holes where a through hole would permit the ingress of moisture.

Mechanisms shall be constructed of materials which will not corrode due to rust, corrosion, brine or dust. Bearings of exposed operating shafts shall be designed to prevent moisture seeping along the shaft into the interior of the equipment.

Equipment and instruments shall not be located in positions where they are vulnerable to falling objects or water drips. Weather shields shall be provided where necessary to protect equipment and instruments from the sun.

2.5. Workmanship

Workmanship and the general finish of Plant installations shall be of first class commercial quality and in accordance with the best workshop practice and shall be performed by persons skilled in their respective trades.

Pipe work, fittings, cables, cable trays, etc., shall be fitted in a neat, straight and symmetrical manner so as to present a pleasing appearance.

Indicating gauges fitted to machine assemblies or to control panels shall generally be of similar style and grouped in a neat manner.

External welds and flame cuts shall have a smooth finish by means of careful grinding. Floor plate covering shall be fixed squarely in their frames and with their patterns lined-up. Hand railings shall be free from burrs.

2.6. Welding

All welding electrodes, wire and fluxes shall be stored in a clean dry place and protected from all forms of deterioration. All welding consumables shall be properly identified and shall retain their identification up to the time of use. Each batch of electrodes and wire shall be identifiable with the respective manufacturer's test certificate and advice note and shall be used in strict delivery rotation.

Gas cylinders shall be supplied to the site marked in accordance with the requirements of ISO 8448. They shall be stored under a suitable sunshade.

All welding equipment shall be of sufficient capacity and be maintained in such a condition as to ensure welds of acceptable quality throughout the range of electrode sizes to be used on the work.

Welding machine earth or ground leads shall be firmly fixed to the workplace. Welding cables shall be maintained in good condition and shall be free from kinks and loose connections.

Welders and welding shall be protected by suitable equipment from wind, airborne sand and moisture. Work shall not be performed when weather conditions do not permit satisfactory workmanship or adequate inspection.

Weld preparation profiles may be prepared by machine, shear, flame or plasma cutting followed by grinding and shall be performed carefully and accurately. Whenever possible, a mechanically guided tool shall be used for flame or plasma cutting. All edges shall be left free of slag, burs, fins, oxides and foreign matter and the finished profile shall conform to the design tolerances for the weld preparation.

Tack welding of weld preparations may be permitted but all tacks must be ground to a feather edge prior to completing the next pass.

Where spacer strip or bridging pieces are used, due care shall be taken when tack welds are removed.

All scars and blemishes shall be grounded prior to submitting the weld for inspection.

Where preheating is required, preheat and inter-pass temperatures shall be checked by temperature recorders on indicating crayons at a distance of not less than 75 mm from the weld groove. The use of hand held torches for heating will not be permitted.

Work which is subjected to heat treatment by use of electricity heated elements shall be monitored by suitable thermocouples connected to a chart recorder. A minimum of two thermocouples shall be used.

All slag, excess filler metal and surface irregularities shall be removed between weld inter-pass runs. Flame gouging is prohibited.

Welding on attachments such as lugs, cleats, supports etc shall be positioned well clear of all pressure retaining welds carrying principal stresses. If it is found essential to bridge or span a principal weld, then the attachments shall be designed so as to ensure that no further weld is positioned within 40 mm of the principal weld.

All tube butt welds shall have full penetration with a maximum of 3 mm excess penetration in the root run. The surface of the finished weld shall not be concave.

Unless otherwise specified, welds subject to radiographic, ultrasonic or other forms of non-destructive test shall be dressed to a smooth contour. Care shall be taken to blend weld and parent metal without under flushing. All weld dressings shall be carried except where otherwise specified or ordered by the Employer.

Mechanical and other non-radiographic test, if required, shall be carried out in the presence of the Employer.

Welder shall be qualified in accordance with the requirements of the appropriate section of BS 4872 or BS 4871 whichever is applicable.

2.7. Castings

The structure of castings shall be homogeneous and free from non-metallic inclusions and other defects. Surfaces of casting which are not machined shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 10 mm in depth or 10% of total metal thickness whichever is less and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques.

If the removal of metal from repair reduces the stress-resisting cross-section of the casting by more than 25% or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25% then the casting shall be rejected.

Castings repaired by welding for major defects shall be stress-relieved.

Non-destructive tests may be required for any casting containing defects whose effect can otherwise be established, or to determine that repair welds have been properly made.

Unless otherwise specified, casting shall be produced to the following standards or equal:

Grey-Iron	BS 1452	Grade 220
Carbon Steel	BS 3100	Steel alloy
Stainless Steel	BS 3100	Steel 316 C16
Copper & Copper alloy	BS 1400	Group A grade LG2 Group B grade CTI, AB2 GRAD C grade G 1

2.8. Forgings

Major stress-bearing forgings shall be made to a standard specification. They shall be subjected to internal examination and non-destructive tests for the detection of flaws and shall be heat-treated for the relief of residual stress.

2.9. Nuts, bolts, studs and washers

Nuts and bolts for pressure fittings as a minimum shall be of zinc plated high quality steel machined on the shank and under the head and the nut. Bolts shall be of such a length that only one to three-threads shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a tight driving fit in the reamed holes they occupy, they shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

When there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions. All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel or brass.

The Contractor shall supply all holding down, aligning and leveling bolts complete with anchorages, nuts, washers and packing required to attach the plant to foundations.

Unless otherwise necessary to meet special requirement all threads shall be have preferred metric sizes with standard coarse thread.

ISO metric black hexagon bolts, nuts and screws shall comply with S11 0585-81, or ISO 885, ISO 888, ISO 898-1 and ISO 898-2 and BS 4190 strength Grade 4.6.

ISO metric precision hexagon bolts, nuts and screw shall comply with ISO 272. ISO 4759-1, ISO 885, ISO888 898-1 and 2 or ASTM F-593, ASTM F-468M, strength Grade 8.8 and BS 3692 strength Grade 8.8.

The dimensions of metric countersunk head bolts, screws and hexagon nuts shall comply with ISO 225 or ISO 888 or ISO 898-1.

Plain steel washer for use with ISO metric bolts shall comply with ISO 887 or ASTM F-884.

Taper steel washer shall comply with ASTM F-844 and ASTM F-436.

2.10. Non-metallic materials

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated with an approved fungicide. Sleeves and fabrics treated with linseed oil varnish shall not be used.

The use of organic materials shall be avoided as far as possible, but where these have to be used, they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be seasoned teak or similar hardwood which is resistant to fugal decay and free from distortion and faults.

Woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these Joints in woodwork shall be dovetailed or tongued and pinned. Metal fitting on wood shall be of nonferrous material. Adhesives shall be impervious to moisture and fungus growth. Synthetic resin cement only shall be used for joining wood. The use of casein cement will not be permitted.

2.11. Guards for moving parts

All moving parts shall be protected by safety guards. Guards shall be rigid, securely fixed and designed to allow normal operation, running, maintenance and routine inspection to be carried out on equipment without the need to remove the guard. Where this is impractical, guards shall be designed for easy fixing, dismantling and re-assembly.

2.12. Safeguarding of Plant

The Contractor shall ensure that the whole of the Work as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise suppression devices, written notices, safety colours and the like shall be provided where necessary during erection and as a permanent feature.

Plant layout shall be designed to provide easy and safe access to valves hand wheels, electrical equipment, instruments and any other operating devices, free from hazardous obstructions.

Nothing in the Specification shall remove the Contractor’s obligation from drawing the attention of the Employer to any feature of the Work which is not consistent with safety or prevents him from making proposals for incorporating equipment of design which would increase the safety of the Plant.

2.13. Rating plates, name plates and labels

The Contractor shall supply a user friendly Plant coding & identification system showing the name and number of each item of the Plant and its respective arrangement drawing number and add any additional items necessary to fully identify it. KKS is not a user friendly system and must not be the option.

The labeling system shall be harmonized with asset management naming conventions and the CMMS software being deployed.

The Contractor shall supply all labels, nameplates, instruction and warning plates necessary for the identification and safe operation of the Plant.

All such labeling shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives will not be permitted.

Nameplates for plant, and equipment identification and record purposes shall be manufactured from stainless steel with a matt or satin finish and engraved with black lettering of a size which is legible from the working position.

Warning plates/labels shall be manufactured from stainless steel engraved with white lettering on a red background and sited in the position where they afford maximum safety of personnel.

All equipment within panels and desk shall be individually identified by satin or matt finish stainless steel labels or laminated plastic labels where approved.

Pipe work systems shall be color coded in accordance with the requirements of BS 1710.

Each valve shall be fitted with a stainless steel nameplate indicating the valve service and reference where nameplates shall be circular and fitted under the hand wheels captive nut. They have to be of such a diameter that there is no danger for persons operating the valve or that they do not prevent lock-off of the valve. For check valves and small valves, the Contractor may provide rectangular nameplates fitted to brackets on the valves or attached to a wall or steel work in convenient positions adjacent to the valves.

2.14. Lubrication:

2.14.1. General

Items of Plant shall be lubricated as necessary to ensure operation, heat removal and freedom from undue wear. Lubricated items shall be designed so that they do not require more than monthly lubrication attendance, unless otherwise required.

All grease nipples, oil cups and dip sticks shall be readily accessible, being piped where necessary to convenient positions.

The Contractor shall supply first fill of oil and grease for both Plant and maintenance equipment. In addition, the Contractor shall provide adequate supplies of lubricants for all equipment sufficient for 12 months of normal operation from the date of the Taking Over.

A complete schedule of recommended oils and other lubricants shall be provided by the Contractor as part of the Operating and Maintenance Manuals. The number of different types of lubricants shall be kept to a minimum. In the case of grease lubricated ball and roller bearing, a lithium based grease is preferred.

2.14.2. Oil lubrication

Oil reservoirs shall be fitted with oil-level indicators of the sight glass type, or where this is not practicable, with dipsticks. The normal, maximum and minimum levels shall be clearly visible to an operator standing on the normal access floor to the particular item of plant. The sight glasses stall be made from toughened glass, easily dismantled for cleaning and in exposed situations, fitted with the guards.

Drain points shall be located or piped to such a position that an adequately sized container can be placed beneath them.

For forced oil lubrication systems, the pressure shall be monitored during operation with automatic shutdown of the machine and alarm on low oil pressure.

All oil lubricated machinery shall utilize a common grade of oil which is readily available in Pakistan. High temperature high performance lubricates shall be avoided as far as possible.

2.14.3. Grease Lubrication

Grease lubrication shall be for steel lubrication nipples manufactured in accordance with BS 1486.

A separate nipple shall be provided to secure each lubrication point. Where a number of nipples supply remote lubricating points, they shall be grouped together on a conveniently placed batter plate, with spacing in accordance with BS 1486.

The Contractor shall provide a grease gun for each size and type of nipple installed. Where different types of greases are involved, separate grease guns shall be provided for each type. They shall be suitably labeled and if possible of different style to prevent incorrect greasing.

2.15. Joint Rings & Gaskets

Joint rings shall be manufactured to conform to BS 2194 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80 ^{o}C or greater to suit the application.

Joints shall be made in accordance with manufacturer's instructions or as specified herein. Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituents soluble in water. They shall be suitable for the climatic conditions at site and shall contain an approved bactericide.

Graphite grease or similar shall be applied to the threads of bolts before joints are made.

2.16. Electroplating, galvanizing and sherardizing

Parts to be galvanized, other than nuts, bolts and fasteners, shall be hot dip galvanized to BS 729 to give a minimum average coating of 610 g/m^2 area covered and a zinc thickness of not less than 85 microns.

Where specified, nuts, bolts and fasteners to be galvanized shall be hot dip galvanized to BS 729 to give a minimum average coating of 305 g/m^2 and a zinc thickness of not less than 43 microns. Where hot dip galvanizing is not practicable, nuts, bolts and fasteners shall be sherardised. Sherardising shall be in accordance with BS 4291, the thickness of zinc coating being not less than 30 microns.

Where chromium plating is used, it shall comply with the requirements of BS 1224 including the provision that no blistering of any surfaces will be accepted. For all base metals, the service condition number 2 shall be used.

2.17. Noise

The Plant shall be designed and constructed to reduce the operating noise level as much as possible. During periods of short duration or abnormal operation (e.g. during startup) higher noise level up to an additional 20 dB (A) may be acceptable at the discretion of the Employer.

Except as provided for below, the noise emitted by any single item of the Plant shall not exceed a sound pressure level of 85 dB (A) when measured at a distance of 1 m from the reference surface of that item in a horizontal direction and under the environmental conditions appropriate to the test requirements of ISO 3746 “Acoustic Determination of Sound Power Levels of Noise – Survey Methods” or the equipment ANSI S1 36.

The Contractor shall carry out noise tests on Site if in the opinion of the Employer, the Plant is excessively noisy. Sound pressure levels shall be measured in dB (A) using a calibrated sound meter meeting the requirements of BS 4197 with a response speed set to “Slow”. The background noise level shall be at least 10 dB (A) below the operating noise level of the machine or other item of the Plant.

For major items of the Plant, the Contractor shall provide workshop certificates from the manufacturer covering noise level tests carried out on the items or type test certificates for similar items of the Plant.

If any item of Plant in its standard built, does not comply with the above requirement, the Contractor shall be required to reduce the sound pressure level by providing improved or additional silencers or fitting sound insulating materials to the item, until the requirement is met.

Noise levels in control rooms and offices shall not exceed 45 dB (A) with equipment such as printers in operation and in local plant control rooms it shall not exceed 70 dB (A).

The background noise level at any point along the boundary of the Site, arising from operation of the Plant shall not exceed 65 dB (A).

2.18. Vibration

All rotating elements shall be dynamically balanced so that the level of vibration at any point on a machine when operating at Site, either singly or with other machines, and at any speed throughout the operating range shall be within the limits of Class IV, Grade B as defined in BS 4675 Part 1.

“Machine” shall mean a complete assembly including its drive shafting, motor and bedplate, generator, and compressor etc.

Pipe work, valves and other equipment connected to the machine or forming part of the operating system, shall be with provided adequate supports, brackets and fixtures, as necessary to restrict any induced vibration to a minimum under any operating condition.

Vibration measurements shall be taken on Site by the Contractor at various points on each complete machine as defined above.

Measurements shall also be taken on connecting Plant. If any item is found to be vibrating beyond the level considered by the Employer to be reasonably minimum for the particular Item, the Contractor shall take further steps to bring vibration to the required level. Equipment with unacceptable vibration levels may be rejected if the Contractor is unable to achieve satisfactory operation of the equipment involved.

2.19. Corrosion and erosion

The Contractor shall make proper provision for the prevention of corrosion and erosion in any part of his Plant. Such provision shall include the use of suitable materials, choice of operating speeds, design of components and type of protective coating and finishes. Particular attention shall be given to the Plant that may be exposed to water from different sources with varying characteristics and possible galvanic reaction with dissimilar metals.

2.20. Precautions against dampness

Special precautions shall be taken to prevent corrosion due to humidity, rainfall and moisture.

All wall-mounted equipment shall be fitted with spacers to provide a minimum gap of 5 mm.

All holes in the equipment shall be effectively sealed against the ingress of water. All items exposed to weather or water shall be free of water traps. Where necessary drain holes shall be provided to prevent the accumulation of water.

All fixings, fastenings and spacers which may be submerged in a corrosive liquid shall be galvanized or sherardised, unless otherwise specified.

All electrical equipment which is not sealed against free movement of air shall be protected from condensation with anti-condensation heaters. In general these heaters shall be thermostatically controlled and switched off when heat is generated by the operation of the Plant.

In choosing materials and their finishes due regard is to be given to the conditions under which the equipment is to Work. Tropical duty materials should be used throughout the Plant.

Iron and steel are to be painted or galvanized in accordance with the Specification. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting, Cores etc which are built up of laminations or cannot for any other reason be antirust treated are to have all exposed parts cleaned and heavily enameled or lacquered.

When it is necessary to use dissimilar metals in contact these should be so selected so that the electrochemical potential difference is not greater than 250 milli-volts and if practicable the two metals are to be insulated from each other by an approved insulating material or by a coating of approved varnished compound.

The use of iron and steel is to be avoided in instruments and electrical relays wherever possible. Steel screws when used are to be zinc, cadmium or chromium plated or when plating is not possible owing to tolerance limitations, are to be of corrosion resisting steel. Springs are to be of brass, bronze or non-rusting material. Pivots for which non-ferrous material is unsuitable are to be of approved rustproof steel where possible.

The use of wood within electrical and mechanical equipment is to be avoided as far as possible and, if used shall be of a type resistant to termite attack and fungal decay.

The use of hygroscopic insulating materials is not permitted except immersed in oil or otherwise suitably sealed to prevent ingress of moisture.

In choosing materials and their finishes due regard is to be given to the conditions under which the equipment is to Work. Typical duty materials should be used throughout the Plant.

Springs are to be of brass, bronze or non-rusting material. Pivots for which non-ferrous material is unsuitable are to be of approved rustles steel where possible.

2.21. Protective finishes

The surfaces of Plant shall be fully protected against corrosion and erosion with the exception of steel or similar corrosion resistant material or where the surface is required to be clear for operational purpose, e.g at glands, bearing, etc.

Parts to be galvanized shall be designed to avoid overlapping surfaces and narrow gaps and pockets which may trap pickling acid. Thermal distortion or the creation of unacceptable residual stresses should not occur.

Nuts, bolts and fasteners shall be of stainless steel Grade 316 S312 or shall have corrosion, resistant finish. Galvanizing, sherardising, or electroplating of fasteners shall be to BS 3353. Cadmium plating shall not be used.

The paint protection system shall be obtained from the same manufacturer and applied strictly in accordance with the manufacturer’s instructions and requirements and in accordance with BS 5493 and 6160. The Contractor shall be responsible for cleaning surfaces and preparing them for protective treatment and protective coatings applied at the place of manufacture and at Site. Coatings shall not be applied to external surfaces at Site during rain, fog, mist or condensation or when wind borne dirt and dust are present or likely to be present before the coating is dry enough to be undamaged.

All items of plant shall be delivered to Site with their protective finish fully applied. Site painting shall be limited to the making good of damaged protective finish and the application of further decorative coats to provide a clean and uniform finish to the whole of the Work. Site painting shall not be carried out unless the surface to be painted is dry and has undergone surface preparation as instructed by the paint manufacturer. In general Site painting shall be applied only when ambient temperatures are above 16 degrees and relative humidity is less than 55%. If these conditions cannot be achieved, a special painting system may be applied with the approval of the Employer.

Mating surfaces shall have primary coats applied before assembly. The mating surfaces of structural steel shall be sealed during erection.

Care shall be taken not to paint over any nameplates, rating plates, labels etc. All bearing and gland surfaces shall be protected during final painting.

All coatings used for any part of the Plant in contact with water for potable use shall be non-toxic, non-carcinogenic, not impart taste, odor, color or turbidity to the water. Only materials included in the approved list of the UK water fittings and by-laws scheme (operated by WRc) or in the “Current Statement of the Committee” on chemicals and materials of the construction for use in public water supply and swimming pools (issued by DOE) shall be used in places where they may come into contact with water to be used for potable purposes.

The protective treatment system shall enable any necessary repairs, whether during the Contract period or subsequently to be made simply, without need for special skills or equipment. “Two pack” product shall not be used on any of the Plant Item.

The following table gives the minimal acceptable finish system for different types of plant. Further detailed requirements for specific items of plant if given in the Specification shall take precedence over any requirement stated here:

Hand-railing, walkways and steel structure installed inside and outside buildings.	Hot dip galvanized/stainless steel where specifically mentioned.
Steel pipe work 100 mm dia. and larger.	Fusion bounded epoxy.
Steel pipe work under 100 mm dia. and smaller.	Hot dip galvanized.
Ductile iron pipe work.	Bitumen coating.
Steel surfaces other than pipe work in damp or wet environment.	Zinc rich epoxy or zinc spray followed by epoxy top coat.
Electrical switchgear in dry uncontrolled atmosphere.	Stove dried enamel or manufacturer's standard finish.
Electrical switchgear in damp uncontrolled atmosphere.	Stainless steel or GRP enclosure self-colored.

Table 2-1: Minimal Acceptable Finish System

Paint finished shall include color coding taping (BS 1710) of pipes for chemicals, treated and raw water to the approval of the Employer.

2.22. Water Compliance of Materials in Contact with Water

Any materials that come or may come in contact with water which is to become potable shall comply with one of the following.

a) The UK Secretary of State for the Environment under Section 25 of the water supply (Water Quality Regulation 1989).

b) The 15th Statement of the UK Department of Environment Committee on Chemical and Materials for use in public water supply.

c) The American Food and Drug Association.

d) Other internationally recognized and approved body.

Where a material does not comply with the above it shall be subject to the approval of Employer. Certificates confirming compliance with the above shall be submitted to the Employer and these shall form part of the approval/acceptance of the Plant.

EMPLOYERS REQUIRMENT FOR MECHANICAL & ELECTRICAL WORKS

CHAPTER 03

GENERAL TESTING, INSPECTION, COMMISIONING AND TRAINING REQUIRMENTS

CHAPTER 03

GENERAL TESTING, INSPECTION, COMMISIONING AND TRAINING REQUIRMENTS

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MATERIAL & WORKMAN SHIP
GENRAL TESTING, INSPECTION, COMMISIONING AND TRAINING REQUIREMENTS

3.1. Work Testing - General

The Contractor shall offer all items of Plant for inspection examination and witness testing by the Employer. In such cases the Contractor shall give the Employer four weeks' notice that the equipment is ready for tests.

The Contractor shall carry out tests,

3.1.1. As stated in the relevant British Standards, (current and updated versions)

3.1.2. Performance tests and such other tests as specified by the OEM, other manufacturers or as necessary.

3.1.3. Main plant, GTGs, BSDG, FOTP, Switchgear and all Controls need to be inspected and FAT witnessed in the places of their manufacture.

to ensure the make of the main plant, major components that these belong to owner required country of origin in terms of manufacturing & assembly both and not made as or under license or assembled only or having an authorized stamp.

3.1.4. Each major item be inspected by owner engineer and shall not be part of OEM random tested in lot test plan.

Where witness tests are not required the test certificate and performance curves shall be forwarded to the Employer. On each test certificate and performance curves sufficient information shall be given for ready identification of the material or equipment to which the certificate refers. Inspection or passing by the Employer of the Work, Plant or materials covered by the Contract, whether carried out or supplied by the Contractor shall not release the Contractor from any of his obligations under the Contract.

The Employer reserves the right to require the Contractor to meet any extra costs which are occasioned by failure of the Contractor to comply with the above testing and inspection requirements including the provision of test certificates, curves, sub-orders, etc. or which in the opinion of the Employer are due to insufficient care having been taken by the Contractor before presenting the Plant for inspection or test. If unauthorized delivery has taken place, the Contractor may be required to arrange for the Plant to be returned to the manufacturer for inspection and/or witness testing or even replacement at the Contractor's expense.

Any equipment used in the testing of the Plant shall in all respect comply with the appropriate safety / EPA regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

The Contract price shall include the costs of all works, inspection, FAT, tests, including temporary erection, labour, materials, instrumentation, stores, fuel and power used, as may be required during all inspections and tests and for the provision of certified records and curves.

3.2. Test instruments

The manufacturer shall ensure Class A accuracy of all the instruments used for the tests and if required shall produce recent calibration tests, or otherwise have them calibrated at his own expense by an independent authority.

Kilowatt hour meter shall be checked for correct calibration and creep tests shall be carried out to ensure that the meter is in-operative with voltage alone if the secondary current transformer is left connected with the primary current interrupted.

3.3. Test certificates

Test certificates shall be provided giving a detailed record of all electrical and mechanical tests carried out on the equipment and material including lifting equipment, pumps, motors, valves, cables and cabling etc. both in the manufacturer's works and at site.

Copies of certificates of all works, hydraulics tests shall be provided.

The Contractor shall submit to the Employer within two weeks of completion of any witness tests, test certificates and curves of all items certifying that they have been satisfactorily tested.

Copies of test certificates of major items shall be included in the Operating and Maintenance Manuals.

3.4. Hydraulic Works Tests

All equipment subject to water or Oil pressure including pumps, pipes, fittings and valves shall be hydraulically tested to the pressure where specified or to at least 1.5 times the maximum working pressure or to 1.5 times the closed valve pressure, whichever is the highest.

3.5. Works Inspection, test and guarantee

All the schedules shall be completed with the guaranteed particulars and efficiencies of the equipment offered at the duties specified and these will be binding and may not be varied.

Witness testing to the relevant standards and to prove guarantees given may be required for the following items:

- GTGs and Black Start DG Set for their performance, Boroscope Inspection, Electrical Efficiency, Heat Rate and Load Rejection, Speed / Frequency Variation, Characteristics Curves, Rated Fuel Consumption, Cold start to Full Load timing, Tri Fuel Transfer Capability, Performance Test of Air Intake Filter, Evap Cooling, Lube Oil Cooling, Fuel Treatment, Compressor Efficiency, Turbine Performance, Generator Hi Pot, Determination of least possible maintenance factor. Main Failure detection and auto / manual start, Excitation Control, Main Plant Control with synchronizing checks.

- Pumps and Valves, Waste Disposal / Incinerator etc
- Fuel Systems Equipment & Colling System Equipment
- Electric motors
- Control / Transformers / Breakers and switchgear panels for fool proof controls and trip tests.
- Cranes and lifting equipment
- Control, measuring, indicating, instruments and alarms
- Electrical measuring instruments and meters
- Alarm systems
- BMS covering mainly Tank Farm Area, FOTP / WTP / IA / FAS / FFS / HVAC / CCTV / PA / Met Tower / Fuel Management / Security / CMMS etc.

The Employer may at his discretion require witness testing of items not included in the above list.

Where items of equipment are of identical size and duty, it may be required at the discretion of the Employer that a reduced number of items be subjected to witness tests. However, this shall not relieve the Contractor from the requirement of carrying out performance tests on all items.

If after inspection, examination or testing, the Employer decides that any material or equipment is not in accordance with the Specification or performance requirement, he shall reject the said item and the Contractor shall replace and retest the item at his own cost.

As and when the Employer is satisfied that the equipment has passed the required tests he shall notify the Contractor in writing to that effect.

3.6. Testing Main Plant

3.6.1. GTG-Control

Not limited to but includes following basic points for testing of plant control. Contractor will submit detailed test protocol and acceptance criteria for each at the bidding stage for employer review and additions if necessary. Such review can be made till a date that contractor have not served a formal notification for testing date. Employer to give at least 15 working days to contractor for review and accept the proposed addition or reject on merit, TBA by the employer.

1. Control System for Gas Turbine – Primary / Secondary Loop Testing and Control Functionality,

- Start-up
- Acceleration
- Speed
- Temperature
- Shutdown and
- Manual Control functions as below,
- Fuel Stroke Reference (FSR)
- Command signal for fuel flow

- Controlling FSR
- Display of only one controlling Loop
- Startup/Shutdown Sequence and Control
- Start-up Control
- Acceleration Control
- Speed Control
- Speed/Load Control
- Isochronous Speed Control
- Droop Speed Control
- Speed Control Schematic
- Synchronizing
- Auto Synchronization
- Synchronizing Scheme
- Temperature Control
- Firing Temperature
- Exhaust Temp control software
- Temperature Control Schematic
- Temperature Control Bias program
- Temperature Reference Select Program
- Fuel Control system
- Servo Drive System
- Liquid Fuel System
- Fuel oil Control – Software
- Speed Ratio/Stop Valve
- Duel Fuel Control
- Fuel splitter – software
- Fuel Transfer
- Fuel Control System
- Modulated Inlet Guide Vane System
- Inlet Guide Vane Operation
- IGV Control Schematic
- Wet Low NOx Control

3.6.2. Excitation System.

- Architecture

The system should consists of redundant controllers, a protection module, power conversion bridges, and the power magnetics / transformers. Typical functions performed in the controller and protection system include:

- **Control**

• Automatic voltage regulator - Reactive current compensator - Volts per hertz limiter – Over-excitation limiter – Under-excitation limiter

• Manual field voltage regulator

- **Protection**

• Volts per hertz, dual level
• Loss of excitation
• Bridge ac voltage phase unbalance
• Generator overvoltage
• Off/online over-excitation

The software to also include the power system stabilizer (PSS). This enables the generator to produce and transmit more power in a stable manner by reducing low frequency rotor oscillations.

3.6.3. Air Intake System / Evap Cooling if employed

- Contractor to submit life cycle base LCC analyses,

- Main points to conduct LCC are given hereunder for the quick ref of contractor.

This section covers the inputs that should be considered for the LCC analysis for a filtration system. It also provides methods to calculate the cost impact for each input. This type of analysis focuses on the overall or lifetime cost of a system. It is a tool that estimates the total cost to purchase, install, operate, maintain, and dispose of equipment. This analysis can assist in determining the best design options, which will minimize the overall cost of a system.

It is important to include initial cost in the analysis, but it is just as important to include operation and maintenances cost. The operating and maintenance cost over the life of a piece of equipment can have a more significant effect, especially if a poorly designed system is chosen. An LCC analysis can help to determine which system configuration can minimize lifetime costs. Some of the costs that are typically considered are shown below. Examples of how this would apply to filtration systems are provided in parentheses:

(i) initial cost (filters, filtration system, spares filters, instrumentation),

(ii) installing and commissioning costs (labor, cost of installation equipment (such as cranes), shipping costs),

(iii) energy costs (pulse system for self-cleaning filters),

(iv) operating costs (labor, inspections),

(v) maintenance (replacing filters, repairing system, labor for maintenance),

(vi) downtime (replace filters, complete offline water washes, anything outside of normal shutdowns for other maintenance),

(vii) gas turbine effects (degradation, performance loss),

(viii) decommissioning and disposal (disposal of filters).

(1). In an LCC analysis, estimates are provided for each cost component of the system. An inflation rate can be applied to the costs which will occur later in the life of a system (such as 10 years from the installed date). Once these costs are established, they are brought back to present value using.

(2).The Net Present Value (NPV) term represents the value of the cost in present terms. A is the value of the cost in the year it occurs. The term i is the discount rate and n is the year the cost occurs in. If there is a price increase (inflation) or decrease, then this can be accounted for by using .

(3).The term e is the increase or decrease in price:

$NPV=A(1+i)-n$,(2)$NPV=A(1+(i-e))-n$.(3)

Projected costs over the lifetime of the system cannot be combined directly when calculating the LCC, because the funds spent at different times have different values to the investor. The discount rate, i, is used to bring the costs to present terms, where they can be directly added together, and is defined as the rate of return that is used to compare expenditures at different points in times. For example, the investor would be equally satisfied to have one amount received earlier and the other amount received later.

If a cost occurs yearly, the NPV of the total recurring costs can be calculated with

(4). If inflation or price escalation is considered in the analysis, the NPV of the total recurring cost can be calculated with

$A NPV=i[](1-1+i-n□)$, (3)

$NPV=A1+e□□□1-e1-1+e□1+i1□$(4)

.(5) . The NPVs must be determined for each cost. Then the cost will be added together to obtain the total NPV or LCC cost, effective after project take-over.

3.6.4. Turbine / Centrifugal Air Compressor..
- Performance Parameters
.

The following seven performance parameters generally describe the performance of a gas turbine and centrifugal compressor. These parameters are commonly used in acceptance testing, testing to determine degradation of the machine, and operational range testing. The primary measurements required in order to calculate these parameters are also described below.

Performance Parameters:

1. Centrifugal Compressor Flow/Flow Coefficient
2. Centrifugal Compressor Head/Head Coefficient
3. Centrifugal Compressor Efficiency
4. Centrifugal Compressor Power Absorbed
5. Gas Turbine Full Load Output Power
6. Gas Turbine Heat Rate (thermal efficiency)
7. Gas Turbine Exhaust Heat Rate

3.6.5. Centrifugal Compressor Test Measurements:

- Suction Temperature
- Suction Pressure
- Discharge Temperature
- Discharge Pressure
- Flow Through Compressor (*Pressure, temperature also required at the flow measurement point)
- Suction or Discharge Gas Composition
- Barometric Pressure
- Speed of Rotation
- Impeller Diameter
- Upstream and Downstream Piping arrangement
- Pipe Diameter (upstream and downstream)

Gas Turbine Test Measurements:

- Engine Inlet and Ambient Temperature
- Barometric Pressure
- Power Turbine Speed
- Gas Generator Speed
- Fuel Flow (*Pressure, temperature also required at flow measurement point for fuel gas)
- Fuel Gas Composition
- Inlet and Exhaust Pressure Loss
- Relative Humidity of Inlet Air
- Water/Steam Injection Rate

all pressures and temperatures used for performance and uncertainty calculations are absolute total (stagnation) values unless otherwise noted

Gas Turbine Power

Four methods exist for determining gas turbine power. These are:
1. Direct torque coupling measurements
2. Direct generator power measurements
3. Indirect driven centrifugal compressor shaft power measurements 4. Indirect gas turbine heat balance measurements

3.6.6. Generator

1. BURDEN AND OTHER OPERATING CHARACTERISTICS
2. LEAD RESISTANCE
3. FAULT LEVELS AND SYSTEM TIME CONSTANT
4. PROTECTION PHILOSOPHY
5. OPERATION UNDER STEADY-STATE CONDITIONS
6. THE LIMITS FOR LINEAR OPERATION
7. OPERATION IN THE SATURATED REGION
8. OPERATION WITH DC TRANSIENT
9. CONTROL OF RESIDUAL MAGNETISM
10. CURRENT TRANSFORMER STANDARDS

3.6.7. Black Start Diesel Generator

Block load test, Full Load Rejection, Auto Loading / Unloading / Governor Control,
Proof of declared guaranteed permeates
Auto . manual operation per owners required mode of synchronization,
Load cut-in / cut-off in event of black start / normalization, load sequencer,
Efficiency of oil / water cooling circuits,
Protection scheme

3.6.8. Valves

Each valve body shall be hydraulically tested, closed ended to 1.5 times the rated pressure. All isolating valve seats shall be tested to the maximum working pressure, at which pressure they shall be drop tight. Each valve shall be tested for functional operation with its own actuator.

3.7. Cranes and lifting equipment

The cranes and unit Rotor lifting beam / lifting equipment shall be assembled and tested in the manufacturer's works to 125 percent of the rated load and a 3rd party witness test certificate be provided.

Full functional / end stops limits tests of all crane motions shall be demonstrated with the crane carrying the maximum working load. All mechanical and electrical equipment shall be shown to operate smoothly within rated capacity. A deflection test in accordance with BS 4666 shall be carried out.

3.8. Motors

Electric motors shall be individually tested off-Site to IEC 60034 & BS 4999: Part 143, at work test ambient temperature at the machine frame power output–rating after application of de-rating factors for Site temperatures, duty factor and Site power supplies. Verification of guaranteed efficiencies and power factor shall be carried out using the de-rated power output application on Site, which shall be nameplate rating. Motors of 5.5 kW rating and over shall each be subjected to full 'Basic' tests, and in addition to noise level tests to BS 4999 Part 109, except that where two or more identical motors are being provided under the Contract. One motor shall be subjected to full 'Basic' tests and the remainder subjected to 'Duplicate' tests. Motor under 5.5 kW rating shall each be subjected to 'Duplicate' tests providing that a Type Test Certificate for full 'Basic' test and noise level test to BS 4999: Part 109 of a similar motor is available. Where no such Type Test Certificate is available, testing shall be as follows for motors with rating of 5.5 kW and over.

Type test certificate shall include the following minimum information and shall be provided for all motors:

a. Manufacture standard
b. Class of insulation
c. Type of cable fittings

d. Type of bearings, sizes and lubricants
e. Type and rating of heaters
f. Brush sizes and maker

3.9. Low and medium voltage switching devices

Low and medium voltage switching devices shall be subjected to Routine Tests in accordance with the following standards:

a. Low voltage devices

(1) Low voltage circuit breakers shall be tested in accordance with IEC 60947 Part 2.

(2) Miniature circuit breakers shall be tested in accordance with IEC 60898

(3) Low voltage air-break switches and fuse-combination units shall be tested in accordance with IEC 60947 Part 3.

(4) Low voltage contactors shall be tested in accordance with IEC 60947 Part 1.

b. Medium voltage devices

(1) Medium voltage circuit breakers shall be tested in accordance with IEC 62271 Part 4. Medium Voltage switches shall be tested in accordance with IEC 60265

(2) Medium voltage contactors shall be tested in accordance with BS 775, Part 2.

(3) Medium voltage direct-on-line starters shall be tested in accordance with IEC-60632 – 1.

(4) All medium Voltage switching devices of current rating 100 A or greater shall be subject to measurement, at the main terminals of each pole with the contacts fully closed of dc voltage and current (at 100A or greater).

The values of resistance for any two similar examples from a particular manufacturer range shall not differ by more than 2%.

3.10. Switchboards and motor control centers

Factory built assemblies of low voltage switchgear and control gear shall be subject to Routine Tests in accordance with IEC 60439.

Medium voltage metal enclosed switchgear and control gear shall be subject to Routine Tests in accordance with IEC 62271

Additionally low voltage and medium voltage switchgear and control gear assemblies shall be tested for the following:

a. Measurements of main circuit resistance

The resistance of each pole of each main circuit from the cable terminal to bushes with all intervening switch contacts fully closed shall be measured and recorded. A similar measurement and record shall be taken along the length of each bus-bar with bus-section switch contacts fully closed. The tests shall comprise of the measurement of dc voltage and current (at 100A or greater) and calculation of resistance.

b. Interchangeability

All components of the same rating and construction, designated as draw-out or plug-in shall be demonstrated as being interchangeable.

c. Protection and control circuits

For all forms of current transformer protection, the following information shall be made available to the Employer before the time of Inspection:

(1) Current transformer magnetizing curve
(2) Recommended relay setting
(3) Calculated primary operating current at this setting
(4) Calculated through-fault stability values where applicable
(5) Values of any stabilizing and setting resistors employed in the system

As far as possible, the satisfactory operation of associated control and protection circuits shall be proved by the following tests:

(1) To ensure the correct operation of all current operated protection relays and direct acting coils at the recommended setting by primary current injection.

(2) To ensure the correct polarity between current and voltage elements of power relays, meters and instruments.

(3) To ensure the correct operation of dc operated auxiliary protection relays, such as Buchholz protection relays at normal operating voltage by simulated operation of associated remote relays.

(4) To ensure the correct operation of control circuits at normal operating voltage by operation of local control switches and simulation of operation from remote control positions.

Note: Checking the operation of all protection relays and control circuits shall be carried out with all closing and tripping circuits energized at their normal rated voltage.

d. Instrument and metering equipment

Indicating Ammeter shall be checked for calibration at 0.25, 0.5 and full scale deflection by primary current injection testing.
Indicating voltmeters shall be checked for normal voltage readings by secondary voltage application.

Where possible, integrating kWh meters shall be tested for correct operation. Tests shall be carried out to ensure that the meter is in-operative with voltage alone, with the each secondary of current transformers connected and the primary current interrupted.

All instruments shall be subject to the manufacturers normal work tests.

3.11. Cables

All cables shall be subject to routine / fire retardant tests in accordance with the relevant Standard Specification.

Test certificates shall be provided against each drum and / or cable length.

The tests carried out on every cable length and / or drum at manufacturer's premises shall include:

a. High voltage dc insulation pressure rest, between cores, each core to earth, metallic sheath or armor as applicable.

b. Insulation resistance test.

c. Core continuity and identification

d. Conductor resistance test

3.12. Process, control and indicating instruments

All flow, level and process measurement controllers, transmitters, recorder, indicators, vacuum and pressure gauges shall be subject to routine tests in accordance with BS 88, BS 1780 and BS3680.

Test certificates shall be provided against each item of equipment.

3.13. Electrical measuring instruments and meters

Tests to ensure accurate operation of all meters, Voltmeters and kiloWatt hour meters shall be undertaken in accordance with BS 89 and BS 37.

3.14. Alarm system

The Contractor shall test all items of equipment comprising the alarm system for correct operation and sequence action.

3.15. Site testing

3.16.1. Co-ordination of Site testing program

The Contractor shall be responsible for coordinating the program of Site testing of all items and to ensure that all parties concerned are present during any tests to obligate their responsibilities.

3.16.2. Cable test during installation

During the period of Site installation, the Employer will carry out inspection of the works to ensure that the standard of workmanship meets the Specification. In the event of any part of the cabling installation failing to meet the requirements, the Contractor shall remedy the deficiency to the satisfaction of the Employer.

The Contractor shall:

a. Inform the Employer prior to the testing of the cables and shall be responsible to liaising with any other party to whose equipment the cables may be terminated to ensure that all parties concerned are aware of the impending tests, to guarantee the safety of personnel and that the isolation of any equipment has been completed. Any special isolation or preparation required to be carried out before cable testing will be carried out by the party responsible for equipment. All tests shall be carried out by the Contractor but shall be supervised by the Employer.

b. Provide high voltage dc test equipment and conduct the high voltage dc test (with necessary isolations and safeguards) at specified voltage in accordance with relevant standards between cores, cores and sheath & cores and armor as applicable on power cables installed on power systems.

c. Demonstrate correct phasing out of cores in all cables throughout the works and test the insulation of all cables, both between the cores and between the cores and earth, during installation with a “Megger” 500 Volt hand generator.

d. Conduct soil resistivity tests in the presence of the Employer to obtain the most suitable location for the earth electrode system.

e. Demonstrate to the Employer that the resistance of the earth electrodes to earth conductor continuity and earth installation is in accordance with the specified requirements.

Tests shall be performed for each major item of plant, by using an “Earth Megger” and auxiliary return conductor.

If any portion of the work fails to pass the tests, another test of the failed portion shall be repeated within a reasonable time.

3.16.3. Testing of Security / Access Control Systems.

Testing of security, access control, surveillance systems to be conducted as per manufacturer guidelines and to demonstrate the compliance specifications stated elsewhere in this document. Being specialized electronics, these packages shall have a 5 years or longer warranty period while OEM support be for at least 20 years, (To be agreed).

3.16.4. Testing Of BMS Systems.

Site Tests for BMS systems must be conducted to demonstrate all built-in functionality as well as all customization and control logic developed for the application. As a minimum these include but not limited to the following,

a. Pre-commissioning checks for the field instruments. (per contractors submitted & employers approved method statement – done minimum 2 weeks prior of testing)
b. DDC panel commissioning.
c. MCC Commissioning.
d. FCUs for Installation & Cabling / permanent power,
e. Head & Graphics for field equipment and permanent power.
f. Printers (alarms and reports)
g. Interface with 3rd party system,
h. Power-up DDC Controllers and Download software at DDC controllers
i. Digital / Analog I/Os
j. FCU Controllers Power Up checks
k. Checking the Sequence of operations

3.16.5. Testing Of HVAC Systems

EPC contractor to submit a test protocol / method statement for the site testing / acceptance of HVAC system per ASHRAE. 1995. “Standard 135-1995 - BACnet - A Data Communication Protocol for Building Automation and Control Networks”. Published by ASHRAE.

Contractor to use preferably the Automated Commissioning Concept.

3.16.6. Testing Of CMMS

Contractor to demonstrate CMMS for the intended features including following as a minimum,

Operating locations - track and organize locations of equipment and monitor its performance
Equipment - keep accurate and detailed records of each piece of equipment
Resources - track capital & labor resources, their costs & skills
Safety plans - numbering safety plan & record data on safety permits, documenting safety requirements

1. nventory control - track inventory movement, complete parts and materials inventory control
2. Work requests - outside service call/dispatch capabilities

3. Work order tracking - calendar- or run-time-based preventive maintenance work order generation
4. Work management - planning and dispatching
5. Planning - labor assignments planned for future shifts, split larger jobs over multiple shifts automatically
6. Dispatching - labor assignments carried out as soon as possible, tracking labor time from the assignment
7. Quick reporting - provides a rapid and easy means for opening, reporting on, and closing work orders, and reporting work on small jobs after the fact

3.17. Tests before completion

Tests before completion shall be undertaken by the Contractor in line with the following general requirements.
In general these tests may be undertaken without supervision or witnessing by the Employer but the Employer shall be kept informed of the program of these tests and given the opportunity to supervise and witness the tests where considered appropriate or a learning session for employer's operator.

Tests before Completion shall as a minimum comprise of:

a. Pressure test to check tightness of joints, coupling etc.

b. Continuity test on power and control cabling, earthing & grounding including armouring

c. Visual inspection and tests for insulation resistance, earth loop impedance, polarity and phase rotation. The test shall be carried out between phases and phase to earth. All circuit breakers, switches and contactors shall be in their circuit position and closed. All secondary small wiring circuits shall be similarly tested.

d. Satisfactory operation of all current operated protection circuits over their whole operating range shall be checked by primary current injection. Where primary injection tests have been previously performed at the manufacturer's premises, secondary current injection testing may be used subject to approval by the Employer.

e. Correct operation of control circuits, indications and alarms shall be demonstrated.

f. Correct operation of current and voltage operated indicating instruments and meters.

g. Electrical pressure test on high voltage equipment.

h. Earth continuity and resistivity test.

i. Off–load operation / function test of all mechanical plant and electrical switchgear.

j. Rotational check on all motor drives.

k. All remedial work required is satisfactorily completed.

3.18. Tests on completion

After erection is completed and the equipment is running satisfactorily after preliminary setting to work the Contractor shall notify the Employer that he is ready to demonstrate the performance of the Plant. Such demonstration referred to herein as Tests on Completion, shall be witnessed by the Employer. The Contractor shall then test fully all items of equipment and shall include provision and arrangement of:-

1. All skilled and qualified operating and test staff for the testing of all equipment.

2. Provision and disposal of all services, lubricants and electricity.
3. All measuring and testing instruments to demonstrate that the equipment operated to the fulfillment of the work tests.

4. All tests shall be carried out by the Contractor under the supervision of and to the satisfaction of the Employer as follows:

3.18.1. Pump sets

Tests, if applicable, in accordance with Part-1 of BS 5316 to demonstrate that each pump set is reliable in operation and is able to cover the whole working range. Each pump shall be tested at the minimum guaranteed and maximum duty points. The values obtained will be compared with the values obtained during the tests on the manufacturer’s premises and any discrepancies shall be rectified by the Contractor. Pump in combination with other duty pumps shall be similarly tested.

3.18.2. Cranes and lifting equipment

The Crane inclusive of rails and beams shall be tested at site with test loads provided by the Contractor to prove that the whole is capable of satisfactorily lifting 125 percent of its rated load (lift in Centre of gantry).

Cranes shall be tested after erection. A vertical deflection test shall be carried out with the "safe working load" suspended from the hook with the crab in the Centre of the span. Workshop functional tests shall be repeated.

A further condition assessment and functional check shall be carried out prior to taking over. Any deterioration resulting from the Contractor’s use of the crane during Plant erection shall be rectified by the Contractor.

3.18.3. Ancillary equipment

The Contractor shall demonstrate the satisfactory operation of the Plant, BOP and associated control equipment.

3.18.4. Pipework

Following completion of installation, all station pipework shall be water tested for leakage at appropriate test pressures. In the case of delivery pipework, and such other pipework on the suction side as may be vulnerable to full delivery pressure, the test pressure shall be the same as the Site test pressure for the associated delivery pipeline.
All pipework erected at Site shall be hydraulically tested, following erection, to at least 1.5 times the maximum working pressure, The Contractor shall provide the necessary equipment including any temporary blank flanges, which may be required to isolate the equipment.

The Contractor shall be responsible for testing of the welds and inspecting and testing of welded joints together with the responsibility of making good of any welding defect. Faulty welds shall be rectified in accordance with the requirements of BS 2971.

The Contractor shall provide all the necessary facilities, labour and equipment for the proper execution of the inspections and bend testing included in BS 2971. Two sets of bend tests shall be allowed for by the Contractor.

Fittings required for temporarily closing the openings in the pipelines to be tested shall be properly designed for the purpose and shall be adequately strutted to withstand the pressure applied.

Where bursting disks are installed, one disk shall be tested to demonstrate satisfactory operation.

3.18.5. Valves

If applicable, All valves on completion of erection shall be fully functionally tested in association with their actuators, controls and bypass system where provided. Each installation shall be checked for water tightness and the valves for any leakage. Valves shall be subject to the system test pressure and shall be demonstrated to function satisfactorily under maximum site differential head conditions. Where appropriate, valves may be internally inspected after functional tests to verify that seals remain in a satisfactory condition.

3.18.6. Surge protection system

The Contractor is required to survey and check the data supplied details to enable him to compute and meet the requirements of power and process surge protection system in different case studies with adequate safety margin. The Contractor shall ensure that protective devices are provided for all possible cases of origin of surge in the system and its damaging effects and adequate safety devices are provided in the installation to avoid damage to the Plant and equipment.

Any equipment supplied under the Contract that requires readjustment during the above tests shall after readjustment again be demonstrated by the Contractor to the satisfaction of the Employer.

Third Party validation of surge Analysis will be got carried out by the Contractor. Profile of the Third Party shall be submitted for review by the Employer.

3.18.7. Air Inlet Filter / Exhaust System

Air inlet on completion of erection shall be fully functionally tested to meet the performance schedule and specifications. Tests on all electrical items and control gear shall be carried out as specified under electrical plant and power systems.

3.18.8. Plant Electrical and power systems

For electrical plant and power systems the tests on Completion shall comprise pre-commissioning test “as detailed below, prior to energization from the power supply source followed by energization and demonstration of the operation of the Plant and associated protection and control systems to the specified performance requirements and maximum operating and load duties.

All tests shall be carried out by the Contractor under the supervision of and to the approval of the Employer.

3.18.9. Switchgear and Motor Control Centers

i. Insulation testing

Power, frequency and pressure tests shall be carried out on all equipment for operation on MV system.

For LV systems equipment insulation tests shall be carried out at 500 volt using an approved test instrument.

These tests shall be carried out with all circuit breaker- contactor panels closed in the circuit position, between phases and phase to earth. All secondary small wiring circuits shall be similarly tested.

ii. Mechanical tests

All mechanical tests specified for conducting on manufacturer’s premises are to be rechecked to ensure satisfactory operation in the final erected state.

iii. Protection and control circuits

The satisfactory operation of all current operated protection circuits over their whole operating range shall be tested by secondary current injection, where primary injection tests have been previously carried out on manufacturer’s premises.

Primary injection tests shall be carried out on restricted earth fault circuits after pilot circuits have been completed for stability and fault conditions. On transformer differential protection circuits where primary injection was not possible at the place of manufacture, the completed relay circuits are to be fully tested by secondary injection with simulated fault conditions. Stability tests are to be carried out using normal load conditions after the system has been completed and energized.

3.18.10. Instruments and metering equipment

Tests shall be carried out to ensure the correct operation of current and voltage operated indication instruments when energized by the actual supply system.

3.18.11. Continuity of earth conductors

Continuity tests shall be carried out on the earth conductor within the switchboard, such tests being done by current injection.

3.18.12. Rotating machines (motors)

Before the application of electric power on the machine windings, the insulation resistance shall be tested with a suitable insulation resistance tester, which shall be greater than the manufacturer's minimum recommended figure when corrected for Site winding temperature. Any necessary drying out of the windings on Site shall be in accordance with the manufacturer's recommendations.

Before rotating any machine under power, the mechanical alignment of the drive shaft with the driven load shall be checked (and adjusted if necessary) and shall be in accordance with the manufacturer's recommendation.

Before mechanically coupling any machine to the driven load, the direction of rotation shall be checked.

Before running any machine on-load, all heavy current connections shall be checked for correctness of make-up and tightness.

3.18.13. Earthing systems

The Contractor shall test that the resistance of the earthing network and electrodes are within the specified limits stated elsewhere in this document and in compliance with the Supply Authority's Regulations.

3.18.14. Electrical equipment and installations

The Contractor will in addition be responsible for arranging and carrying out such witnessed or un-witnessed tests and inspections as may be required by the Electric Supply Authority and obtain and hand over to the Employer their certificate of approval of the complete electrical installation.

3.18.15. Building and site services

The Contractor shall demonstrate that the building services and installations conform to the Specification and applicable local regulations.

The tests shall include but not limited to:

a. For lighting installations to demonstrate that the illumination levels conform to the specified values. The emergency light is good to go from Solar PV source installed for this purpose.

b. For ventilation and air-conditioning installations to conduct all operational tests for all plants.

The measurement of air ventilation and air volumes at test points shall demonstrate:

a. The specified performance duties of all installed fans.

b. The correct balancing of air duct systems, if applicable.

c. The satisfactory regulation of all air grills and diffusers to achieve the specified air flow rates at all points in the system.

d. The measurement and recording of noise levels to demonstrate compliance with the Specification.

3.18.16. Transformers

Routine and type tests shall be carried out on transformers to IEC 60076, IEC 60137, IEC 60296 & IEC 60060 or equivalent. Routine tests shall include:

i. Insulation resistance
ii. Ratio, polarity and phase relationship
iii. Measurements of winding resistance on all tap positions and phase
iv. Impedance voltage
v. Over voltage withstand
vi. Load loss
vii. Noise level

3.19. Training of Employees O & M staff

3.19.1. General

The Contractor shall impart training to the Employees staff on all aspects of plant operation for a period of one month. This will be in house on-the-job training after completion of testing and commissioning works before take over. The Contractor shall submit his staffing proposal to the Employer which will be for three shift operation per day and for the day maintenance staff. The staffing schedule shall be forwarded to the Employer 2 months before the commencement of commissioning and Reliability Trials period to enable the Employer to appoint /depute the required staff.

The staff will remain under the supervision and control of the Contractor for evaluating their capabilities and performance. The Contractor shall ensure that the staff is fully conversant with all aspects of plant operations and are capable to take over the plant after completion of their training.

3.19.2. Familiarization Programs

These programs shall be theoretical as well as practical during one month uninterruptable operation before take over. Theoretical programs shall cover all aspects of plant operation and maintenance through lectures and audio/video devices. As a minimum these shall comprise of:

(1) Day to day operation and maintenance procedures

(2) Proper procedures for carrying out repair and replacement works

(3) Trouble shooting

(4) Material procurement and storage

(5) Maintenance and janitorial services of the Plant

(6) Security

(7) Actions required under emergencies viz fire, earthquake and rains etc.

(8) Job description of all positions.

(9) Printed hand-outs in Urdu / English for each position holder for carrying out responsibilities described therein.

3.19.3. Practical training

This shall comprise of:

(1). OJT during one month uninterruptable run before take over,

(2). Daily job assignment as required on entire project.

Practical training to include BMS, Power Management Security software (if separate) and CMMS.

3.20. (Blank)

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3.21. Taking over

After satisfactory completion of all mechanical, electrical and civil works as per Contract provisions and on 15 days RR test completion of each generating unit, one month complete plant interruptible Reliability Run test period including passing Full Load Rejection & Full Performance Test , the Work shall be taken over by the Employer operator Engro as per provisions of Contract.

3.22. Defect Liability Period

After issue of taking over certificate by the Employer, except agreed upon extended warranty packages, the Defect Liability Period of minimum 12 months shall commence. The Contractor's responsibility at no additional cost in the Contract shall include but not limited to:

a. Providing skilled maintenance staff in each discipline for the whole period
b. Monitoring performance of the Work, especially the heat rate after planned outages.
c. Investigation fault in similar equipment under similar conditions
d. Rectifying fault at his cost with out delay. Any delay will attract cost of generation charged back for the down time of GTG-1/2.
e. Using required spares and own tools / consumables.
f. Issue proper report and reason / RCA for the occurrence of that defect and ensure that the same fault will not re-occur through the plant life.
g. Warranty management from owner side will be assigned at the start of defect liability period.
h. On components, parts and equipment effected with defect liability during liability will enter extended defect liability period but not more than 2 years in any case.
i. Defect investigation will be through a work permit system issued on contract's request to shift charge / owner warranty manager. Owner O&M staff will support / witness the defect investigation / rectification.
j. In case any consumables, spares or tools from owner inventory are used during defect investigation / rectification, same will be replenished by the contractor with out delay and no cost to owner. For this purpose a Contractor auditable debit / payback account will be opened in plant stores .

K. In case, contractor likes to pay in cash or kind, it shall be calculated on cost plus freight bases.

EMPLOYER'S REQUIRMENT FOR
MECHANICAL & ELECTRICAL WORKS

CHAPTER 04
MATERIALS & WORKMANSHIP
MECHANICAL WORKS

CHAPTER 4

MATERIALS & WORKMANSHIP
MECHANICAL WORKS

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CHAPTER 04
MECHANICAL WORKS

4.1. Introduction

This Chapter of the Specification sets out the minimum standards of materials, workmanship and design to be used by the Contractor for mechanical works. Reference to any specific material or equipment does not necessarily imply that such material or equipment is included in the Work.

All components/parts of the Work shall, unless otherwise specified, comply with the provisions of this Chapter unless overridden by the Employer's Requirements or be subject to the approval of the Employer.

4.2. Reference of Standards

All goods, materials and workmanship shall comply with the requirements of the latest issue (with up to date amendments) of the appropriate standard or standards of the British Standards Institution or, if none is applicable, with the standards of best practice.

Where standards other than British Standards are proposed by the Contractor in his tender, the acceptance of the tender based on such standards shall only signify the approval to the use of such standards, but shall not make the Employer liable to accept any standard subsequently found inferior to the corresponding British Standard. The Employer shall be empowered to reject any material components and workmanship found to be inferior to the appropriate British Standard and the Contractor shall make good the deficiency at his own expense.

The Contractor may propose at no extra cost to the Employer the use of any alternative relevantly authoritative and internationally recognized reference of standard which shall be no less exacting than the corresponding standard quoted in the Specification. The Contractor shall demonstrate to the Employer that the alternative standard is suitable and equivalent to the specified standard as well as provide proof of previous successful use.

4.3. Abbreviations for references of standard

The following abbreviations where used in the specification refer to standard; codes of practice and other publications published by the organizations listed below:

ACI	:	American Concrete Institute
ANSI	:	American National Standard Institute
API	:	American Petroleum Institute
ASA	:	American Standard Association
ASCE	:	American Society of Civil Engineers

ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
AWS	:	American Welding Society
AWWA	:	American Water Works Association
BS	:	British Standard Institute
CP	:	British Standard Institution (Code of Practice)
DIN	:	German Industrial Standard
HMSO	:	Her Majesty's Stationary Office
IEE	:	The Institute of Electrical Engineers
IEC	:	International Electro-technical Commission
I Mech E	:	The Institute of Mechanical Engineers
ISO	:	International Organization for Standardization
JIS	:	Japanese Industrial Standard
NEMA	:	National Electrical Manufacturers Association
SI	:	International System of Units
SIS	:	Swedish Standard Commission

4.4. Plant design and life

Plant must be designed with strong structure w.r.t seismic conditions, at highest degree of safety and reliability, dynamically well balanced, process, piping layout and equipment to result minimum losses of any form of energy, thus operating with highest possible efficiency, minimum heat rate and maximum allowable operating hours between the planned outages. The plant layout must have necessary lay down areas for planned / un-planned maintenance of each major equipment. The plant equipment must have necessary provisions for In-Service Inspection.
The plant as a whole including consumables, parts and spares shall be absolutely new, of sound workmanship, robustly designed for a long reliable operating life and shall be capable of 24 hours per day continuous operation for prolonged periods at site conditions and with minimum maintenance required. Particular attention shall be given to temperature changes, rust, dust, humidity and corrosion effects. The stability of paint finish must be for high temperatures. The IP rating, electrical machinery protection class, thermal overload, services, cooling systems and the choice of lubricants to be for possible high and prolonged operation at high ambient temperature.

The plant shall be designed to provide easy and safe access and replacement of component parts which are subject to wear, without the need to replace whole units except for consumable items. No part subject to wear shall have a life of less than five years from new to replacement or repair. Where major dismantling is unavoidable to replace a part, the life of such part shall not be less than ten years. Monkey ladders are not recommended for access.

Component parts shall be designed to be manufactured to strict limits of accuracy and to be interchangeable with parts of similar plant.

Design features shall include the protection of Plant against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Plant shall operate without undue vibration and parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service. Materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause which may have a detrimental effect upon the performance or life of the Work. All materials in contact with water shall be impervious to it and not impart taste, odor and toxicity or otherwise be harmful to health or adversely affect the quality of water conveyed.

Manually operated plant located outside a building or structure shall be vandal-proof in addition to any other requirement in the Specification in respect of security. Plant should be designed for minimum possible number of staff per operation shift and same needs be demonstrated by the contractor.

Outdoor equipment shall be weatherproof and designed to exclude dust and to prevent the collection of water at any point. Metal-to-metal joints will not be permitted and all external bolts or screw shall be provided with blind tapped holes where a through hole would permit the ingress of moisture.

Mechanisms shall be constructed of materials which will not corrode due to rust, corrosion, brine or dust. Bearings of exposed operating shafts shall be designed to prevent moisture seeping along the shaft into the interior of the equipment.

Equipment and instruments shall not be located in positions where they are vulnerable to falling objects or water drips. Weather shields shall be provided where necessary to protect equipment and instruments from the sun.

The Open Cycle Power Plant (OCPP) be designed to provide a highly reliable, efficient, and low cost means of generating electricity. Design features of the plant must be carefully considered, resulting in an optimum balance between capital cost and Operations and Maintenance benefits. The plant be also designed to minimize environmental impacts to the fullest extent possible by employment of the best available technologies and utilization of clean burning fuels.

The plant consists of the following major equipment:

- Two (2) GE US / ABB Germany - Swiss / SIEMENS Germany / HITACHI Japan or equivalent 2.5 MW each net to site conditions Combustion Turbine and preferably water cooled separate excitation controlled Generators with appropriate excitation and control systems.
- Two (2) inlet air filters unit / evap cooling, Inlet and exhaust preferably with Stack
- Two (2) Selective Catalytic Reductions (SCR) for NOx Control
- Two (2) CO Catalyst
- One (2) on line Water Wash Units
- One (1) Water Cooled or Air Condenser for cooling lube oil
- One (1) Water Treatment Plant if the owner supplied water found out of required specs,
- Balance of Plant Equipment Consisting of FOTP, Tank Farm Area, BMS, CCTV, Security, PA, Met (optional), Sludge Handling, BSDG, Pumps, Heat Exchangers, Transformers, Switchgear, etc.
- One (1) Integrated Plant Distributed Control System (DCS) / BOP Control per employers choice among various EPC contractor presented options,
- 11 kV Substation and associated Switchgear.

The plant be designed for base load operation, but must be capable of working under cyclic load conditions.

4.4.1. MAIN PLANT OPERATION,

Ambient air is drawn into the compressor element of the combustion turbine through the inlet air filtration and if silencing system where it is compressed to suitable atmospheres. Inlet air filtration be accomplished with a pad type filter. Fuel will be fired in the combustion section, and hot gases then expand through the turbine element. The combustion turbine has two functions: to produce electrical power through its directly connected water or air cooled Generator and to supply part of the hot gases to the HFO heating system (if possible to use part of it for building heating during winter season) and exhaust the rest where its monitored for continuous emission monitoring and control.
The combustion turbine is designed to be ignited with distillate and run with HFO. The combustion turbine will be designed for Dry Low NOx Combustor operation

Exhaust gases from the combustion turbine pass through the exhaust system and pass part of it for heating HFO and during winter season for building heating while un-used major part of it is open exhaust in a way to minimize the pollution in environment. . Further NOx control will be accomplished by the supply of the SCR system if possible. Also, a Continuous Emission Monitoring System (CEMS) is provided to monitor and control stack emissions.

By virtue of this cycle design, maximum power is generated at an economical energy cost, while maintaining the simplicity of the total plant arrangement. An off line combustion turbine compressor water wash system is provided to help maintain plant performance between maintenance outages.

4.4.2. ELECTRICAL

A conventional, conditioned ventilated, 11 kV substation arrangement is provided. The substation shall be per single line diagram for interconnection of 11 KV back up priority connection from WAPDA, BSDG and both GTGs in a fool proof synchronizing way via necessary capacity step-up transformer. Disconnect switches, instrument transformers, metering and protective relaying, as well as the steel structures and bus work, are provided.
Critical services, such as DCS power, field instruments, etc., will be served from the vital well designed power's uninterruptable power supply system via step down transformers.
Emergency and fence lighting will be via well designed solar system installed on plant roof for this purpose,
Various plant operating modes have been spelled out else where in this volume requesting vendor to come up with an electro-mechanical fool proof interlocks synchronizing system, using a reference bus or better option to synchronize all power sources.

4.4.3. INSTRUMENTATION AND CONTROL

The Distributed Control System (DCS) will be the principal operation and control system for the plant. The DCS being an on-line real time system that provides automatic operation, control, monitoring, and data trending and logging of all plant processes from the central control room by means of a control system which will provide for programmed sequence and analog control. The DCS continuously monitors the parameters of the plant process systems. The monitored data will be used by the DCS to determine whether the various processes are operating correctly, to identify any alarm conditions to the DCS operator, and to generate operating and management reports. The DCS automatically controls the operation of all process component systems to provide smooth control over design operating ranges. The DCS also provides to the control room operator interactive control stations. The operator utilizes the control stations for process system operations including start-ups and shutdowns and modification of operating parameter set points. The DCS provides parameters for control of the combustion turbine, Black Start Diesel Generator, FOTP, and other systems, including combustion turbine generator load selection, fuel controls, active and reactive load and voltage control, synchronizing controls, Fuel & Building Heating steam temperature and pressure control and monitoring.

The orientation of the plant must be selected in such a way to reduce environmental impact and optimize runs of interconnecting lines with the Fuel pipeline and the power sub station. The electrical switchgear, control room, and associated auxiliary equipment shall all be located within pre-engineered civil structured buildings. All other equipment shall be in controlled ventilated buildings. Sufficient operations, administrative and support facilities be provided. A central control room provides a controlled atmosphere from which to monitor and control plant functions. Plant computers and a programming office are located in the control room. Offices for plant management and administrative staff are also to be provided. Locker facilities are to be provided for operations and maintenance staff. A maintenance shop is also provided. Sufficient laydown area has been provided around the combustion turbine. Mobile crane access has been provided to facilitate maintenance of equipment located outdoors.

A tank farm area with 10-15 days full load fuel consumption and demineralized water storage tank is provided to store water from the plant water treatment system. An induced draft cooling tower system will provide the heat sink for the plant. Make up water will be provided by the owner from its RO plant output.

Site access roads are provided as required to permit normal operations and maintenance (including major equipment overhauls). A storm drainage system of swales and ditches is provided. Appropriate site lighting is provided. Potable water will be piped from the site boundary. Plant waste water will be treated and discharged. Sanitary wastes will be piped to an onsite septic system and leach field. Sludge and waste fuel handling will be provided with incinerator and associated equipment leading active disposal.

4.4.4. PLANT ARRANGEMENT

The overall site and building arrangement shall be developed to minimize space requirements while maintaining ample access for operation and maintenance activities. Future expansion of 2 more GTGs be considered to me well accommodated in the same building.

4.4.5. AUXILIARY SYSTEMS

Lubricating and Hydraulic Systems The lubricating provisions for the turbine and generator are incorporated into common lubrication system. Oil is taken from this system, pumped to a higher pressure, and used in the hydraulic system for all hydraulic oil control system components. The lubrication system includes oil pumps, coolers, filters, instrumentation and control devices, a mist elimination device and an oil reservoir.

4.4.5.1. Pumps

The lubrication system relies on several pumps to distribute oil from the reservoir to the systems which need lubrication. Similarly, redundant pumps are used to distribute high pressure oil to all hydraulic oil control systems components. These and other oil pumps are listed below.

- Lubrication oil pumps –
- Dual redundant ac motor-driven main lubrication oil pumps are provided. –
- A partial flow, dc motor-driven, emergency lubrication oil centrifugal pump is included as a back up to the main and auxiliary pumps.
- Hydraulic pumps - Dual redundant ac motor-driven variable displacement hydraulic oil pumps are provided.
- Seal oil pump - An auxiliary generator seal oil pump driven by piggyback AC/DC motors is provided as backup to distribute seal oil to the generator.
- Oil Pump for pressure lift journal bearings –
- Oil for the pressure lift bearings is provided by the hydraulic oil pump.

4.4.5.2. Coolers

The oil is cooled by dual stainless steel plate/frame oil-to-coolant heat exchangers with transfer valve. The coolers shall have an ASME code stamp.

4.4.5.3. Filters

Dual, full flow filters clean the oil used for lubrication. Each filter includes differential pressure transmitter to signal an alarm through the gas turbine control system when cleaning is required. A replaceable cartridge is utilized for easy maintenance. Filters have an ASME code stamp.

Dual filters clean the oil for the hydraulic system. Each filter includes a differential pressure transmitter to signal an alarm through the gas turbine control system when cleaning is required. A replaceable cartridge is utilized for easy maintenance. Filters must have an ASME code stamp.

4.4.5.4. Mist Elimination

Lubrication oil mist particles are entrained in the system vent lines by seal air returns of the gas turbine lubricating system. In order to remove the particles, a lube vent demister is used as an air-exhaust filtration unit. The demister filters the mist particles and vents the air to the atmosphere while draining any collected oil back to the oil reservoir. The lube vent demister assembly consists of a holding tank with filter elements, motor-driven blowers, and relief valve. One assembly is provided for the vent line from the lubrication oil reservoir.

Oil Reservoir The oil reservoir should have enough economical capacity per OEM advised capacity gallons and mounted within the accessory module. It is equipped with lubrication oil level switches to indicate full, empty, high level alarm, low level alarm, and low level trip. In addition the following are mounted on the reservoir:

- Oil tank thermocouples
- Oil filling filter
- Oil reservoir drains

4.4.5.5. **Inlet Filtration**

If feasible, a suitably sized Inlet Filter Compartment must be well designed per laid down criteria else where in this volume Dust-laden ambient air flows at a very low velocity into filter modules which are grouped around a clean-air plenum. The filter elements are pleated provide an extended surface. The air, after being filtered, passes through venturis to the clean air plenum and into the inlet ductwork.

The filter elements are contained within a fabricated steel enclosure which has been specially designed for proper air flow management and weather protection.

4.4.5.6. Inlet System Instrumentation

Inlet System Differential Pressure Indicator Standard pressure drop indicator (gauge) displays the pressure differential across the inlet filters in inches of water. Inlet System Differential Pressure Alarm When the pressure differential across the inlet filters reaches a preset value, an alarm is initiated. This alarm may signify a need to change the filter elements.

4.4.5.7. **Exhaust System**

The exhaust system arrangement includes the exhaust diffuser section in which a portion of the dynamic pressure is recovered as the gas expands. The gas then flows axially into the exhaust system.

4.4.5.8. **Gas Turbine Packaging Enclosures**

Gas turbine enclosures consist of several connected sections forming an all weather protective housing which may be structurally attached to each compartment base or mounted on an off-base foundation. Enclosures provide thermal insulation, acoustical attenuation, and fire extinguishing media containment. For optimum performance of installed equipment, compartments include the following as needed:

- Ventilation
- Heating
- Cooling In addition, enclosures are designed to allow access to equipment for routine inspections and maintenance
- . Acoustics Lagging consisting of glass wool protected with perforated metal is used the interior of the side and roof panels of the turbine and accessory

compartments for acoustical attenuation

4.5. Painting

The exteriors of all compartments and other equipment are painted with two coats of alkyd primer prior to shipment. The exterior surfaces of the inlet compartment and inlet and exhaust duct are painted with one coat of inorganic zinc primer. Interiors of all compartments are painted as well with the turbine compartment interior receiving high-temperature paint. The interior and exterior of the inlet system is painted with zinc rich paint.

4.6. Lighting

AC lighting on automatic circuit is provided in the accessory compartment. When ac power is not available, a dc battery-operated circuit supplies a lower level of light

4.7. Fire Protection System

Fixed temperature sensing fire detectors are provided in the gas turbine accessory and liquid fuel/atomizing air compartments, and #2 bearing tunnel. The detectors provide signals to actuate the low pressure carbon dioxide (CO_2) automatic multi-zone fire protection system. Nozzles in these compartments direct the CO_2 to the compartments at a concentration sufficient for extinguishing flame. This concentration is maintained by gradual addition of CO_2 for an extended period.

The fire protection system is capable of achieving a non-combustible atmosphere in less than one minute, which meets the requirements of the United States National Fire Protection Association (NFPA) # 12.

The supply system is composed of a low pressure CO_2 tank with refrigeration system mounted off base, a manifold and a release mechanism. Initiation of the system will trip the unit, provide an alarm on the annunciator, turn of ventilation fans and close ventilation openings.

4.8. Cleaning Systems

Compressor water wash is used to remove fouling deposits which accumulate on compressor blades and to restore unit performance. Deposits such as dirt, oil mist, industrial or other atmospheric contaminants from the surrounding site environment, reduce air flow, lower compressor efficiency, and lower compressor pressure ratio, which reduce thermal efficiency and output of the unit. Compressor cleaning removes these deposits to restore performance and slows the progress of corrosion in the process, thereby increasing blade wheel life.

4.9. Starting System

4.9.1. Cooldown System

The cooldown system provides uniform cooling of the rotor after shutdown. A low speed turning gear with motor is used for the cooldown system.

Starting is through a starting electric motor engaged on starting command that disengages the turning gear and keep it engaged till the OEM designed speed followed by ignition and combustion.

4.9.2. Equipment Low Speed Turning Gear

The turning gear assembly is located on the collector end of the generator and is used for slow speed operation (approximately 6 rpm), cooldown and standby turning, and rotor breakaway during startup

4.9.3. COMBUSTION TURBINE AND STATIC EXCITATION SYSTEM

4.9.4. ELECTRICAL RATING

The generator is designed to operate within Class "B" temperature rise limit per ANSI standards, throughout the allowable operating range. The insulation systems utilized throughout the machine are proven Class "F" materials. The generator is designed to exceed the gas turbine capability at all ambient conditions between 0 and 50 deg C .

4.10. Packing

The generator shall be designed for compactness and ease of service and maintenance. Location permitting, the unit ships with the rotor, gas shields and end shields factory assembled. The high voltage bushings, bearings, oil deflectors, seals, and coolers be factory assembled. The collector cab ships separately for assembly to the generator at the customer site. Clearances of the bearings, rub rings, fans, seals and deflectors are factory fitted and only require a minimum amount of field inspection these components. Prior to full assembly, the generator stator receives a pressure test at 150% of operating pressure followed by a leakage test at 100% of operating speed. Feed piping between the bearings are stainless steel and mounted on the unit in the factory to a common header. All connections to the end shields are assembled. All assembled piping is welded without backing rings and a first pass TIG weld. A full oil flush is performed prior to shipping**.**

4.11. FRAME FABRICATION

The frame is a stiff structure, constructed to able to withstand in excess of 14 kg/cm2 (200 psi). It is a hard frame design with its four-nodal frequency significantly above 120Hz.
The ventilation system completely self contained, including the water coolers within the structure. The structure is constructed of welded steel plate, reinforced internally by radial web plates and axially by heavy wall pipes, bars and axial braces.

4.12. **CORE**

The core is laminated from grain oriented silicon steel to provide maximum flux density with minimum losses, thereby providing a compact electrical design. The laminations are coated on both sides to ensure electrical insulation and reduce the possibility of localized heating resulting from circulation currents. The overall core is designed to have a natural frequency in excess of 170 hertz, well above the critical two-per-rev electromagnetic stimulus from the rotor. The axial length of the core is made up of many individual segments separated by radial ventilation ducts. The ducts at the core ends are made of stainless steel to reduce heating from end fringing flux. The flanges are made of cast iron to minimize losses. To ensure compactness, the unit receives periodic pressing during stacking and a final press in excess of 700 tons of stacking.

4.13. LEAD CONNECTIONS

All the lead connection rings terminate at the top of the excitation end of the unit and the six high voltage bushings (HVBs) exit at the top of the frame. Each of the circuits are connected to the high voltage bushings (HVBS.) The bushings, which provide a compact design for factory assembly and shipment, are positioned in the top of the frame and are offset to allow proper clearances to be maintained. This configuration also allows connections to the leads to be staggered and provides ease of bolting and insulation. The bushings are made up of a porcelain insulators containing silver plated copper conductors which form a hydrogen tight seal. The bushings are assembled to non-magnetic terminal plates to minimize losses. Copper bus is assembled to the bushings within an enclosure. Customer connections are made beyond the terminal enclosure and the specific mating arrangements are provided within the enclosure, not inside the generator.

4.14. LUBRICATION SYSTEM

Per OEM design, preferably the lubrication for the generator bearings is supplied from the turbine lubrication system. Generator bearing oil feed and drain interconnecting lines are provided, and have a flanged connection at the turbine end of the general package for connection to the turbine package.

4.15. GENERATOR TERMINAL ENCLOSURE.

The Generator Terminal Enclosure (GTE) is a reach-in weather-protected enclosure made of steel and/or aluminum and is located on the generator. The GTE is convection cooled through ventilation louvers to the outside of the enclosure.

The louvers are designed to inhibit debris from entering into the compartment.

The GTE houses the following major electric components:

- Neutral current transformers (CTs)
- Line CTs
- Lightning arresters
- Neutral grounding transformer with secondary resistor
- Fixed voltage transformers (VT)
- Disconnect switch
- Motor operated neutral disconnect switch

4.16. **VOLTAGE REGULATOR**

The generator field current and terminal voltage is controlled by a combined AC/DC (manual) regulator. The DC (manual) inter control loop controls generator field current with setpoint normally provided by the AC regulator output. The AC regulator controls generator terminal voltage with reactive current compensation

4.17. CONTROL SYSTEM
I4.17.1. INTRODUCTION

The control system for the open cycle generation plant has been designed to provide the following features:
Flexible Operation: The plant provides independent plant operating configurations at levels of automation which provide the user with complete flexibility in the starting and loading of the individual subsystems either of the combustion turbine (CT), BSDG and the BOP.

- Safe Operation: Start-up and loading of the entire plant can be accomplished without risk to equipment from the central control room.
- Flexibility to accommodate the future addition of hardware and software.
- Color graphic operator stations.
- Installed spare I/0 and layout space for additional I/0.

4.17.2. CONTROL SYSTEM DESCRIPTION

The control system for the gas turbine, BSDG and major balance of plant equipment (not packaged) utilizes a 32-bit microprocessor based Distributed Control System (DCS) on a data highway which permits automatic operation of the complete plant. The operator is provided with interface equipment, information and display devices, and protection devices to ensure confident, safe and efficient operation. The control system, along with associated safety systems, is partitioned according to major plant subsystems, thereby increasing the plant availability and operating flexibility to meet the needs of the operator. Using field proven hardware, the control system generates command signals to devices such as fuel, water injection and combustion turbine inlet guide vanes, and display devices as a function of inputs from the plant sensors and operator inputs.

4.17.3. Control Levels

The control system allows the operation of major subsystems at two operating control levels, namely Operator Automatic Control Level and Manual Control Level.

1. Operator Automatic Control Level

At this level, the system will automatically implement all the monitoring, controlling, operator’s interface and primary information and display functions for each major subsystem. The system requires that the initial sequencing of the various major subsystems and loading are the responsibility of the operator.

2. **Manual System Control**

The control system, through interactive operator stations, may be utilized to control selected equipment as long as it does not interfere with plant protection. Functions required to make the transition from the cold shutdown condition to the ready-to-start conditions are at the manual control level and include operating equipment such as: water and fuel supply block valves, drain valves and process pump controls.

3. **Operator Console(s)**

- Central Control Room. The interactive operator console includes CRT's with color graphic displays and operator keyboards required to control the turbines and water, Oil and fuel cycle. In addition, a single screen engineer's station is provided for the control system modifications, configurations, and maintenance. The expected use of these CRT's is as follows:

- Overall plant summary
- Combustion turbine
- Black Start DG
- Balance of plant
- Plant alarms

The consoles have preprogrammed color graphics pages with dynamic data update and various video enhancements such as reverse video, blinking, scrolling, etc. Pages will include:

1. Alarm Review - A list of all active alarms and their times of occurrence. Alarms will be highlighted until acknowledged. For the sequence of events alarms, the first out alarms are highlighted.
2. Maintenance Display for DCS equipment status
3. Selected Group Review
4. Data Trend
5. Quality of Points Review
6. Plant Graphics for each area of the plant
7. Annunciator Panel Graphic

The DCS graphics displays negate the need for a hard-wired alarm annunciator panel. The alarm annunciator graphic contains alarm "windows" to provide visual backup to critical alarms being printed on the alarm summary. It is expected that one CRT display will be dedicated to the alarm graphic. The DCS graphics also negate the need for a mimic panel. Both high level and detailed P&ID type displays provide the operator a clear understanding of the process. Process schematics and the one line schematics are overlaid with real-time data to maximize operator's knowledge of system performance. DCS graphics are arranged in a hierarchical or tree structure starting with the unit overall performance summary with branching into each major component; CT, BSDG, FOTP, FAS, and B.O.P. In addition to the operator consoles, the central control room contains a hardware type critical operator panel with pushbuttons for tripping the combustion turbine, BSDG etc

4.17.4. Plant Control Equipment

Local control equipment is provided to control CT and BSDG functions as well as the continuous emissions monitoring system (CEMS). These local controls communicate with the control room DCS to provide a single point for plant control, operation and system status. Vendor will also provide PC's for monitoring and control of the CT and BSDG as well as vibration monitoring. Additionally, local instrument panels are located throughout the plant consisting of gages, transmitters, converters and transducers related to control and monitoring of the various processes.

DCS equipment located in the main control room include:

1. One (1) multiple CRT Operator console.
2. One (1) Engineer's console.
3. Plant logger.
4. Historical Storage and Retrieval.

DCS located remote from the control room include those that interface with:

1. Combustion turbine functions
2. BSDG functions
3. B.O.P. functions
4. FOTP, FF, and CEMS etc functions

4.17.5. CONTROL PHILOSOPHY

- The following control philosophy is used on individual major components and systems. This control philosophy permits efficient plant operation with a minimum of control room operators and roving plant operators.
- Sufficient and accurate information is provided at the central control room operator consoles to permit safe start-up/operation and rapid operator response to plant anomalies.
- It shall be necessary for the roving operators to place auxiliary equipment into operation manually at the equipment location or at a motor control center in order to establish ready-to-start status.
- The control system provides sufficient protective features to ensure safe operation. The system has built-in logic and circuitry to alarm, annunciate and trip as a result of any abnormal operating condition. Logic is employed to provide interlocks wherever it will improve plant availability and will prevent the operator from exceeding design limits
- Major safety protection systems are inherent to the basic control system, such as over speed trips, reverse current trip of the generator, etc. The use of such protection systems is in accord with accepted power plant practices. Manual trips are provided for all energy input components; e.g., fuel and control valves.

4.17.6. Combustion Turbine Control

The combustion turbine control system provides the operator with one-button automatic start-up from a cold condition to base load. When desired, the operator may elect to synchronize and load the generator manually from the electrical/control package, otherwise synchronization is automatic. Start-up and operation of the combustion turbine requires status information which is generated by position switches, temperature measurements, pressure switches and other instrumentation. This information is sent to the control through transducers, amplifiers, isolation transformers, and other signal conditioning equipment

4.18. PLANT ELECTRICAL SYSTEMS

4.18.1. Conceptual

A major objective of this plant design is to promote safety, flexibility, reliability, economy and consistency in the electrical design effort, which also encompasses engineered mechanical "packages" that include electrical apparatus, materials and systems as an integral part.

The primary consideration in the design of the electrical system is that the plant must have external power from the utility system or other source to start. In addition, depending on length of shutdown and ambient conditions, some supplemental power for heating and/or cooling may be required before a start can be initiated.

The plant will have an 11 kV substation that will connect main plant and an 11 KV Wapda back up priority connection. BSDG will be tied on 400 Volts bus. Ref plant various operation modes, contractor needs to study single line electrical conceptual drawing and come back with detailed system one line drawing to have a fool proof synchronizing and normal / essential electrical distribution system besides BSDG load sequencing and essential lighting solar PV system.

The single line diagram depicts the major electrical system and devices. Synchronization of the CTG , BSDG and Wapda back up interconnection will be accomplished across their respective 11 KV / 400 Volts circuit breakers.

The switchyard consists of three generator step-up transformers, three 11 kV power circuit breakers, disconnect switches, instrument transformers, surge arresters, substation steel structures, a separate control room and protective relaying equipment. The combustion turbine generator and black start generator are each connected to their own two-winding; outdoor, oil filled step-up transformer of necessary rating, Vacuum Circuit Breakers and necessary switchgear / protection.

125 V Auxiliary DC System Emergency power at the main plant is afforded through station batteries and an uninterruptible power supply to provide power for critical processes and instrumentation/ control system loads to effect a safe and orderly shutdown of facility operation. Components included in this system are located in the turbine building and are:

- Battery System
- Battery Chargers
- DC Motor Control Centers

4.18.2. **Uninterruptible Power Supply BATTERY SYSTEM**

)The battery system comprises necessary quantity of lead-acid type cells and provides 125 Vdc. The batteries are rack mounted in a separate ventilated room in the turbine building.

4.18.3. **BATTERY CHARGER**

The battery charger fulfills the dual function of providing power to the DC bus during normal operation as well as maintaining a float charge on the unit battery. The charger contains a solid-state rectifier and front mounted output voltmeter and ammeter. Three phase power is supplied to the charger from a 440V Motor Control Center.
Output 125 volt DC voltage is automatically regulated to ± 1 % with load variations of 0 to 100%. A low voltage relay provides an alarm if the DC bus voltage drops to a dangerously low level.

U4.18.4. UINTERRUPTIBLE POWER SUPPLY

The uninterruptible power supply provides 120V AC single-phase power for critical loads in the central control room and in the combustion turbine Electrical/Control Package. The UPS system consists of an inverter, a static switch, a manual bypass switch, a regulated alternate power source, and an AC panelboard. DC power is provided from the battery system.

4.19. Workmanship

Workmanship and the general finish of Plant installations shall be of first class commercial quality and in accordance with the best workshop practice and shall be performed by persons skilled in their respective trades.

Pipe work, fittings, cables, cable trays, etc, shall be fitted in a neat, straight and symmetrical manner so as to present a pleasing appearance.

Indicating gauges fitted to machine assemblies or to control panels shall generally be of similar style and grouped in a neat manner.

External welds and flame cuts shall have a smooth finish by means of careful grinding. Floor plate covering shall be fixed squarely in their frames and with their patterns lined-up. Hand railings shall be free from burrs.

4.20. **Welding**

All welding electrodes, wire and fluxes shall be stored in a clean dry place and protected from all forms of deterioration. All welding consumables shall be properly identified and shall retain their identification up to the time of use. Each batch of electrodes and wire shall be identifiable with the respective manufacturer’s test certificate and advice note and shall be used in strict delivery rotation.

Gas cylinders shall be supplied to the site marked in accordance with the requirements of ISO 8448. They shall be stored under a suitable sunshade.

All welding equipment shall be of sufficient capacity and be maintained in such a condition as to ensure welds of acceptable quality throughout the range of electrode sizes to be used on the work.

Welding machine earth or ground leads shall be firmly fixed to the workplace. Welding cables shall be maintained in good condition and shall be free from kinks and loose connections.
Welders and welding shall be protected by suitable equipment from wind, airborne sand and moisture. Work shall not be performed when weather conditions do not permit satisfactory workmanship or adequate inspection.

Weld preparation profiles may be prepared by machine, shear, flame or plasma cutting followed by grinding and shall be performed carefully and accurately. Whenever possible, a mechanically guided tool shall be used for flame or plasma cutting. All edges shall be left free of slag, burs, fins, oxides and foreign matter and the finished profile shall conform to the design tolerances for the weld preparation.

Tack welding of weld preparations may be permitted but all tacks must be ground to a feather edge prior to completing the next pass.

Where spacer strip or bridging pieces are used, due care shall be taken when tack welds are removed.

All scars and blemishes shall be grounded prior to submitting the weld for inspection.

Where preheating is required, preheat and inter-pass temperatures shall be checked by temperature recorders on indicating crayons at a distance of not less than 75 mm from the weld groove. The use of hand held torches for heating will not be permitted.

Work which is subjected to heat treatment by use of electricity heated elements shall be monitored by suitable thermocouples connected to a chart recorder. A minimum of two thermocouples shall be used.

All slag, excess filler metal and surface irregularities shall be removed between weld inter-pass runs. Flame gouging is prohibited.

Welding on attachments such as lugs, cleats, supports etc shall be positioned well clear of all pressure retaining welds carrying principal stresses. If it is found essential to bridge or span a principal weld, then the attachments shall be designed so as to ensure that no further weld is positioned within 40 mm of the principal weld.

All tube butt welds shall have full penetration with a maximum of 3 mm excess penetration in the root run. The surface of the finished weld shall not be concave.

Unless otherwise specified, welds subject to radiographic, ultrasonic or other forms of non-destructive test shall be dressed to a smooth contour. Care shall be taken to blend weld and parent metal without under flushing. All weld dressings shall be carried except where otherwise specified or ordered by the Employer.

Mechanical and other non-radiographic test, if required, shall be carried out in the presence of the Employer.

Welder shall be qualified in accordance with the requirements of the appropriate section of BS 4872 or BS 4871 whichever is applicable.

4.21. **Castings**

The structure of castings shall be homogeneous and free from non-metallic inclusions and other defects. Surfaces of casting which are not machined shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 10 mm in depth or 10% of total metal thickness whichever is less and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques.

If the removal of metal from repair reduces the stress-resisting cross-section of the casting by more than 25% or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25% then the casting shall be rejected.

Castings repaired by welding for major defects shall be stress-relieved.

Non-destructive tests may be required for any casting containing defects whose effect can otherwise be established, or to determine that repair welds have been properly made.

Unless otherwise specified, casting shall be produced to the following standards or equal:

Grey-Iron	BS 1452	Grade 220
Carbon Steel	BS 3100	Steel alloy
Stainless Steel	BS 3100	Steel 316 C16
Copper & Copper alloy	BS 1400	Group A grade LG2
		Group B grade CTI, AB2
		GRAD C grade G 1

4.22. **Forgings**

Major stress-bearing forgings shall be made to a standard specification. They shall be subjected to internal examination and non-destructive tests for the detection of flaws and shall be heat-treated for the relief of residual stress.

4.23. **Nuts, bolts, studs and washers**

Nuts and bolts for pressure fittings as a minimum shall be of zinc plated high quality steel machined on the shank and under the head and the nut. Bolts shall be of such a length that only one to three-threads shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a tight driving fit in the reamed holes they occupy, they shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

When there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions. All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel or brass.

The Contractor shall supply all holding down, aligning and leveling bolts complete with anchorages, nuts, washers and packing required to attach the plant to foundations.

Unless otherwise necessary to meet special requirement all threads shall be have preferred metric sizes with standard coarse thread.

ISO metric black hexagon bolts, nuts and screws shall comply with S11 0585-81, or ISO 885, ISO 888, ISO 898-1 and ISO 898-2 and BS 4190 strength Grade 4.6.

ISO metric precision hexagon bolts, nuts and screw shall comply with ISO 272. ISO 4759-1, ISO 885, ISO888 898-1 and 2 or ASTM F-593, ASTM F-468M, strength Grade 8.8 and BS 3692 strength Grade 8.8.

The dimensions of metric countersunk head bolts, screws and hexagon nuts shall comply with ISO 225 or ISO 888 or ISO 898-1.

Plain steel washer for use with ISO metric bolts shall comply with ISO 887 or ASTM F-884.

Taper steel washer shall comply with ASTM F-844 and ASTM F-436.

4.24. **Non-metallic materials**

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated with an approved fungicide. Sleeves and fabrics treated with linseed oil varnish shall not be used.

The use of organic materials shall be avoided as far as possible, but where these have to be used, they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be seasoned teak or similar hardwood which is resistant to fugal decay and free from distortion and faults.

Woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these Joints in woodwork shall be dovetailed or tongued and pinned. Metal fitting on wood shall be of nonferrous material. Adhesives shall be impervious to moisture and fungus growth. Synthetic resin cement only shall be used for joining wood. The use of casein cement will not be permitted.

4.25. **Guards for moving parts**

All moving parts shall be protected by safety guards. Guards shall be rigid, securely fixed and designed to allow normal operation, running, maintenance and routine inspection to be carried out on equipment without the need to remove the guard. Where this is impractical, guards shall be designed for easy fixing, dismantling and re-assembly.

4.26. **Safeguarding of Plant**

The Contractor shall ensure that the whole of the Work as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise suppression devices, written notices, safety colours and the like shall be provided where necessary during erection and as a permanent feature.

Plant layout shall be designed to provide easy and safe access to valves hand wheels, electrical equipment, instruments and any other operating devices, free from hazardous obstructions.

Nothing in the Specification shall remove the Contractor's obligation from drawing the attention of the Employer to any feature of the Work which is not consistent with safety or prevents him from making proposals for incorporating equipment of design which would increase the safety of the Plant.

4.27. **Rating plates, name plates and labels**

The Contractor shall supply a friendly Plant identification system showing the name and number of each item of the Plant and its respective arrangement drawing number and add any additional items necessary to fully identify it. (not like KKS which is not user friendly)

The Contractor shall supply all labels, nameplates, instruction and warning plates necessary for the identification and safe operation of the Plant.

All such labeling shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives will not be permitted.

Nameplates for plant, and equipment identification and record purposes shall be manufactured from stainless steel with a matt or satin finish and engraved with black lettering of a size which is legible from the working position.

Warning plates/labels shall be manufactured from stainless steel engraved with white lettering on a red background and sited in the position where they afford maximum safety of personnel.

All equipment within panels and desk shall be individually identified by satin or matt finish stainless steel labels or laminated plastic labels where approved.

Pipe work systems shall be color coded in accordance with the requirements of BS 1710.

Each valve shall be fitted with a stainless steel nameplate indicating the valve service and reference where nameplates shall be circular and fitted under the hand wheels captive nut. They have to be of such a diameter that there is no danger for persons operating the valve or that they do not prevent lock-off of the valve. For check valves and small valves, the Contractor may provide rectangular nameplates fitted to brackets on the valves or attached to a wall or steel work in convenient positions adjacent to the valves.

4.28. **Lubrication**

4.28.1. **General**

Items of Plant shall be lubricated as necessary to ensure operation, heat removal and freedom from undue wear. Lubricated items shall be designed so that they do not require more than monthly lubrication attendance, unless otherwise required.

All grease nipples, oil cups and dip sticks shall be readily accessible, being piped where necessary to convenient positions.

The Contractor shall supply first fill of oil and grease for both Plant and maintenance equipment. In addition, the Contractor shall provide adequate supplies of lubricants for all equipment sufficient for 12 months of normal operation from the date of the Taking Over.

A complete schedule of recommended oils and other lubricants shall be provided by the Contractor as part of the Operating and Maintenance Manuals. The number of different types of lubricants shall be kept to a minimum. In the case of grease lubricated ball and roller bearing, a lithium based grease is preferred.

4.28.2. **Oil lubrication**

Oil reservoirs shall be fitted with oil-level indicators of the sight glass type, or where this is not practicable, with dipsticks. The normal, maximum and minimum levels shall be clearly visible to an operator standing on the normal access floor to the particular item of plant. The sight glasses stall be made from toughened glass, easily dismantled for cleaning and in exposed situations, fitted with the guards.

Drain points shall be located or piped to such a position that an adequately sized container can be placed beneath them.

For forced oil lubrication systems, the pressure shall be monitored during operation with automatic shutdown of the machine and alarm on low oil pressure.

All oil lubricated machinery shall utilize a common grade of oil which is readily available in Pakistan. High temperature high performance lubricates shall be avoided as far as possible.

4.28.3. **Grease Lubrication**

Grease lubrication shall be for steel lubrication nipples manufactured in accordance with BS 1486.

A separate nipple shall be provided to secure each lubrication point. Where a number of nipples supply remote lubricating points, they shall be grouped together on a conveniently placed batter plate, with spacings in accordance with BS 1486.

The Contractor shall provide a grease gun for each size and type of nipple installed. Where different types of greases are involved, separate grease guns shall be provided for each type. They shall be suitably labeled and if possible of different style to prevent incorrect greasing.

4.29. **Joint rings & Gaskets**

Joint rings shall be manufactured to conform with BS 2194 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80 ^{o}C or greater to suit the application.

Joints shall be made in accordance with manufacturer's instructions or as specified herein. Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituents soluble in water. They shall be suitable for the climatic conditions at site and shall contain an approved bactericide.

Graphite grease or similar shall be applied to the threads of bolts before joints are made.

4.30. **Electroplating, galvanizing and sherardising**

Parts to be galvanized, other than nuts, bolts and fasteners, shall be hot dip galvanized to BS 729 to give a minimum average coating of 610 g/m^2 area covered and a zinc thickness of not less than 85 microns.

Where specified, nuts, bolts and fasteners to be galvanized shall be hot dip galvanized to BS 729 to give a minimum average coating of 305 g/m^2 and a zinc thickness of not less than 43 microns. Where hot dip galvanizing is not practicable, nuts, bolts and fasteners shall be sherardised. Sherardising shall be in accordance with BS 4291, the thickness of zinc coating being not less than 30 microns.

Where chromium plating is used, it shall comply with the requirements of BS 1224 including the provision that no blistering of any surfaces will be accepted. For all base metals, the service condition number 2 shall be used.

4.31. **Noise**

The Plant shall be designed and constructed to reduce the operating noise level as much as possible. During periods of short duration or abnormal operation (e.g. during startup) higher noise level up to an additional 20 dB (A) may be acceptable at the discretion of the Employer.

Except as provided for below, the noise emitted by any single item of the Plant shall not exceed a sound pressure level of 85 dB (A) when measured at a distance of 1 m from the reference surface of that item in a horizontal direction and under the environmental conditions appropriate to the test requirements of ISO 3746 “Acoustic Determination of Sound Power Levels of Noise – Survey Methods” or the equipment ANSI S1 36.

The Contractor shall carry out noise tests on Site if in the opinion of the Employer, the Plant is excessively noisy. Sound pressure levels shall be measured in dB (A) using a calibrated sound meter meeting the requirements of BS 4197 with a response speed set to “Slow”. The background noise level shall be at least 10 dB (A) below the operating noise level of the machine or other item of the Plant.

For major items of the Plant, the Contractor shall provide workshop certificates from the manufacturer covering noise level tests carried out on the items or type test certificates for similar items of the Plant.

If any item of Plant in its standard built, does not comply with the above requirement, the Contractor shall be required to reduce the sound pressure level by providing improved or additional silencers or fitting sound insulating materials to the item, until the requirement is met.

Noise levels in control rooms and offices shall not exceed 45 dB (A) with equipment such as printers in operation and in local plant control rooms it shall not exceed 70 dB (A).

The background noise level at any point along the boundary of the Site, arising from operation of the Plant shall not exceed 65 dB (A).

4.32. **Vibration**

All rotating elements shall be dynamically balanced so that the level of vibration at any point on a machine when operating at Site, either singly or with other machines, and at any speed throughout the operating range shall be within the limits of Class IV, Grade B as defined in BS 4675 Part 1.

“Machine” shall mean a complete assembly including its drive shafting, motor and bedplate, generator, and compressor etc.

Pipe work, valves and other equipment connected to the machine or forming part of the operating system, shall be with provided adequate supports, brackets and fixtures, as necessary to restrict any induced vibration to a minimum under any operating condition.

Vibration measurements shall be taken on Site by the Contractor at various points on each complete machine as defined above.

Measurements shall also be taken on connecting Plant. If any item is found to be vibrating beyond the level considered by the Employer to be reasonably minimum for the particular Item, the Contractor shall take further steps to bring vibration to the required level. Equipment with unacceptable vibration levels may be rejected if the Contractor is unable to achieve satisfactory operation of the equipment involved.

4.33. **Corrosion and erosion**

The Contractor shall make proper provision for the prevention of corrosion and erosion in any part of his Plant. Such provision shall include the use of suitable materials, choice of operating speeds, design of components and type of protective coating and finishes. Particular attention shall be given to the Plant that may be exposed to water from different sources with varying characteristics and possible galvanic reaction with dissimilar metals.

4.34. **Precautions against dampness**

Special precautions shall be taken to prevent corrosion due to humidity, rainfall and moisture.

All wall-mounted equipment shall be fitted with spacers to provide a minimum gap of 5 mm.

All holes in the equipment shall be effectively sealed against the ingress of water. All items exposed to weather or water shall be free of water traps. Where necessary drain holes shall be provided to prevent the accumulation of water.

All fixings, fastenings and spacers which may be submerged in a corrosive liquid shall be galvanized or sherardised, unless otherwise specified.

All electrical equipment which is not sealed against free movement of air shall be protected from condensation with anti-condensation heaters. In general these heaters shall be thermostatically controlled and switched off when heat is generated by the operation of the Plant.

In choosing materials and their finishes due regard is to be given to the conditions under which the equipment is to Work. Tropical duty materials should be used throughout the Plant.

Iron and steel are to be painted or galvanized in accordance with the Specification. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting, Cores etc which are built up of laminations or cannot for any other reason be antirust treated are to have all exposed parts cleaned and heavily enameled or lacquered.

When it is necessary to use dissimilar metals in contact these should be so selected so that the electrochemical potential difference is not greater than 250 milli-volts and if practicable the two metals are to be insulated from each other by an approved insulating material or by a coating of approved varnished compound.

The use of iron and steel is to be avoided in instruments and electrical relays wherever possible. Steel screws when used are to be zinc, cadmium or chromium plated or when plating is not possible owing to tolerance limitations, are to be of corrosion resisting steel. Springs are to be of brass, bronze or non-rusting material. Pivots for which non-ferrous material is unsuitable are to be of approved rust proof steel where possible.

The use of wood within electrical and mechanical equipment is to be avoided as far as possible and, if used shall be of a type resistant to termite attack and fungal decay.

The use of hygroscopic insulating materials is not permitted except immersed in oil or otherwise suitably sealed to prevent ingress of moisture.

In choosing materials and their finishes due regard is to be given to the conditions under which the equipment is to Work. Typical duty materials should be used throughout the Plant.

Springs are to be of brass, bronze or non-rusting material. Pivots for which non-ferrous material is unsuitable are to be of approved rustles steel where possible.

4.35. **Protective finishes**

The surfaces of Plant shall be fully protected against corrosion and erosion with the exception of steel or similar corrosion resistant material or where the surface is required to be clear for operational purpose, e.g at glands, bearing, etc.

Parts to be galvanized shall be designed to avoid overlapping surfaces and narrow gaps and pockets which may trap pickling acid. Thermal distortion or the creation of unacceptable residual stresses should not occur.

Nuts, bolts and fasteners shall be of stainless steel Grade 316 S312 or shall have corrosion, resistant finish. Galvanizing, sherardising, or electroplating of fasteners shall be to BS 3353. Cadmium plating shall not be used.

The paint protection system shall be obtained from the same manufacturer and applied strictly in accordance with the manufacturer's instructions and requirements and in accordance with BS 5493 and 6160. The Contractor shall be responsible for cleaning surfaces and preparing them for protective treatment and protective coatings applied at the place of manufacture and at Site. Coatings shall not be applied to external surfaces at Site during rain, fog, mist or condensation or when wind borne dirt and dust are present or likely to be present before the coating is dry enough to be undamaged.

All items of plant shall be delivered to Site with their protective finish fully applied. Site painting shall be limited to the making good of damaged protective finish and the application of further decorative coats to provide a clean and uniform finish to the whole of the Work. Site painting shall not be carried out unless the surface to be painted is dry and has undergone surface preparation as instructed by the paint manufacturer. In general Site painting shall be applied only when ambient temperatures are above 16 degrees and relative humidity is less than 55%. If these conditions cannot be achieved, a special painting system may be applied with the approval of the Employer.

Mating surfaces shall have primary coats applied before assembly. The mating surfaces of structural steel shall be sealed during erection.

Care shall be taken not to paint over any nameplates, rating plates, labels etc. All bearing and gland surfaces shall be protected during final painting.

All coatings used for any part of the Plant in contact with water for potable use shall be non-toxic, non-carcinogenic, not impart taste, odor, color or turbidity to the water. Only materials included in the approved list of the UK water fittings and by-laws scheme (operated by WRc) or in the "Current Statement of the Committee" on chemicals and materials of the construction for use in public water supply and swimming pools (issued by DOE) shall be used in places where they may come into contact with water to be used for potable purposes.

The protective treatment system shall enable any necessary repairs, whether during the Contract period or subsequently to be made simply, without need for special skills or equipment. "Two pack" product shall not be used on any of the Plant Item.

The following table gives the minimal acceptable finish system for different types of plant. Further detailed requirements for specific items of plant if given in the Specification shall take precedence over any requirement stated here:

Hand-railing, walkways and steel structure installed inside and outside buildings.	Hot dip galvanized/stainless steel where specifically mentioned.
Steel pipe work 100 mm dia. and larger.	Fusion bounded epoxy.
Steel pipe work under 100 mm dia. and smaller.	Hot dip galvanized.
Ductile iron pipe work.	Bitumen coating.
Steel surfaces other than pipe work in damp or wet environment.	Zinc rich epoxy or zinc spray followed by epoxy top coat.
Electrical switchgear in dry uncontrolled atmosphere.	Stove dried enamel or manufacturer’s standard finish.
Electrical switchgear in damp uncontrolled atmosphere.	Stainless steel or GRP enclosure self coloured.
Nuts, bolts, washers and other small hardware.	Stainless steel.

Table 4-1: Minimal Acceptable Finish System

Paint finished shall include color coding taping (BS 1710) of pipes for chemicals, treated and raw water to the approval of the Employer.

4.36. Water Compliance of Materials

Any materials that come or may come in contact with water which is to become potable shall comply with one of the following.

a) The UK Secretary of State for the Environment under Section 25 of the water supply (Water Quality Regulation 1989).

b) The 15th Statement of the UK Department of Environment Committee on Chemical and Materials for use in public water supply.

c) The American Food and Drug Association.

d) Other internationally recognized and approved body.

Where a material does not comply with the above it shall be subject to the approval of Employer. Certificates confirming compliance with the above shall be submitted to the Employer and these shall form part of the approval/acceptance of the Plant.

4.37. High lift pump sets

If applicable, The Contractor shall provide for all the required components of the pumping Plant at Site in accordance with the Specification and Conceptual Drawings.

In selecting suitable pump sets for the stated performance, the Contractor shall ensure that as many components and items as possible are identical. Complete interchangeability of spares and other parts between all pumps is desirable.

All pumps shall be suitable for continuous operation at the performance specified and their duty levels shall be in the stable region of the pump characteristic curves. When required to do so, the pump shall operate satisfactorily in parallel with other pumps which may either be two or three or four in number.

Pumps shall be of vertical shaft type meant for dry / wet pit installation as required, coupled with vertical shaft motors at ground floor level. They shall be quiet in operation and free from vibration. All rotating parts shall be dynamically balanced to BS 5265 and shall be so designed and constructed as to be capable of running unattended for long periods.

The component parts of the pumps shall be constructed from carefully selected materials designed to avoid all metallic corrosion resulting from the interaction of water with dissimilar and incompatible metals.

Fully detailed catalogues of the manufacturer and pump performance curves shall be submitted with the Tender. These shall cover the full operating range of all pumps whether operating alone or in parallel. Curves shall be plotted for flow, head, input power, and overall pump efficiency.

The Contractor shall submit a schedule of technical particulars on a prescribed Performa with the guaranteed performance with his Tender. The guarantees of performance shall be achieved by the Plant under the condition of works tests and Site tests and shall be considered binding and not be departed from without the written consent of the Employer.
The pumps shall be fitted with renewable wear rings or sleeves in areas of close tolerance and where there is a high degree of wear.

Mechanical seals of cartridge or gland packing where specified, shall be used which shall be rated for continuous service without adjustments.

Pumps shall be capable of passing weed/algae present in lake water and shall be designed to avoid possible choking by weeds or other tough sinuous materials.

Unless otherwise specified, all bearings shall have a design running life of not less than 50,000 hours. Bearings shall be designed for loading 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow, if this is greater.

The rotating assemblies shall be statically and dynamically balanced to BS 5265 and designed so that the first critical speed of the pump and its drive is at least 50% higher than the normal operating speed.

4.38. **Pump performance guarantees**

If applicable, Pump performance guarantees shall relate to the flow rate, the total head when tested at the manufacturer’s works. Verification of factory test results shall form part of the Site test on completion.

The pump shall operate at its duty point within the acceptance tolerances for flow and total head laid down in Clause 9.4.1 of BS 5316: Part 2 (ISO 3555),1997.

Each pump shall be tested at manufacturer’s factory in accordance with BS 5316: Part 2 (ISO 3555) or other relevant standards in conjunction with one of the Contract motors.

Notwithstanding the requirements of BS 5316, the Contractor shall guarantee the pumps to operate safely, without cavitation, undue vibration or wear over the complete range of duties in which the pumps will operate.

The tests shall be carried out on at least one pump set using the Contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

Where similar drive shaft arrangements have been installed by the Contractor and have proven satisfactory in service, this requirement may be withdrawn subject to the approval of the Employer.

The tests shall be carried - out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads when only one pump is operating.
Sufficient readings shall be taken at each test to produce accurate curves of the head, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

Vibration and noise dB (A) levels shall be measured and shown to be acceptable. The contractor shall provide acceptable test certificates, showing that the NPSH requirements for the pump are sufficiently less than the NPSH available under all working conditions.

4.39. **Submersible pumps**

Submersible pumps shall be of the single entry design supplied complete with boltless self – aligning duct - foot assemblies giving automatic connection to the discharge pipe work. The pump casing shall be manufactured from close grained grey iron to BS 1452 or appropriate code with respect to application.

An oil filled casing shall separate the electric motor from the submersible pump. Mechanical seals shall be fitted to the pump shaft, which shall prevent water from entering the oil casing, and oil from entering the motor casing. A moisture detection system shall be provided to initiate an external alarm.

The motor housing shall be impregnated to protect the ingress of moisture. The shaft bearings shall be sealed and lubricated for life.

The pumps shall be controlled and started from the main distribution board and be fed with three phase supply. Control shall be via adjustable float level switches mounted adjacent to the pumps.

The pumps shall be supplied with all necessary pipe work, including reflex and isolating valves and suitable lifting gear for lowering and removing the pump from the sump.

The pump impeller, which shall be of stainless steel, shall be designed to pass solids of sizes which may enter the drain chamber.

4.40. **Pipe work and fittings**

The term pipe work shall include pipe of any description and associated flanges, adapters, couplings, jointing material, fittings, fixings, supports, drain valves, traps and the like, which are necessary to complete installation of pipe work systems associated with plant.

Pipe work shall conform to the requirements of the relevant British Standards. All recommended tests shall be carried out and certified in writing.

Adequate provisions shall be made to anchor, support, drain vent, pressure test, dismantle and clean all pipe work.

Pipe work systems shall be designed to withstand the maximum internal and external forces which could occur in service and under hydraulic test pressure in accordance with Section 5.8.9 and Appendix 1 of Water Research Centre's "Pipe Material Selection Manual" 1988 Edition. The configuration and method of support shall minimize bending stresses.

Systems shall be sized so that the maximum design flow through the pipe work will not produce cavitation, erosion, excessive noise or vibration. Systems shall also be sized where practicable so that the minimum operating flow of fluid will prevent deposition of suspended solids. No forces developed within the pipe work system shall be transferred to civil structure.

None of the forces and movements transmitted by pipes to connected machines, apparatus and other components exceed the maximum permissible values given by the manufacturer of these items.

Special care shall be taken in the design of pipe hangers and supporting elements. They shall be arranged, dimensioned and fastened in such manner that no vibration and undue stresses appear during start-up, operation or shutdown and during field tests. The reaction forces and moments of the piping system shall be borne by fixed points. Loads on walls, foundations and other civil structures, are to be reduced to the minimum.

The Contractor shall provide suitable thimbles and flashing where pipelines pass through floors and walls. Floor thimbles shall be installed to provide 90mm projection above the finished floor surface.

Plastic pipes, flexible pipes and fittings shall be supported throughout their length.

Ductile iron pressure pipes and fittings shall conform to BS 4772 or equivalent unless otherwise specified and shall have flanged joints.

Pipe work shall be colour coded to the approval of the Employer. The normal direction of flow shall be clearly marked on the pipe near each valve, junction, terminal and other positions as required by the Employer. Where applicable, colour coding shall be added after protective coatings, lagging and cladding have been applied.

The pipe work shall be laid out and designed so as to facilitate the erection, painting and dismantling of any section for maintenance, and to give a constant and uniform flow of working fluid with a minimum of head loss. Where steel pipe work is used, the number of flanges shall be kept to a minimum and size of each unit of pipe work is to be determined by the ease of handling, installation and general appearances of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe support or thrust blocks.

Flexible or collapsible joints shall be provided where necessary to facilitate removal of Plant and / or to allow for differential settlement of building structure. Wherever practical, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipe work as a whole.

All pipes and fittings over 150mm diameter and within the confines of building structure shall be in steel. Minimum grade of steel shall be Grade B. All pipes and fittings under 150mm shall be manufactured either in steel or in ABS plastics in accordance with BS 3867.

Where steel and cast flanges are mated together, the steel flanges shall be machined over its full face after welding to its respective pipe. Whenever possible, standard fittings shall be used in preference to fabricated or special fittings.

Facilities shall be provided for draining pipe work systems and releasing air. The drainage fluid shall be piped into the appropriate drainage system.

Flanges shall conform to BS 4504 and shall be drilled in accordance with the appropriate pressure rating.

Where a pipes passes through a wall, or is subject to thrust, it shall incorporate a puddle flange which shall conform to the dimensions stated in BS 4504 but shall remain undrilled.

Large piping installation shall be provided with means of isolating sections to facilitate drainage.

Fluid velocity shall not exceed 2.5 m/s in pump suction and discharge pipe work. It shall not exceed 2.5 m/s in delivery manifolds at the duty flow with a maximum of 3.5 m/s at the designed maximum flow.

All pipe work shall be tested at the manufacturer's Works in accordance with the appropriate British Standard and pressure rating to which it is manufactured.

All pipe work shall be hydraulically pressure tested to 1.5 times the maximum working pressure or the surge pressure, whichever is greater, after installation. For pump delivery pipe work, the maximum working pressure shall be taken as the closed valve head of the pump. The Contractor shall supply and fit all necessary blank flanges and equipment to carry out the test. Prior to the test the pipe work shall have been thoroughly cleaned out. Precautions shall be taken to remove all air from the system under test. The test shall maintain with the drop in pressure not exceeding 2.5% for a period of 30 minutes.

Buried pipes shall be designed to limit these deflections to avoid damage to the pipes or their protective coatings. The external design loads for buried pipes shall include earth pressure due to the weight of the backfill over the pipe and the surcharge from vehicular loadings.

4.41. **Steel Specials**

If applicable, Steel specials shall have the same length and shall be compatible in all other aspects with the pipes with which they are to be used.

Flat tapers shall have one side of the taper at right angle to the end so that they may be laid with invert level or crown level as may be required.

Collars shall comply with BS 324 Clause 25.

Bends shall be of even curvature type only, unless otherwise approved by the Employer.

Specials shall be hydraulically tested in accordance with Clause 3.9 of BS 1640: Part 3.

4.42. **Pipe Fabrication and Installation**

a. The Contractor shall setup his own pipe fabrication shop with all the power equipment and tools necessary to fabricate pipes in accordance with relevant standards and codes of practice. The Contractor's fabrication shop shall be prior inspected and accepted for reliability of facilities, equipment and location by the Employer. If certain manifolds or pipe appurtenances are to be sub-contracted to other fabricators, their shops shall be subjected to prior qualification by the Employer.
b. All MS pipes shall be fabricated from new mild steel plates of required thickness conforming to ASTM A283D.

c. Edges of plates to be joined by welding shall be formed to true cylindrical shape. The resulting edges for welding shall be uniform throughout the length of the plates and shall form a straight line.

d. If it is necessary to reshape pipe after it has been welded, reshaping shall be performed by rerolling. Hammering will not be permitted. Sizing of pipe ends to come within specified tolerance will be permitted.

e. Each end of the pipe shall be a circle so that two ends may form a perfect joint. The end of each section of pipe shall be accurately measured and shall not exceed the tolerances set forth below, provided, that such tolerances do not interfere with the making of the joint:

   (1) For a distance of not less than 250mm from the end, the outside circumference of the pipe shall be accurately measured and shall not be less than 1.5mm smaller nor more than 3mm (upto 0.5 percent

variation) than the circumference computed from the nominal dia. of the pipe.

(2) The ends of all pipe sections shall not vary more than 3mm at any point from a true plane at right angles to the axis of the pipes.

f. The dimensional tolerances of the prefabricated piping parts shall not exceed the limit given in U.S standard PFI – ES – 3.

g. All piping shall be fabricated accurately and closely aligned during installation so that stresses are avoided in bolting up or welding into final position.

h. Flanges shall be oriented with the bolt holes, stranding the horizontal and vertical centerlines of the pipes. Precautions shall be taken throughout the fabrication process not to mar the gasket face on the flanges.

i. All screwed pipes shall be accurately cut to lengths with no "springing" required to fit the individual pieces.

j. All pipe supports shall bear fully on supporting work etc., and shall be placed with centerline of support perpendicular to centerline of the pipe.

k. Saddles shall not overlap pipe joints. Pipe saddles shall be welded to the pipe after the pipe run has been assembled, positioned in place and anchored.

l. Welded steel inserts shall be manufactured of steel plates of required thickness. Pipe and fitting materials, method of manufacture and shop testing of pipes shall conform to the requirements of AWWA standard C 201 – 60T "Standard for Fabricated Electrically Welded Steel Water Pipes"

4.43. Blank.

4.44. **Blank**

4.44.1. Type A electric actuators

If Applied, This type of actuator shall be suitable for both electric and manual local operation and electric remote operation and shall be provided with the following:

a) An alternative system for manual hand-wheel operation.
b) An interlock, to prevent engagement of the hand-wheel whilst the actuator is being power driven and positively disengage the manual drive when the power drive has started.
c) LOCAL/AUTOMATIC/OFF OR LOCAL/REMOTE/OFF electrical rotary selector switch, for the transfer of control panel with

changeover volt-free contacts for remote indication of switch position.

d) Local “OPEN”, “STOP” and “CLOSE” push button with facility for remote operation or automatic operation.
e) Potentiometer for remote indication of valve position.
f) One volt-free contact for remote indication of “motor running” condition.
g) Limit switches at each end of travel having two changeover volt-free contacts for remote indication.
h) Torque switches for mechanical overload protection on opening and closing with one changeover volt-free remote trip indication.
i) Thermal overload protection
j) One changeover volt-free contact for “motor tripped on over load” remote indication.
k) Two changeover volt-free contacts for interlock circuits on the associated power plant.
l) One changeover volt-free contact for “power supply to actuator failed” remote indication.
m) Remote control available “monitoring relay with volt-free contacts”, phase discriminator for single phase and phase reversal relay.
n) Two interposing relays to provide for three buttons OPEN; STOP/CLOSE remote control with facility to reverse in mid-travel. The provision of this facility shall not prevent the connection of remote controls directly to the integral control supply where distances are suitably short.

4.44.2. **Type B Electric Actuators**

This type of actuator shall be similar to Type A actuator but remote operation facility will not be provided.

4.45. **(Not Applicable)**

4.46. **Types of Valves**

4.46.1. **Gate Valves**

Gate valves larger than 50mm diameter shall generally comply with BS 5163 when used with water and BS 5151 when used with slurries or sludge.

Valves shall be of the non-rising stem type with flanged ends to BS 4504 PT 16.

The body, wedge, bonnet, stuffing box, gland and thrust bridge shall be of mechanize cast iron to BS 1452 Grade 14, the seats, nuts, faces and guides of gunmetal to BS 1400 Grade LG 2-C and the stem of forged Bronze to BS 2872 Grade CZ 114 or stainless steel.

Valves shall be arranged for clockwise closing and be suitable for operation from the closed position by a maximum “push pull” effort of 13 kg(total 26 kg) at the rim of the hand wheel or tee key. Cast iron hand wheel of generous dimensions having CLOSED direction arrows casted upon shall be provided.

Each valve shall have a drain plug fitted at the bottom of its seating.

Stuffing boxes shall be designed to have soft packing fitted.

Unless otherwise provided for, valves shall be rated for 10 bar working pressure with the bodies capable of withstanding a test pressure of 15 bar and the seat 10 bar without leakage.
Gate valves, 50mm diameter and smaller shall be in accordance with BS 5154.

Valves used with water shall not contain bronze having more than 5% Zinc.

4.46.2. **Ball Valves**

Ball valves shall be of the full-bore asymmetric split-body type. The ball shall be trunnion mounted. Valves shall comply with BS 5159 for normal duties and BS 5351 for more arduous duties. The line valve bore shall have a diameter as to meet the inside diameter of the adjoining pipe work.

End flanges shall be cast or forges integral with the body.

The valve body shall be of cast steel ASTM A216 WCB or better and incorporate a drain tapping complete with drain tap. The ball shall be forged steel ASTM A0 105 with chrome or nickel plated surface finish.

Internal wetted valve parts shall be protected with fusion bonded epoxy coating system suitable for potable water; other parts shall be of stainless steel AISI 304 or better. The internal bore of the ball valve shall be chromium plated.

The design shall be such that the stem shall not be capable of ejecting whilst under pressure. Except for valves below 50mm, glands shall be of the one piece bushed or two pieced self-aligning type.

Body seals ring assemblies shall be designed to be renewable. Ball ports shall be cylindrical. Valves shall be operated by hand wheels, wrench or actuator and arranged for clockwise closure. Maximum force required to open / close valve shall not exceed 350N.

Valve seals shall be designed for minimal maintenance. Where valves are very infrequently operated (pipeline isolation application), seal life shall be similar to the design life of the valve as a whole.

Hand wheels shall be marked to show direction of closing. Valves arranged for manual control shall incorporate a valve position indicator.

Stops shall be provided at both the fully open and fully close operation.

Ball valves shall be designed when open to permit the free passage of pipeline scraper equipment.

The sealing between ball and body at both sides of the valve shall be accomplished by elastomeric material suitable for the medium being shut-off.

The seal surface shall be perfectly spherical and lapped. Chromium plating shall be perfectly applied and the Contractor will be responsible for any spalling.
The sealing between the stem and the cover shall be accomplished by means of O – rings, neck bushing and additional secondary sealant or equivalent. The O – rings shall be of a material suitable for the pressure and the temperature.

4.46.3. **Check Valves**

Check valves shall be of the tilting disc type with double offset disc. The valve size and design shall be selected to give optimum performance taking full account of the system within which the valve is to be installed specially when the system includes surge bypass or when the static pressure is high and the system has to bypass large volumes of water.

In case of possibility of shock due to sudden interruption in flow, causing rapid flow reversals, a hydraulic damping device having a time lag system for controlling the rate of closures of the valve disc and bypassing all up and down surges through the system, shall be provided . Alternatively surge suppressor vessels for controlling water hammer are accepted. The damping device shall be sized by computer programmed to match the characteristics of the application. In addition, the analysis shall cover the adverse effects of column separation, if caused due to up surge or down surge pressure on the pumping system alternatively. The Contractor shall also recommend additional equipment or device, if required for mitigation of the adverse effects of column separation. All computations and data shall be forwarded by the Contractor to the Employer for his review. For vertical installation, the valve shall be equipped with weight loaded arms on either one or both sides.

The valve shall be of the short body type, double flanged and pressure tested with a minimum of 15 bar. The seal shall be pressure tested at 10 bar and the rating shall be to DIN/BS 4504 T16. The valve shall generally comply to BS 5153 unless otherwise specified.

Corrosion protection shall be by an approved epoxy coating which shall be safe for potable water.

The maximum velocity through any check valve shall not exceed 2.5 m/s without the written approval of the Employer.

Material requirements shall be as follows or better.

Body or Disc	:	Ductile cast iron SG GGG –
50 DIN Body seat and disc facing ring		Austenitic Cr Ni Steel
Sealing ring	:	Elastic (NRB)
Valve shaft	:	Ferric chrome steel containing
min.		13% Cr.
Shaft bearing bushes	:	Maintenance free (Steel / Tin /
PTEF) Shaft Seal	:	NBR O – Ring
Lever arm	:	Steel
Counter Weight	:	Cast Iron

Hydraulic damping devices shall be double acting and shall include a flow control valve. Body components shall be injected cast iron to C6 25 iuB or better and piston rod of ferric chrome steel to 1.4122.05.

Only manufacturer with proven valve design having minimum experience of 10 years with this type of valve and ISO 9000 certification shall be accepted.

4.46.4. **Butterfly valves**

If applicable, Butterfly valves shall be of the double flanged drop tight closure offset, rubber seat type generally in accordance with BS 5155 or BS 3952 and AWWA C504
– 80 Class 150.

Valve seats shall be gunmetal to BS 1400 secured to the valve body by corrosion resistant screws.

Bypass valves and air release plugs shall be fitted on all valves of 200 mm or larger.

Valves shall be designed for watertight and airtight shut off and shall be suitable for mounting in any position.

Valves shall be mounted with shafts horizontal unless otherwise specified or shown on the drawings. Manually operated valves over 350mm bore shall be provide with hand wheels and bevel gearing. All valves shall be fitted with indicators to show the position of the disc.

In general, the material of construction chosen shall be corrosion resistant to the source water referred to in the Specification. All bolts, nuts and other fixings which will be in contact with the flow or with the ground shall be of stainless steel.

Valves shall be suitable for frequent operation as well as for operation after long periods of idleness in any position.

Disc edges shall be machined with rounded corners and shall be polished to a smooth finish. The valve disc shall rotate through an angle of 90 degrees from the fully opened to the fully closed position, and the seat shall be designed so as to allow the disc to close at an angle normal to the axis of the pipe. Adjustable mechanical stops shall be provided to prevent over travel of the valve disc. The stops, shaft, and disc fixing shall be capable of absorbing full operating torque, with a minimum design safety factor of five.

The shaft shall be made of stainless steel. Shaft seals shall be nitrite rubber O ring type. Packing shall fastenings set flush in the water passage to minimize flow resistance.

Valve seats which extend over the face of the flanges to secure the seal in place will not be acceptable. Each valve shall be tested in accordance with the requirements of BS 5155, for body, seat and disc strength test. Seat tests shall be carried out in each direction and the valve shall be drop tight. Disc strength tests shall also be carried out in each direction.

Valves of 600mm and above shall be metal faced. It shall be possible to adjust the seat clearance to obtain as near a watertight condition as possible, without the need to remove the valve body from the pipe work in which it is fitted. The valves shall have metal seating. Body mounted replaceable stainless steel face rings shall be fitted and disc rims shall be hard metal plated where they contact the face rings.

Unless otherwise provided for, valves shall be rated for 10 bar working pressure with the bodies capable of withstanding a test pressure of 15 bar and the seat 10 bar without leaking.

Bypass for valves 400mm diameter and over shall be provided with integral bypass as follows:

ND 400	:	50mm dia. bypass
ND 600	:	80mm dia. bypass
ND 800	:	100mm dia. bypass

4.46.5. Flow control valves

Flow control valves shall be designed for the operating conditions specified and shall be of the type specified for the particular application.

The valves shall be capable of controlling the required parameter of flow or pressure within ± 5% of the set value. The rate of response of opening and closing of the main valves shall be controllable at the valve. Means for external indication of the position of the valve element shall be fitted. Any hydraulic control system shall include isolating valves to permit maintenance or replacement without interrupting the supply.

4.46.6. Ball float valve

Ball float valves shall be fitted if required to prevent overflow. Ball float valves shall close slowly over a long period of travel and shall be consistent with the design for surge protection. Ball float valves shall be fitted inside the tanks and shall be of the Glenfield series 1040 or similar approved.

4.46.7. Pressure relief valves

Safety valves shall comply with BS 6759: Part 1. They shall be designed to below off at the specified pressure and re-close and prevent further release of fluid after normal pressure conditions of service have been restored.

Shell material shall be from the materials listed in Table PE – 1 BS 1560: Part

2. Trim material shall be stainless steel ASTM A 743 Grade CF8 or better.

Flanged ends shall be class 900, raised face type complying with ANSI B
16.25 or Table PE – 1 or BS 1560: Part 2. But welded ends shall be in accordance with section 8 of BS 1868.

All valves installed above ground shall be furnished as far as necessary, with a bonnet pressure relieving system to protect the valve against damage caused by thermal expansion of the medium. This system may be either completely internal or external using a spring loaded relief valve.

4.46.8. **Automatic air relief valves**

Automatic air relief valves shall be designed to meet the following conditions

a. Discharge air during charging of the pipework
b. Admit air during emptying of the pipework
c. Discharge air accumulated at local peaks along pipelines under normal operating conditions.

Conditions a. and b. shall be met by employment of a large orifice capable of discharging large volumes of air at a high flow rate, and condition c. by a small orifice capable of discharging small quantities of air as they accumulate.

Valves with air intake or exhaust facilities shall have approved screening arrangement to prevent the ingress of foreign matter.

4.46.9. **Diaphragm valves**

If Applicable, Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS 4504.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional "O" ring seal of nitrite rubber or other approved material.

Diaphragm shall be composed of moulded reinforced, flexible material attached by studs. Diaphragm materials shall, where required, be composed of corrosion resistant material.

4.47. **Electric overhead traveling crane**

Overhead traveling crane shall comprise of a bridge assembly with hoist having cross traverse and long travel movements. It shall be complete with all necessary gantry beams, rails and fixings to the building superstructure. Crane and beams shall be of such dimensions as to conform to those shown on the Conceptual Drawings in respect to span, travel and hoist etc.

Crane bridge assembly shall be designed, constructed and tested in accordance with BS 12573 and BS 466 as appropriate. Bridge girders shall be constructed from BS 4360 and BS 4 structural steel. Safety end travel stops shall be fitted to prevent over travel of the hoist carriage and bridge assembly. Hoist assembly shall be supported on at least four flanged runners rotating in ball bearings. Hook block fitted with safety catch and having fully guarded rope sheave shall be of forged steel to BS 2903 and carried on a heavy duty
thrust bearing fixed to the main trunnion allowing 360 degrees rotation of the hook.

Load chain shall be grade 40, 60 or 80 alloy steel to BS 1663, BS 3113, or BS 3114 as appropriate and contained in a suitably sized chain bucket fitted to the hoist assembly. Chain shall be sherardised Grade 30 mild steel to BS 590.

Crane shall be capable of travel and traverse movements when fully loaded with the heaviest item of the Plant during erection and maintenance.

Safe working load shall be clearly labeled on the crane and beams in characters easily legible from the working floor. Labeling shall include the date tested and test load which shall exceed the safe working load by factors appropriate to the compliance standard.

The load bearing capacity of the slings and shackles shall be suitable for the crane. The maximum tension in the ropes shall not exceed 1/8th of the calculated capacity of the rope. The ropes shall be of the standard type and galvanized wires shall be used. The eyes of the ropes shall be at least 15 times the diameter of the rope. Sufficient slings, ropes, shackles, lifting beams, etc. shall be supplied to handle all items of the Plant covered by the crane. They shall be labeled or marked with the safe working load (SWL) and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of safe working load, and test certificates shall be submitted by the Contractor.

The end carriage shall be of the welded box girder design. Buffers shall be provided at the faces of the end carriage. The end carriage shall also be fitted with wheel breakage supports designed to prevent derailment as well.

The crane running wheels and the crab running wheels shall be of the double flange type and shall be equipped with antifriction bearings lubricated for life. Jacking pads shall be provided at the end carriages to facilitate wheel removal.
Load chain shall be of sufficient length to enable the hook to be lowered to the bottom of the pump chamber and shall be provided with a chain collecting box to hold the slack chain.

The operation of the crane shall be from ground floor level by bridge-mounted pendant pushbutton controls. Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. Maximum pendant control voltage shall not exceed 115 Vac. The pendant shall be supported independently of the electric cable and shall be arranged for extending operation when necessary.

The crane shall be fitted with limit switches to prevent excess travel, over hoisting and over lowering of the crane hook. Electromechanically fail safe brakes shall be incorporated on all power-operated motions.
Down shop conductors shall be of the fully insulated shrouded busbar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for the cross travel. A crane isolator padlockable in the off
position and incorporating a warning lamp, illuminated when the supply is on, shall be provided at the bottom of the access ladder. A second isolator shall be provided at the control cubicle located on the crane platform.

All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the loaded hook. Facilities shall be provided for the accurate location of the hook by means of ‘inching’ the cross travel and down shop travel motions.

The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repair shall be provided and installed by the Contractor.

All electrical equipment shall be fully tropicalised.

Site test shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the contractor after successful tests have been carried out.

4.48. **Access steelwork**

Access steelwork shall mean all ladders, platforms, covers, steel flooring and handrails supplied and fixed under the Contract. It also means all small areas of floor plating or similar covering that are necessary to cover gaps between items of Plant and surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance which forms part of the Contract. This includes access steelwork to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Floor plating shall be of ‘Durbar’ or other non-slip pattern not less than 4.5mm thick (exclusive of pattern) and hot dipped galvanized after fabrication in accordance with BS 729.

Aluminum alloy flooring may be offered as an alternative, manufactured in accordance with BS 1470 material H 30 TB.

Handrailing shall be double rail 1100 mm high. On stairways, it shall not be less than 900mm high above the stairs, measured vertically from the nose of the tread.

Standards shall be double 38mm diameter solid forged steel to BS 4360 Grade 43A with 60mm diameter solid forged steel balls at handrail locating points drilled to give 1.5mm clearance to handrails. Each ball shall incorporate a concealed grub-screw with Allen type head to secure the rail. Standards shall have a minimum base width of 65mm; drilled for M 16 fixing bolts and set at maximum 1800mm centers.

Handrails shall be 33.7mm OD x 3.2mm thick tabular steel to BS 1775 Grade
13. Joints shall be arranged to coincide with the spacing of standards where possible; otherwise they shall have butt joints with tabular steel ferrule, plug welded or fixed with a 5mm diameter countersunk head pin.

Removable sections of hand railing shall have half-lap joints secured with a countersunk head pin.

Chains across openings shall be 10mm x 3mm links per 100mm galvanized mild steel. The hooks and retaining eyes shall be securely fixed to the balls of the standards.

All components for handrailing shall be hot dip galvanized after manufactured in accordance with BS 729.

4.49. **Pressure Gauges**

Pressure gauges shall be of the Bourdon tube type with stainless steel wetted parts conforming to BS 1780. They shall have non-corrodible metal cases with stainless steel bezels and shall be not less than 100mm in diameter. Gauges shall be scaled in meters head of water, with zero representing atmospheric pressure unless otherwise specified. Lettering shall be black on white ground except for negative pressure on compound gauges which shall use red lettering. The range of the gauges shall be 30 – 50% higher than the maximum working pressure.

Diaphragms shall be fitted to all gauges subject to dirty or corrosive fluids. Snubbers shall be fitted to all gauges subject to pulsating pressure, alternatively glycerin filled gauges shall be supplied. The gauge shall be mounted to minimize damage from vibration. Each pressure gauge shall be fitted with an isolating valve at the point of connection to the main system and, where mounted remotely, the gauge shall also be fitted with a local isolating valve.

4.50. **(Blank)**

4.51. **(Blank)**

4.52. **(Blank)**

EMPLOYERS REQUIRMENT FOR MECHANICAL & ELECTRICAL WORKS

CHAPTER 05
MATERIALS & WORKMANSHIP
ELECTRICAL WORKS

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5.1 Introduction

This Chapter of the Specification sets out the minimum standards of materials, workmanship and design to be used by the Contractor for electrical plant. Reference to any specific material or equipment does not necessarily imply that such material or equipment is included in the Work. These requirements are in addition to those given in the Materials and Workmanship - General Chapter No.1. In case of any conflict between this Chapter and the General Chapter No.1, the requirements of this Chapter shall take precedence. Items requesting / offered options to be agreed after review.

All component parts of the Work shall, unless otherwise specified, comply with the provisions of this Chapter unless overridden by the Particular Requirements or be subject to the approval of the Employer.

5.2 General Requirements

The electrical installations shall comply with and be tested in accordance with the latest edition of BS7671 “Requirements for Electrical Installations" hereinafter referred to as “IEE Wiring Regulations”.

All works shall be carried out by licensed workmen authorized to undertake such works under the provision of Electricity Act, 1910 and the Electricity Rules 1937 as adopted and modified by Government of Pakistan.

The installation in general shall be carried out in conformity with the BS, the Electricity Rules 1937 as amended and the latest Edition of the Regulations for the Electrical Equipment for Buildings by the Institute of Electrical Engineers, London (IEE). However, in case of any conflict between these specifications and the IEE Regulations, the former shall prevail.

Any special requirement of the local electric supply authority particularly WAPDA shall be complied with.

The Contractor shall be responsible for submitting the test certificates and getting the installations passed by the Electric Inspector, Government of Sindh.

If required, The Contractor shall take all necessary steps for obtaining the power connection from WAPDA including obtaining and submitting the prescribed forms to the relevant authorities and shall maintain liaison with WAPDA till power connection is made and energized However, all cost as per estimates for the power connection obtained by the Contractor from the concerned authorities shall be paid directly by the Employer.

The Contractor shall arrange for the electric supply authority to undertake any testing and inspection necessary for the electricity supplies to be connected when required. On completion of the tests and inspections the Contractor shall supply to the Employer copies of the Electrical Installation Completion Certificate and of the electric supply authority's test certificates etc.

The Contractor shall be responsible for determining the requirements of the concerned authorities for:

a. Applications for power supply,
b. Approval procedures,
c. Inspection and testing procedures,
d. Any other documentation.

The Contractor shall be responsible for implementing the same and obtaining all approvals for connection of a new supply.

5.3 Environmental conditions

All electrical equipment shall be designed and manufactured for operation under maximum duty loads under the specified climatic and environmental conditions at site.

Where electrical equipment is installed in a controlled environment, it shall be capable of continuous full load operation under the condition of failure of the air conditioning or ventilation systems. The normal working conditions for controlled environments are:

a. Air conditioned areas:

- Ambient air temperature	-	maximum +45 °C
	-	minimum 05 °C
- Relative humidity	-	96%

b. Ventilated areas

- Relative humidity	-	100%
- Minimum ambient temperature	-	05 °C
- Maximum ambient temperature	-	50 °C or any higher temperature determined to be applicable

The Contractor shall determine the maximum ambient temperature in Ventilated areas. This shall comprise the peak internal ambient temperature based on the maximum specified external temperature together with internal building heat gain due to energy losses from the full load

operation of all installed duty plant and direct solar heat gain through the building fabric.
All electrical equipment which is not sealed against free movement of air shall be protected from condensation with anti-condensation heaters. In general these heaters shall be thermostatically controlled and switched off when heat is generated by the operation of the Plant.

Iron and steel are to be painted or galvanized in accordance with the Specification. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting, Cores etc which are built up of laminations or cannot be antirust treated for any other reason be antirust treated are to have all exposed parts cleaned and heavily enameled or lacquered.

When it is necessary to use dissimilar metals in contact these should be so selected so that the electrochemical potential difference is not greater than 250 milli-volts and if practicable the two metals are to be insulated from each other by an approved insulating material or by a coating of approved varnished compound.

The use of iron and steel is to be avoided in instruments and electrical relays wherever possible. Steel screws when used are to be zinc, cadmium or chromium plated or when plating is not possible owing to tolerance limitations, are to be of corrosion resisting steel.

The use of wood within electrical equipment is to be avoided as far as possible and, if used shall be of a type resistant to termite attack and fungal decay.

The use of hygroscopic insulating materials is not permitted except immersed in oil or otherwise suitably sealed to prevent ingress of moisture.

5.4 Equipment Protection

As a minimum and where not specified otherwise, the IP ratings for electrical equipment shall be:

- for outdoor installation IP65
- for indoor installation adjacent to water carrying plant IP54

Notwithstanding the location in which it is installed, electrical equipment and materials provided for external installation shall incorporate additional design/protection features to provide resistance against windblown sand and dust, and salt laden atmosphere. All externally mounted electrical equipment and materials shall be directly protected or shaded against heat gain or damage by solar radiation. Sunshades shall be of a non-metallic material for protection from embitterment due to prolonged exposure to high intensity u/v radiation.

All fixings used for the anchorage, support or connection of all materials and equipment associated with the electrical works shall be of stainless steel grade 316L. Where a fixing is in contact with a dissimilar material such that galvanic action can occur, a spacer of inert material shall separate the materials.

5.5 Abbreviations of electrical terms

For the purpose of this Specification the following abbreviations of electrical terms have been used.

R	-	red phase
Y	-	yellow phase
B	-	blue phase
N	-	neutral
ac	-	alternating current
dc	-	direct current
A	-	Ampere
mA	-	milli-Amp
V	-	Volt
kW	-	kiloWatt
kWh	-	kiloWatt hour
kvAr	-	kiloVolt Ampere reactive
kVA	-	kiloVolt Ampere
Hz	-	Hertz (cycles per second)
CT	-	current transformer
PT	-	potential transformer
SP	-	single pole
SPN	-	single pole and neutral
DP	-	double pole
TP	-	triple pole
TPN	-	triple pole and neutral
SPSwN	-	single pole and switched neutral
TPSwN	-	triple pole and switched neutral
MCB	-	miniature circuit breaker
MCCB	-	moulded case circuit breaker
RCD	-	residual current device
MCC	-	Motor Control Center

5.6 Polarity

All cables shall be so connected between main switchboards, distribution boards, plant and accessories so that the correct sequence of phase rotation is preserved throughout the system.

All non-flexible cable cores shall be identified with phase colors for three and four wire circuits. Single-phase circuits shall be red and black.

Where more than one phase is incorporated on a common system in one room, the live cores shall be red, yellow, or blue as appropriate. The neutral

shall always be black. All fittings and switch accessories shall be permanently labeled and segregated.
Harmonized systems of phase layouts on plant and equipment of cable and plant phase identification, and of cable core insulation coloring shall be used throughout the work.

The polarity of all apparatus used in the Work shall be arranged as follows, when viewed from the front:

a. For two pole apparatus, the phase or live poles at the top (or left hand side) and the neutral or earthed pole at the bottom (or right hand side).

b. For three or four pole apparatus, the phases in order, red, yellow, blue and neutral reading from top to bottom or left to right in the case of vertical or horizontal layouts respectively.

5.7 Fault withstand ratings

The fault withstands ratings for the electrical equipment will be calculated by the Contractor based on the network data.

The network data given in the Tender Documents is indicative only.

5.8 Electric motors

5.8.1. Rating and duty

Motors shall comply with the general requirements for construction, rating and performance as stipulated in BS 4999, BS 5000 and BS EN 60034-1 and VDE 0530/DIN 57530 except where amended. Unless otherwise specified, motors shall be suitable for continuous operation duty type SI at rated output at any voltage between 94 and 106 percent and any frequency between 98 and 102 percent of rated values.

Cage induction motors shall be full voltage direct-on-line started and wound rotor induction motors shall be rotor resistance started.

The starting performance of cage induction motor shall comply with BS EN 60034-15 design “N”, “NY” or “D” as appropriate for DOL starting. The minimum voltage at the motor terminals shall be assumed to be a constant value of 90% of rated voltage during the acceleration period and the starting current shall not exceed 6 times the full load current.

Medium voltage motors and other motors for main plant drives shall be capable of the following minimum starting cycle duties.

a. Two consecutive starts from “cold” state per hour;
b. Four restarts from “hot” condition at rated maximum operating temperature per hour.

Motors shall be capable of operating under conditions of three phase supply imbalance where the negative and zero phase sequence components of the voltage do not individually exceed 2% of the positive phase sequence components.

5.8.2. Windings and Insulation

Winding insulation shall be Class F or better to BS 2757 and the maximum temperature shall not exceed that permitted for class B.

Windings shall be supported, braced, wedged and blocked to provide adequate rigidity and strength to withstand all thermal, mechanical and vibration stresses under all operating conditions for the full service life of the motor. Special attention shall be given to the windings of direct-on-line started motors and the support of windings of vertical motors to prevent any permanent displacement during the service life.

Electrical joints and connection shall withstand the mechanical and thermal stresses under normal and abnormal operating conditions. Stator end windings shall be blocked and braced to provide high rigidity.

Completed windings including connections shall be subjected to a minimum of two cycles of vacuum impregnation with solvent-free resin varnish followed by curing to effectively fill gaps between individual conductors, to enhance mechanical strength and to provide a high resistance to moisture, oil and chemical contamination.

The insulation of flexible cables connecting starter windings to terminal boxes shall be of the chlorosulphonated polyethylene (CPS) or ethylene propylene (EPR) rubber. Natural rubber insulated cables shall not be used. Cables shall be securely fixed to the stator frame.

On 11 kV motors both ends of the stator windings shall be brought out to an accessible link assembly mounted within the stator main cable box or in a segregated link chamber with bolted cover plate.

The winding insulation materials and cable insulation shall be resistant to flame propagation.

5.8.3. Degree of protection for motor enclosures

The degree of protection for motor enclosures shall be in accordance with BS 4999; Part 105 and IEC 34, 72 and 79. Unless otherwise specified the following minimum degrees of protection shall apply.

a. Motors located indoor : IP54
b. Motors located outdoor: IP65

Fans and blades external to the enclosure shall be protected against contact by means of guards.

Totally enclosed motors shall be provided with suitable means for breathing and for drainage to prevent the accumulation of water.

5.8.4. Cooling

Cooling arrangements shall be in accordance with BS EN 60034-6. Unless otherwise specified, the cooling classification shall be as follows:

a. Motors located indoors in a dry and clean environment	IC01 or IC611
b. Motors located indoors in damp or wet areas	IC41
c. Motors located outdoors	IC41

5.8.5. General constructional features

Motor dimensions shall be in accordance with BS 4999 Part 141 and IEC 60034, 60072 and 60079.

Motor frame shall be cast iron, fabricated from steel plate or aluminum as appropriate. Frames shall incorporate substantial ribbing to provide high structural strength.

End covers, end shields, external fan cowls and other external components shall be of adequate strength and robustness and shall be constructed of metal unless otherwise approved by the Employer.

Plastic components shall be designed to take into account the environmental conditions and the long term effects of operating temperature, ageing and thermal stability of the material. Where used for external components, the material shall be resistant to flame propagation. Where plastic covers enclose live parts, the design shall eliminate the risk of electrical shock to personnel during operation of the motor.

5.8.6. Bearing

a. General:

   Bearings shall be capable of accepting:

   (1) Mechanical and electrical forces imposed on them by the rotor.
   (2) Forces imposed by the motor mounting.
   (3) External forces due to the drive method.

Bearings shall be of the rolling type as determined by consideration of rotor rating and speed, shaft system, duty, method of drive and the type of bearing of the driven equipment.

Unless otherwise specified or approved, motor speed above and including 400 kW will not exceed 1000 rpm. Higher speed may be adopted for motors of lower ratings.

“Sealed for life” maintenance free bearings shall be provided on motors rated up to 10 kW.

Bearing insulation to the main frame to suppress shaft circulating currents shall be of the double insulation system on each bearing and shall be connected to earth at one point via link. The link shall be removable to permit testing of the bearing insulation. The insulation shall not be short circuited by the application of electrically conducting paint.

Rolling type bearings shall comply with the relevant British and the International Standards and the assembly shall be designed to exclude the ingress of dirt and water. The bearings shall be grease lubricated and shall be sealed to prevent leakage of the lubricant along the shaft and designed to permit easy removal of bearings.

Rolling type bearings shall be selected to meet the following requirements:

(1) Minimum life of 40000 hours when the forces on the bearings are from the motor only and 32000 hours when the forces include those from motor and driven unit.
(2) Re-lubricant interval preferably of 8000 hours but not less than 4000 hours.
(3) Maximum outer case temperature of 80 degree centigrade.

Rolling bearings of the “sealed for life” type shall operate for a minimum of 18,000 running hours or for a period of 5 years if the later occurs sooner.

Grease lubricated bearings shall be packed with lithium based grease at the time of assembly.

A separate grease nipple shall be provided for each lubricating point, grease nipples shall be manufactured from steel and shall comply with BS 1486: Part I. Bearings shall be provided with faculties to eject surplus grease

Where there is a danger of vibration from other plant being transmitted to a stationary motor, provisions shall be made to prevent fretting damage to bearings.

It shall be possible for lubrication to be carried out with the motor stationary or running and without the need to remove guards.

5.8.7. Balancing

Rotors shall be dynamically balanced with full key. The rotors of motors fitted with an external fan shall be initially balanced without the fan and then with the previously statically balanced fan. Any additional weights required shall be fitted to the fan balance rings in accordance with IEC 60034.14.

5.8.8. Noise levels

Unless otherwise specified, the mean sound power level shall not exceed those given in BS EN 60034-9 Class “Normal”

5.8.9. Vibration levels

Unless otherwise specified, the maximum limits of vibration severity for horizontally mounted motors shall be quality grade “N” (normal) as given in BS 4999 Part 142. For vertical motors the same limits shall apply to lower bearings and 1.5 times these limits for top bearings unless otherwise agreed or as per IEC 60034.14.and NEMA MGI.

5.9 Lifting facilities

All heavy parts of motors shall be provided with facilities for lifting.

5.10 Temperature monitoring devices

Monitoring devices for motor winding temperature indication and thermal protection shall be of the RTD resistance type. For thermal protection application only, positive temperature coefficient (PTC) type thermistors shall be used unless otherwise specified.

Resistance monitoring devices shall be distributed evenly around the stator periphery and installed at the hottest points. The devices shall not be directly exposed to the cooling air. Each phase shall have a minimum of two RTDs, one of which shall be spare.

Thermistor shall be installed in the stator end windings and shall be distributed evenly over the winding periphery. The thermistor reference temperatures for alarm and tripping shall be in accordance with BS 4999: Part –III

For medium voltage motors RTDs shall have surge suppressers.

Monitoring devices shall be wired to an insulated terminal strip within a dedicated terminal box fitted with an identification label.

Devices for bearing and cooling air temperatures monitoring shall be of the RTD or PTC type.

5.11 Anti-condensation heaters

Anti-condensation heaters shall be fitted to all high voltage motors.

Anti-condensation heaters shall be fitted to low voltage motors of rated output 10 KW and above and to all low voltage motors, if required.

The rating per unit length of the heaters shall be such that the surface temperature of the heater does not exceed 200° C in an ambient temperature of 45 °C. The heater voltage shall be 220 V unless otherwise specified.

Heater shall be connected to an insulated terminal strip within a dedicated terminal box by means of flexible butyl rubber insulated leads. The terminal box cover shall be fitted with a warning label advising the need to isolate the supply before removing.

5.12 Switchboard anti-condensation heaters

Each cubicle or panel section within a switchboard shall be fitted with an anti-condensation heater and rotary action isolating switch. A common singly-phase supply controlled by suitably placed calibrated adjustable thermostat shall energize all the heaters.

An individually mounted cubicle shall have a thermostatically controlled heater, isolating switch and circuit breaker.

5.13 Motor anti-condensation heaters

Where specified provision shall be made to supply a motor anti-condensation heater from its motor starter. The heater shall be energized from the cubicle isolator and controlled by a normally closed auxiliary contact on the main contactor. The heater circuit shall be protected by an internal circuit breaker and thermo-statically controlled.

5.14 Terminal boxes

Terminal boxes shall be cast iron or fabricated from sheet steel as appropriate to motor frame construction and shall have matching cover. A neoprene bonded gasket shall be fixed between the box and motor frame and between the box and cover.

Cable boxes on medium voltage motors shall have an enclosure specification not less than IP55 NEMA 4 protection and IEC Regulation.

Terminal boxes shall be dimensioned to permit external cables to be satisfactorily connected.

The termination arrangement for low voltage motors shall be of the air insulated stud type. The termination arrangement for high voltage motors shall be of the phase insulated, phase separated or phase segregated stud type.

Terminations, associated leads and terminal boxes shall be able to withstand the effect of a short –circuit at motor terminal without damage. For low voltage motors, unless otherwise specified, it may be assumed that the supply protective device will be of the current limiting type. For medium voltage motors, the short-circuit withstand requirements shall be specified.

Winding terminations and terminal markings shall comply with BS 4999 Parts 145 and 108 respectively.

5.15 Power Transformers

5.15.1. Reference codes and standards

The equipment and material selection design, manufacturing testing and inspection shall conform to the latest editions of the IEC Regulations.

In addition to IEC Regulations, National Standards and WAPDA requirements shall also be complied.

In the event of conflict between the standards, most stringent shall prevail.

5.15.2. Service conditions

The transformers shall be suitable for continuous operation under the prevailing ambient conditions with a minimum of supervision and maintenance. Minimum degree of protection of the enclosures shall be IP 55 in accordance with IEC 60529.

5.16 Main electrical Characteristics

Auxiliary MV /LV transformers shall be fed from the 11 kV system to step down the voltage supply to 400 / 230 V.

Characteristics of main power supply system shall be as follows:

Voltage	11 kV ± 6%
Phase	3
Frequency	50 Hz ± 2%
Neutral System	solidly earthed.

Transformers shall be designed and build for continuous service at full load with occasional overload capacity, in accordance with IEC 60076. Under combined variation of both voltage and frequency as stated above, without exceeding the permitted temperature.

The temperature rise limit for top oil and for average temperature rise (by resistance measurement) shall not exceed the values given by IEC 60076-2.

Impedance voltage shall be less than 4% and when computed from the impedance volts and watts, shall not exceed the guaranteed values at unity and 0.8 lagging power factor by more than 10%

The transformers shall be designed and constructed to withstand the dynamic and thermal effects of short circuit currents in accordance with IEC 60076.

The maximum permissible average winding temperature specified in the standards shall not exceed the fault duration as specified above.

5.17 Design requirements

a. Construction

Transformers shall be of welded steel construction, three phase, step down, mineral oil immersed forced cooled (ONAF), core type, double wound, wheel mounted, with conservator, dehydrating breather and Buchholz relay, and suitable for outdoor installation.

The transformer tanks and tank covers shall be constructed of electrically welded mild steel sheets of sufficient strength to withstand full vacuum without developing any deformation and a pressure at least 25% greater than the maximum operating pressure caused by the expansion of oil/ gas under service conditions.

The transformer tanks shall be mechanically strong, leak proof and suitable for proper heat dissipation. They shall be shot blasted and tested under pressure for detecting any leakage before assembly.

The tank's covers shall be of sufficient strength to prevent distortion when lifted and shall be directly bolted to the top rim of transformer tanks using gasket for oil seal. They shall essentially be constructed in a manner that they can be separated from the transformer tanks without core and windings when required. These shall be designed to ensure the elimination of all air pockets during oil filling operation and shall be provided with pockets for oil temperature indicators.

The conservators shall be fabricated from welded steel sheets, complete with drain valves, filling plugs and having a suitable percentage of oil in the radiators and the main transformer tanks, they shall be vacuum tested under pressure for detecting any leakage.

The connections between the cover and conservator shall be placed so as to ensure positive operations of the Buchholz relay upon the formation of gas or sudden movement of oil. Water shall not accumulate on the outside surfaces.

The joints between tank and cover and the hand hole/manhole joints shall be provided with suitable flanges, bolts and gaskets. Gaskets between metal surfaces shall be set in grooves or held in position by retainers so arranged that all parts are bolted metal to metal. The gaskets shall be made of resilient material which will not deteriorate under the action of hot oil.

The cooling system for ONAF shall consist of fixed radiators welded on the tank sides and shall be designed to withstand the same vacuum and pressure conditions as the transformer tank. These radiators shall be designed to sufficiently cool down the heat generated by the transformers due to losses.
Transformers shall be supplied filled with insulating oil which shall be mineral oil for use as insulating and cooling medium. Due to site extreme conditions, forced air cooling be provided in addition to above design considerations.

b. Tap changer

Transformers shall have means for manual tap changing. This shall be by means of externally operated, side mounted hand wheel or crank designed for operation when transformer is isolated from the supply. Interlock shall be provided to prevent energization of the transformer when the handle is engaged. Or it should be on load tape changer to prevent any mishap. Contractor will demonstrate safe tap changing before take over. The tap changing equipment shall provide:

- Primary winding variations of 0, ±2.5%, ±5% - 7% in addition to principle tapping, with mechanically operated stops to prevent over-travel beyond the maximum raise and lower positions. These tapings shall be of full kVA rated output.

- Clearly marked corrosion resistant local position indicator located where it can be read while operating the tap changer.

c. Cores

The cores shall be made of high grade, non-aging, and cold-rolled electrical silicon steel. Laminations shall have low losses and high permeability. After the laminations have been cut and sharp projections removed, they shall be annealed to relieve shearing stresses. All laminations shall be machine coated to ensure a thin uniform coating. The coating material shall be heat resistant, inert to hot oil and shall be baked on. The core shall be rigidly clamped with insulated clamping bolts or by other approved method into one piece steel structure which will retain its shape under the most severe stresses encountered during shipment and handling and under short-circuit conditions. Insulated packets of the core shall be connected so that potential difference does not exist between them. Flux distortion will be minimized to reduce noise level.

The design of the magnetic circuit shall avoid static discharges, development of short circuit paths and production of flux components at right angles to the plane of the laminations which may cause local heating.

d. Windings

Transformer windings shall be made of high conductivity electrolytic copper without impurities, burr and cracking, insulated thoroughly with insulating varnish or equivalent compound, as necessary, to withstand not only available short circuit forces but also impulse voltages and to minimize deterioration. All materials used shall be insoluble and chemically inactive in the hot oil or shall not soften or become brittle under operating conditions.

The windings shall be located in a manner which will ensure that they remain electro statically balanced and that their magnetic centres remain coincidental under all conditions of operation.
The coils shall be wounded and assembled so that the voltage between turns is kept as low as is consistent with good design and co-coordinated with voltage gradient distribution during voltage surge.

The windings and leads of all transformers shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other transient service condition.

The windings shall be arranged concentrically around the core limbs providing vertical and horizontal cooling ducts to ensure that cooling oil is in intimate contact with every portion of the core and windings.

The star point of secondary windings shall be brought out to a neutral terminal.
The windings shall be Dyn11 unless otherwise specified.

e. Terminal boxes

The design shall provide for mechanically well protected and insulated enclosed terminals and bushings with adequate space for cable termination. Exposed bushings are not acceptable.

All incoming cables shall enter from below.

Entries for cables shall be provided with removable cable gland plate of non-magnetic material suitable for the reception of either multiple or single core shielded cables compatible with the type, size etc. of cables.

All terminal bushings shall be wet process porcelain, homogenous, free from laminations, cavities or other physical flaws and shall be glazed, brown coloured, rigidly clamped with effective creeping distances. Fittings made of steel shall be galvanized.

Bushings shall be removable without the need of untanking of the transformer or removing/dismantling the tank cover.

Cable boxes shall be finished with corrosion resistant paint and shall be fitted with externally removable drain plugs.

Earthing studs shall be provide within the terminals compartment to facilitate direct earthing of cable screens and outside for earthing cables.

f. Auxiliary terminal box

Auxiliary circuits for measurement, control and protection requiring external connection shall be wired up to an auxiliary terminal box mounted on the transformer, when specified.

Auxiliary circuit’s box shall in general be fitted with terminal blocks with 20% spare terminals on each block and with the manufacturer’s standard wire numbers at both ends.

Cable glands shall be provided at the bottom of the terminal box

The cabling between the terminal box and the auxiliary devices shall be made using PVC insulated wires in metal conduits. The minimum conductor size shall be 2.5 sq.mm.

g. Accessories

Each transformer shall be fitted with the following accessories as a minimum.

(1) A pressure relief device for rapid release of any dangerous pressure within the transformer. The device shall operate at a pressure less than the test pressure of the tank and the outlet shall be arranged to face away from the bushings.

(2) Oil level indicator fitted on one end of the conservator provided with alarm contacts for low oil level.

(3) Dial type temperature indicator of mercury type stem-mounted in a closed well. Adequate mechanical protection shall be provided for the capillary tube.

5.18 Medium voltage switchgear and motor control assemblies

5.18.1. General

a. **Construction**

Switchgear and motor control assemblies shall comply with BS 5227 and IEC 60694 and shall be metal clad.

Assemblies shall be constructed of sheet steel of not less than 2 mm thick braced to form a rigid structure. The degree of protection against approach to live parts and contact with moving parts shall be IP3X as defined by BS 5490. Those covers or doors that are required to be opened for normal operation shall not reduce this level of protection.

The floor surface on which the assembly is installed shall be considered a part of the assembly and shall not reduce the level of protection.

Assemblies shall be constructed to maintain the same level of protection during normal operation of the assembly and during and after removal of any parts designed to be removed during normal operations, test or for isolation purposes. Facilities shall be provided to padlock removable parts in ‘service’, ‘test’ or ‘isolated’ positions and shutters in the closed position.

Bus-bar shutters shall be coloured red and labelled "BUSBARS". Circuit shutters shall be colored yellow. Shutters in bus section units shall be coloured red and shall be labelled with large white arrows pointing in the direction of bus-bar section to which the contacts are connected.

Cable chambers shall be suitable for three core or single core cables and designed for dry type joints.

b. **Interlocks**

Interlocks shall be provided between different components of the assemblies to ensure safety and convenience for operation

These interlocks shall ensure that:

(1) Withdrawal or engagement of circuit breaker, switch or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position;

(2) Operation of a circuit breaker, switch or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position;

(3) It shall be impossible to close the circuit breaker, switch or contractor in the service position unless it is connected to the auxiliary circuit and unless it is designed to open automatically without the use of an auxiliary circuit;

(4) Earthing switches having a short circuit capacity less than the rated peak withstands of the circuit shall be mechanically interlocked with the associated disconnections.

(5) Integral bus-bar and circuit earthing arrangements shall be provided within the assembly.

The position of removable parts, earth switches, switch disconnections and the like shall be clearly and unambiguously indicated.

c. **Auxiliary power supply**

Assemblies incorporating short circuit protection other than that provided by fuses shall be provided with an independent external dc power source for the supply of protection relays, shunt trip coils and the like.

d. **Testing facilities**

Assemblies shall be provided with facilities for high voltage cable testing, for checking of phase rotation and for primary injection testing.

e. **Voltage transformers**

Voltage transformers designed for use with the assemblies shall be of the cast resin type incorporating an earthed metal screen between the high and low voltage windings. Voltage transformers shall be withdrawable.

5.19 Medium voltage circuit breakers

Medium voltage circuit breakers shall comply with IEC 62271-100. The rated operating sequence shall be for 3 min-co-3 min co.

Circuit breakers for internal use shall be withdrawable with the circuit breaker assembly truck mounted. Isolation shall be by either horizontal or vertical withdrawal. They shall be motor charged / manually spring charged with manual release.

Two auxiliary contacts shall be provided of each type in addition to that required for control, indication and interlocking of the circuit breakers.

For circuit breakers to be used for starting motors of 11 kV, surge suppressors shall be fitted.

Circuit breakers for external use shall be of the open terminal type and shall have their operating mechanism, control, instrumentation and protective equipment located within a lockable, sturdy ground-mounted, weatherproof housing. Current transformers shall be accommodated in weatherproof enclosure on the bushings.

The circuit breaker shall be of a simple and rugged construction and designed for minimum maintenance.

5.20 Medium voltage motor starters

If applicable, Medium voltage motor starters shall comply with BS 5227 and IEC 60694 and shall be fully compartmentalized to avoid the possibility of fault propagation (metal clad).

Each starter shall comprise of:

a. Bus-bars;
b. On-load circuit earthing switch;
c. Vacuum circuit breaker;
d. Motor protection relay;
e. Control transformer;
f. Ammeter and phase selector switch;
g. Hour counter;
h. Controls as specified

The vacuum circuit breaker shall be withdrawable with positions for ‘service’, ‘test’ and ‘disconnected’. Removal from the ‘service’ position shall automatically apply to the earth circuit.

Facilities shall be provided for operation of the breaker in the ‘test’ position.

Control transformer shall be double wound, single phase. The windings shall be encapsulated with an earthed metal screen between the windings.
The major protection relay shall be solid state and provide protection for:

a. Thermal overload with adjustable inverse current/time curves;
b. High set over current;
c. Locked rotor and stall;

d. Earth fault;
e. Phase imbalance, breaking and reversal;
f. Insulation fault between turns;
g. Stator frame;
h. Under and over voltage;
i. Incomplete starters

The relay shall be of the self-supervisory type with continuous monitoring of hardware and software.

The relay shall be hand resettable and give clear indication of the reason for resettable operation.

Starters shall be provided with power factor correction capacitors. Unless otherwise specified the capacitors shall raise the power factor to 0.95 lagging when operating at the duty point. If VFD provides power factor above 0.95 power factor compensation is not required.

Capacitors shall comply with BS 1650 and IEC 60871. They shall be low loss (approximately 0.20 W/kVAr) and of large number of high quality, self heating round makeup elements wired to each other.

Capacitors shall be provided with HRC fuses and inrush current inductors if required.

Each capacitor shall be fitted with discharge resistors and shall bear a label clear warning of the need to allow a discharge time after isolation prior to working on the capacitor.

The starter cable box shall provide provision for the connection of a capacitor supply cable such that the capacitor current does not pass through the motor protection relay.

Where specified provision shall be made to supply a motor anti condensation heater from its motor starter. The heater shall be energized from the cubicle isolator and controlled by a normally closed auxiliary contact on the main contractor. The heater circuit shall be protected by an internal circuit breaker.

5.21 Variable frequency drive

If Applicable, The variable drive should have the ability to bypass any one cell during operation while maintaining the full output voltage. It should provide 18 pulse or better input harmonz cancellation with a power factor above 0.95 under any operating conditions. Output voltage should be close to perfect sine wave shape. Overheating and increased torsional vibration should not occur. Instead of tripping the drive and automatically shutting down the system due to a malfunction it should provide system of warnings. Following is the technical requirement:

Voltage	:	11 kV
Power	:	1050 kW
Cooling	:	Air cooled
Maximum output frequency	:	330 Hz
Open/close loop control	:	sensor less vector control

Communication with all current BUS systems

Automatic motor identification

Automatic startup

Standards	:	ANSI; NEMA; UL; CSA; CE

5.22 Switchgear and motor control assemblies (less than 1000 V)

5.22.1. Construction

Cubicles and enclosures for electrical equipment shall be constructed of sheet steel not less than 2 mm thick or other approved material suitably traced to form a rigid structure. Adjacent frames dividers and covers shall be securely bolted or welded to ensure earth continuity throughout.

The exterior corners and edges shall be rounded to give a smooth overall appearance with projections kept to a minimum.

Lifting lugs shall be provided for installation purposes and shall be replaced with corrosion resistant bolts after installation.

5.22.2. Enclosures

Multi-enclosure assemblies shall be constructed to BS 5486 and IEC 60947-2 with internal separation of compartments to Form 4. Where more than one outgoing circuit occupies a common distribution section all cable terminations, cable lugs and such like shall be fully insulated or screened to allow work to be carried out on any one circuit with other circuits remaining live.

Unless otherwise specified assemblies shall be floor standing with lockable hinged front doors, and bolted removable rear panels where access to live equipment such as bus-bars and terminals is possible. The panel height shall not exceed 2300 mm.

Instrumentation shall not be positioned above 2000 mm and devices for isolation and switching shall be accessible within the zone 800 mm to 1600 mm above floor level. Suitable warning labels and instructions for earthing and isolating shall be fitted where necessary.

Unless otherwise specified, cable entry shall be from the base and shall enter an accessible cabling compartment via suitable cable glands and gland plate. Access to cable terminations shall be via bolted panels either from the rear or front as specified.

Cubicles and enclosures for outdoor locations shall be fitted with lockable doors and housing so designed that all controls, instruments are fully enclosed, with the whole assembly being weather and vandal proof. The doors shall be fitted with stays arranged to prevent overstraining of the hinge fixings and allow fixing of the doors in the open position.

The internal cubicles shall also be weatherproof to allow operation of the controls when the outside doors are open during inclement weather.

Enclosures shall give a degree of protection as follows:

Indoor Installation:

a.	Substation or switch room	-	IP4X
b.	Plant room	-	IP43
c.	Outdoor Installation:		
	Undercover	-	IP65
d.	Exposed	-	IP65

5.23 ‘Electrical Safety

The Contractor shall be responsible for the electrical safety of all equipment supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on Site. If necessary this shall include fencing off areas that are considered to pose a risk, and erecting warning notices.

The Contractor shall be responsible for ensuring that competent and authorized personnel carry out the electrical installations and that the work is carried out in accordance with standard procedures and regulations. Before any piece of apparatus is energized it shall be thoroughly examined to ensure that it is free of dirt, water, vermin or other foreign matter.

Electrical equipment shall be designed and constructed to provide a maximum standard of safety for operating and maintenance.

Access to any enclosure shall be possible only when the circuit isolator is open and connections within the enclosure are isolated or fully shrouded against accidental contact or when connections within the enclosure are not at a voltage exceeding 50 V.

Where a test facility exists for use with the enclosure door open all live contacts shall be shrouded to prevent accidental contact.

5.23.1. Withdrawable components

Where removable or withdrawable components are specified they shall, where appropriate, be provided with distinct locations for test and removed position. Provisions shall be made to padlock the withdrawable part in each position. Withdrawable parts shall not be withdrawn or re-inserted unless the main circuit has been interrupted.

The degree of protection applying to the connected position shall be maintained in the test and disconnected position and during transfer from one position to another.

Withdrawable parts shall be fitted with positive guides to ensure correct alignment of the isolating contacts in which ever circuit or earthing position is selected.

5.23.2. Safety shutters

A set of safety shutters shall be provided to cover each of the three phase groups of stationary isolating contacts. The shutters shall be opened automatically by a positive drive from the circuit breaker moving portion and when closed shall prevent access to the stationary isolating contacts. When the circuit breaker is withdrawn each set shall be capable of being individually operated and of being padlocked in the closed position.

To facilitate inspection and testing, a device shall be provided for propping (not locking) the shutters in the open position and for releasing them into the closed position. The device shall be arranged to be cancelled by the moving portion to ensure the restoration of the automatic feature of shutters.

Busbar shutters shall be coloured red and labeled BUSBARS in large white letters. Circuit shutters shall be labeled with a large white arrow pointing in the direction of the section of busbars to which the contacts are connected.

5.23.3. Short circuit

Unless otherwise specified the short circuit rating of assemblies shall be 50 KA for 1 second. Where possible short circuit protective devices shall be coordinated to ensure that a fault in any outgoing branch does not operate the assembly incoming protection device.

5.24 Labels

The assembly as a whole and each compartment shall be clearly and unambiguously identified.

The labels shall be engraved letters and numbers filled black on a white background. They shall be affixed with non-corrodible rivets or screws.

Warning labels shall be engraved and filled red on a white background.

Internal labels shall be used to identify all components and terminal strips. They shall be non-degradable paper fabric or plastic in construction and shall be affixed adjacent to the component to which they appertain.

5.25 Switchboard ancillary equipment

The following ancillary articles shall be supplied with each switchboard

a. Operating handles, tools
b. 1 set of maintenance warning labels
c. 1 set of padlocks
d. 1 set of earthing leads, if required.
e. Other tools, gloves, notices etc. required to comply with the statutory legislation.
f. Black colored rubber safety mat running the length of the switchboard

Items a., b., c. & d. shall be contained within a lockable wall mounted steel cabinet.

5.26 Switchboard assembly component

Switchgear control components shall be as such that those components mounted on the external surfaces of assemblies shall not reduce the degree of protection from that specified.

5.27 Indicating instruments and meters

All instruments and meters shall be flush mounted and digital multimedia with electrical analyzer with more than 100 parameters with size 96 x 96 mm. Digital output for remote monitoring.

Ammeters in motor starter circuits shall be capable of withstanding the starting current.

Kilowatt-hour meters shall be electronic meters with built in communication interface.

All instrumentation shall be capable of communication on modbus/rtu protocol

5.28 Indicator lights

Indicator lights shall not be less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring. Lamp holders shall be keyed into panels to prevent rotation. Lens colours shall comply with IEC 60073 as follows:

Power on	:	White*
Running	:	Green
Tripped / alarm	:	Red
Status (open, closed, etc)	:	Blue
Warning (no imminent danger)	:	Amber

*Note: white may be used where doubt exists as to which other color to use.

The lights shall be long life LEDs.

5.29 Push buttons

Colours of pushbuttons shall generally comply with BS 4099 (IEC 60073) and in particular shall be as follows:

Stop, emergency stop	-	Red
Start	-	Green
Jogging / inching	-	Black
Reset (when not also acting as stop)	-	Blue
Lamp test	-	Blue
Override/alarm accept	-	yellow

5.30 Terminal blocks

Terminal blocks shall be of the screw clamp, rail mounted type to VDE 0611; Part 1 for connection of copper conductors upto 1000 V.

The terminals used shall be suitable for the type of wire to be terminated and current carrying capacity.

Each terminal rail and each individual terminal shall be indelibly marked with a unique number corresponding to the schematic diagram terminal numbering system.

No more than one cable shall be terminated per clamp. Cross connections shall be used to link adjacent terminals when multiple wire connections are required.

Each terminal shall be coloured green /yellow and shall clamp to the fixing rail in order to provide earth continuity.

Terminals of different sizes and voltage terminations shall be partitioned.

Where un-isolated external voltages may be present terminals shall be screened and a warning label fitted.

Terminals used in conjunction with current transformers shall have facilities for shorting-out of the output to enable removal of instrumentation.

In any terminal arrangement adequate space shall be provided for the neat and logical termination of the incoming wiring. Terminal rails shall have provision for the installation of at least 10% additional terminals.

Terminals within cubicles and enclosures shall not be obscured and shall be easily accessed for installation and testing purposes, without removal of equipment.

5.31 Contactors

Contactors shall comply with BS 5424. They shall be maintenance free and where possible allow replacement of the coil, without disturbance to the wiring.

The mechanical life shall be in the region of 10 million operations and 3 million operations for contactors rated in excess of 400 kW AC3 utilization category.

Contactors shall be provided for AC3 utilization category.

5.32 Relays

Relays shall comply with BS 4794. They shall be suitable for mounting to rail to BS 5584. Positive locating being assured by a built-in screw clamp or clip.

Terminals shall be numbered in accordance with BS 5472

Relays shall be designed to accept top adder auxiliary contact blocks, latch and timer attachments.

5.33 Switchboard assembly small wiring

Switchboard wiring shall be carried out in 600/1000 V PVC cable to BS 6231 and the conductors shall not be less than 1 mm^2 and shall be stranded.

Current transformer secondary circuits shall have a minimum cross-sectional area of 2.5 mm^2. Earth wires of meters, doors, etc shall have a minimum cross-sectional area of 2.5 mm^2.

Wiring within the switchboard shall be marked with ferrules at each end for identification. The letters and numbers used shall correspond with the switchboard wiring diagram.

The wiring colour code shall be as follows:

Phases	-	Red, yellow, blue
Neutral	-	Black
Control	-	Grey
Earth	-	Green/ yellow

The wiring shall be neatly laced and cleated to the switchboard structure or contained within purpose designed plastic trunking and arranged so that access to equipment is not impeded. Cables installed in trunking shall have a space factor not exceeding 50%. Where wiring passes through metalwork the access hole shall be fitted with a suitable grommet.
Cable ferrules shall be applied to all cable ends to ensure sound termination to terminal blocks and all circuit components. The type of ferrule used shall be suitable for the application in each instance.

Wiring between cubicles or panel sections shall be terminated in terminal blocks at each end. Such arrangements shall only be permitted between sections which have to be split for transportation purposes.

No tees or joints between termination points shall be permitted.

5.34 Local control stations

These shall be of heavy duty construction and with the smaller sizes designed for mounting on or near the plant to be controlled.

The bottom face shall be arranged to accept, with adequate space for the use of spanners, gland terminations for the number of cables required.

Terminals shall be provided for interconnections and shall be easily accessible and marked with identification numbers/letters corresponding with the associated diagrams.

Indicator lamps shall not be less than 20 mm diameter and shall have projecting lenses with a wide angle of vision.

Pushbuttons and selector switches shall be of heavy duty, oil tight type of matching design. Legend plates shall be provided to identify plant to be controlled and the purpose of each operating or indicating device.

Pendant type control for cranes, hoists, etc. shall be of the moulded neoprene or equivalent heavy, flexible, high impact strength materials, with a long moulded-in cable strengthening sleeve, to minimize the possibility of cable fracture at the bending point. The enclosure shall be coloured in safety yellow.

5.35 Current transformers

Current transformers shall comply with BS 3938 IEC 60044-1 and shall be of the wound-primary or bar-primary type according to ratio required. All current transformers shall have a short-time current ratio of not less than that of the switch panel in which they are incorporated. For bar-primary current transformers this rating shall be for a period of 3 seconds. For wound-primary patterns the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the Employer's approval.

Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios. All ratio terminals shall be connected to the multi-core terminal box and be clearly marked. These connections shall also be shown on panel wiring diagrams.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboards.

Current transformers for balanced earth fault protection shall be designed for a stability of not less than six times the rated primary current.

Current transformers for unit protection schemes shall be designed for a stability of not less than the maximum through fault of the units.

Where attracted armature relays are employed the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

Magnetization characteristics, calculated performance and protection settings shall be provided.

Current transformers shall be of Class 1 accuracy for use with measuring instruments and Class 10P for use with protective relays. Class 5P shall be used for combined overcurrent and earth fault protection of the inverse time overcurrent type. The Contractor shall ensure that the class and capacity of the current transformers is corrected for the meter or relay being supplied. Separate current transformers shall be used for instrumentation circuits unless otherwise approved.

Each group of current transformers shall be earthed at one point via a removable test link.

The accuracy limit factor selected for protection of current transformers shall take due account of the prospective short circuit current and the connected burden.

5.36 Voltage transformers

Voltage transformers for use with measuring and protective equipment shall comply with BS 3941 and IEC 60044-2.

Single phase voltage transformers shall have a secondary voltage of 110 V. Three phase voltage transformers shall have a secondary line to neutral voltage of 63.5 V.

Voltage transformers shall have a rated burden at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meters to which they may be connected via test blocks. The primary circuits shall be protected by HRC fuses. The connections between the fuses and the switchgear primary conductors shall have a short-circuit rating equal to that of the switchgear.

The secondary circuit shall be protected by fuses or miniature circuit-breakers mounted as close as possible to the secondary terminals. Fuses and miniature circuit-breakers shall be accessible for renewal or resetting without the need to isolate the switchgear.

Where voltage transformers are of the isolatable pattern they shall be arranged for padlocking in the service position. Safety shutters shall be provided to automatically cover the fixed contacts when the transformer is withdrawn. Means shall be provided to enable the shutters to be padlocked in the closed position.

5.37 Air break switches, switch disconnectors and fuse switches

Air break and fuse switches for use in distribution and motor circuits for voltages upto 1000 V ac shall comply with BS 3419.

Switches for distribution circuit's use shall be of utilization category AC 22

Switches for motor circuits shall be of utilization category AC 23

Utilization category shall be as defined in BS 5419.

Provision shall be made for them to be located in the "off" position.

5.38 Low voltage motor starters

Each starter shall comprise of:

a. Fully door interlocked switch disconnecter of utilization category AC 23 as defined by BS 5419, lockable in the off position.

b. HRC fuses or MCCBs for short-circuit protection, when not provided upstream of the starter.

c. Contactor.

d. Overload.

e. Thermostatically controlled anti-condensation heater with protection and isolator.

f. Start and stop push buttons.

g. Running, stopped and fault indication

h. Ammeter and hour runs meter where specified. Ammeter fitted in blue phase (for starters above 10 kW).

The starter shall be housed in its own enclosure or shall be incorporated within a switchgear assembly constructed to BS 5486. Small individual starters may have front panels secured by screws. Above 15 kW front covers shall be hinged and lockable unless otherwise approved by the Employer.

The utilization category of the starter shall be AC 3 and the duty class coordination shall be Type C as defined by BS 4941.

Overload protection unless otherwise specified shall be by hand resettable thermal overload providing differential single phase protection. Where the requirement for stall, earth fault or phase reversal protection is specified, an electronic protection relay shall be provided.

Where specified starters shall be provided with power factor correction to raise the power factor to 0.95 lagging when operating at the duty point, where practical, they shall be incorporated within the starter or in a location approved by the Employer.

The capacitor shall comply with BS 1650. It shall be fitted with discharge resistors and shall bear a label clearly warning of the need to allow a discharge time after isolation prior to working on the capacitor.
The capacitor current shall not pass through the motor protection thermal overload.

5.39 Circuit breakers

5.39.1. Moulded case circuit breakers

Moulded case circuit breakers shall comply withI IEC 947, and shall have a category of duty Ics = Icu.

They shall be of the low energy let through type incorporating positive ion quenching in order to ensure rapid arc quenching.

The operating dolly shall have three positive positions ‘ON’ ‘OFF’ and ‘TRIPPED’

Tripping characteristics shall be ambient temperature compensated and selected according to application, i.e., distribution, generation or motor duty.

5.39.2. Miniature circuit breakers

Miniature circuit breakers shall comply with BS 387 : Part 1 or IEC 60898. They shall be type 3 with a breaking capacity of at least 4.5 kA at 240/415 V unless the fault level at the point of installation dictates otherwise.

5.39.3. Residual current circuit breakers

Residual current circuit breakers shall be current operated and comply with BS 4293. The tripping current shall be selected dependent on location within the supply network and the calculated loop impedances. It shall operate to trip all phases including the neutral.

Unless otherwise specified the following sensitivities shall be applied:

(1) Individual ring mains, ring main groups or socket outlets 30 mA

(2)	Small consumer boards incorporating no other RCCB protection	30 mA
(3)	Small consumer boards incorporating RCCB protection on Outgoing ways	100 mA
(4)	Large consumer board incoming RCCB	at least 300 mA

The residual current circuit breaker shall be capable of withstanding the likely fault current at the point of installation.

5.39.4. Air circuit breakers

Air circuit breakers shall comply with BS 4752 and shall be ASTA certified to 50 kA Cat P2.

Circuit breakers shall be withdrawable.

a. **Operating mechanisms**

All circuit breakers shall be provided with operating mechanisms as detailed in Specifications, the selection being from the following types:

a. Independent manual spring
b. Hand charged spring with manual release
c. Motor charged spring with electrical release
d. dc solenoid

All operating mechanisms shall have mechanical 'ON' and 'OFF' indicators and a manual trip device fitted with means for locking. Hand charged and motor charged spring mechanisms shall have mechanical indicators to show 'SPRINGS CHARGED' and 'SPRINGS DISCHARGED'.

Operating mechanisms of the hand charged and motor charged spring types shall be arranged so that release of the springs to close the circuit breaker can only be achieved by a deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor spring mechanisms shall be arranged so that charging is initiated automatically following a discharge, and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism. It shall be possible to hand charge a motor charged spring mechanism in an emergency.

Spring operated mechanisms shall be provided with volt-free contacts to give indication that the springs are charged.

The closing solenoids of dc solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage and shall not maloperate or cause excessive vibration when energized at a voltage equal to that of the closing battery with the charge set at the maximum rate or equal to that from a full wave rectified source designed for multiple simultaneous operations. Unless otherwise agreed, this higher voltage shall be taken as 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contract, it shall be possible to slow close the circuit breaker but this operation shall only be possible in the fully withdrawn position. Any necessary operating handle, lever or tube shall be supplied.

b. **Interlocks and test operation facilities**

All circuit breakers shall be provided with interlocks to ensure that:

(1) The circuit breaker cannot be plugged in or isolated whilst it is closed; attempted isolation shall not trip a closed circuit breaker;

(2) The circuit breaker cannot be closed until it is fully plugged in or completely isolated;

(3) The circuit breaker cannot be closed in the service position without completing the auxiliary circuits between the fixed and moving portions;

(4) The circuit breaker cannot be ‘slow-closed’ except in the fully withdrawn position;

(5) With hand charged or motor charged spring mechanisms the springs cannot be discharged until they have been fully charged or until the means for charging has been fully removed and disconnected;

(6) With the circuit breaker plugged-in to an earthing location tripping can only be effected by the manual device on the operating mechanism.

(7) Where mechanical key interlocking is employed, tripping of a closed circuit breaker shall not occur if any attempt is made to remove trapped key from the mechanism.

c. **Protection**

The circuit breaker shall incorporate an integral overcurrent protection relay offering facilities for site selection of inverse, very inverse and extremely inverse characteristics. The circuit breaker shall incorporate integral protection current transformers.

5.40 Power system protective relays

Protective relays shall be mounted on the front of the switchgear or relay panel in such a position that operation and maintenance can be conveniently carried out. Auxiliary relays may be mounted inside a cubicle provided that they are readily accessible.

Protection relays shall comply with BS 142 and shall where possible be of solid state design.

Flush, jack in type relays are preferred. Each relay shall have an indicator device to show when the relay has operated and, where appropriate, which phase element. Resetting devices shall not require the removing or opening of the relay.

Solid state relays shall be of the module type comprising of a number of plug in elements allowing interchange of functions. Each of the protection elements shall have adjustable controls for current and time settings as required.

A build-in test facility shall be provided for individual testing of the settings of each of the protection elements. The tests shall be carried out by means of test sockets so that elements do not have to be removed from the panel.

(1) Over current and earth fault relays shall have site selectable inverse characteristics and where specified shall be capable of incorporating definite time, high set, earth fault and restricted earth fault tripping characteristics.

(2) Overvoltage/ under voltage relays shall operate between 105 to 135% and 70 to 100% of rated voltage in 5% steps. The relay shall incorporate an adjustable time delay to suit the application.

Generally, if relay types are specified other than those mentioned above no further details are required as relays are so standardized these days. It is important for the Contractor to demonstrate that the system is fully coordinated.

5.41 Fuses and links

Fuses used for the protection of power circuits shall be of the high rupturing capacity, HRC type.

(a) Low voltage

Fuses shall comply with BS 88.

Fuse carriers and bases shall be black. Solid link carriers and bases shall be white.

Fuses and links shall be shrouded and positioned to enable easy removal of the fuse and carrier without risk of contact with live parts.

(b) High voltage

Fuses shall comply with BS 2692 for use in oil or air. Fuses shall be equipped with striker pins where appropriate to operate a trip mechanism.

When used for distribution transformer protection they shall be sized in accordance with IEC 60787

High voltage fuses sized to DIN 43625 tested to IEC 60282 are also acceptable.

5.42 Distribution boards

Distribution boards and consumer units shall be metal clad, with cases of good quality folded sheet steel construction and shall have a protection classification of at least IP 31

Distribution boards and consumer units shall conform to BS 5486: Parts 12 and 13 respectively.

The bus-bars shall be mounted on non-hygroscopic insulators and shall be completely shrouded or covered with PVC sleeving which shall be coloured to denote the appropriate phase.

Neutral and earth bars shall be provided with separate terminals for each circuit.

All phases shall be identified and each circuit shall be labelled, typewritten or stenciled and fixed to the inside cover of the board.

Unless otherwise specified spare ways shall be fitted with the maximum size of miniature circuit breaker for the board and other circuits shall be rated as indicated on the circuit diagrams.

Distribution boards for outside use shall be of a corrosion resistant design and fitted with a lockable outer door to give protection of at least IP 41.

Incoming supplies to the distribution board shall enter by means of a lockable isolator, switch fuse, residual current device or moulded case circuit breaker. Outgoing supplies shall be protected by miniature circuit breakers.

5.43 Marshalling panels and boxes

Marshalling panels and boxes shall be constructed of sheet steel with ample space for routing and terminating cables and cores.

Cable entries shall be from the underside of the box. Front and rear enclosure access shall be provided for floor mounting marshalling panels.

Every marshalling panel and box shall be provided with:

a. Undrilled gland plates
b. Anti-condensation heater with fuse
c. Padlocking facility
d. Earthing bar with terminal holes
e. Door-controlled internal light with fuse
f. Front door label, labels for fuses and terminal blocks
g. Panel wiring diagram secured in internal plastic covers
h. Transparent plastic covers on terminal blocks.

5.44 Earthing

EPC contractor needs to keep following points in consideration while opting the appropriate plant earthing system and associated details.

1. **Grounding System Design & Planning.**

Grounding system selection & design shall starts with the site analysis, collection of geological data, and soil resistivity of the area w,r,t equipment manufacturers specified resistance-to-ground number. The opted design must comply with the National Electric Code (NEC) that states the maximum acceptable resistance-to-ground in ohms for the individual circuits and entire set up. Data collection and data analyses be made towards the grounding system design.

2. **Electrical Earthing System** be designed, installed and connected to all electrical machineries and equipment as well as the plant's bulk equipment as Electrical earthling network. The overall earthing resistance of the electrical earthing system should not be greater than 4 OHM, no matter which point of the grid is put under measurement.

3. **Instrument Earthing Systems**. For the sophisticated power and electronic equipment, protective measures should be taken to safeguard the instrumentation and the relevant control panels against the sudden high voltages which might hit the earthing system in the event of a fault (short-circuit) in the power circuit of the installation.

   As a standard design practice, a separate earthing system be defined, designed and installed in the plants such that the earthing resistance should not be greater than 1 OHM throughout the instrument earthing network. Details on instrument earthing system, particularly the different types of instrument earthing shall be offered during the specific course. Sufficient distance should be maintained between the instrument earth wells and the electrical earth wells. Standard distance is at least twice that of the greatest length of the earth rod driven in either the instrument or the electrical well.

4. **Lightning earthing system**

   Be designed per NEC codes and be submitted alongwith plant design documents / drawings for review.

5. **Neutral Grounding Transformers**

   System to be incorporated with necessary grounding resistor systems to protect power transformers and generators from damaging fault currents. Low resistance grounding of the neutral shall limit the ground fault current to a high level (typically 50 amps or more) in order to operate the protective fault clearing relays and current transformers. These devices shall be able to quickly clear the fault.
   The limited fault current and fast response time must also prevent over-heating and mechanical stress on conductors.. Ground fault protection for high voltage transformer and generator grounding applications would require a grounding

transformer to lower the voltage .

6. Resonance Grounding System,

Points to be discussed by EPC are mainly,

1.Solid vs. resonance neutral
2.How can be reduce fault current further from isolated neutral systems?
3. Value added in terms of proposed resonance grounding
4. Zero sequence measurements
5. .Effect of asymmetry and conductive line charging
6. Resonance grounded system during fault (L=constant)
7. Directional over-current relay – resonance ground de systems
8. Trip zone
9. Relaying logic

7. Arc Suppression System.

Single-phase neutral earthing (grounding) reactors (Arc Suppression Coils) shall be incorporated to compensate for the capacitive line-to-earth current during a 1-phase earth fault. The arc-suppression coil (ASC) represents the central element of the Trench earth-fault protection system.

Because the electric system is subject to changes, the inductance of the ASC used for neutral earthing must be variable. The earth-fault detection system developed by Trench utilizes the plunger core oil (moveable-core design). Based on extensive experience in design, construction and application of ASCs, Trench products can meet the most stringent requirement for earth-fault compensating techniques.

Resonant grounded systems suppress transient ground faults and enable to continue power supply even during single pole earth faults.

For special requirements neutral point coupler (earthing transformer) and stepless adjustable ASC shall be housed in a common tank forming a so called Neutral Earthing Aggregate.

5.44.1. General arrangement

The electrical installation shall where required be connected to the general mass of the earth and the earthling system shall comply with BS 7671

The installation shall comprise of one or more earth electrodes, high conductivity copper earthling tape network, mesh or a combination of these in order to obtain the required earth electrode resistance and shall comply with the requirements of BS Code of Practice CP 7430 Earthling.

Each earth electrode shall be of copper and will be provided with an approved clamp for the connection of the earthing conductor or tape as required. These connections shall each be housed in individual concrete inspection pits set flush to the finished ground level and shall allow disconnection for testing of individual electrodes.

All materials used for the earth electrode installation shall be purpose made for the application and site conditions shall be approved by the Employer.

All excavation of trenches and c.c. work for the installation of the earth electrodes and the inspection pits shall be carried out by the Contractor. After the earth installation has been completed. The contractor shall demonstrate to the Employer that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the position of the electrodes and buried conductors. The markers shall be similar to those provided for cable routes.

5.44.2. Network

Where specified a main earth bar shall be installed in an approved location. This shall comprise of a 50 mm x 6 mm minimum copper bar supported on porcelain barrel type insulators and wall mounted. The bar shall be of sufficient length to accommodate bolted earth bonding connections from transformers, major items of plant, building structural steel work, concrete reinforcement and the earth electrode system.

5.44.3. Earth continuity conductors

An earth continuity conductor shall be provided between all electrical plant, mechanical plant, exposed steelwork and the like as required to meet the requirements of BS Code of Practice CP 7430 - Earthing and Pakistan Electricity Rules. This can be as follows:

(a) Copper tape connections forming part of the earth network

(b) Where the distributor is an armoured cable, the metal sheath and armouring of the cable shall be securely bonded at each end to the metalwork of the apparatus or to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the terminal gland prove inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

(c) Where the distribution system is contained within conduit or trunk, a separate earth conductor shall be provided for each circuit. Steel conduit or trunking must not be used as an earth continuity conductor.

(d) Earthing of each section of a trunking or cable tray installation shall be ensured by bonding. This requirement will be fulfilled by installation of:

(i) A continuous earth continuity conductor bonded to each section, or
(ii) bonding straps installed across each joint

(e) Where the distribution system is mineral insulated copper sheathed cable the sheath can be used.

(f) Main equipotential bonding conductors and supplementary bonding conductors shall be installed and sized in accordance with IEE Regulations for Electrical Installations.

5.44.4. Lightning protection

For buildings or sections of the plant to be protected against lightning or static charges, an earthing system shall be provided. The installations shall be carried out in accordance with BS 6651

The down connectors shall be of hard drawn high conductivity copper of 25mm x 3mm section. The tape shall be fixed to the outside of the structure by means of standoff saddles. Where required connections shall be made to the concrete reinforcing. The route of the tapes and the fixings shall be discussed with the Employer before installation.
Where the conductors specified shall be PVC insulated to prevent corrosion and to blend with the building fabric.

A test link shall be installed in each down conductor adjacent to the earth rod at a height of 1.2m above ground level. The overall resistance of the earth termination system to earth shall not exceed 10 ohms. If this requirement is not met the number of earth electrodes shall be increased or they shall be interconnected until a value of 10 ohms is attained.

5.45 Cables and wires

5.45.1. General

Each drum or coil of FR cable complying with BS or IEC approved equivalent standard shall be accompanied by a certificate stating the manufacture's name, cable size, number of cores, length, result and date of tests as required in the Specification.

Cables manufactured more than 12 months before delivery will not be accepted.

All cables shall be FR, delivered with cable ends effectively sealed. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture.

Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

5.46 Standards

a. Low voltage (600/1 000 V grade)

(1) PVC/SWA/PVC and XLPE/SWA/PVC multicore cable to BS 4346 and BS 5467, IEC 60502-1 respectively. Installed direct in the ground, in ducts, on trays or clipped direct. Aluminium wire amounting shall be used for single core cables

(2) PCV/PVC multicore cable to BS 6346, IEC 60502-1 Installed in floor ducts, trunking or conduits.

(3) PVC single core non-sheathed (450/750 V grade) to BS 6004 Installed on tray or clipped direct.

(4) Mineral insulated, copper clad to BS 6207, Installed on trays or clipped direct

(5) EPR/CSP multicore cable to BS 6883 or IEC 29-3 Installed as down borehole cabling to submersible equipment or trailing leas.

(6) PVC single core non-sheathed /600/1 000 V) to BS 6231. Installed as internal wiring within switchgear and control assemblies.

(7) General purpose-PVC insulated copper conductor white PVC sheathed overall, rated at 300/500 V in accordance with BS 6004

b. Medium voltage 3.3kV to 33kV

(1) XLPE/SWA/PVC cable to BS 6622 or IEC 60502. Installed direct in the ground, in ducts or clipped direct, Aluminium wire armouring shall be used for single core cables.

c. Telecommunications

Depending on the contractor best choice of system and subject to the review / approval of the employer, option will be made, As an preferred option,
Please use cables and telecommunications system in line with modern standards such as EIA/TIA. The telecommunications system infrastructure needs to be developed and incorporated as a structured cabling system as per EIA/TIA regulations for industrial applications, preferably Industrial Ethernet such as ProfiNET or Modbus/TCP.
Passive infrastructure should be implemented as an end to end fiber optic cabling infrastructure. Details of passive and active infrastructure to implement voice, data, security, monitoring and control applications to be included.

However for the purpose of choice the options may include following specs as well,

(1) **External Use**
The cable shall be cellular polyethylene insulated armored telephone F R cable manufactured generally in accordance

with British Telecom Specification CW 1128. The conductors shall be
0.9 mm diameter copper. The insulated conductors shall be twisted together in pairs and shall be identified by colour. The cable shall be fully filled with tropical grade petroleum jelly and a polyethylene sheath shall be applied over the laid up pairs. A layer of galvanized steel wires shall be applied over this sheath. The armouring shall comply with British Telecom Specification CW 1198.

A black coloured PVC or Polyethylene sheath shall be applied overall.

The electrical Characteristics shall be within manufacturing tolerances which are as follows:

a.	Conductor loop resistance (at 20ºC)	60 ohm/km
b.	Insulation resistance (at 20ºC)	1500 mega-ohms/km
c.	Mutual capacitance (at 1 kHz)	60 µf/km
d.	Maximum capacitance unbalance between pairs at (1 kHz)	275 µf/km
e.	Characteristics impedance (at 1 kHz)	390 ohms
f.	Attenuation (at 1 kHz)	0.85 dB/km

Installed in ducts, pipe ducts and direct in the ground.

(2) **Internal Use**

The cable shall have tinned copper conductors of 0.5 mm diameter with PVC insulation and PVC oversheath. It shall comply generally with British Telecom Specification CW 1293 and shall meet following:

(i) The colour of the sheath shall be cream
(ii) For use indoors for internal distribution and connection to extension instruments.
(iii) Installed in conduct, trunking or clipped direct.

5.47 Rating

The Contractor shall ensure that cables and wires associated with the distribution and control systems, plant wiring and all over installations throughout the Work are adequately rated for their use.

In assessing the rating of any cable or wire, the following factors shall be taken into account:

a. Supply voltage and frequency.
b. Maximum voltage drop permissible.
c. Type and magnitude of load.

d. Fault level and duration related to circuit protection relays and fuses.
e. Circuit overcurrent protection.
f. Route length and disposition of cables.
g. Ambient temperature.
h. Method of installation.

5.48 Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

The colour coding should be as follows:

a. 3 phase	red, yellow and blue
b. Single phase or dc	red and black
c. Earth	green/yellow
d. Control	grey

5.49 Conductors

Copper conductors shall be used throughout. Cores of cross-sectional area greater than 1.5 mm² Small power cables shall be of a minimum cross-section of 2.5 mm². Control cables shall be stranded.

Internal wiring of control panels shall be of a minimum cross-section 1.0 mm² flexible and stranded.

5.49.1. General

Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.
Cables shall be segregated into the following categories:

a. Power (greater than 1000 V)
b. Power (less than 1000 V)
c. Instrumentation/ telemetry
d. Control
e. Telecommunications

Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of equipment installed within the Work. As a general rule the following minimum clearances shall be adhered to wherever practical.

There shall be a minimum separation of 600 mm between HV power and all other cables and 300 mm between all other categories.

These separations are minimum and special circumstances such as the presence of high current flows or harmonic content may necessitate larger separation distances

All cables shall be permanently identified at each end and at entry and exit points of ducts. Identification shall be by means of approved cable markers with semi rigid black PVC carrier strip which shall be fixed axially by means of two PVC straps or other marker type.

On rotating plant and transformers where the required direction of rotation or phasing is to be achieved, if it is not possible to connect the phase cores to the appropriate terminals additional core ferrules shall be fitted to identify each core with the terminal to which it is connected.
Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of ferrule markers. The size of the ferrule markers shall be such that it matches the overall diameter of conductor plus insulation. Numbering shall read away from the termination on all cores.

5.49.2. Direct in ground

Buried cable up to 1000 V shall have a minimum cover of 500 mm measured to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.

High voltage cables shall be buried with a minimum cover of 1000 mm.

The bottom of the cable trench shall be free from sharp stones and the like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above. Interlocking cable protective covers, minimum 1000 mm long x 300 mm wide marked ‘Danger – Electric Cable’ in English and in vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.

Warning tape shall be laid a minimum of 200 mm above the protective covers.

Cables are to be installed without tees or though joints unless otherwise approved by the Employer. Single core cables are to be run in trefoil formation.

The thermal resistivity of soil shall be determined at proximity of the cable, after laying of the cable and after compaction of the soil but before complete backfilling. The value of the thermal resistivity of soil as determined above at random points shall be less than 120 ^{o} C – cm/W

5.49.3. In Underground ducts

Underground ducts shall be constructed of impact resistant uPVC glazed earthenware or concrete tiles laid at a minimum depth of 500 mm. Ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1000 mm deep and encased on all sides by 150 mm of concrete.

The Contractor shall ensure that sufficient draw-in-points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

Where cables pass in or out of any duct entries into or within buildings, such entries together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Employer. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated.

5.49.4. In conduits

Conduits shall be galvanized heavy gauge solid drawn on welded screwed steel type and be in accordance with BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized and shall comply with BS 4568, 4607 and 6099 as appropriate.

A space factor of 40% shall not be exceeded, but in any case conduit of less than 25 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable plates shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.

Where conduits are greater than 24 mm, straight through joint boxes shall be of the through type where conduit and/or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.

Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on the mating faces of coupling or other adjacent accessories. All junction boxes draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The Whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Employer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws or other approved type.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement etc and covers, either temporary or permanent, shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

a. **Surface installation**

Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Employer before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steel work shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Employer. Any drilling or access which is required through any structural member of the building shall be agreed with the Employer before carrying out the work.

Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

b. **Concealed installation**

Concealed conduits shall be securely fixed to prevent movement before placing of concrete slabs in floor / ceiling. Floating of plaster, casting of columns or other building operations necessary after the conduit installation. Cram pets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Conduits installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed conduits installed in floors shall be sealed against ingress of moisture.

The conduit installation shall be inspected by the Employer before the building operation conceals the work.

c. **Flexible conduits**

Flexible conduits shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduits shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduits complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid, conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment. The earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc. will not be permitted; Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

5.49.5. In cable trunking – metal

Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5 m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitting, the bared ends shall immediately be given a zinc rich cold galvanizing paint.

Cable and conduit/trunking runs shall be determined by the Contractor and agreed by the Employer before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services.

Conduit/ trunking systems erected outside a building shall be weather proof.

5.49.6. On cable trays

Cable trays shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width and not less than 1.5 mm for trays from 150 mm to 300 mm width. All cable trays and supports shall be in accordance with BS 6946.

Cable trays shall be hot dipped galvanized to BS 729 or PVC coated as specified. Cable tray supports shall be of a compatible finish with the associated cable trays, or where manufactured at site, be given a protective finish of a suitable paint/ coating in accordance with DIN 55928.

All cable tray tees, intersection units, bends, turns and sets shall, whenever possible, be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray

Trays shall only be joined by couplers supplied by the manufacturer and the joint shall be secured by 8 (eight) bolts in each instance.
Cable tray supports supplied by a manufacturer or made up on site shall be of ample strength to maintain rigid support to the fully laden cable trays along its entire length and shall ensure that the deflection of any one section does not exceed 10 mm at mid-span.

Where proprietary channel section cable support racks are being used elsewhere on the Contract with cable cleats, then any such channel used for support of cable trays shall be of the same type and make.

Wherever possible, cable trays shall be installed in full lengths without cutting, should it be necessary to cut or drill a length of tray, then for galvanized trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. Similarly for PVC coated trays, the bared ends shall be immediately sprayed using a PVC aerosol. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

All Cables shall be firmly secured to the tray using purpose made saddles, as approved by the Employer, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the trays shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid-span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

The sizing of the cable trays shall provide a minimum of 25% spare capacity.

Cable tray runs shall be determined by the Contractor and agreed by the Employer before any work is started. The trays shall be run at least 150 mm clear of plumbing and mechanical services.

5.49.7. On ladder rack system

Ladder racking either light or heavy weight be constructed from heavy galvanized steel and shall be proprietary item and installed in accordance with manufacturer's instructions. Bends in the installation shall take account of the minimum bending radii of cables to be installed.

Cables shall be clipped to the ladder rack using clips designed for the system in use and appropriate to the type and size of cable installed.

The sizing of the cable rack system shall provide a minimum of 25% spare capacity.

Ladder racking runs shall be determined by the Contractor and agreed by the Employer before any work is started. The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

5.49.8. Clipped direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed.

Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

5.50 Internal floor trenches

a. Shallow trenches (maximum depth 500 mm)
In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layout only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner.

Where the trench is shared by other services, cable shall be installed on the walls of the trench in an approved manner.

b. All other trenches including "walk through service ducts"
Cabling shall be installed to the walls of the trench in an approved manner. Where other services are present the cables shall be segregated from them and wherever possible kept above 'cold' services. Cables should not be run, if at all possible, above or in close proximity to 'hot' services.

The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation.

Cross covers shall be kept to a minimum.

The cable trench shall be cleaned prior to and after completion of the installation.

5.51 Cable terminations and joints

5.51.1. Terminations

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.
Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.
Adequate provisions shall be made to bond the cable armouring to the box and/ or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system. Glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.

Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeves or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where terminations of multicore type have to be made onto items of plant which have to be dismantled for maintenance, these shall be made of through glands into an adaptor box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

5.51.2. Joints

Through joints shall only be allowed with the approval of the Employer. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre packed ready for use. The boxes shall preferably be of split moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Employer prior to filling the box with the compound. Wrapped pressure type joints will not be accepted.

Conductor cores shall be jointed number to number or colour to colour.

5.51.3. Cable identification

At each end of each cable in a uniform and visible position, a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Employer. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

5.51.4. Marking locations of underground cables

The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.

In addition concrete marker posts shall be installed at intervals of not more than 50 meters at all junctions and changes of direction along the cable route. Such marker posts shall be not less than 200 mm high and of substantial construction. A drawing or sample of a typical marker post shall be submitted for the approval of the Employer.

The markers shall be marked ‘electric cable’ in English and in vernacular shall be laid on top of the sieved sand.

5.51.5. Cable glands

Glands shall generally be of the mechanical compression hangon type. Earth continuity of brass glands shall be assured. This may be achieved by the rigid clamping of the amour within the gland and the intimate contact between the threaded components of the gland and the equipment. Each gland shall be installed completely with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.

Each gland shall be installed completely with proprietary lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.

5.52 Electrodes

Electrodes shall be stainless steel rods with PVC coating and housed in appropriate enclosures. Means shall be provided for adjusting the length of each electrode by a minimum of 75 mm without cutting. External enclosures shall be totally weatherproof to IP 55 with tapped cable entries.

Holders subjected or liable to flooding shall be gasketed between cap and body and fitted with a sealed external terminal for connection with the electrodes.

Electrodes for alarm or level control shall have robust, water and airtight heads. Suitable arrangements shall be provided for the withdrawal of the electrodes.

In all applications a separate electrode shall be provided for the earth return circuit.

Each alarm or control signal shall be initiated from a separate single electrode unit, Multi electrode units will not be accepted.

The relay control box shall be totally weatherproof to IP 55 and suitable for wall mounting. It shall include a hand-off-auto, switch, inline fuses and neon lamp indicating the relay condition. The alarm and control contacts in the relay box shall be set for “fail safe”. In the event of the electrical supply to the relay box failing or the signal cabling being damaged, the alarms and control circuiting will be initiated.

The sensitivity shall he adjustable between 100 and 20000 ohms and the switching differential should be better than 5% of sensitivity setting.

The supply voltage shall be 110 V, 50 Hz. The electrodes circuit shall be 25 V maximum open circuit, 30 mA short circuit. The relay contacts shall be related for 5 A and 220 V, 50 Hz inductive load.

5.53 Electromagnetic flow meters

Flowmeters shall be of the fully submersible electromagnetic type suitable for fitting in a chamber outside the pump station, in accordance with BS 5792 with protection to IP 67.

Flowmeters installed in steel pipelines which are to be cathodically protected shall be provided complete with insulating flanges, continuity bonding, earthing, etc.

Flowmeters shall be flanged and rated to suit the delivery pipework and provided with a detector head and associated equipment to provide a linear 4 to 20 mA dc output, proportional to the rate of flow. Any equipment required to operate in conjunction with the flowmeter shall be fully submersible or mounted in a location not subject to flooding.

The calibrated accuracy shall be better than $\pm$ 0.596 of actual flow from full scale flow rate to 50% flow rate increasing progressively to $\pm$ 1% of actual flow rate at 10% flow. Flowmeters shall be installed in accordance with the manufacturer’s instructions and with a minimum of five diameters straight pipe upstream and two diameters downstream.

5.54 Ultrasonic flow meters

Weirs and flumes shall comply with BS 3680. An ultrasonic transducer shall measure the height of flow before the flume or weir and, via a microprocessor based system, convert this depth reading to flow. Computation of flow shall be to BS 3680 but the system shall allow the entry of user defined data. The system accuracy shall be within $\pm$1% of the instrument span over 5% to 100% flow.

The flowmeter electronics shall be housed in an environmentally protected enclosure to 1P 67, with transparent front section containing displays and operator control. The sensor shall be suitable for mounting in the open and shall be protected to IP 68.

The minimum output requirements are one isolated 4 to 20 mA output proportional to flow and one 24 V pulse output for driving a counter.

5.55 Ultrasonic level sensors

The sensor head shall be protected to IP 68.

Sensing heads shall be mounted on stainless steel 316 brackets and positioned with due regard given to an unhindered beam path and within easy reach of maintenance personnel.

The signal converter shall be supplied in an IP 55 minimum polycarbonate enclosure and shall comprise of a base unit and a programming device. Communication between the programmer and the signal converter shall be in such a manner that the IP rating is not prejudiced.

The unit shall be suitable for either 24 V dc or 240 / 110 V ac operation.

5.56 Float level switches

The equipment shall consist of a mercury switch housed within a plastic casing and a locally mounted control unit. The casing containing the mercury shall be of polypropylene suitable for total immersion in liquid. The control unit shall be weatherproof to a minimum of IP 55 and contain a transformer, relay fuses, terminal board and isolation contacts for two wire control of remote equipment.

5.57 Supervisory Control And Data Acquisition System (SCADA System)

5.57.1. General

(EPC tabled different options need be discussed and the best techno-commercial option to be agreed)

PLC shall receive inputs from 11 kV and LV protection and control and will provide outputs to annunciation control for all desired operations and will perform all logical functions.

PLC shall be constructed in modular form having provision for accepting add-on cards and shall be capable of operating without trouble in a temperature range of 0-55°C, relative humidity of 10% to 95% and should be environmentally protected not less than IP30. All incoming cables shall terminate in the cable marshalling area and not directly on the PLC for which a separate housing shall be provided.

A personal computer (PC) running SCADA software and MIS application shall communicate with the PLC on Industrial Ethernet network and shall provide all required features of control and monitoring such as:

(1) Real time data of all variables.
(2) Trends and graphs of all desired parameters.
(3) Data logging
(4) Report and statistical analysis.
(5) Alarm management and event based programming.
(6) Advanced graphic display for real time mimic display.
(7) 8 levels of password protection.
(8) Multi users support, LNA, PSTN dialup, RAS, WAN and internet fully supported.
(9) Operator Log

A 24 inch high resolution monitor LED/LCD shall be provided on the module for displaying all logical functions.

Twelve DVDs shall be supplied additionally for storage, data and programs. Compatible latest HP Laser printer with 6 Nos. black cartridges shall be provided.

UPS shall be provided for PC and PLC power supply only for minimum 60 minutes back up time on full load.

The UPS shall be part of the DC power system. The DC power system shall provide power to all controllers, PLCs, emergency lighting, and computer equipment through a UPS. Battery backup should be minimum 1 hour. Batteries to be deep cycle, valve-regulated lead-acid battery be maintenance free type.

Protection relays shall communicate with the PLC on same data network to allow monitoring of all critical parameters such as RTD temperatures, protection and safety. PLC will send signals to annunciation panels in case of any fault.

LV I/Os shall be connected to PLC and SCADA system to monitor and control all pressures, levels, flow rates and overload relays etc.

An application Process shall record all critical parameters.

5.57.2. Power supply unit (PSU)

Power Supply Unit shall be suitable for the specified supply voltage having protection against voltage and frequency fluctuations and harmonics. The unit shall be provided with battery backup for all volatile registers and memory locations to allow retention of data and programs for a period of not less than three months. Indication shall also be provided on the PSU to show that the power supply is on.

The PSU shall be designed so that forced ventilation is not required.

5.57.3. Input/output Units (I/Os)

The Contractor shall determine the number of I/Os to suit operational requirements with an allowance of 25% spare capacity. Incoming cables from the Plant shall be terminated in the cable marshalling area and not directly onto the PLC. LED indicators shall be provided to show status of I/Os which shall be individually isolated to prevent system transients and radio interference affecting the normal operation or decoupling shall be provided for I/0 signals. Digital and analogue output devices shall be capable of switching 5 A on either 30 V dc or 240 V ac circuits. Where output contacts switch ac or dc loads, arc suppression devices shall be fitted. All outputs shall have individual fuses.

5.57.4. Central Processing Unit (CPU)

Central Processing Unit shall operate at a speed of operation suitable for carrying out all specified duties and shall have all necessary built-in timers, relays and mathematical functions etc. The processor shall have non-volatile Erasable Programmable Read Only Memory (EPROM) and a volatile Random Access Memory (RAM). Allowance shall be made for 25% spare volatile and non-volatile memory.

Programming function for the CPU shall be built into the PLC or Personal Computer (PC). Program entry and modifications shall be possible in mnemonic language, ladder diagram or flow charts. Security arrangement shall be provided to prevent unauthorized tempering with the PLC control.

The contractor shall be responsible to provide Operating System and Application Software on separate media, Preferable on DVDs. The contractor shall train Employer’s staff for installation, testing, commissioning, customization, O & M and archiving/restoration of system.

5.57.5. Control of process through PLC

a. **Pre requisites**

1. Wapda 11 KV Back up available, connected on 11 KV mains in synchronized state with ref bus and operational by feeding normal / essential loads and or as a minimum,
2. Black Start DG available, Running in case 11 KV Wapda not available, connected at 11 KV mains in synchronized state with ref bus and feeding essential load via its load sequencer,
3. Control Power and Controls available in healthy states,
4. No blocking alarm persists or cleared by operator,
5. Stand alone Skids available and in healthy state, no blocking alarms,
6. Safety systems in tested good condition, like FFS and CEMS,
7. GTG on Turning Gear, Oil Cooling, Lift Oil, Cooling Oil, Lube Oil, Distillate and Heavy Fuel Oil Systems available and operations,
8. Fuel and water tanks at normal level and no fuel leakages, no haz gas alarms, no fire alarm does persist,.
9. Ambient conditions at normal as indicated on Met Instruments,
10. Field check outs OK and no safety threats does exist, Plant HVAC systems

operational and control panels at cool condition,

11. Air Inlet Filters Fine, No high differential alarm does exist,
12. All PECC MCCBs selected on Auto unless under LOTO and will not hinder plant operation. LOTO addressed by operator, no people working on main plant systems.
13. Auxiliary compartment, Starting Motor, Fuel Flo Divider, Compressors section, Inlet, Turbine section, Electric Ignitor, Load Gear, Exhaust channel and Generator plus all on base field instruments be at normal,
14. Once these field safety and equipment readiness checks are done, operator to ensure no such work permits is issued where some one can take a chance to start work on any of plant equipment that become unsafe. Than a PA announcement be made to aware all of plant being started in next 10 minutes so if some have a valid concern, it can be addressed,
15. Having all green to go, operator is now ready to push the start command.

1. Main plant

a. Vendor specific philosophy will be followed to start and run these units, over-riding principal being the safety of GTGs in case of triple failure event mode like an entire black start condition where Waoda back up is already gone and black start DG refuses to run when both or only one running GTG trips, besides each plant operating scenario must be discussed for relevant control logic and should it be helping for demonstration purpose to operators, a user friendly programmable hybrid computer simulator be provided as trainer.

b. Vendor specific procedure to be applied and operator will be vigilant to see that control sequence taking place on field devices per procedure.

2. Control philosophy

Main plant and BOP / Black Start Control goes with vendor standard logic. Owner inputs have already been stated as what could be the possible operating scenarios. Vendor needs to develop a fool proof logic and optimized control means keeping in consideration of triple failure of various plant equipment's an components and table the best possible solution according to power plant prudent practices and engineering standards. Necessary redundancies be kept in place to cater for possible safety risks to plant equipment and components. Pre-requisite

(1) Operation of Main Plant Equipment

Machine off Turning gear and spinning starts with starting motor to a speed set by vendor where purge cycle starts followed by electric ignition and fuel intake enabling combustion under proper sequence.

The main points to be considered in control philosophy of the gas turbines.

a. IGV LVDT calibration is **VERY** critical to power output ***at Base Load***. For example, if the IGVs are actually, physically at 82.7 DGA but the LVDTs are calibrated such that the Control thinks the IGVs are at 84 DGA (maximum operating angle for a LOT of GE-design heavy duty gas turbines), then the air flow through the axial compressor--and hence the power output of the gas turbine--is limited.

b. Axial compressor and IGV cleanliness is also very important to power output--efficiency.

c. The manufacturer is required to verify performance of the gas turbine and compressor to the customer. To the manufacturer, the field test provides a baseline for the gas turbine and compressor at the site of delivery to compare to the factory performance test, although the field test accuracy may be inherently lower. In addition, the field performance test is the final validation from the manufacturer to the customer of the guaranteed performance. • The user needs to verify performance of the gas turbine and compressor. Baseline performance data is obtained from the initial field performance test. The baseline test can be used for comparing and monitoring the health of the gas turbine-driven compressor package in the future. • The user or manufacturer needs to assess performance of the gas turbine or compressor because of degradation concerns. Based on the field test results, a performance recovery program may be initiated. • The user requires calibration of an installed historical trend monitoring system. The field test is used to provide initial calibration of the system based on the first performance of the gas turbine and compressor. • The user needs to determine the operating range of the installed equipment after an upgrade, restage, or physical system change. In this case, the surge point may also need to be re-assessed

d. **PLC interface with SCADA**

All information available to PLC shall be transferred to PC through Industrial Ethernet such that complete monitoring of the plant can be carried out through HMI. (The different options need be discussed and the best techno-commercial option to be agreed.)

e. **Industrial Ethernet**

General.

a. EPC contractor considering site conditions, as an option may suggest a best networking equipment with "Industrial Ethernet" grades such as:
b. DIN-Rail mounting for convenient installation in industrial spaces
c. Redundant DC power inputs to ensure the maximum running time
d. Rugged housing for best protection
f. Wide operating temperature support of -40°C to 75°C

Certifications for Industrial Ethernet.

The networking equipment is required to operate in noisy and hazardous environments such as gas vapors, electrical surges, EMI (electromagnetic interference), and other environmental threats. Therefore EPC contractor to seek additional industrial certifications for selected industrial Ethernet equipment to properly design a reliable industrial network for project applications:

1. **Typical Certification**

- Class I Division 2 for Hazardous Environment –
- Nothing is more important than safety & reliability. In a place where oil Class-I-Division-2 and gas vapors may accidentally exist, all the equipment must meet Class I Division 2 certification.
- Class I type of hazard environment which is created by the flammable gases or vapors in the air, such as nature gas or gasoline vapor. When these vapors are found in the air, it creates a potential for an explosion which may be ignited by the electrical devices.
- Division 2 (Zone 2), where hazardous vapors do not exist under normal operations such as oil & gas filling operations, but may accidentally exist.
- IEC-61850 for Utilities Substation – A reliable network is the most important key factor for modern substations that transmit and distribute electric power over large areas. Since substation environments tend to be extremely varied, making Ethernet networks reliable and rugged is essential to achieve higher reliability, availability and up-time of substation communication.

- **IEC-61850. -** requirements of industrial Ethernet using in substation environment.

- **Meet IEC-61850 standard for excellent EMI shielding**. The equipment which meets this standard shall be capable of protecting against electrical surges and EMI.

- **Tolerant of temperature extremes**. To perform flawlessly in climate-uncontrolled utility substation, this equipment are designed from complete fan-less operation in a wide temperature range of -40°C to 75°C.

- **Maintaining high network availability**. To ensure high network availability, network redundancy must be implemented and respond in milliseconds. In addition, redundant power for equipment is necessary for the backup source.

- **EN50155** – defines IP-based Ethernet networks. Devices in the application must be able to suffer severe pollution, vibration, sock and EMC. The Electronic EN50155 Equipment is the common standard used in industrial applications with key factors such as:

- **Wide temperature.** Similar as IEC-61850, usually running in the climate-uncontrolled environment. The fan-less design of the industrial Ethernet devices must be running flawlessly. Most of the devices can be operated in the range of -40°C to 75°C.

- S**hock and vibration.** The equipment used must withstand vibration and shocks, and provide the reliable use during the product life. The anti-vibration is a critical element of the product designed.

- **Electrical service conditions**. EN50155 also defines several standard for electrical condition such as the voltage range, voltage ripple and impure surges. All the equipment must meet these requirements in order to provide the stable services in railway applications.

2. Reliability

- Industrial Ethernet networking equipment be designed with much higher quality and reliability specifications compared against a similar commercial grade product:
-
- **Longer MTBF** (Mean Time between Failures). MTBF is the predicted time between failures. Higher the MTBF, the less likely the unit will fail. The industrial Ethernet switches must have a much higher MTBF (40 years or more) than the commercial switches. Making it durable and reliable for the demanding project applications.

- **Best ROI (Return on Investment) / Lower RMA**, Any downtime is costly. Not only does the entire generation process has to stop, but also the raw material or man-power can be wasted during the waiting time. A good industrial solution should reduce this costly downtime.

- **5-Year Warranty**. Not only should the industrial Ethernet equipment be durable and reliable, they should also last longer than similar commercial products. The industrial Ethernet manufactures most often offer 5-year warranty compare with 1 or 2-year warranty for most commercial products.

- (In view of above considerations, as an option, EPC contractor may also the different options need be discussed and the best techno-commercial option to be agreed)

5.57.6. Blank

5.58 Programming medium

The programmer for the CPU shall either be built into the PLC, or shall be the hand-held type complete with suitable connections.

Manual program entry and modifications shall be possible in a mnemonic language and either flowchart or ladder diagrams. The programmer should also allow for reading of programs. Security arrangements should be provided to prevent unauthorized tampering with PLC control.

Unless otherwise specified a programming device shall be supplied with each PLC.

5.59 Peripheral equipment

Where specified, and EPROM erasing device shall be provided. This shall have a built-in 0 to 60 minute timer, and a safety interlock that automatically shuts off the UV source as soon as the drawer holding the EPROM is removed. The cabinet shall be fully sealed against UV leakage and electrical screening shall eliminate interference.

A spare programmed EPROM shall also be provided. This shall be suitably prepared for storage in a container providing protection from static electricity and light. The container should be externally labeled with details of the program version and date.

5.60 Small power, lighting and lighting installations

a. Power Socket outlets

Power socket outlets for small electrical accessories shall be 15 A, 230 V single phase 2 pole and earth 3 pin shuttered pattern and shall be complete with a mounting box and an earthing terminal.

In office rooms, stores, washrooms etc. socket outlets shall be white plastic plate type and shall be provided at every 10 m distance.

In plant areas, socket outlets shall be splash proof, high impact resistant thermoplastic pattern with spring operated cover plates and complying to BS 4343 and shall be fixed as specified or approved by the Employer.

b. Switch Control

All lighting and power circuits complete with cables, conduit and installation material, shall be controlled by MCBs installed on the main LV distribution board as specified in the Particular Requirements Chapter.

Internal lighting switches in offices, stores, washrooms etc. shall comply with BS 3676 and shall be complete with box, cover plate and fixing screws. At multi-switch position, the switches shall be contained in multi- gang boxes.

c. Building Lighting Installations

In addition to an agreed illumination scheme for the entire project, EPC contractor to ensure proper lux level in different areas, uniformity, colour rendering and glare requirements as per UGR in line with CIBSE or relevant codes. Lux intensity shall be checked using lux meter and recorded for employers approval.
Building lighting installations shall be designed in accordance with the latest edition of the UK Chartered Institute of Building Service Engineers “Code for Interior Lighting” or equivalent approved standard.

The minimum service illumination levels shall be in accordance with the subsequent clauses.

In no case shall the illumination be below that necessary to perform work or other essential activity in any particular location.

In areas housing rotating machinery, lighting shall be arranged on multiple phase circuits to prevent stroboscopic effects.
Lighting in high bay area’s shall be designed to ensure that ease of maintenance to ensure that use of scaffolding to change bulbs is not required.

Lighting shall be provided in all building areas to provide the following average Luminance levels which, unless otherwise specified, shall be at ground level.

Area	Illuminance (VA)	Type of luminaire
Offices	500	A
Control room/PLC room	500	A
Turbine Hall / SWGR rooms / FOTP Building	300	D
Transformer rooms	200	B
Storage rooms	150	B
Workshop & tool rooms	300	B
Toilet areas	150	A
External lighting	50	F
Battery , UPS equipment rooms, BSDG, Stand Alone Skids (WTP/WW/CEM	200	C

Table 5-1 Average Luminance Levels

Type A Fluorescent luminairs with stove enamel metal clad body and M6 metallic louver.

Type B Florescent luminairs with totally enclosed plastic coated metal or GRP canopy body to protection standard IP54 and totally enclosing high impact clear acrylic diffuser.

Type C As type B, but fully corrosion resistant construction to enclosure protection IP65, and also compliant with BS 4533 Part 102.

Type D Metal halide “Highbay” type luminaries.

Type E Techno-polymer body with integral electronic control gear with white trim opalescent diffuser surface or recessed mounting as required.

Type F Weather proof flood lighting luminairs with diecast aluminum housings, high impact glass or polycarbonate diffusers and suitable for LED lamp

Lamps shall be of a type and size available locally.

(As an option, EPC contractor may also offer illumination scheme based on LED with minimum efficacy of 80lm/W. The different options need be discussed and the best techno-commercial option to be agreed)

5.61 Building emergency lighting

Building emergency lighting shall comprise of general area emergency lighting and emergency escape lighting preferably fed through Solar pv panels..
The Contractor shall design the emergency escape lighting installations to comply with the requirements of BS 5266 Part 1.

General area emergency lighting shall be provided in the Turbine Hall, FOTP Building, sub station, Electrical Rooms, Stand Alone Skids, Security Building, Admin Building, Local and main Control Rooms and other essential areas like toilets etc.

(An an option, EPC contractor may also offer illumination scheme based on LED with minimum efficacy of 80lm/W. The different options need be discussed and the best techno-commercial option to be agreed. In case and opted the Solar system shall feed into the DC bus through a smart controller)

5.62 Wiring

Internal building services installation wiring shall be carried out by single core multi-stranded PVC insulated fire retardant cable installed in steel conduit.

In office, control room and similar rooms use MICC and Hubble/ Twist Lock three pin industrial grade. Plug / light / power sockets.

Elsewhere, conduit/trunking and service fittings shall be surface mounted:

The minimum cable sizes shall be,

a. 2.5 mm^2 for lighting circuits
b. 4 mm^2 for socket outlet circuits

5.63 Batteries and chargers

5.63.1. Batteries

Battery units shall comprise of a floor standing or wall-mounted front access type steel cabinet accommodating batteries, battery charger and distribution facilities.

Unless otherwise specified batteries shall be of VRLA, deep cycle maintenance-free type having cells housed in translucent, high impact plastic containers. The containers shall be fitted with vented filler plugs. High and low electrolyte levels shall be permanently marked on the containers.

Cell terminals shall be of the bullet type. The terminal polarity shall be permanently marked.

Battery cells shall be arranged so that each is accessible for test and inspection Cells shall be located in the lower section of the cabinet and shall not be less than 300 mm above floor level.

Batteries shall be supplied completely with all necessary connections. The connections between tiers and cells and disconnection links and fuses shall be of the multi-standard plastic insulated type.

The nominal battery voltage shall be 24 V unless technical considerations otherwise dictate. The battery capacity shall be adequate to supply all connected loads for a minimum period of 8 hours.

(EPC contractor may table as an option of using Nickle Cadmium Batteries that Employer may review and agree to best techno-commercial option.)

5.63.2. Battery charger

The battery charger shall be of the load state design incorporating “Float” and “Boost” charging facilities. In the “Float” charge mode, the charger shall automatically maintain the battery in a fully charged condition whilst supplying its rated current. In the “Boost” charger mode the charger shall be capable of fully charging the battery from a fully discharged state in a period not exceeding 7 hours.

The charger shall be equipped with the following:

a. Incoming supply On/Off switch
b. Supply on indication
c. Output voltmeter
d. Output ammeter

e. Float/Boost charge selector switch
f. Charger failed alarm relay
g. Charger failed indication

5.64 Un-Interruptible power systems (UPS)

The UPS shall consist of rectifier, static inverters, static switches with bypass and sealed VRLA batteries. The system shall be capable of the following modes of operation. It shall be a double conversion online UPS. Reference make is APC Smart UPS VT.
EPC contractor may table as an option of using Nickle Cadmium Batteries that Employer may review and agree to best techno-commercial option.

a. Normal mode

During normal operation the UPS shall provide precisely regulated and transient free power to its load. Power to the rectifier shall be supplied from the primary ac source. The rectifier shall supply the inverter with regulated dc power. The inverter shall convert the dc power into regulated ac power for the load..

b. Emergency mode

On failure of the primary ac power, input power to the inverter shall be supplied automatically from a battery. When the ac power is restored input power to the inverter shall be supplied automatically from the rectifier. If the ac power is not restored before the discharge limit of the battery is reached (the discharge limit being designated by the battery manufacturer) the UPS shall automatically shut itself down in an orderly manner.

c. Bypass mode

The static switch shall transfer the load automatically without interruption to a power conditioner energized from the ac supply on a failure of the UPS output. Circuit breakers shall be provided as part of the static switch such that the complete UPS including the static switch may be isolated electrically for maintenance once the load has been transferred to the alternative supply.

Each power semiconductor circuit shall be fused to prevent cascaded or sequential semiconductor failure. Indicating devices shall be provided to show blown fuses.

The UPS shall not generate noise in excess of a sound pressure level of 75 dBA measured one meter from its surface under any mode of operation and at any load upto the maximum rating.

The primary ac source shall be single phase for units upto 5 kVA, single phase or 2 phase for units between 5 and 10 kVA, and shall be 3 or 4 wire, three phase supply for units greater than 10 kVA. The output ac neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall be connected to the instrumentation earthing system. The UPS output as neutral shall be connected to the station earth via a disconnecting link.

The UPS shall have built-in protection against under voltage, overcurrent and overvoltage including surges on the primary as source and voltage and current surges on the output including those caused by load transfer between itself and an external synchronized source.

UPS to support full SNMP communications as well as should provide a built-in web server.

The complete UPS shall be capable of being started up by the operation of a single switch whose action shall initiate an automatic start up sequence.

The rectifier shall be capable of supplying an overload current of not less than 125% of full load current for 10 minutes. Current limiting shall occur above 125% of full load current.
The inverter transient voltage variation shall not exceed 10% under any of the following circumstances.

a. 50% load application and reduction with zero and 50% initial load respectively.

b. Transfer of rated load to the alternative source following an inverter fault.

The system output voltage shall return to within 5% of the steady state value within 30 milliseconds and to within 2% of the steady-state value within milliseconds of the occurrence of any change. The inverter voltage shall remain within these steady state bands under the following circumstances.

a. Inverter “drop” onto the battery whilst supplying the full rated load

b. Retransfer of rated load from the alternative source to the inverter

The inverter shall have an output circuit breaker.

The inverter section of the UPS shall include an integral static switch with bypass. The control unit shall contain an automatic transfer circuit which shall monitor the status of the inverter logic signals and alarm conditions and, shall ensure an uninterrupted transfer of the load to the alternative source without exceeding the transient limits specified herein, when a malfunction occurs in the UPS.

The static switch shall be a naturally commutated high speed, static transfer device. The bypass static switch shall be connected in parallel with a circuit breaker which is activated at the same time as the static switch and which shall provide positive connection of the load to the alternative source independently of the internal logic and control supply. Circuit breakers shall be provided in the static switch section of the UPS giving complete isolation of the UPS and static switch for maintenance.

Volt-free contacts shall be provided to operate the following remote alarms and indications.

a. UPS on bypass
b. UPS on
c. UPS battery discharging

The battery cells shall be mounted on wood or painted steel blocks and shall be accommodated in a special battery cubicle for installation adjacent to the UPS. The battery shall be capable of feeding the required load for 1 hours without the battery and UPS failing on under voltage.

EMPLOYER'S REQUIRMENT FOR MECHANICAL & ELECTRICAL WORKS

CHAPTER 06
MATERIALS & WORKMANSHIP
PAINTAING & PROTECTION

CHAPTER 6
MATERIALS & WORKMANSHIP
PAINTING AND PROTECTION

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CHAPTER 06
MATERIALS & WORKMANSHIP
PAINTING AND PROTECTION

6.1. General

The preparation, application and condition for work shall comply with the recommendations of BS 5493 and CP 231 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Paints. primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc and carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 16 deg C and the relative humidity less than 55%. The Employer shall approve the methods for removing all dirt, oil, grease, etc before Site painting commences.

Test plates carrying finishes from the actual coating used may be required by the Employer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.

Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials of the plant.

All paint thickness shall be checked using alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Employer.

6.2. Surface Preparation

Surface preparation for the various substrata shall be as follows unless otherwise specified under detailed paint system.

i) Steelwork

All steelwork including structural steel and steel doors and frames shall be prepared by blast cleaning in the shop. Blast cleaning shall be to a visual standard in accordance with Swedish Standard SIS 05 59 00 Sa 2½ at the time of painting (equivalent to 2nd Quality BS 4232).

Only dry abrasive blast cleaning techniques shall be employed. Abrasives shall be expendable copper slag or re-usable iron and steel grit or shot. All surface defects, including cracks, surface laminations and deep pitting, likely to be detrimental to the protective painting system shall be removed as laid down in BS 4360. All fins at saw cuts, burrs, and sharp edges shall be similarly removed. Where extensive grinding has been necessary, the dressed areas shall be re-blasted to remove all rust and provide an adequate painting surface.

After blast cleaning, before the surface has time to re-rust, and in any case within 4 hours of blast cleaning (2 hours for outdoor blast cleaning) the first coat of primer shall be applied.

ii) Metal sprayed coating to BS 2569: Part 1 (Zinc)

The metal deposition shall be coated at-once with two pack zinc chromate etch primer, and the first coat of the paint system shall be applied within 1 to 4 hour.

iii) Galvanized and non-ferrous surface

Surfaces shall be cleaned of dirt and building debris. All grease and handling marks shall be removed by the application of zinc chromate etch primer thinners.

The clean dry surfaces shall then be primed with two pack zinc chromate etch primer followed by the first coat of the paint system within 1 to 4 hours.

6.3. Detailed Paint System

i) Structural steelwork

Shop applied – apply overall:

1 coat high build alkyd zinc phosphate primer to a minimum dry film thickness of 75 microns followed by 1 coat phenolic /alkyd coating containing micaceous iron oxide to a minimum dry film thickness of 50 microns.

Site applied

Any damaged areas to be prepared as for the shop coats and made good with the original shop coat to the specified dry film thickness.

ii) Apply overall

1 coat phenolic/alkyd coating containing micaceous iron oxide to a minimum dry film thickness of 50 microns followed by 1 coat alkyd decorative enamel to a minimum dry film thickness of 40 microns.

Where dissimilar metals are in proximity and where the possibility of electrolytic or similar corrosion exists the mating surfaces shall be insulated.

Test plates carrying a sample of the actual coating used may be requested by the Employer for test and inspection purposes.

AII items of Plant shall be delivered to Site with their protective paint finish applied and except where otherwise specified or instructed by the Employer shall be given further coats of final paint finish at Site of sufficient thickness to give uniform colour and appearance.

Site painting shall not be carried out unless the surface to be painted is completely dry, the air temperature is above 16°C, and the surface temperature is at least 3°C above the dew point. Immediately before Site painting, all oil, grease etc. shall be removed from the surfaces to be painted and all damage to the factory applied finish made good.

Unless otherwise specified or approved by the Employer (e.g. where the Contractor’s normal protective finish is of a special nature giving equal or better protection) or where the material of construction has an inherent corrosion resistant property, the Plant shall be protected in accordance with the following:

- Component parts which may be in direct contact with water (excluding the Pumping Station steel pipework)

a) blast clean in accordance with the requirements of Swedish Standard SIS 05 59 00 Sa 1½.

b) Ferrous metal
Within 4 hours of (a) above apply zinc metal spray to a thickness of 100 microns or greater in accordance with BS 2569.

OR

Within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy zinc rich primer containing at least 90% of zinc in the dry film to give a minimum dry film thickness of 30 microns.

c) Non-ferrous metal
Within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy etch primer to give a minimum dry film thickness of 50 microns.

Thoroughly clean and degrease previous finish and within 2 hours apply sufficient coats of tar or pitch epoxy resin to give a minimum dry film thickness of 250 microns.

i) **Steel door and Frames**

Shop applied:
1 coat high build alkyd zinc phosphate primer to a minimum dry film thickness of 75 microns followed by 1 coat alkyd based undercoat to a minimum dry film thickness of 40 microns.

ii) **Site applied:**

1 coat alkyd based undercoat to a minimum dry film thickness of 40 microns. 1 coat decorative alkyd enamel to a minimum dry film thickness of 40 microns.

iii) **Steelwork in contact with water**

Shop applied:
Hot dip galvanised to BS 729

Site applied:
Any damaged areas to be thoroughly cleaned of rust and surface deposit and painted with 1 coat of epoxy zinc phosphate to a minimum dry film thickness of 75 microns followed by 1 coat of epoxy micaceous iron oxide undercoat to a minimum dry film thickness of 100 microns, followed by 1 coat of epoxy micaceous iron oxide to a minimum dry film thickness of 60 microns.

iv) **Pipework and valves**
All pipe work and valves above ground. unless otherwise specified, shall be treated as described herein for pumping station. Steel pipework and valves in chambers shall be treat as described for buried pipework.

v) **Mechanical and Electrical equipment**
Paints, including primers and undercoats, shall be obtained from the same manufacturers and shall, except where application has to be made within a limited time of mixing, be ready mixed for use and compatible with one another. Only paints which are delivered in sealed containers, bearing the name of the manufacturers and properly labeled as to their quality and instructions for use, will be acceptable.

The manufacturer's proposed paint and protection system for all mechanical and electrical equipment shall be submitted to the Employer for approval at the time of submission of shop drawings.

AII surfaces of Plant shall be protected against corrosion and/or erosion with the exception of stainless material and rotating gland or bearing surfaces.

Immediately before Site painting, all oil, grease etc. shall be removed from the surfaces to be painted and all damage to the factory applied finish made good.

- Power station steel pipework:

  a) Fettle to remove all flash, weld spatter, sharp and rough surfaces.
  b) Blast clean in accordance with the requirements of Swedish Standard SIS 05 59 00 Sa 2½.
  c) Within 4 hours of (b) above apply one coat epoxy polyamide primer to give a minimum dry film thickness of 25 microns.
  d) Apply second and third coat amine adduct cured epoxy, each coat to give a minimum dry film thickness of 125 microns.

- Exposed plant, not coming into direct contact with water.
  a) Blast clean in accordance with the requirements of Swedish Standard SIS 05 59 00 Sa 2½.
  b) Within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy primer containing red oxide or zinc phosphate to give a minimum dry film thickness of 50 microns.
  c) Thoroughly clean and degrease previous finish and within 2 hours apply sufficient coats of polyamide cured epoxy micaceous iron oxide to give a minimum dry film thickness of 100 microns.

- Plant installed inside buildings excluding electrical panels and the pumping station steel pipework.

  a) Thoroughly clean surfaces to remove rust, scale, dirt, loose paint etc. and degrease by the use of solvents which are compatible with the paint finish to be applied.
  b) Within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy or alkyd resin based primer to give a dry film thickness of not less than 40 microns.
  c) Thoroughly clean and degrease previously applied finish and within 2 hours apply sufficient coats of polyamide cured epoxy or alkyd resin based undercoat and gloss finish paint to give an even and uniform colour and covering.

- Electrical panels installed within buildings shall be finished with sufficient stove dried enamel primer and gloss finish to give a dry film thickness of not less than 90 microns.

- Electrical panels installed in exposed positions or in damp conditions shall receive a surface preparation containing zinc prior to stove enameling.

6.4. Colour coding and labeling of pipes and equipment

All pipes and requirement shall be colour coded to a schedule to be agreed with the Employer before any Site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment, the pipe colour shall extend upto but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval of the Employer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labeled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Employer.

EMPLOYER'S REQUIRMENT FOR MECHNAICAL & ELECTRICAL WORKS

CHAPTER 07
WORK ITEMS

CHAPTER 7
EMPLOYERS REQUIRMENT
WORK ITEMS

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CHAPTER 7
EMPLOYERS REQUIRMENT
WORK ITEMS

7.1 Brief Description of the project

-This is to to Construct a New 2X2.5 MW Tri Fuel operation with Fuel Transfer Capability at any load, and configured for distillate start / HFO run Turbine unit,

- equipped with a suitable air inlet Filter to stop dust ingress keeping in view of Nabisar site data of frequent dust storms. Air inlet must take care of high ambient temperature by incorporating arrangements similar to Evap Cooling or any other latest state of the art, or in practice modern techniques. Instrument air cleaning or any other means to remove the dust from filters to sustain the filter elements before replacement.

Unit must have a High Efficiency multistage Compressor, Turning Gear, starting motor, accurate Fuel Flow Divider, Main / Emergency Oil Pumps, distillate start, HFO Run multi combustor, air cooled multi stage turbine and air cooled separately exited multipole Generator- GTG operating in Open Cycle,

GTGs are meant to feed uninterrupted power to owner RO/Pre-filter plants facility with a 5 MW Sub Station as incomer back up to feed partial load in case of outage of any GTG , Main plant to be Synchronized at Owner's 11 KV Main Bus per Electrical SLD, Vendor to review SLD critically and may table a better configuration that can be discussed and finalized.

Main Plant and BOP to include Oil Cooled step up / step down / isolation transformers per vendor plan, matching Switch Gear, fool proof Interlocks, Fuel Oil Treatment Plant, Water Treatment Plant, necessary Testing Labs for Oil and Water Test,

(Fuel and Potable Water from RO plant will be supplied by the owner,) Compressor be equipped with On Line Water Wash and Exhaust system with Continuous Emission Monitoring System,

Generator and other electrical distribution systems be with Necessary sub-station, Switch Gear and Protection. Interconnections be with Electromechanical Fool Proof Synchronizing,

Plant Safety be provided by feeding essential load with a sufficient capacity Black Start Diesel Engine through a load sequencer.
Units be provided with Redundant Normal and Emergency Cooling equipment / System, As a standard power plant practice, Normal and

Essential Power Systems, Fire Detection & Fire Fighting Systems, Excitation and GTG Control Systems, PECC, Main Control Room, Waste Management Systems, Fuel Management & Consumption Audit System, CCTV, Key Control and Access Control systems etc be provided.

Plant Building be equipped with Dehumidifying and Air-conditioned Systems,

Plant and BOP be provided with including all compatible process links and economically matching electro-mechanical connecting hardware with long life, anticorrosion coating,

Including all above but not limited to what else is required per vendor specific proposal, to become integral part of plant at Nabisar on EPC Turnkey basis.

Each GTG to pass reliability test of uninterruptable 15 days run while overall plant / BOP Combined Reliability Run with one month continuous operation of Power Station before hand-over to operator (Engro),

Owner are targeting an overall high electrical efficiency and low heat rate and low maintenance factor to provide maximum possible number of operating hours between planned outages.

EPC Contract is on a Fixed Price Lump Sum Basis including but not limited to any and all expenses, costs taxes, levies, etc. The Contract Amount shall be deemed to include but not limited to any and all expenses, costs, taxes, levies etc.

Following are the plant operating states need be implemented in a fool proof and errorless manner.

Site Scenario #	Main Plant Units	GTG-1/2 Operating Status	WAPDA BACK UP Status	BLACK START Status	Auto Action
1	GTG-1/2	Operating at FSNL	Available and 11 KV Mains Energized	Ready Shut Down State	GTG-1/2 Synchronize one after one on 11 KV Main with WAPDA
2	GTG-1/2	Both or one Tripped	Available and 11 KV Mains Energized	Ready Shut Down State	WAPDA Supplies 5 MW back Up Load - Load sharing to be indicated in Control Room and locally
3	GTG-1/2	Both or One available and on FSNL	Not Available	In Operation and feed GTG Essential Load through a load sequencer	BS synchronized using Ref Bus. GTG-1/2 Synchronize one after one on 11 KV Main with BS DG to receive incoming WAPDA synchronizing automatic or manual as selected.
4	GTG-1/2	One Unit Operating and connected at 11 KV Mains	WAPDA Resumes, not synchronized on 11 KV Mains	Back on Auto Standby Mode	GTG-1/2 synchronized using Ref Bus. WAPDA be synchronized as incomer back up available,
5	GTG-1/2	Both Units Operating and Synchronized at 11 KV Mains	Available and synchronized at 11 KV mains	Auto-Standby Mode	Demonstrate Operator actions to test various scenarios of switch-in/out
6	GTG-1/2 in Outage	Unavailable	On / Off Frequently	Feeding Essential Load through a load sequencer	Advise optimum action how to synch WAPDA and how to share the load

7.2 General

The Contractor may submit alternative proposals for electrical, Process systems, mechanical plant and civil works which in his opinion are more innovative, cost effective and facilitating plant operation. The Contractor shall justify his proposals by providing examples of satisfactory operation of similar plants working under similar environmental conditions as prevailing at the proposed site area. In addition to other requirements of the Contract, he shall provide the methodology for controlling vibration, sound and heat to keep them within acceptable limits.

The works shall be executed in accordance with the latest issues (or their updated amendments) of standards and codes referred to in this Chapter.

The Contractor shall submit the names of the plant manufactures and their work place / country for all Work Items for the Employer's review.

7.3 Employer’s requirements: Mechanical works

7.3.1 Introduction

The Contractor shall provide all plant and equipment of the power house including Main plant / complete matching BOP, Tank Farm Area, FOTP, Black Start DG, Stand Alone Skids / Systems, Necessary Electrical & Control Systems, Starting Motor, Turning Gera, Fuel Flow Divider, Electrical Ignition, Multi Stage, High Efficiency Compressor, Multi Stage, Multi Combustor Tri Fuel Capability Turbine, Separately Excited Generated, Step Up / Step Down Transformers with switch gear and protection, PA, CCTV, Fuel Management System, Cooling Systems, HVAV, CEMS, on-line WW, FAS, Waste Handling, Met Instrumentation, Incinerator, overhead travelling crane and all required services and equipment to construct a power house of the highest operative condition. The Contract Work shall be within the limits as shown on the Conceptual Drawings. Proper air intake and exhaust duct system shall be provided for high efficiency, low heat rate and low emission. Project works have been lumped but not limited to the following work items. EPC contractor may lump the wok items according to his best management and can be reviewed by the owner engineers for mutual agreement. EPC contractor are welcome to table better quality and cost effective simple options that will ease out the plant operation with more relaiability and cut the maintenance cost.

7.3.2 Work Item No.1: Tank Farm Area

S. No.	Sub-Work Item	Quantity	Brief description
1	1.0	One Lot	Delivery , Installation, Testing and Commissioning Of a complete Tank Farm Area for Capacity of 10 days storage of Distillate / HFO Tanks with suitable equipment, piping and heating, etc– Engg standards, specs and Main factors to be considered are given hereunder and elsewhere in this volume, standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C.

EPC Contractor to manage a tank farm area to store the liquid fuels and water in cylindrical tanks for the plant fuel consumption of at least 10 days and water for 15 days, above the ground.

Fuel that owner will deliver in commercial tankers , may contain dust, water and other contaminants. A proper test on delivery and treatment be set using FOTP and other necessary arrangements, like fuel additives etc so to maintain the best quality to suit the combustion and deliver best heat rate.

A recommended storage estimate is for at least 10 days of normal consumption.

Industrial heating in fuel storage tanks will be required , Its proposed that contractor may use part of combustion turbine exhaust heat for fuel heating when any of the CT is in operation besides initial heating through electric heaters are HFO burners as be feasible,

Vertical mild steel tanks mounted above ground be considered as an option. For safety and environmental reasons, bund walls around be constructed around the tanks to contain accidental spillages.

As a certain amount of settlement of solids and sludge that will occur in tanks over time, cleaning means be built-in for regular cleaning with intervals-annually for heavy fuel and every two years for distillate fuels.

Leak proof couplings to be provided for oil decanted from the tanker to storage tank. All leaks from joints, flanges and pipelines must be taken into account. After necessary treatment, Fuel oil should be free from possible contaminants such as dirt, sludge and water before it is fed to the combustion system. Following warning sign must also be displayed.

CAUTION. LOSS OF EVEN ONE DROP OF OIL EVERY SECOND CAN COST YOU OVER 4000 LITRES A YEAR.

Removal of Contaminants Heavy Fuel oil arrives at site either in tank lorries by road . Oil will then decanted into the main storage tank. To prevent contaminants such as rags, cotton waste, loose nuts or bolts or screws entering the system and damaging the pump, coarse strainer of 10 mesh size (not more than 3 holes per linear inch) shall be positioned on the entry pipe to the storage tanks. Progressively finer strainers should be provided at various points in the oil supply system to filter away finer contaminants such as external dust and dirt, sludge or free carbon. **Contractor to provide these filters in duplicate to enable one filter to be cleaned while oil supply is maintained through the other.**

SIZES OF STRAINER REQUIRED AT VARIOUS LOCATIONS

		STRAINER SIZE	STRAINER SIZE
	LOCATION	MESH	HOLE LINEAR INCHES
1	Between tank lorry decanting point and main storage tank	10	3
2	Between service tank and pre-heater	40	6
3	Between pre-heater and burner	100	10

Pumping

Depending on the FOTP and Fuel Contractor may recommend the best option w.r.t long life, ease of maintenance and overall cost however Heavy fuel oils are best pumped using positive displacement pumps, as they are able to get fuel moving when it is cold.

A circulation gear pump running on LDO should give between 7000-10000 hours of service.

Diaphragm pumps have a shorter service life, but are easier and less expensive to repair.

A centrifugal pump is not recommended, because as the oil viscosity increases, the efficiency of the pump drops sharply and the horsepower required increases.

Light fuels are best pumped with centrifugal or turbine pumps. When higher pressures are required, piston or diaphragm pumps should be used.

Storage Temperature and Pumping Temperature

Contractor needs to set the most practical temp and temp means for storage and pumping keeping in view of site average ambient temperatures over the year. The viscosity of heavy fuel increases with decrease in temperature, which makes it difficult to pump the oil. At low ambient temperatures (below 25 deg C), furnace oil is not easily pump-able. To circumvent this, preheating of oil shall be accomplished in one of the two ways: Contractor to pick the best and most economical one even to implement a different technique.

a) In case, the entire tank is to be preheated. In this form of bulk heating, steam coils be placed at the bottom of the tank, which must be fully insulated; Its suggested that part of the combustion Turbine exhaust shall be used for this heating when one or both CTs are in operation.

b) If the oil is be heated as it flows out with an outflow heater. To reduce steam requirements, it is advisable to insulate tanks where bulk heating is used. Bulk heating may be necessary if flow rates are high enough to make outflow heaters of adequate capacity impractical. In the case of outflow heating, only the oil, which leaves the tank, is heated to the pumping temperature. The outflow heater is essentially a heat exchanger with steam or electricity as the heating medium.

Temperature Control

Thermostatic temperature control of the oil is necessary to prevent overheating, especially when oil flow is reduced or stopped. This is particularly important for electric heaters, since oil may get carbonized when there is no flow and the heater is on. Thermostats should be provided at a region where the oil flows freely into the suction pipe. The temperature at which oil can readily be pumped depends on the grade of oil being handled. Oil should never be stored at a temperature above that necessary for pumping as this leads to higher energy consumption.

For water metal storage cylindrical tanks, , contractor may follow the engg standards given in a previous section and the plant prudent practices for the storage of 15 days consumption of process , drinking and utilities water. Further guide line is given under work item WTP.

7.3.3. Work Item Number 2. Fuel Oil Treatment Plant

S. No.	Sub-Work Item	Quantity	Brief description
1	2.0	One Lot	Delivery , Installation, Testing and Commissioning Of a complete Fuel Oil treatment plant with storage of Distillate and HFO Tanks capacity for 10 days with suitable centrifuge equipment, settling, heating with CT exhaust / Solar PV panels / elcitric heating, pumping, piping, storage, test lab, Fire Detection and Fire Fighting systems , etc– FOTP and Fuel Administrative Systems be housed in civil structured building. Safety standards to be considered to prevent fire risk. Engg standards, specs and Main factors to be considered are given hereunder and elsewhere in this volume, standard station power and matching out put

			with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C.

Contractor proposal shall be discussed and finalized by owner engineer.

For Work Item No 2: Fuel Oil Treatment Plant, following points be considered.

Contractor needs to study the locally available qualities / parameters of HFO and if required, he must set up the necessary fuel oil treatment plant to address the following,

The quality specifications for gas turbine fuel oils are extremely stringent. Harmful trace elements such as water-soluble sodium, potassium and calcium as well as oil-soluble vanadium and lead can cause major problems. An excessively high concentration of trace elements in the fuel results in corrosion. Sediments such as sand, rust and cat fines lead to increased wear.

Contractor must refer to gas turbine manufacturers specification limits for the trace elements to ensure safe and economical operation. For sodium and potassium these limits are between 1 ppm and 0.1 ppm. The harmful water-soluble trace elements are reduced to the required levels by separation only or by a combination of washing and separation. Contaminants such as sand, rust and cat fines be removed from the fuel oil under high centrifugal force.

Regarding Oil-soluble trace elements like vanadium and lead that cannot be separated. Contractor may consider adding a suitable inhibitor to the fuel to counteract the high temperature corrosion caused by vanadium ash. Self-cleaning separators with disc-type bowl are used for purifying and dewatering the fuel oil. While using separators, essential feature of the separators should be the optimum separation efficiency even with constantly changing composition of the product to be separated. Efficient separation be achieved on principle of density difference between water, oil and solids.

FOTP must be designed for following key factors,

- Increase of turbine life-time
- Necessary general overhauling of gas turbine at longer intervals
- Reduction of gas turbine´s ”Power Loss“
- Reduction of operating costs for downstream equipment

Optimizing Fuel Combustion

EPC Contractor must ensure that following factors have been 100% achieved and implemented in his design so that fuel consumption is optimized,

(1) Temperature of the fuel is brought high enough to ignite and maintain ignition of the fuel,

(2) Turbulence or intimate mixing of the fuel and oxygen, and

(3) Time sufficient for complete combustion.

Contractor must prove in design that, Means have been used,

1. To Atomize the oil completely to produce a fine uniform spray.
2. To Mix the air and fuel thoroughly
3. To Introduce enough air for combustion, but limit the excess air to a maximum of 15% to keep the burners in good condition

Failing to prove all or any one of above will be unacceptable to owner & will call to review the design.

HFO Specifications,

Contractor to explore the locally available best spec HFO, get it tested to confirm the specs and suggest the required treatment. Contractor may notify to the owner the best spec HFO local source so owner can also review and buy the best for use with the GTGs.

Owner provided sample specs are given here-under.

Specifications	Unit of Measurement	Value	Remarks
Density at 15°C (60°F)	Kg/Litre	0.96 max	
Kinematic Viscosity at 50°C	cST	180* / 125** max	
Flash Point (Pensky-Martens)	Deg C	66.00 min	
Pour Point	Deg C	24.00 max	
Calorific Value (Gross)	Btu/lb	18000 min	
Water Content	% volume	0.5 max	This exceeds allowable limit, must seek lower values.
Sediment	% weight	0.25 max	
Ash Content	% weight	0.10 max	
Sulphur Content	% weight	3.50 max	Exceeds allowable limit, must seek lower values.
Conradson Carbon Residue	% weight	12.00 max	
Vanadium Content	ppm weight	100 max	This exceeds allowable limit, must seek lower values.
Sodium Content	ppm weight	100 max	

7.3.4 Work Item No.3: Water Treatment Plant

S. No.	Sub-Work Item	Quantity	Brief description
1	3.0	One Lot	Delivery , Installation, Testing and Commissioning Of a complete water treatment plant with storage of Dimin, Drinking and Utility Water Tanks capacity for 15 days with suitable equipment, piping , etc– Engg standards, specs and Main factors to be considered are given hereunder and elsewhere in this volume, standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C.

As a feed to Water Treatment Plant, the Owner will provide treated water from its RO WTP to following specs.

TDS < 500.

PH = 7

EPC contractor to check the required water quality specs from GTG vendor for use at water injection, air inlet and cooling water circuits, In case further treatment of site supplied water is required to demineralized water , contractor shall supply a suitable unit with sufficient quantity including use on 2 similar units for future expansion .

Its recommended that an Ion Exchange, media type water treatment plant be designed with regeneration facility.

Enough resins and consumables be supplied for at least 2 years use without risk of exhaust or expiry of life. Contractor may also

notify the source of these chemicals along with MSDS and safe handling procedures.
During installation, testing and commissioning of WTP, owner operatives be trained for service an degeneration of the plant.
Contractor to build necessary overhead tanks for at least 30 days of process water for plant entire use.
If temperature control of water tanks be a consideration, contractor may shift location of these tanks from tank farm area to basement in consultation with the owner engineer for allocation of proper area and associated pump installation and pipe routing.

Tanks and associated pumps / piping must comply with the engineering standards and codes described in previous sections.

Options on Choice of technology and WTP layout etc be discussed as part of proposal with owner engineer for agreement.

Plant life and other aspects / specs be well elaborated in the proposal.

An onsite water testing lab should be self sufficient from test instruments and chemical point of view to conduct entire tests as required for process water chemistry. Since contractor have the option to use owner supplied water to treat in stages, It will be advisable to propose which part of treated water train can be used as drinkable per WHO limits and which part can to be sued for plant utilities.

Necessary color coding of process water, drinkable water and utility water be applied as already spelled out in previous sections of this volume.
Proper PPE be provided for use on WTP for handling of chemicals.
An eye wash and a shower be provided at WTP for quick use in case required so.
Waste handling during normal service an degeneration be well spelled out and well designed for active / non-active.
Active or chemical waste must be handled per regulatory laws of the land / international laws.
Routine water testing and pints of sampling be well advised and should be set as part of plant operation procedures.
Cleaning of water tanks and preservation of water piping, cooling water loops be included as part of plant O&M manuals.
System normalization, isolation, necessary maintenance on parts be easy and well defined.
Plant control needs be through a local PLC or standard vendor advised panel built to suite site conditions.

(This item is subject to that employer provided water supply is out of plant equipment required specs)

7.3.5 Work Item No. 4. Combustion Turbine Generator Installation – GTG-1/2

S. No.	Sub-Work Item	Quantity	Brief description
1	4.0	2X Lot	Delivery , Installation, Testing and Commissioning Of a complete Distillate Start, HFO Run 2.5 MW each net at site conditions the Combustion Gas Turbine Generators + BOP from a US / Europe reputed make like GE/ABB/Siemens/MAN/Wartsila or equivalent standards, etc– Engg standards, specs and Main factors to be considered are given hereunder and elsewhere in this volume, standard station power and matching out put with owner 11 KV mains. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C and 8 meter altitude above sea leval.

Installation procedure, safety practices to be adopted while lifting of units and placing on foundations, alignment procedures, critical measurement, shop drawings, flushing procedures and acceptance criteria, inlet, exhaust, Fuel Flow Divider, turning gear, starting motor, atomizing air, fuel systems piping connections, accessory base, on base piping, off base piping, fire protection system, CO2, water wash skid, continuous emission monitoring systems, compressor , Turbine and generator alignment, lift oil system, cooling oil and oil cooling systems etc to be installed, tested and commissioned per vendor specific procedures.

Contractor to strictly refer to OEM procedures and OEM TAs to execute the installation / installation supervision, testing and commissioning including GCBs, Excitation system and control system, local control panels and central control room, HVAC systems, and any other / all associated equipment / system, be strictly installed by or under the supervision of OEM TAs.

7.3.6 Work Item No. 5. Inlet / Exhaust Systems

S. No.	Sub-Work Item	Quantity	Brief description
1	5.0	2X Lot	Delivery , Installation, Testing and Commissioning Of complete inlet and exhaust systems for combustion Turbines etc– Engg standards, specs and Main factors to be considered are given hereunder and elsewhere in this volume, standard station power feed and matching out put with plant. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C and 8 meter altitude above sea leval.

1. **Introduction**.

An inlet air filtration system is essential for the successful operation of a gas turbine. The filtration system protects the gas turbine from harmful debris in the ambient air, which can lead to issues such as FOD, erosion, fouling, and corrosion. These issues if not addressed will result in a shorter operational life and reduced performance of the gas turbine. Modern day filtration systems are comprised of multiple filtration stages. Each stage is selected based on the local operating environment and the performance goals for the gas turbine.

Gas turbines ingest a large amount of ambient air during operation. Because of this, the quality of the air entering the turbine is a significant factor in the performance and life of the gas turbine. A filtration system is used to control the quality of the air by removing harmful contaminants that are present. The selection of the filtration system need special attention by the EPC contractor, because there are many factors to consider. The system should be selected based on the operational philosophy and goals for the turbine, the contaminants present in the ambient air for which site data over the year must be reviewed carefully, and expected changes in the contaminants in the future due to temporary emission sources or seasonal changes be considered.

In view of the importance of AIF design, contractor must consider the following important factors,

2. Consequences of Poor Inlet Filtration

When the quality of the air entering the gas turbine is not well controlled, there are several consequences which can occur. The most common degradation mechanisms including erosion, fouling, and corrosion must be avoided.

2.1. Erosion

Erosion will occurs when solid or liquid particles approximately 10 μm and larger impact rotating or stationary surfaces in the gas turbine. The particles will impact the surface and remove tiny particles of metal which eventually lead to changes in the geometry of the surface. This change in geometry causes deviations in the air flow path, roughening of smooth surfaces, alteration of clearances, and reduction of cross-sectional areas of metal components possibly in high stressed regions. Erosion is a non-reversible process; therefore, the gas turbine components must be replaced in order to regain their original condition. However, particles 10 μm and larger are easily removed by commercial filters

2.2. Fouling

Fouling of compressor blades must be considered seriously by EPC contractor and means must in-place to avoid any of such issues. This effect causes performance deterioration in gas turbines over time. Fouling is caused by the adherence of particles to airfoils and annulus surfaces. Particles that cause fouling are typically smaller than 2 to 10 μm even Smoke, oil mists, carbon, and sea salts can cause. Fouling needs be controlled by an appropriate air filtration system and often reversed to some degree by detergent washing of components. The adherence factors must be avoided by suitable means which are oil or water mists. The result is a build-up of material that causes increased surface roughness and to some degree changes the shape of the airfoil (if the material build up forms thicker layers of deposits). Fouling in turn causes a decrease in the performance of the gas turbine.

Effective and efficient selection of filters can remove the majority of particles that cause fouling. But there are several submicron particles that are difficult to remove from the flow stream. The build-up of particles not removed by the inlet filtration system is removed with the use of compressor washing. This process recovers a larger portion of the compressor performance but cannot bring the gas turbine back to its original condition. EPC contractor needs to discuss all such possible events and discuss the effectiveness of his design to cater for these factors.

2.3. Corrosion

EPC contractor must address the situation in when chemically reactive particles adhere to surfaces in the gas turbine, corrosion can occur. Corrosion that occurs in the compressor section is referred to as **"cold corrosion"** and is due to wet deposits of salts, acid, and aggressive gases such as chlorine and sulfides. Corrosion in the combustor and turbine sections is called **"hot corrosion."**

Contractor to consider some of the more common forms of hot corrosion which are sulfidation, nitridation, chlorination, carburization, and vanadium, potassium, and lead hot corrosion. Contractor shall discuss one by one how they can occure and how he has arranged to vaoid.

Since hot corrosion can occur due to both sulfur and salt (e.g., sodium chloride or potassium chloride or chloride) that present in the very hot gas stream in and downstream of the combustor. Besides**, sulfur and salt can come from the inlet air, from the fuel, or water** (if water is injected) therefore it's the primary and essential responsibility of contractor to address this and avoid it through careful design. The potassium hot corrosion mechanism is similar to sulfidation but is less frequently observed in gas turbines, unless the fuel contains significant quantities of potassium.

Since corrosion is a nonreversible degradation mechanism and the corrosion also initiates or advances other damage mechanisms in the gas turbine like intrude into cracks or other material defects and accelerates crack propagation therefore owner stress contractor to take extreme consideration in design of AIF, fuel and water quality before & after treatment.

3. Filtration Characteristics

Contractor must highlight, as a minimum, the following factors in his AIF design / selection.

3.1. Filtration Mechanisms

That's the mechanisms employed to remove contaminants from the air. The filter media, fiber size, packing density of the media, particle size, and electrostatic charge that influence how the filter removes contaminants.

3.2. Filter Efficiency and Classification

Filter efficiency over the max life without pressure loss be declared, the ratio of the weight, volume, area, or number of particles captured in the filter to the weight, volume, area, or number of the particles entering the filter, respectively. Owner expects a 95 percent filtration efficiency for particles greater than 5 μm.

3.3. Filter Pressure Loss

In view of this most important and critical factor, owner targets a pressure losses on inlet filtration systems not beyond f 2 to 6 inH2O (500 to 1500 Pa). Contractor will prove this just before end of one month run before take over or just before the replacement of inlet filters which ever is later.

Issue becomes sensitive as a 0.2 inH2O (50 Pa) reduction of pressure loss can result in a 0.1 percent improvement in power output therefore owner stress on contractor to be much considering, choosy and touchy on AIF. As AIF pressure drop or increasing differential causes a reduction in compressor inlet pressure. For the compressor to overcome the inlet system losses, the gas turbine will consume more fuel, and it also has a reduced power output. As the pressure loss increases the power decreases and the heat rate increases linearly. Owner likes to remind that heat rate and compressor efficiency are listed as guarantee items.

3.4. Filter Loading (Surface or Depth)

If feasible, Its recommended to employ a surface depth type and have a pulse cleaning system to remove dust. In case not a contractors option, contractor needs to justify his selection and choice thereof.

3.5. Face Velocity

Contractors choice among, high, medium or low?

3.6. Water and Salt Effects

Although site is not generally damp however contractor to consider water effects in winters and salty atmosphere round the year. Sea breeze during the night and salty air from nearby salt lakes to be considered seriously. Slat can easily range from 0.05 to 0.5 ppm on a typical day . If the filtration system is not equipped to handle the salt, it can enter the compressor and the hot section of the gas turbine. Salt is present in the air, either as salt dust or dissolved in seawater, and contains sodium chloride, magnesium chloride, and calcium sulfate. Salt may also come from localized sources such as a dry salt bed.

4. Components of a Filtration System

Owner believes this is a site where contractor must give special consideration to the following factors towards IAF components so to protect the gas turbine by introducing one or more of following devices, preventing from the variety of contaminants present in the ambient air,.

4.1. Weather Protection and Trash Screens

4.2. Anti-Icing Protection – (Not Applicable for this site)

4.3. Inertial Separators

4.4. Moisture Coalescers

4.5. Prefilters

4.6. High-Efficiency Filters

4.7. Self-Cleaning Filters

The self-cleaning filtration system developed for the areas where gas turbines are subject to frequent sand storms. Although capacity of Nabisar GTGs is not classified as heavy duty however contractor may ask his Turbine Vendor if he can make similar provision as site is a part of desert Thar and a self cleaning system even at smaller scale, seem to be the best outfit.

4.8. Staged Filtration

5. Operating Environment

5.1. Coastal, Marine, or Offshore

Looking st site conditions, it looks like falling in this class, by definition, the gas turbine is considered in an offshore environment when it is located at least 100 ft (30.5 m) off of the ocean surface. Gas turbines located below 100 ft (30.5 m) are considered to be in a marine environment. (Site altitude being 8 Mtr altitude).
In coastal environments, it is present as dry contaminants (areas with lower humidity), site is located in dry areas – desert of Thar. Contractor may consider these factors seriously should it **call for high efficiency filters**.

5.2. Land-Based Environment – further classified as under,

5.2.1. Desert - Contractor may study this deeply as it looks the site falls in this class,

By definition the desert is classified as an area with a dry and hot climate. Large amount of dust is present and there is little vegetation. Sand storms are common and can quickly load filters to their maximum dust holding capacity. The main regions of the world which can be characterized by desert like environments are across the Sahara desert in Africa, the Middle East, and parts of Asia. However, small localized areas with high dust concentrations do exist. These can include gas turbines installed near quarries, dried lakebeds, loess, industrial areas, dirt tracks, dry agricultural land, and construction sites. There are three typical conditions that exist in the desert: clean air, dust haze, and sand storms. Dust is the main contaminant in the desert for these conditions. This can be sand or other fined grained material such as desert pavement. Desert pavement is the layer of large stones left on the floor of the desert. While these stones are not harmful in their solid state, they can easily be broken by human or animal traffic and crumbled into fine particles. These particles can range from large (500 μm) to very fine (submicron size). Due to the lack of vegetation and protection of the ground dust from the wind, more dust can be lofted into the air than in other environments. This leads to a high concentration of dust.

The filtration systems in deserts are usually solely designed for dust removal. However, some desert locations experience periods of dense fog and high humidity. This is especially true for deserts near a coastal region. The moisture can collect on the surface of cartridge filters on self-cleaning systems and cause the dirt to form a cake on the filter. This cake of dust can significantly reduce the effectiveness of filtration and pulse cleaning. If fog and high humidity are present at the desert-type site, then this should be considered for the filtration system.

Dust loads in the desert can range from mild (low wind) to fairly high (dust storms). Conventional non-self-cleaning filtration systems can quickly become loaded and require frequent filter change outs. Also, high pressure losses can trigger a shutdown if they become excessive. In order to avoid the constant maintenance and labor required for changing filters out, a self-cleaning system is needed. Filtration systems without self-cleaning filters have proven to be more expensive due to the labor cost and maintenance required with filter replacements

5.2.2. Arctic – Not Applicable

5.2.3. Tropical

5.2.4. Rural

5.2.5. Large City

5.2.6. Industrial Area

5.3. Temporary and Seasonal Contaminant Sources

5.4. Site Layout

5.5. Site Evaluation

6. Life Cycle Cost Analysis

6.1. Life Cycle Cost Basics – Contractor is encouraged to table this for discussion

6.2. Considerations for an Inlet Filtration System –

are six main parameters: purchase price/initial cost, maintenance cost, availability/reliability of the gas turbine, gas turbine degradation and compressor washing, pressure loss, and failures of the filtration system or gas turbine due to inlet air quality

6.2.1. Purchase Price/Initial Cost - Contractor is encouraged to table this for discussion

6.2.2. Maintenance Cost - Contractor is encouraged to table this for discussion

6.2.3. Availability/Reliability of Gas Turbine – Owner likes to request contractor to consider this factor as highest priority in his design key factors.

6.2.4. Gas Turbine Degradation and Compressor Washing

Gas turbine degradation be taken by contactor the most important cost in the analysis. This is often the cost which drives the analysis to favor one filtration system option over another. The cost of gas turbine degradation is calculated based on the reduced power output and increased heat rate due to inlet air quality.

Once the degradation rate is calculated the lost profit due to reduced gas turbine output can be calculated. If the gas turbine is operating at full load, then it is expected that the fuel cost will decrease due to the lower power output. For part load operations, it is expected that the fuel cost will go up since the engine will be operated at the desired power output. The change in fuel cost should be calculated based on the change in heat rate and operational philosophy and be included in the analysis. This cost should be included in each year of the analysis.

6.2.5. Pressure Loss

The pressure loss across the inlet filtration system have a significant effect on the cost of the inlet filtration system. An increase in the pressure loss across the filtration system leads to reduced power output from the gas turbine and an increased heat rate. The cost of these effects should be included yearly in the LCC analysis.

6.2.6. Failure/Event Cost

The last cost is any cost associated with a failure or event that occurs due to the inlet filtration system or inlet air quality. This could be a failure of a filter material, which requires shutdown for replacement or a failure of a gas turbine blade which occurred due to corrosion from poor inlet air quality. These costs are often included based on past experience with the gas turbine or other filtration systems.

7. Conclusions

In summary, the selection and operation of an inlet filtration system is highly dependent on the environment where the gas turbine is operating. The contaminant present in the ambient air will dictate the type filters that are used. It is important to quantify what type and size of contaminants are present in order to correctly select the filters to be used. Temporary and seasonal variations must also be considered for the inlet filtration system. A life cycle cost analysis provides a convenient method to quantify and compare various filtration system options such that the optimal system can be selected.

EXHAUST SYSTEM

Turbine exhaust system will be installed as part of main plant and strictly in accordance to the OEM supplied drawings, schematics and procedures. Installation to be done by OEM TAs or under the supervision of OEM TAs.

7.3.7 Work Item No. 6. Distillate, HFO Systems

The heavy fuel oil must be supplied within a certain specification of cleanliness in order to prevent high temperature corrosion, ash deposition and fuel system problems. High temperature corrosion can result from the presence of trace metals in the fuel, notably sodium, potassium and vanadium. Ash forming impurities may be present in the fuel as oil soluble metallic compounds, water-soluble salts and solids, which may be deposited on hot-gas path components during combustion, resulting in a loss of efficiency. Fuel system problems such as clogging of filters and fuel distributors and erosion of fuel pumps can result from the presence of water and solids such as sand, rust, scale and dirt as well as microorganisms.

Contractor supplied fuel treatment process must be designed to overcome these harmful effects. By ensuring consistent compliance with specific fuel oil purification requirements, HFO treatment plant will contribute to longer service life of plant machinery, and to a reduction in operating costs through less maintenance and downtime. Tried and tested GTG vendor required specifications. Contractor shall combine his field experience in Heavy fuel oil treatment with a dynamic development programme adapted to the power generation industry requirements. Contractor's Innovative design and precision engineering must combine to provide compact and robust solutions that are built for consistent performance and easy maintenance. Rapid delivery, rapid pay-back.

Contractor to ensure future support so that the most complex fuel oil treatment solutions be quickly configured on supplied equipment. Considerations must be on competitive capital investment combined with significant operational savings resulting rapid return on investment.

As a minimum the supplied centrifuge / FOTP performance be as under,

Element	Reduction
Sodium + Potassium	80–99%
Calcium	20–80%
Magnesium	40-60%
Water	80-90%
Ash	10-50%
Particle	70-90%

S. No.	Sub-Work Item	Quantity	Brief description
1	6.0	One Lot	Delivery , Installation, Testing and Commissioning Of a complete, unloading, storage, treatment, pumping, treatment, service tanks for 10 days use, storage thru suitable Distillate / HFO buildings, equipment, piping , centrifuges etc for the main plant / BSDG till end use and waste disposal / incinerator / sludge handling etc. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C.

7.3.8 Work Item No. 7: Cooling Systems

Vendor is required to spell out the quantity of excessive heat that needs be removed from different plant systems, mainly from air intake system, Compressor, Turbine, Generator, cooling water or cooling media itself, excitation system, building systems, and table the best arrangement to remove the excessive heat in an most economical and efficient manner. Necessary models be built up in support of the selected cooling system and equipment performance to prove that system is well studied and well engineered to give a long life with best optimum efficiency in the best cost effective manner complying with engineering standards and prudent power plant practices. Contractor needs to table and discuss that maintenance of installed equipment is not complicated and can be done at site by the plant operator adopting easy ways in safe manner.

Most critical and essential being among all being the heat removal or cooling of Lube Oil System for which normally the oil Coolers are utilized on lubricating oil reservoirs to control viscosity and reject heat. Lube oil cooler performance is impacted by a number of plant-specific variables, such as ambient temperature, plant utilities, equipment condition, and the like. Contractor to study and consider all these design considerations, and come up with an engineered approach and plant case system for cost-effective, heat rejection from lube oil reservoir or tank as the case may be.

The success of the contractor approach depends, on an accurate engineering understanding of heat transfer in lubricating oil systems. Performance predictions from commercially available computer models had been found to be misleading. A spreadsheet-based model that included mass/heat transport in viscous, laminar flow is normally found to be quite accurate. Field data taken during operation confirmed the conclusions and validated the spreadsheet model.

Contractor must take the temperature control as challenging task. Lubricating oil systems that support rotating equipment are subjected to variable of various heat rate inputs. Sufficient heat must be removed so that oil returned to service is within OEM desired temperature range. That range is rather narrow. The means for removing heat from the oil is generally limited and the oil has poor heat transfer characteristics. Heat rejection and temperature control, while related, are two distinct topics. Contractor might not take it casually and should not treated as one topic.

Lubricating oil systems supporting such machinery incorporate heat exchangers for heat rejection and temperature control. Enthalpy is extracted from the lubricating oil by heat transfer through the exchanger wall. The extraction rate is a function of the resistance to heat transfer, the heat transfer surface area, and the temperature driving force. Contractor to apply the following generally recognized typical thermal transport relation is:

$$\triangle Q = \overline{U} * A * (CMTD)$$

where:

$\triangle Q$ = energy transfer, Btu/hr

$\overline{U}$ = overall heat transfer coefficient, Btu/h ft^2 F

A = heat transfer area, ft^2

$CMTD$ = corrected mean temperature difference, F

The energy balance equations for the two constituent streams (lubricating oil and coolant) are given as:

$$dQ = m * C_p(T) * dT$$

where:

dQ = energy transfer, Btu/hr

m = (mass) flow rate, lb/hr

$C_p(T)$ = (mass) heat capacity, Btu/lb F, function of temperature

dT = temperature difference, F

The resulting three equations allow the user to quantify the performance of the heat exchanger and predict the lubricant oil temperature returning to the machine. To use the equations, however, the user must have a good value for U, the overall heat transfer coefficient. The coefficient is composed of five components that make a significant contribution to the result:

$$U = \frac{1}{\left(\frac{1}{h_H} + \frac{1}{h_C} + \frac{t}{k} + R_{f,tube} + R_{f,shell}\right)}$$

where:

U = overall heat transfer coefficient, Btu/hr ft^2 F

h_H = hot side heat transfer coefficient, Btu/hr ft^2 F

h_C = cold side heat transfer coefficient, Btu/hr ft^2 F

t = thickness of heat transfer surface, ft

k = thermal conductivity of heat transfer surface, Btu ft/hr ft^2 ftF

R_f = shell and tube side fouling factor, hr ft^2 F/Btu

In lubricating oil systems, estimation of one of these components—hH, the oil side heat transfer (film resistance) coefficient—can make the difference between an accurate and inaccurate prediction. The film resistance coefficient represents the resistance to heat transfer from the bulk flowing stream to the wall of the heat exchanger. It reflects the complex interactions of heat, mass and momentum transport.

Considerable study of this physical phenomenon has been made over the last 70 years. To date, it has defied rigorous modeling. Rather, good progress has been made by means of semi-empirical predictions. These predictions utilize well-known Dimensionless Numbers, including:

Reynolds	$N_{Re} = Dv\rho/\mu$
Prandtl	$N_{Pr} = Cp\mu/k$
Nussult	$N_{Nu} = UD/k$

And secondary numbers:

Stanton	$N_{St} = N_{Nu}/(N_{Re}{*}N_{Pr})$
Graetz	$N_{Gr} = N_{Re}{*}N_{Pr}{*}D/L$

Where, in consistent units:

D	= diameter
v	= velocity
ρ	= density
μ	= viscosity
C_p	= heat capacity
k	= thermal conductivity
U	= heat transfer coefficient
L	= length

All of the dimensionless numbers above, with the exception of the Prandtl number, have components that characterize mass transport. Heat transfer is facilitated in turbulent flow, and hindered in laminar flow. Reduced thickness of the boundary layer adjacent to the heat transfer surface wall and greater mixing in the bulk stream are consequences of turbulent mass transport. These result in improved heat transfer.

The semi-empirical predictions in today's models make use of the relationship between mass flow conditions and the film resistance coefficient. It is in the modeled relationship between mass transport and heat transfer that the cautionary issue arises. Lubricating oils are specially formulated for their viscosity properties. As a result, generalized correlations which predict mass, heat and momentum transport phenomena for hydrocarbon streams can be inaccurate when used on lubricating oils. Generalized hydrocarbon correlations are used to calculate the components of dimensionless numbers and, in turn, to predict the film resistance coefficient. The generalized correlations are not sensitive to the specialized nature of lubricating oils.
Besides above guidance, contractor have a choice among a number of popular,

commercially-available computer simulation programs to assist in analysis of lube oil systems. Properties and conditions can be entered into the programs, and heat exchanger sizing and performance predicted. As an additional aid, libraries of pre-determined properties are available as integral parts of the programs.

Prediction of heat removal from lubricating oil can be a challenge to commercially-available models. The thermos-physical properties of lubricating oil create a situation where the results of the computer programs can be misleadingly optimistic. In a typical model study, Four commercial programs were utilized in the design of the case study. All four gave predictions, with lube oil, of higher heat transfer than was actually observed in the field.

The design of every system is unique to the conditions of that system. Every design represents a compromise among a number of elements, including available utilities, ambient conditions, cost, anticipated needs, machine mechanical condition and others. The nature of a compromise is that it generally does not completely satisfy all of the elements. Furthermore, some of the elements change over time. One result is that the lubricating oil cooling system can become, under some conditions, limited and unable to achieve the desired oil temperature.

Contractor is required to calculate all requirement of cooling systems which are mainly,

Lube Oil Cooling System –

1. using dry or wet cooling system. Considering the site data, it's recommended that wet cooling system be introduced.
2. Cooling and Sealing Air System.
3. Air Inlet / Evap Cooling System
4. Building Ventilation Air Cooling – Air Conditioning System.
5. Process Water Cooling System.
6. BSDG associated Cooling System.
7. Any other equipment, system required to be addressed.

Lube Oil Cooling

Turbine lube oil cooling is critical to the reliability of turbine-generator or turbine-driven pump applications.
An air cooled or water cooled suitably designed equipment & conforming to the standards be offered, typical specs are as under,

Specifications

1. Fan diameters from 48" or as suitable,
2. Electric motor or hydraulic drive configurations
3. Multi-fan Forced or induced draft
4. Typical compression HP: 50- or as suitable

Features

1. Cooler finish per vendor specifications, including tint-to-match paint and galvanizing
2. Multi-speed drives or auto-variable fans can provide superior degree of temperature control
3. Column extensions to accommodate any headroom clearance
4. Framed drive-mount system, allowing side access for easier electric motor maintenance and improved structural integrity
5. Louvers (manual or automated) downstream of the cooling sections to control air flow for temperature control
6. Auxiliary louvers (manual or automated) located upstream of the cooling sections to provide additional protection in cold weather climates
7. Warm air recirculation systems available over the end or side of the unit to better control process outlet temperature in cold weather climates
8. Hailguard over cooling section coils, independent or integral with shutters, to protect cooling sections
9. Low noise emission fans
10. Bug screens/lint screens over air intake to minimize external fouling of cooling sections

Process Water Cooling

Contractor's suitable option conforming to engineering standards ACC or ACW.
Cooling fans, electric-motor-driven process-type coolers can be built to API 661 to service the needs of the refinery and petrochemical industries.

Specifications

1. Fan diameters from 24" or as suitable,
2. multi-fan configurations, Forced or induced draft
3. Electric motor or hydraulic drive configuration
4. Typical compression HP:50 or as suitable

Features

1. Cooler finish per vendor specifications, including tint-to-match paint and galvanizing
2. Multi-speed drives or auto variable fans can provide superior degree of temperature control
3. Louvers (manual or automated) located upstream of the cooling sections to provide additional protection in cold weather climates
4. Warm air recirculation systems available over the end or side of the unit to better control process outlet temperature in cold weather climates
5. Hailguard over cooling sections, independent or integral with shutters, to protect cooling sections
6. Low noise emission fans
7. Bug screens/lint screen over air intake to minimize external fouling of cooling sections
8. Convenient accessibility to all components: fan, drive and bearings

Evap Cooling.

Contractor to study site conditions and apply in its best applicable form the evaporative cooling system for turbine inlet air as a useful option for installations similar to site of high ambient temperatures and low relative humidity . With an evaporative cooler, necessary amount of water be added to the inlet air of a gas turbine. Part of the water evaporates absorbing latent heat from the air.

As a result, the air, which gives up sensible heat, cools and increases in density. This gives the machine a higher mass flow rate and pressure ratio resulting in an increase in turbine output and efficiency. For example, considering a dry-bulb temperature of 40°C with 20% relative humidity, the output power can be increased by about 12% if an 80% effective evaporative cooler is used. Correspondingly, the heat rate decreases by about 4%. The benefit of an evaporative cooler system from an economic point of view is strictly related to the potential average annual increase in output, mainly as under,

a. Increase in turbine output
b. Increase in turbine efficiency/decrease in heat rate
c. No modifications to the gas turbine The evaporative cooler system installation be made specific to plant where it is to be installed.
d. . Contractor to take caution that adding the evaporative cooler must not cause additional pressure drop in the inlet ducts. In case its unavoidable, it must not exceed the limits of approximately 15 mm of H_2O. This system be fed with a supply of suitably treated water from the site WTP circuit.

The amount of water which must be provided as makeup is the sum of evaporation, carryover and blowdown. The rate at which the water is evaporated into the air stream depends on the ambient temperature, humidity and pressure, cooler effectiveness, and turbine airflow.

A certain amount of water is entrained in the form of droplets by the air stream entering the turbine. It may either have escaped from the channels or have dripped from the medium retainers.

To reduce carryover, mist eliminators are installed on the downstream side of the medium. These capture the droplets by impingement of the air flow and drain the liquid to the cooler tank. Since the cooling water recirculates, part of it must be drained periodically (termed blowdown) and be made up with new water.

This makes it possible to control the concentration of substances present in the water supply that could cause scaling and corrosion if allowed to reach excessive concentrations.

Referring to an 80% effective evaporative cooler operating at 35°C and 20% R.H. The amount of makeup is calculated by taking into considering the replacement of enough raw water (high $CaCO_3$ hardness) with treated water (low $CaCO_3$ hardness) to maintain a level of 140 PPM of water hardness as

$CaCO_3$.

Scope of Supply .This uprate is very customer/site specific and must be engineered on an individual basis.

Contractor scope of supply includes: • Header • Medium retainers • Mist eliminator • Instrumentation • Evaporative cooler arrangement • Control system • Modification and installation drawings.

The pipe work including specials, bends and flexible slip out joints shall be in mild steel of minimum wall thickness 10 mm and minimum grade of steel Grade B.Work.
Item No.7 shall comprise following Sub Work Items. The Contractor may claim payment against each Sub Work Item, if he so desires.

S. No.	Sub-Work Item	Quantity	Brief description
1	7-0	1 Lot	Cooling Oil System – On Base / Off Base equipment, piping designed, supplied and installed to suite main plant / BOP, tested and commissioned.
2	7-1	1 Lot	Process (Oil Cooling) Cooling System. On Base / Off Base equipment, piping designed, supplied and installed to suite main plant / BOP, tested and commissioned
3	7-2	1 Lot	Building Ventilation and Air-conditioning . Ventilation, air-conditioning equipment of suitable make, proper capacity to maintain 20 deg C and control humidity to suite installed electronic equipment in all plant / BOP, admin, security buildings, supplied, installed and commissioned
4	7-3	1 Lot	Complete Evap Cooling System, designed to suite main plant , supplied, installed and commissioned, guaranteed for the intended use.

7.3.9 Work Item No. 8: Black Start Diesel Generator

The Contractor may claim payment against each Sub Work Item, if he so desires.

Each discharge branch shall comprise of its complete scope.

S. No.	Sub-Work Item	Quantity	Brief description
1	8.0	One Lot	Delivery , Installation, Testing and Commissioning Of a suitable, XXX KVA (TBA) Black Start Generator Set with justified capacity (TBA) and with associated BOP / Cooling skid /Control Panel along with all necessary process connections, Piping, electrical isolations, protections, Fire detection / control and control connections / terminations. Synchronizing with 0.4 KV and feeding essential load via a load sequencer. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C and altitude 8 Meters above sea level.

7.3.10 Work Item No. 9: BMS

Work Item No.8 shall comprise following Sub Work Items. The Contractor may claim payment against each Sub Work Item, if he so desires.

S. No.	Sub-Work Item	Quantity	Brief description
1	9-0	Lot	Delivery , Installation, Testing and Commissioning Of a all Building Management Systems for the 2X2.5 Power Plant / BOP / Security / Safety / CCTV / Tele / Fuel Management / Labs / work shops / car park / staff entry / visitor control / HVAC etc along with all necessary process connections, electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with ambient temp of 50 deg C. BMS scope includes but not limited to the following, a. Pre-commissioning checks for the field instruments. (per contractors submitted & employers approved method statement – done minimum 2 weeks prior of testing) b. DDC panel commissioning. c. MCC Commissioning. d. FCUs for Installation & Cabling / permanent power, e. Head & Graphics for field equipment and permanent power. f. Printers (alarms and reports) g. Interface with 3rd party system, h. Power-up DDC Controllers and Download software at DDC controllers i. Digital / Analog I/Os j. FCU Controllers Power Up checks k. Checking the Sequence of operations

7.3.11 Work Item No. 10: Excitation System

Work Item No.10 shall comprise of following Sub Work Items. The Contractor may claim payment against each Sub Work Item, if he so desires.

S. No.	Sub-Work Item	Quantity	Brief description
1	10-0	2X Lot	Delivery , Installation, Testing and Commissioning Of a Self Ventilated Generator Auto Excitation System for the 2.5 MW unit along with all necessary electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied generator. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with max ambient temp of 50 deg C.

7.3.12 Work Item No. 11: CEMS, CO2 Skid, WW Skid, Fire Fighting, Inst Air

One lot each per OEM recommendation and best serving for the intended use.

S.No	Item	Quntity	Brief Description
1	11-0	2X Lot	Delivery , Installation, Testing and Commissioning Of a Continuous Emission Monitoring System for the 2.5 MW Combustion Turbine unit exhaust along with all necessary process connections, electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with ambient temp of 50 deg C.
2	11-1	2XLot	Delivery , Installation, Testing and Commissioning Of a CO2 Skid for the 2.5 MW Gas Turbine Generator unit Fire Fighting system along with all necessary process connections, electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with ambient temp of 50 deg C.
3	11-2	2XLot	Delivery , Installation, Testing and Commissioning Of an On-Line / Off-Line Water Wash System Skid for the 2.5 MW Combustion Turbine driven centrifugal multistage compressor unit along with all necessary process connections, electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with ambient temp of 50 deg C.

4	11-3	2XLot	Delivery , Installation, Testing and Commissioning Of an Instrument / Atomising Air System Skid for the 2.5 MW Combustion Turbine unit along with all necessary process connections, Electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with ambient temp of 50 deg C.
5	11-4	One Lot	Delivery , Installation, Testing and Commissioning Of a Fire Detection and Fifgting System for the 2.5 MW Plant / BOP / Buildings along with Suitable Fire Detectors / Fire Suppression systems alongwith all necessary process connections, electrical isolations, protections and control connections / terminations. Unit input – standard station power and matching out put with vendor supplied combustion turbine. Final acceptance will be upon one month combined reliability run / performance test before take over. Unit must be suitable for site installations with ambient temp of 50 deg C.

7.3.13 Work Item No. 12: Electric overhead gantry crane

1 No- Electric overhead traveling crane comprising a bridge assembly with hoist and having cross traverse and long travel facilities complete with all necessary gantry beams, rails and fixings to the building structure for a safe working load of 10 ton to facilitate handling of all equipment such as 11 KV motors, electric panels, pumps, valves and pipework installed in the pump house building with controls by means of divorced pendant.

An access platform 1000 mm wide in chequered in aluminum alloy shall be provided complete with hand railing on one side of the crane to facilitate maintenance of the pump house ceiling and lighting installations. The trolley shall have guard rails to provide access for crane maintenance.

One fixed access ladder with guards to provide a safe route to crane platform shall be included at one end of the motor room.

Load chains shall be of sufficient length to enable the hook to be lowered to the bottom of the pump chamber and shall be provided with a chain collecting box to hold the slack chain.

Adequate quantity of lifting beams, slings and all other tackle needed for handling all equipment shall be supplied with the crane. The Contractor shall provide all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and failsafe protection in the event of an interruption in the power supply. All necessary ladders and platforms beside those specified above or in the Specification shall be provided.

7.3.14 Work Item No. 13: Dewatering Pump

2 No- Dewatering pumps of minimum 20 l/sec discharge at 10 m head, one duty and one standby, shall be provided in a sump in the pump chamber to pump gland leakage and drainage water during maintenance of pumps and pipework to the suction well. The pumps shall be complete with pipework, valves and float type level controls for automatic/manual and start/stop operations.

7.3.15 Work Item No.14: Steel Plate Flooring, Hand Rails, Access Ladders

Work Item No.13 shall comprise of following Sub Work Items. The Contractor may claim payment against each Sub Work Item, if he so desires:

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S. No.	Sub-Work Item	Quantity	Brief description
1	14-0	lot	Steel plate flooring covers on all openings and cable ducts in motor room of Durbar or non-slip pattern of minimum 4.5 mm thick steel plate hot dip galvanized after fabrication to BS 729.
2	14-1	lot	Hand railing consisting of double bar forged steel standards with tubular rails hot dip galvanized in accordance with BS 729 shall be provided around inlet chambers, screen chamber, pump sump, valve and flow meter chambers and other areas as required. All hand railing at ground floor viz motor room including that of balcony shall be stainless steel to BS 970 Grade 316.

S. No.	Sub-Work Item	Quantity	Brief description
3	14-2	lot	Access ladders and platforms of minimum width 1000 mm made in checkered aluminum alloy in accordance with BS 1470 material H 30 TB to be provided in the pump basement (dry-pit) for access to all six pumps and all suction, discharge and non-return valves for facilitating O&M works as shown on Conceptual Drawings. Hand railing consisting of double ball forged steel standards with tubular rails hot dip galvanized in accordance with BS 729 shall be provided where required.
4	14-3	lot	Access ladders of sturdy design built-in steel, hot dip galvanized to BS 729, for installation in valve /flowmeter chambers, screening stream chambers, inlet chambers and pump sump etc.

7.4 Employer's Requirements: Electrical Works

7.4.1. General

Preliminary power,

Normal Working mode of the Nabisar Power Plant is to feed an interrupted 5 MW, 11/0.4 KV 3 phase 4 wire 50 cycles per second power at 0.8 pf to owner's RO plant and pre-filtration plants except when one or both GTs trip for any planned or un-planned reason.

For initial construction support, and as a back up during the partial or full outage oh Nbailsar Power Plant, a 3 phase 5 MW 11 KV 50 cps Wapda supply is available at owners 11 KV substation / main bus which shall feed partial or full load according to requirement. For an easy indication, power flow directional indicator and a 3 phase 4 wire indicating type integrator energy meter will be installed to record the power intake from WAPDA to NPP fecality. This is not a custody meter but for owner's own use and record. Meter should be equipped with isolation for calibration and replacement provision in case required.

A Black Start of adequate capacity per vendors installed essential load will be used in case of both Nabisar Power and the WAPDA back up up power are not available. Black Start DG will be connected safely on 0.4 KV bus without any mismatch effect in case of CTs / Wapda back up are restored,

GTG-1/2 output will be connected to owners 11 KV mains through a suitable rating step up transformer if the vendor installed Generators supply a different terminal voltage like 6.6 KV etc, In case its 11KV than an Isolation transformer shall be installed. Transformers will have compatible configuration, necessary Isolation for any maintenance and protection switchgear. Contractor must explain reasons for their design and product selection with trip / fault protection scheme & calculations related to different operating / fault scenarios including instantaneous and distance short-circuit, differential, earth fault etc that could effect the equipment. Lightening arrestors and grounding with appropriate size must be employed. Bottom line being safety of personal an equipment being supreme most and on the top. Equipment reliability and cost are also important factors for consideration. Transformers, breakers and protection systems be a product of AEG / ABB Br or equivalent installed in proper vault. Option be explored and tabled for the supply / installation of local make reliable transformers with same protection and warranty / gurantee.

Plant synchronization shall be fool proof and errorless, especially against a negative of phase sequence from either of the power sources.

Following operating modes / scenarios of plant be considered in mind while designing the auto / manual synchronizing scheme.

Site Scenario #	Main Plant Units	GTG-1/2 Operating Status	WAPDA BACK UP Status	BLACK START Status	Auto Action
1	GTG-1/2	Operating at FSNL	Available and 11 KV Mains Energized	Ready Shut Down State	GTG-1/2 Synchronize one after one on 11 KV Main with WAPDA
2	GTG-1/2	Both or one Tripped	Available and 11 KV Mains Energized	Ready Shut Down State	WAPDA Supplies 5 MW back Up Load - Load sharing to be indicated in Control Room and locally
3	GTG-1/2	Both or One available and on FSNL	Not Available	In Operation and feed GTG Essential Load through a load sequencer	BS synchronized using Ref Bus. GTG-1/2 Synchronize one after one on 11 KV Main with BS DG to receive incoming WAPDA synchronizing automatic or manual as selected.
4	GTG-1/2	One Unit Operating and connected at 11 KV Mains	WAPDA Resumes, not synchronized on 11 KV Mains	Back on Auto Standby Mode	GTG-1/2 synchronized using Ref Bus. WAPDA be synchronized as incomer back up available,
5	GTG-1/2	Both Units Operating and Synchronized at 11 KV Mains	Available and synchronized at 11 KV mains	Auto-Standby Mode	Demonstrate Operator actions to test various scenarios of switch-in/out
6	GTG-1/2 in Outage	Unavailable	On / Off Frequently	Feeding Essential Load through a load sequencer	Advise optimum action how to synch WAPDA and how to share the load

A GE MK VI DCS/PLC/SCADA system shall provide outputs to annunciation & control of all desired operations and perform all logical functions for complete monitoring and automatic operation of the Power House for acquisition and display of the desired data.

7.4.2. Work Item No.15: 11 kV switchboard

Quantities if given here under or ratings etc are conceptual and need be calculated / well set by the EPC contractor in line with the plant equipment / revised electrical drawing.

The 11 KV switchboard shall comply with the WAPDA specifications:

11 kV sheet steel, floor mounting, totally enclosed, compartmentalized, fully interlocked, air insulated, indoor type, suitable for operation at 11 kV, 75 kV BIL, 3 phase, 50 Hertz supply, completely wired and tested in accordance with relevant latest IEC standard or equivalent having rated peak withstand current of 45 kA, rated short circuit and comprising breaking current (1 sec) of 18 kA and rated short circuit making current of 45 kA. or as compatible per alternate EPC concept, subject to discussion and approval by owner engineer.

2 No - Incoming panels from WAPDA :

(Contractor to consider provision of digital instrumentation with MODBUS/RTU communications interface option)

1- Sheet steel floor mounting, housing.

1- Set of 3 phase, rated for a suitable MVA, including future expansion provision, HDHC heat shrunk, Raychem sleeved, round edged copper busbars and all joints silver plated.

6- Single pole fixed and moving type isolating contacts having isolating facility in each phase.

1- Set of automatic safety shutters having padlocking facility.

1- Well rated amps, motor operated having rupturing capacity of 20 kA / 1 sec, triple pole, vacuum circuit breaker mounted on a rollout truck to facilitate vertical dropdown isolation and horizontal withdrawal.

1- Circuit breaker lowering mechanism fitted with removable operating handle.

1- Circuit breaker hand/motor charged spring closing mechanism of the trip free pattern complete with:

a. Voltage operated release.

b. Set of ON/OFF/EMERGENCY trip push buttons.

c. Mechanical ON/OFF position indicators.

d. Spring closing hand charging mechanism

The operating mechanism and stored energy shall allow the following sequence:

0-3 min - co-3 min - co

1- Set of indication lamps.

3 - Current transformers having ratio of 600/5/5 amps and with:

Core 1: 10VA, 1 M 5
Core 2: 15 VA, 5 P 20

1- 96 x 96 mm Ammeter scaled 0-500 Amp having suitable overload scale and with Ammeter selector switch, 3 way and off.

1- 96 x 96 mm Voltmeter scale 0-15 kV with voltmeter selector switch, 3 way and off.

1- 96 x 96 mm CT and PT operated power factor meter.

2- Single pole cast resin voltage transformers, ratio 11000/√13 /110√3, 200 VA, accuracy class-l, 75 kV BIL, with primary protection fuses.

1- KWh meter, 3 phase, 3 wire with MD1 (30 min) suitable for CT and PT connections of 5A, 110 V and 50 Hz.

1- kVArh meter, 3 phase, 3 wire suitable for CT and PT connections of 5A, 110 V and 50 Hz.

1- 11 kV capacitive voltage detector in yellow phase on the circuit side.

1- Earthing switch equal to the rating of the switchgear.

1- Set of support insulator with creepage distance of 350 mm.

1- Auxiliary relay for contact multiplying.

1- 3 phase Over Current, Earth Fault & Short Circuit relay (50/51/51N) with selectable tripping curve and three independent O/C, E/F & S/C thresholds including communication ports.

1- Under voltage relay.

1- Over voltage relay.

1- Set of instrument fuses.

2- Sets of electrical & mechanical castel inter locks.

1- Operation counter meter

1- Anti-condensation heater with thermostat.

1- Designation label.

- 2 Sets of potential free Aux Contacts to enable remote ON/OFF switching from SCADA.

1 No - Bus coupler complete with:

1- Sheet steel floor mounting housing.

1- Set of 3 phase proper Amps rating HDHC heat shrunk, sleeved, round edged copper busbars and all joints silver plated.

6- Single pole fixed and moving type isolating contacts having isolating facility in each phase.

1- Set of automatic safety shutters having padlocking facility.

1- 500 Amps motor operated having rupturing capacity as specified for incoming panel, triple pole, vacuum circuit breaker mounted on a rollout truck to facilitate vertical dropdown isolation and horizontal withdrawal.

1- Circuit breaker lowering mechanism fitted with removable operating handle.

1- Circuit breaker hand/motor charged spring closing mechanism of the trip free pattern complete with.

a. Voltage operated release.

b. Set of ON/OFF/EMERGENCY trip push buttons.

c. Mechanical ON/OFF position indicators.

d. Spring closing hand charging mechanism.

1- Set of ON/OFF indication lamps.

1- Set of electrical and mechanical interlocks.

1- Anti-condensation heater with thermostat.

1- Designation label.

X No. Motor outgoing feeders each with:

1- Sheet steel floor mounting housing.

1- Set of 3 phase 500 Amps rating HDHC heat shrunk, sleeved, round edged copper bus-bars and all joints silver plated.

6- Single pole fixed and moving type isolating contacts having isolating facility in each phase.

1- Set of automatic safety shutters having padlocking facility.

1- Minimum 500 Amps, motor operated having rupturing capacity as specified for incoming panel, triple pole, vacuum circuit breaker mounted on a rollout truck to facilitate vertical dropdown isolation and horizontal withdrawal.

1- Circuit breaker lowering mechanism fitted with removable operating handle.

1- Circuit breaker hand/motor charged spring closing mechanism of the trip free pattern complete with:

a. Voltage operated release.

b. Set of ON/OFF/EMERGENCY trip push buttons.

c. Mechanical ON/OFF position indicators.

d. Spring closing hand charging mechanism.

1- Set of indication lamps.

2- Current transformers having ratio of 150/5/5 amps and with
Core 1: 10 VA, 0.5 M 5
Core 2: 15 VA, 5 P 20

1- 96 x 96 mm flush mounted ammeter scaled 0-100 amps having suitable overload scale and with ammeter selector switch, 3 way and off.

1-Motor protection relay with following features.

a. Thermal overload protection.

b. Short circuit protection.

c. Earth fault protection.

d. Stalled rotor / mechanical jam.

e. Prolonged start.

f. Time between starts.

g. Speed switch input.

h. Programmable scheme logic.

i. Eight RTDs.

1- 11 kV capacitive voltage detector in yellow phase on the circuit side.

1-96 x 96 mm flush mounted CT and PT operated power factor meter.

1- 96 x 96 mm flush mounted operation hour counter.

1- Earthing switch, for short circuiting and earthing of disconnected system, should be rated as specified for incoming panel. It should be 3 poles with snap action closing mechanism and mechanical interlock with switching device and shall be equipped with 4 pole auxiliary switch.

1- Hooter

1- Set of instrument fuses.

1- Operation counter meter.

1- Remote/local selector switch.

1- Anti-condensation heater with thermostat.

1- Designation label.

Note: Provision to be made for remote control of pumps from PLC/SCADA control desk.

2 No - Transformer feeders each with:

1- Sheet steel floor mounting housing.

1- Set of 3 phase, XXX Amps rating HDHC heat shrunk, sleeved, round edged copper bus-bars and all joints silver plated.

6- Single pole fixed and moving type isolating contacts having isolating facility in each phase.

1- Set of automatic safety shutters having padlocking facility.

1- Minimum XXX Amps, motor operated having rupturing capacity of 20 kV/1 sec, triple pole, vacuum circuit breaker mounted on a rollout truck to facilitate vertical dropdown isolation and horizontal withdrawal.

1- Circuit breaker lowering mechanism fitted with removable operating handle.

2- Circuit breaker hand/motor charged spring closing mechanism of the trip free pattern complete with:

a. Voltage operated release.

b. Set of ON/OFF/EMERGENCY trip push buttons.

c. Mechanical ON/OFF position indicators.

d. Spring closing hand charging mechanism.

1- Set of ON/OFF indication lamps.

3- Current transformers, ratio of 50/5/5 amps having:
Core 1: 10 VA, 1 M 5
Core 1: 15 VA, 5 P 20

1- 96 x 96 mm flush mounted ammeter scaled 0-150 amps with ammeter selector switch 3 way and off.

1- 3 Phase digital 0/C, E/F and S/C relay (50/5/5IN) with selectable 3 tripping curves and 3 independent 0/C, E/F & S/C thresholds including communicating ports.

1- Earthing switch for short circuiting and earthing of disconnected system should be rated for peak current of 20 kA at 12 kV. It should be 3 pole with snap action closing mechanism and interlocking with switching device and shall be equipped with 4 pole auxiliary switch.

1- 96 x 96 mm) flush mounted operation hour counter.

1- Set of instrument fuses.

1- Anti-condensation heater with thermostat.

1- Designation label.

7.4.3. Work Item No.16: Capacitors

6 No- 11 kV capacity XXX kVAr power factor correction units each equipped as under:

a. Medium voltage capacitor for power factor correction to be provided with self-healing dielectric and very low losses suitable for direct coupling with motor terminals with backup fuses and fuse bases to be placed in a compartmentalized enclosure having IP42 protection close to the11 kV switchgear.

b. Capacitor shall be suitable for continuous operation at motor output rating plus a 3.5% margin for maintaining, power factor above 0.90 lagging.

c. The actual active capacitor element shall consist of a large number of high quality, self-healing round MKP elements, which are wired to each other.

d. Capacitor shall not contain chlorinated substances or presents ecological problems and shall be in accordance with IEC 60871.

e. Capacitor containers shall be of sealed construction stainless steel suitable for outdoor / indoor use providing efficient heat transmission.

f. Porcelain bushings shall be suitable for 11 kV voltage connections and for polluted conditions.

g. Dielectric losses shall be below 0.20 W/kVAr at ambient temperature. Total capacitor losses shall not exceed 0.25 W/KVAr

h. Capacitor residual voltage should reduce to below 75 V within 10 minutes after disconnection from the circuit.

i. Power factor improvement relay shall maintain the power factor between 0.9 lagging and unity and shall not attain leading power factor. It shall also rotate the use of capacitors to maintain equal usage for all capacitors.

j. Cooling / ventilating arrangement shall be provided.

k. Life expectancy (permitted failure rate) shall be greater than 100,000.

7.4.4. Work Item No.17: LV switch board

415 V 3 phase, 4 wire, 50 Hz sheet steel, floor mounting, totally enclosed, compartmentalized fully interlocked, air insulated type suitable for operation on low voltage supply, completely wired and tested in accordance with relevant IEC standard or equivalent having rupturing capacity of 50 kA/1 sec, equipped as under:

2 No - Incoming panels from transformers each with:

1- Sheet steel floor mounting housing.

1- Set of bus-bars, XXX amps rating. HDHC, heat shrunk, sleeved, round edged copper bus-bars and all joints silver plated.

1- Set of automatic safely shutters having padlocking facility.

1- XXX amps triple pole, withdrawable, quick make/break, moulded case circuit breaker with adjustable thermal and magnetic trip devices for overload and short-circuit protection and complete with under voltage release.

1- 96x96 mm, flush mounted CT operated ammeter scaled 0-400 amps along with a 3-way and off selector switch.

1- 96x96 mm flush mounted voltmeter, scaled 0-600 volts along with a position selector switch.

3- CTs of ratio 400/5 CTs shall be of 5VA, class-1 for metering.

1- Earth leakage relay with an appropriate CT.

2- ON/OFF indication lamps.

1- Set of electro-mechanical key interlock.

1- Set of instrument fuses.

1- Anti-condensation heater with thermostat.

1- Designation label.

1 No- Bus coupler complete with:

1- Sheet steel floor mounting housing.

1- Set of bus-bars, XXX amps rating HDHC heat shrunk Raychem sleeved, round edged copper bus-bars and ail joints silver plated.

1- Set of automatic safety shutters having padlocking facility.

1- XXX amps, triple pole, withdraw-able, quick make/break, moulded case circuit breaker with adjustable thermal and magnetic trip devices for overload and short-circuit protection and complete with under voltage release.
2- ON/OFF indication lamps.

1- Set of electro-mechanical key interlock.

1- Anti-condensation heater with thermostat.

1- Designation label.

Outgoing circuits:

The outgoing circuit breakers panel shall as a minimum be equipped as under:

1- Sheet steel floor mounting housing complete in all respects and with anti-condensation heater, thermostat and designation label.

1- Set of bus-bars, XXX amps rating, HDHC, heat shrunk, Raychem sleeved, round edged copper bus-bars and all joints silver plated.

Triple pole moulded case circuit breakers:

LV circuit breakers shall comply with IEC 60947 and as a minimum be equipped as under:

56- Triple pole moulded case circuit breakers with adjustable trip device for overload and fixed magnetic / Thermal short-circuit protection and complete in all respects and each feeder, having a designation label and “ON” indicator for following applications: MCCB’s shall comply with IEC 60947.

6- 32 amps MCCBs for motor control and anti-condensation heaters.

6- 16 amps MCCBs for PECC connected field load,

6- 16-amps MCCBs for FOTP.

1- 16-amps MCCB for Fuel Management and

Waste Treatment / Disposal, including incinerator.

3- 32 amps MCCBs for CO2 WTP.

2- 32 amp for WW Skid.

1- 16 amp MCCB for Cooling pumps.

2- 1- 25 amp MCCB for PLC/SCADA

System.

1- 25 amp MCCB for battery chargers.

12- 16 amp MCCBs for 3 phase exhaust fans.

6- 32 amp MCCBs for 3 phase industrial sockets.

1- 16 amp MCCB for electric overhead travelling crane.

3- 63 amp MCCBs as spare.

4- 32 amp MCCBs as spare.

4- 25 amp MCCBs as spare.

The quantities of MCCBs specified are the indicative but not limited to. The Contractor may increase the quantity according to his design plus 10 % spares for future use.

Minimum number of single pole miniature circuit breakers:

MCB's shall comply IEC 60898 and as a minimum be equipped as under:
Lot - 16 amp single pole miniature circuit breakers with designation labels for internal and external illumination of the pumping station.

12- 32 amp single pole miniature circuit breakers with designation labels for single phase, 3 pin - switch-socket - outlets.

6- 32 amp single pole miniature circuit breakers as spare.

6- 16 amp single pole miniature circuit breakers as spare.

7.4.5. Work Item No.18: Instrumentation panel

Sheet steel, floor mounting housing for following gauges and instruments complete with transmitters for monitoring with PLC.

1- On base panels for filed instrumentation of GTG-1

1- On base panels for field instrumentation GTG-2.

1- Local Instruments panel for Water Wash Skid vendor specs..

1- CO2 Skid Mounted Instruments panel.

1- WTP Skid Mounted Instrument Panel.

1- Black Start DG skid mounted Instrument panels.

1- FOTP, Fuel Management, Waste Handling ,Incinerator, CCTV.

PA, security, FAS, FFS and other BOP,

Above list is an indicative list including but not limited to. Actual vendor specific / required list to be added and updates in as built subject to the approval of owner engineer.

7.4.6. Work Item No.19: 11 kV motors. (If Applicable)

- Squirrel cage induction motors for direct on line starting suitable for operation on 11 kV, 3 phase, 50 Hz supply and for coupling with pumps through extension shafts described under clause 4.2.3: and Work Item No 6 and each complying with following specifications.

Output of motor:	Approximately 1000 kW but should be 10% in excess of power required by the pump at duty point and 5% in excess at run-out condition.
Speed:	Approximately 740 rpm.
Efficiency at full load:	Not less than 96%
Power factor at full load:	Approximately 0.82 lagging
Motor Design:	Vertical type with two bearing end shields, with antifriction bearings of ball/roller type, with one cable end box of suitable size, with gland, one set of anti humidity heater system working on station auxiliary supply of 415 V, 3 phase 50 Hz, totally enclosed, and tube cooled, winding insulation class F and maximum temperature not to exceed that permitted for class B, ambient temperature of operation 50°C and motor suitable for operation in humid and tropical climate, with protection class IP 54 according to IEC 60034. The motor shall be supplied with following accessories:

a. Winding RTDs : 6 No
b. Bearing RTDs : 2 No
c. Space heater : 1 No

One portable stand shall be provided to enable a motor to be stood in vertical position when removed for maintenance purposes. Temporary motor terminal covers shall be provided to cover motor terminal studs.

Motors shall be fitted with means for locking rotors to avoid damage occurring to bearings when motors are laid horizontally and to facilitate transportation in this mode.

7.4.7. Work Item No.20: 11 kV/400V transformers

2 No - Three phase, Oil immersed transformers, forced cooled according to IEC 60076, double wound, core type in sealed tank design with oil conservators and bi-directional flat rollers, suitable for parallel operation and each according to WAPDA specifications. ABB Br make or equivalent, Main parameters shall be as under:

Rated load	:		Suitable KVA
Phases	:		3
No load voltage ratio	:		11 kV/415 V
On load or Off Line tap changer	:		0 ± 2.5% ± 5% - 7.5%
With fool proof E/M interlocks			
Frequency:			50 Hz
Basic Impulse level (BIL)			75 kV
Copper temperature rise (Avg.)	:		40^{o} C
Oil temperature rise (Max.)	:		35^{o} C
Peak Ambient air temperature	:		50^{o} C
Mean max. Temperature (24hr)	:		35 ^{o} C
Min. temperature	:		10^{o} C
Impedance at nominal tap	:		about 5%
Efficiency	:		Minimum 98.5%
Maximum short circuit duration	:		2 Secs
Vector Group	:		DY 11
Cooling	:		ONAF
Place of installation	:		Indoor
Accessories	:	1-	breather
		1-	dial type thermometer with trip contact

7.4.8. Work Item No.21: Exhaust fans

If required -3 phase exhaust fans, For Turbine Hall and FOTP building, of constant speed, minimum 600 mm sweep, having reverse and forward motion for operation on 415V, 3 phase, 50 Hz supply, with type bearing for noiseless operation in necessary number.

ON/OFF switch and auto star/delta starter for individual fan shall be mounted on the LV distribution board. The fans shall have stove enamel finish of approved colour and shall be made to Pakistan Standard PS-1 1958. The make shall be Pak, Millat or approved equivalent.

Frames for mounting, the fans shall have stove enamel finish and shall be mounted on the walls at designated locations with appropriate sized G.I. nuts and bolts.

The fans shall be protected with G.I .mesh of sturdy design to prevent bird entry.

4 No- Single phase exhaust fans for transformer room, control room, PLC/SCADA room and battery room of constant speed and 450 mm sweep for operation on 220V, single phase, 50 Hz supply with grooved type bearings for noiseless operation.

ON/OFF witch for individual fan shall be mounted in the respective room. The fans shall have stove enamel finish of approved colour and shall be made to Pakistan standard PSI 1958. The make shall be Pak, Millat or approved equivalent.

The fails shall be louvered type.

2 No- 300 mm sweep exhaust fans suitable for operation on 220V, single phase, 50 Hz supply of Pak, Millat or any other approved make complete with ON/OFF Switch for installation in bathrooms.

7.4.9. Work Item No.22: MK VIE / PLC/SCADA

Purpose

Vendor specific and well proven Control Philosophy equipment like GE MK VIE, Siemens Schematics or equivalent standards PLC shall receive inputs from main pant / BOP / BSDG, FOTP, Stand Alone Skids, BMS including 11 kV and LV protection /control and will provide outputs to annunciation control for all desired operations and will perform all logical functions for safe control & security of the entire plant.

PLC shall be constructed in modular form having provision for accepting add- on cards and shall be capable of operating without trouble in a temperature range of 10-50°C and relative humidity of 10% to 95%. All incoming cables shall be terminated in the cable marshalling area without loop / jumper wiring and with proper isolation in panels against field unwanted potential injection and not directly on the PLC for which a separate housing shall be provided. Shielding, grounding or floating ground to be done per vendor specific requirements.

Power Supply Unit

Power Supply Unit shall be suitable for the specified supply voltage having protection against voltage and frequency fluctuations and harmonics. The unit shall be provided with battery backup for all volatile registers and memory locations to allow retention of data and programs for a period of not less than three months.

Inputs / Outputs

The Contractor shall determine the number of I/Os to suit operational requirements with an allowance of 25% spare capacity. LED indicators shall be provided to show status of I/Os which shall be individually isolated to prevent system transients and radio interference affecting the normal operation or decoupling shall be provided for I/0 signals.

Central Processing Unit

Central Processing Unit shall operate at a speed of operation suitable for carrying out all specified duties and shall have all necessary built-in timers, relays and mathematical functions etc. The processor shall have non-volatile EPROM and a volatile RAM. Allowance shall be made for 25% spare volatile and non-volatile memory.

Programming function for the CPU shall be built into the PC. Program entry and modifications shall be possible in mnemonic language, ladder diagram or flow charts. Security arrangement shall be provided to prevent unauthorized tampering with the PLC control.

The contractor shall be responsible to provide Operating System and Application Software on separate media, Preferable on DVDs. The contractor shall train KWSB staff for installation, testing, commissioning, customization, O & M and archiving/restoration of system.

SCADA

PLC shall take inputs of 11 kV protection and control to provide outputs from annunciation and control for each motor and pump. The PLC shall monitor and control all desired operations and perform all logical functions.

A personal computer running SCADA software shall communicate with the PLC on Industrial Ethernet network and shall provide all required features of control and monitoring such as:

a. Real time data of all variables.
b. Trends and graphs of all desired parameters.
c. Data logging
d. Report and statistical analysis.

e. Alarm management and event based programming.
f. Advanced graphic display for real time mimic display.
g. 8 levels of password protection.
h. Multi users support, LNA, PSTN dialup, RAS, WAN and internet fully supported.
i. Operator Log

A 24 inch high resolution monitor LED/LCD shall be provided on the module for displaying all logical functions.

Twelve DVDs shall be supplied additionally for storm, data and programs.
Compatible latest HP Laser printer with 6 Nos. black cartridges shall be provided.

UPS shall be provided for PC and PLC power supple only for minimum 15 minutes back up time on full load.

Protection relays shall communicate with the PLC on same data network to allow monitoring of all critical parameters such as RTD temperatures, protection and safety. PLC will send signals to annunciation panels in case of any fault.

LV I/Os shall be connected to PLC and SCADA system to monitor and control all pressures, levels, flow rates and overload relays etc.

An application Process shall record all critical parameters.

an alarm will be initiated. SCADA terminal will continuously monitor and record the data.

a. If circuit breaker trolley is in test position, its remote "ON" will be blocked.

b. Starting of pumps will be interlocked with discharge valves both during start and stop operations.

c. Fully open/close position of limit switches will be indicated by an indication lamp.

d. Power fuse blow control or operation of motor protection relay will give tripping command to motor as well as trigger an alarm.

e. Stopping of pumps will be staggered.

f. Any other requirement of the pump manufacturer.

PLC interface with SCADA

All information available to PLC shall be transferred to PC through Industrial Ethernet such that complete monitoring of the plant can be carried out through HMI.

Split Air Conditioner

1 No- Supply and installation of a split type air conditioner of l.5 ton capacity in the PLC/SCADA room.

Control of process through PLC

Pre requisites

a. Wapda 11 KV Back up available, connected on 11 KV mains in synchronized state with ref bus and operational by feeding normal / essential loads and or as a minimum,
b. Black Start DG available, Running in case 0.4 KV bus not available, connected at 0.4 KV mains in synchronized state with ref bus and feeding essential load via its load sequencer,
c. Control Power and Controls available in healthy states,
d. No blocking alarm persists or cleared by operator,
e. Stand alone Skids available and in healthy state, no blocking alarms,
f. Safety systems in tested good condition, like FFS and CEMS,
g. GTG on Turning Gear, Oil Cooling, Lift Oil, Cooling Oil, Lube Oil, Distillate and Heavy Fuel Oil Systems available and operations,
h. Fuel and water tanks at normal level and no fuel leakages, no haz gas alarms, no fire alarm does persist,.
i. Ambient conditions at normal as indicated on Met Instruments,
j. Field check outs OK and no safety threats does exist, Plant HVAC systems operational and control panels at cool condition,
k. Air Inlet Filters Fine, No high differential alarm does exist,
l. All PECC MCCBs selected on Auto unless under LOTO and will not hinder plant operation. LOTO addressed by operator, no people working on main plant systems.
m. Auxiliary compartment, Starting Motor, Fuel Flo Divider, Compressors section, Inlet, Turbine section, Electric Ignitor, Load Gear, Exhaust channel and Generator plus all on base field instruments be at normal,
n. Once these field safety and equipment readiness checks are done, operator to ensure no such work permits is issued where some one can take a chance to start work on any of plant equipment that become unsafe. Than a PA announcement be made to aware all of plant being started in next 10 minutes so if some have a valid concern, it can be addressed,
o. Having all green to go, operator is now ready to push the start command.

Main plant

a. Vendor specific philosophy will be followed to start and run these units, over-riding principal being the safety of GTGs in case of triple failure event mode like an entire black start condition where Waoda back up is already gone and black start DG refuses to run when both or only one running GTG trips, besides each plant operating scenario must be discussed for relevant control logic and should it be helping for demonstration purpose to operators, a user friendly programmable hybrid computer simulator be provided as trainer.
b. Vendor specific procedure to be applied and operator will be vigilant to see that control sequence taking place on appropriate equipment.

Control philosophy

General

1. Main plant and BOP / Black Start Control goes with vendor standard logic. Owner inputs have already been stated as what could be the possible operating scenarios. Vendor needs to develop a fool proof logic and optimized control means keeping in consideration of triple failure of various plant equipment's an components and table the best possible solution according to power plant prudent practices and engineering standards. Necessary redundancies be kept in place to cater for possible safety risks to plant equipment and components.Pre-requisite

Pre-requisite

As stated above.

Conceptual Operation of Central Plant Equipment. (Typical of a medium duty GTG)

Control loops include,

- Start-up
- Acceleration
- Speed
- Temperature
- Shutdown and
- Manual Control functions

MAJOR CONTROL LOOPS

- Start-up GTG
- Speed Control and
- Temperature Control

SECONDARY CONTROL LOOPS

- Acceleration Control
- Manual FSR Control and
- Shut Down

- Output of these control loops is fed to a minimum value gate circuit
- Fuel Stroke Reference (FSR)
- Command signal for fuel flow
- Controlling FSR

- Lowest of the six control loops
- Establishes the fuel input to turbine @ rate required by system which is in control
- Only ONE control loop will be in control at anytime.
- The control loop which controls FSR is displayed in operator friendly CRT

Startup/Shutdown Sequence and Control

- Startup control brings the gas turbine
- Zero speed up to Operating speed.
- Allows proper fuel to establish
- Flame & Accelerate the turbine in such a manner as to minimize the Low cycle Fatigue of the hot gas path parts during the sequence Software Sequencing involves
- Command signals to Turbine Accessories, Starting device and Fuel control system
- Safe and successful start-up
- depends on proper functioning of GT equipment.
- Software Sequencing ensures safe operation of Turbine
- Control logic circuitry is associated not only with actuating control devices, but enables protective circuits and obtains permissive conditions before proceeding.
- Control settings play a vital role in determining the proper sequencing.
- Actual site specific control settings be generated by OEM
- Speed detection - by magnetic pickups
- L14HR Zero-Speed (Approx. 0% TNH)
- L14HM Min Speed (Approx.. 16% TNH)
- L14HA Accelerating Speed (Approx. 50% TNH)
- L14HS Operating speed (Approx..95% TNH

RSU Start-up Control - FSRSU

- Open loop control
- Uses preset levels of fuel command
- Various Fuel levels
- Zero, Fire, Warm-up, Accelerate and Max. Typical values of a medium duty GTG
- Fire 15.62%
- Warm-up 11.62%
- Accelerate 19.82%
- Maximum 100%

Open Loop Control

- Startup control FSR (FSRSU) signal operates through the MIN value gate to ensure other control functions can limit FSR as required
- Speedtronic Control Start-up software generates Fuel command signal
- (FSR).Speedtronic Control Software also sets the MAX and MIN limits for FSR for Manual Control FSR [FSRMIN < FSRMAN < FSRMAX]
- When Turbine Breaks away (starts to rotate)
- L14HR pick-up
- Starting clutch solenoid 20CS de-energizes
- Shuts down the hydraulic ratchet motor (88HR

Acceleration Control - FSRACC

- Acceleration control software
- compares the present value of Speed signal with the value at the last sample time.
- Difference between these two numbers is a measure of acceleration.
- When actual acceleration is greater acceleration reference, FSRACC is reduced, which reduces FSR, thus reduction in fuel supply to turbine.
- During startup-acceleration reference is a function of turbine speed.
- Acceleration control takes over after Warm-up state Acceleration reference is a Control constant programmed in <RST> EEPROM

Speed Control - FSRN

- Speed Control System software
- controls the speed and load of the gas turbine generator
- in response to the actual turbine speed signal (TNH) and the called-for speed reference(TNR)

Speed/Load Control

- Turbine Speed is held constant when Generator Breaker is closed onto Power grid
- Fuel flow in excess of the necessary to maintain FSNL will result in increased power produced by the generator.
- Thereby Speed control becomes Load control loop
- Speed Control:
- Isochronous Speed control
- Droop Speed Control

Speed Control Droop Speed Control

- Droop Control is a proportional control.
- Any change in actual speed (grid frequency) will cause a proportional change in unit load.
- This proportionality is adjustable to the desired regulation or ‘Droop’

Synchronizing – FSRSYN

- Automatic synchronization software
- Algorithms programmed into <RST> controller and <P> software. Bus and Generator voltage are input signals to Protective core <P>
- Isolation transformers are built into <P> core <RST> software drives the synch check and system permissive relays.
- Sequencing and algorithms are programmed into <RST> EEPROM <P> hardware and software sends voted command to actual breaker closure.

7.4.10. Work Item No.23 cables

11 kV Cables

As applicable, 8.7/15 kV, 3 core, XLPE/SWA/PVC, PVC insulated triple extruded copper conductor Fire Retardant cables for following applications (as per IEC 60502.2 and BS 6622 also meeting WAPDA specification):

2-feeder: Minimum 300 sq mm between WAPDA switch room panels and two 11 kV incoming panels.

6-feeder: 120 sq mm between motor outgoing panels to respective 11 kV motors and power factor improvement capacitors.

2-feeder: 70 sq mm between transformer outgoing panels and 250 kVA transformers.

LV Cables

As Applicable, 600/1000 V, PVC/PVC insulated Fire Retardant copper conductor single or multi-core power, instrument and control cables for following applications conforming to IEC 60502-1 and BS 5467.

2 feeders: 3.5 core, minimum 300 sq mm, between transformers and transformer incoming panels.

Lot: All single and multi-core cables of required cross-sections for power instrumentation and control between all supply points and all items of plant necessary for setting to work the whole plant.

All cables shall be laid together with ECC in trenches, trays and GI/PVC pipes with all required accessories for proper installation and termination as per specifications and requirements of the work as approved by the Employer.

All 11 kV and LV cables shall be of Delta Crompton Cables or their approved equivalent.

The Contractor shall make all assessments of the cable lengths and sizes including installation material required for completing the work as per specifications and drawings. No claims for extra payment shall be entertained by the Employer on any account.

7.4.11. Work Item No.24: Earthing system

1 Set- Complete earthing system for the entire power station including, switch gear, cable conduits, cable trays, Motors, Instrument panels, Transformers, Excitation Unit, Stand Alone Skids and Building Management Systems, Pipework, ancillaries and accessories etc. to be provided by two separate and distinct connections with earth in accordance with prevalent Electricity Rules of Pakistan and Code of Practice 7430 and BS 951 shall comprise of:

a. Earth copper plates of 600 x 600 x 3 mm in individual earthing pits interconnecting earth bars/cables/standard earthing copper conductors.
b. Earthwork / C.C work including inspection covers.
c. Earth connecting points/jointing material.

Power house / BOP Buildings building shall be provided with 2 No. wall mounted earth bars and earth pits independently linked to all exposed conductive metal parts. This shall include but not be limited to pump set frames, main switch and control panels, screens, crane rails, hand railing, all pipe work entering/leaving and within the building and lightning, protection system etc.

Extraneous metal parts shall be bonded as required by the IEE Regulations/local Electrical rules including building structural steel and concrete reinforcement bars.

Following points be considered in Earthing , grounding & AS system.

Neutral Grounding Transformer

System to be incorporated with necessary grounding resistor systems to protect power transformers and generators from damaging fault currents. Low resistance grounding of the neutral shall limit the ground fault current to a high level (typically 50 amps or more) in order to operate the protective fault clearing relays and current transformers. These devices shall be able to quickly clear the fault.

The limited fault current and fast response time must also prevent over-heating and mechanical stress on conductors.. Ground fault protection for high voltage transformer and generator grounding applications would require a grounding transformer to lower the voltage reflected to the neutral grounding resistor.

Resonance Grounding System

Points to be discussed by EPC are mainly,

1. Solid vs. resonance neutral
2. How can be reduce fault current further from isolated neutral systems?
3. Value added in terms of proposed resonance grounding
4. Zero sequence measurements
5. Effect of asymmetry and conductive line charging
6. Resonance grounded system during fault (L=constant)
7. Directional over-current relay – resonance ground de systems
8. Trip zone
9. Relaying logic

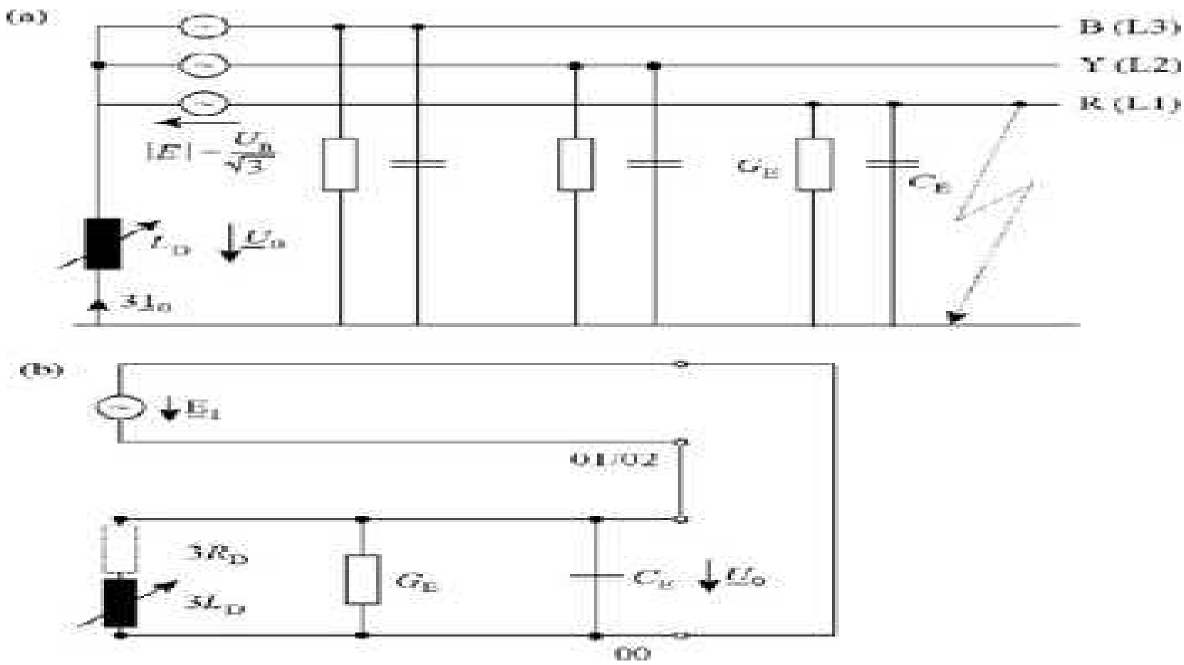

Fig. Typical System With Resonance Earthling – Erath Fault in Phase R.

Arc Suppression System

Single-phase neutral earthing (grounding) reactors (Arc Suppression Coils) shall be incorporated to compensate for the capacitive line-to-earth current during a 1-phase earth fault. The arc-suppression coil (ASC) represents the central element of the Trench earth-fault protection system.

Because the electric system is subject to changes, the inductance of the ASC used for neutral earthing must be variable. The earth-fault detection system developed by Trench utilizes the plunger core oil (moveable-core design). Based on extensive experience in design, construction and application of ASCs, Trench products can meet the most stringent requirement for earth-fault compensating techniques.

Resonant grounded systems suppress transient ground faults and enable to continue power supply even during single pole earth faults.
For special requirements neutral point coupler (earthing transformer) and stepless adjustable ASC shall be housed in a common tank forming a so called Neutral Earthing Aggregate.

7.4.12. Work Item No.25: Lightning protecting system

1 set-Complete lightning protection system as per Specification and latest IEC and BS standards requirements of the system comprising as a minimum:

a. Lighting arrestor of copper rod minimum size 25mm dia., 1 m long complete with mounting base, connectors and clamps etc.

b. Earth electrodes.

c. Down connectors of copper 25 x 3 mm from lightning arrestor to earth electrodes.

d. Required bonding with building structural steel and concrete reinforcement bars.

7.4.13. Work Item No.26: 110 V DC system

2 sets-110 V dc nickel cadmium pocket plate type battery systems each rated to give 100% of the entire dc load under site environmental conditions plus a 30% surplus output capacity with internal resistance lower than 0.08 ohms/C5 medium rate characteristic and comprising of:

Batteries

a. Each battery cell shall be enclosed in a transparent / translucent, shock absorbing, plastic container having a sealed cover with removable plugs.

b. Copper connections between rows of cells and from battery to through wall bushings shall be annealed copper of adequate cross section supported on insulators. Copper rods shall be insulated by PVC sleeving or approved type of taping. Cell connectors shall be insulated by PVC covers.

c. Each battery main copper connections shall be connected to a suitably located double fuse box having high breaking capacity, fuses suitable for battery charger/dc distribution board and should be able to discriminate clearly in case of faults. A separate fuse box for each charger shall be providing for auxiliary purposes i.e. for charging of separate cells etc. In case of parallel operation of charger outputs, suitable terminals and flexible wire connections of sufficient length shall also be provided.

d. Cells shall be mounted on stands in single rows of single or double tiers and so arranged that bottom of the batten shall not be less than 300 mm above the floor level. Stands shall be treated with minimum two coats of leach resistant paint of approved color.

e. Clearances provided by racks and the method of connection of banks shall ensure that each cell or group of cells can be easily removed without disturbance to other adjacent cells.

Each battery system shall have following accessories.

a. 2 syringe hydrometer.

b. 2 thermometers.

c. 1 digital type cell testing voltmeter reading to 3 decimal digits.

d. 1 plastic jug.

e. 1plastic tank for distilled water storage, minimum capacity 60 liters.

f. 1 maintenance tool box.

g. Set of auxiliary devices and auxiliary flexible cables.

h. 6 spare cells with electrolyte.

i. Set of instruction cards and battery record book.

Bidders are required to submit technical report, comparisons and merits / demerits of proposed Ni-Cd batteries viz-a-viz equivalent lead acid batteries particularly detailing behavioral differences under ambient conditions, maintenance facilities and spare parts requirements. Alternative cost prices may he provided with economic comparison of the two systems.

Battery Chargers

The Contractor shall ensure that general design of batteries and chargers shall be coordinated, if supply from different sources is proposed. O&M

instructions labels, instruction plates and danger signals shall be sufficiently detailed as required under relevant standards. Each charger shall have following minimum provisions:

a. Dc output voltmeter.

b. Dc output ammeter.

c. Green lamp indicating charger on duty.

d. Red lamp indicating charger on boost charge.

e. Under voltage relay with timer.

f. AC supply failure relay.

g. Battery charger failure.

h. Earth fault relay with additional measurement instrument to detect magnitude of defect.

i. Battery circuit supervision.

j. Push button for checking all indication lamps.

Each alarm shall be indicated by its local indication lamp. 110 V dc common alarms shall be wired to a remote indication. Remote indication of charger failure signal shall be suppressed in case of failure of charger auxiliary supply.

Supervision relays shall initiate bypassing of semi-conductors in order to maintain voltage at dc load within specified limit.

7.4.14.Work item No 27: Light fittings and auxiliary AC supply system

Following light fittings and power supply points shall be provided complete with power supply and control cables, wires and all installation material in GI for internal and external illumination of the power House/ BOP Buildings.

S.No	Location	Description	Type
1	Turbine Hall / FOTP	Metal halide light fitting Phillips type MDK-900 with 400 W MDK lamp or equivalent.	D
2	PECC/PLC/SCADA	Fluorescent light fitting Phillips type TCS-398 M6 with 2x36 W lamp or equivalent.	A
3	Transformer, Skids and	Fluorescent light fitting Phillips type GKD-240 with 2x36 W lamp or equivalent.	B
4	Bathrooms and Battery Room	Fluorescent light fitting Phillips type TMW-140 with 1x36 W lamp or equivalent.	C
5	Office	Reflecta-free LED fitting Pierlite type LED 600 X 600, 35W, 4000K, white, low glare	E
6	External illumination of Turbine building	LED Flood Light Pierlite type Hippo Midi 50W LED, IP 65, Die cast Aluminum	F
7	Office PLC/SCADA store and battery room	56 inch sweep ceiling fans with regulator	
8	Motor room and Cable Gallory	Industrial plug and socket 32A, 5 pin, 3P+N+E	
9	Motor room and Marshalling	2 pin + E 16 amp switch socket outlets	
10	Street light	Philips mercury light fitting SGX 186 with 1x150 W SON lamp or equivalent complete with fixing material, brackets, nuts and bolt etc. mounted outside the pump house building and GI tubular poles, minimum height 8 m	G
11	Flood light for illumination of screen chambers mounted on 3 Nos. GI poles	Philips mercury flood light fitting type SNF-300, 1 x 250 W SON lamps or equivalent complete with junction box, CB. Fixing material, brackets, nuts and bolts etc. flood lights mounted on a GI tubular pole minimum height 8 m	H

(EPC contractor are requested to table an alternate option based on equivalent LED with minimum 80 lum/W efficacy and 35,000 hours life time. 70% lumen depreciation on completing lifetime that will be reviewed, discussed and decides w.r.t techno-commercial aspects.)

7.4.15. Work Item No.28: Emergency lighting

Emergency lighting system to be provided in accordance with BS 5266 and BS 5499.

Lights shall be of the independent self-contained 3 hour non-maintained type with 8 watt high efficiency fluorescent lamps and prismatic diffuser, with maintenance free Ni-Cd batteries / chargers / inverter equipment, separate baseplates and plug-in luminaries with locking screws. The emergency output shall typically be 180 lumens.

As an alternate option, EPC contractor to offer Emergency/ egress lighting of LED based with supply from centralized DC system. luminaires to have required pictograms to route occupants. emergency lighting to provide adequate horizontal and vertical illumination along escape routes, as per BS standards

All lead acid / Nickle cadmium batteries shall be of the high temperature type, with rated life of at least 5 years and the lights shall be warranted for 3 years from the date of commissioning.
(EPC contractors are encouraged to offer a long life, maintenance free, reliable cost effective solar power system for emergency / egress lighting so to be reviewed by the owner engineer and agree if techno-commercially better option)

7.4.16. Work Item No.29: Telephone system

The Contractor shall provide cables, telephone junction boxes and telephone instruments of 30 lines Intercom System.

Proposed cable routes and places where telephone connections are to be provided will be decided by the employer.

The telephone cables shall have minimum 30% additional pairs for future use/ replacement purposes.

Cables shall be laid in underground heavy gauge metal conduits, minimum dia 75 mm. Water tight cable draw-pits shall be provided at convenient locations viz at bends and entry to the building etc.

Vandal proof and weather proof Distribution Cabinets on C.C pads shall be provided at appropriate locations.

As an alternate option, EPC contractor to provide VoIP SIP based PBX (Asterisk based) and TDM gateways to enable connection of POTs and data lines to PBX as well as flexibility to add IP or regular POTs phone sets. the entire voice system shall utilize the Industrial Ethernet and structured cabling system at datalink and physical layers. (This option will be reviewed by employer and if found techno-commercially suitable, will be opted)

7.5 Supplies and services

7.5.1 Work Item No.30: Training of employer’s O&M personnel

Training programs/services for periods specified in the Specification, Volume-II.

7.5.2 Work Item No.31: Drawings

Drawings including, construction and as-built drawings shall be provided in six (06) copies as given in the Specification, Volume-II along with soft copies.

7.5.3 Work Item No.32: Operating and maintenance manuals

Operating and maintenance manuals shall be provided in six (06) copies as given in the Specification, Volume-II along with soft copies.

7.5.4 Work Item No.33: Precautionary equipment

As a minimum, the Contractor shall provide following precautionary equipment.

20 No- fire extinguishers of suitable type and capacity at approved locations.

100 m-rubber mating of black colour, 1 m wide and 6 mm thick for placing before all HT/LV panels.

20 No-regulation safety charts of approved design.

5 No- 11 kV danger signals “CROSS BONE AND SKULL” on metal sheets in standard colours provided at approved locations.

7.5.5 Work Item No.34: Submersible pumps

EPC contractor to ensure size and number for the entire project normal / emergency need to take care of all possible situations in the project life. Techno-commercial proposal be submitted for review and approval of owner engineer.

Pumps to have following features as a minimum,

Suction strainer	:	stainless steel
Discharge pipe		2No, each 30m long

Motor:

Motor design	:	Submersible and directly coupled with pump
Power supply	:	400 V, 3 phase and 50 Hz
Rated power	:	as required
Speed	:	2900 rpm
Start	:	star / delta
PVC/PVC insulated cable	:	30 meter long
Type of shaft seal	:	mechanical
Bearing types	:	angular and deep grooved ball bearing
Insulation	:	Class F
Protection	:	IP 68
Motor shaft	:	stainless steel
O-rings	:	nitrite rubber
Motor jackets	:	stainless steel

7.5.6 Work Item No.35: Security system

Entire Power Station is a sensitive area and unwanted / undesired movements are required to be monitored. Therefore, a security system is required, comprising CCTV cameras, recording system, display units and other affiliated material/equipments.

The Station perimeter and inside building is required to be monitored on 24/7 basis with Digital CCTV cameras having Infra Red & motion detection facility for Day/Night recording. A separate storage device with minimum 30 days recording backup capacity is to be provided. The outdoor camera should have IP65 protection housing.

Contractor will also propose archiving system for CCTV recordings with all required hardware/software.

Minimum requirements shall be as under:

Item No.	Description	Qty.
1	Digital CCTV Camera Max Video Resolution (Pixel) 1,280x960 True Day/Night Power Source (PoE+) ** All outdoor cameras will have speed zoom and audio with supported codec and housed in IP65 box	18
2	Recording System (NVR)	1
3	LCD 21”	3
4	PTZ Controller	1
5	Providing, Installing and fixing at any height CCTV cameras with cables, connectors and power supply, including poles complete in all respect.	1

CCTV (closed-circuit television) will be primarily meant / used for surveillance and security purposes.

CCTV based on strategic placement of cameras, and observation of the camera’s input on monitors mainly in control room. The cameras shall communicate with monitors and/or video recorders across private coaxial cable runs or wireless communication links, they gain the designation "closed-circuit" to indicate that access to their content is limited by design only to those able to see it.
CCTV displays be color, high-resolution displays and can include the ability to zoom in on an image or track something (or someone) among their features.
Talk CCTV allows an overseer to speak to people within range of the camera’s associated speakers.

CCTV system to include but not limited to following features of main interest. :

1. Maintaining perimeter security in medium- to high-secure areas and installations.
2. Observing behavior of incarcerated inmates and potentially dangerous patients in medical facilities.
3. Traffic monitoring.
4. Overseeing locations that would be hazardous to a human, for example, highly explosive or toxic industrial environments.
5. Building and grounds security.
6. Obtaining a visual record of activities in situations where it is necessary to maintain proper security or access controls .

7. CCTV use in law-enforcement if required, might become a part of police procedure.

7.5.7 Work Item No.36: Lighting arrangement on boundary wall

Perimeter lighting to illuminate the boundary wall approx: 1300 meter and its surroundings shall be included. Narrow beam flood lights with high pressure Sodium Vapor Type lamps set with auto on off during dark / day light shall be used.

Design calculations and hook up scheme shall be submitted for approval of the Employer.

(EPC contractor are requested to table an alternate option based on equivalent LED with minimum 80 lum/W efficacy and 35,000 hours life time. 70% lumen depreciation on completing lifetime that will be reviewed, discussed and decides w.r.t techno-commercial aspects.)

7.5.8 Work Item No.37: Equipment Spare Parts, CAPS & Consumables

Priced lists of recommended spare parts, Caps, Consumables and Engg / Caps Refurbishment Services for five years as provided in Clause 1.24 of the Specification, Volume-II.

The spare parts cost shall not be included in the total Tender Cost but given separately and will be given due weightage in the evaluation of the Tender. Separate order for supply shall be placed by the Employer on the basis of approved items of spare parts and charged to the provisional sum.

Prices of spare parts given in Annexure-B may also be included in the recommended list.

7.5.9 Work Item No.38: Special tools and test equipment

Priced list of tools, special Tools and test equipment as provided in Clause 1.25 of the Specification, Volume-II.

The cost of Special tools (Including CI/HGPI/MI Kits/ Rotor/Field Removal etc) and test equipment including BI/Vibration Monitoring including Balance Shots & other ISI / condition monitoring shall not be included in the total Tender Cost but given separately and will be given due weightage while evaluating the Tender Separate order for supply shall be given by the Employer on the basis of approved items and charged to the provisional sum.

Prices of tools given in Annexure-c may also be included in the recommended list.

7.5.10 . Work Item No 39. CMMS - one lot be delivered and made operational.

CMMS to be used to schedule and record operation and preventive/planned maintenance activities associated with facility equipment. The CMMS shall generate and prioritize work orders and schedules for staff to support "trouble" calls and to perform periodic/planned equipment maintenance. Upon completion of a work order, performance information, such as the date work was performed, supplies/inventory, and manhours expended be loaded into the database for tracking, to support future operations/planning.

CMMS shall be used by facilities maintenance organizations to record, manage, and communicate their day-to-day operations. The system shall provide reports used in managing the plant resources, preparing facilities **key performance indicators (KPIs)**/metrics to use in evaluating the effectiveness of the current operations, and for making organizational and personnel decisions. CMMS be used for recording work requirements, tracking the status of the work, and analyzing the recorded data in order to manage the work, produce reports, and help control costs, generate management reports and historical data.
As a minimum system to address the following main points,

a. Address all resources involved,
b. Maintain maintenance inventory,
c. Record and maintain work history,
d. Include work tasks and frequencies,
e. Accommodate all methods of work accomplishment,
f. Effectively interface and communicate with related and supporting systems, ranging from Work generation through work performance and evaluation,
g. Support each customer’s mission,
h. Ensure communication with each customer,
i. Provide feedback information for analysis, and reduce costs through effective maintenance planning.
j. **Return on investment (ROI)** analysis

System to include following modules as a minimum,

A. Operating Locations

The CMMS may include an application that allows an operator to enter and track locations where equipment operates and organize these locations into logical hierarchies or network systems. Work orders can then be written either against the location itself or against the equipment in the operating location. Using operating locations allows for the tracking of the equipment's lifecycles (history) and provides the capability to track the equipment's performance at specific sites.

B. Equipment

C. Resources

D. Safety Plans

Manual or automatic safety plan numbering.

Building safety plans for special work.

Tracking hazards for multiple equipment and locations.

Associating multiple precautions to a hazard.

Tracking hazardous materials for multiple equipment and locations.

Ability to reference hazards and precautions once they are entered into the system.

Tracking ratings for health, flammability, reactively, contact, and Material Safety Data Sheets for hazardous materials.

Defining lock-out/tag-out procedures.

Defining tag identifications for specific equipment and locations.

Defining safety plans for multiple equipment or locations.

Viewing and linking documents.

Associating safety plans to job plans, preventative maintenance masters, and work orders.

Ability to print safety plans automatically on work orders.

Allowing tag-out procedures to be associated to hazards or directly to locations, equipment, and safety plans or work orders.

E. Inventory Control

F. Work Request

G. Work Order Tracking

H. Work Management

Planning—In planning, labor assignments would be planned for future shifts. Each person's calendar availability would be considered when the assignments are made. The assignments would be created sequentially over the shift, filling each person's daily schedule with priority work for the craft. It could even split larger jobs over multiple shifts automatically.

Dispatching—In dispatching, labor assignments would be carried out as soon as possible. This system could begin tracking labor time from the instant the assignment is made. The system operator could interrupt work already in progress to reassign labor resources to more crucial work.

I. Quick Reporting

J. Preventive Maintenance

The following capabilities may be provided in a CMMS to manage a Preventive Maintenance (PM) program:

Supporting multiple criteria for generating PM work orders. If a PM master has both time-based and meter-based frequency information, the program should use whichever becomes due first, and then update the other.

Generating time-based PM work orders based upon last generation or last completion date. Next due date and job plans should be displayed.

Permitting and tracking PM extensions with adjustments to next due date.
Triggering meter-based PM by two separate meters.
Printing sequence job plans when wanted.
Creating a PM against an item so new parts have PM automatically generated on purchase.

Specifying the number of days ahead to generate work orders from PM masters that may not yet have met their frequency criteria.

Consolidating weekly, monthly, and quarterly job plans on a single master.
Assigning sequence numbers to job plans to tell the system which job plan to use when a PM work order is generated from a PM master.

Permitting overriding of frequency criteria in order to generate PM work orders whenever plant conditions require.

Routing PM with multiple equipment or locations.
Generating work orders in batch or individually for only the equipment specified.
Cability to be used with the system scheduler to forecast resources and budgets.

K. Utilities
L. Facility/Equipment History
M. Purchasing
N. Facilities Maintenance Contracts
O. Key Performance Indicators (KPI)/Metrics
P. Specialized Capabilities and Features

Contractor to demonstrate CMMS for the intended features including following as a minimum,

1. Operating locations - track and organize locations of equipment and monitor its performance
2. Equipment - keep accurate and detailed records of each piece of equipment
3. Resources - track capital & labor resources, their costs & skills
4. Safety plans - numbering safety plan & record data on safety permits, documenting safety requirements
5. Inventory control - track inventory movement, complete parts and materials inventory control
6. Work requests - outside service call/dispatch capabilities
7. Work order tracking - calendar- or run-time-based preventive maintenance work order generation

8. Work management - planning and dispatching
9. Planning - labor assignments planned for future shifts, split larger jobs over multiple shifts automatically
10. Dispatching - labor assignments carried out as soon as possible, tracking labor time from the assignment
11. Quick reporting - provides a rapid and easy means for opening, reporting on, and closing work orders, and reporting work on small jobs after the fact

7.5.11 . Work Item No. 40. Biometric Access Control. One Lot be Delivered and Demonstrated

Finger print authentication biometric system is to be proposed for employer's review and agreement, provided / installed and tested as under,

1. To control un-manned entry of men (regular staff cum visitors) and material vans entering from the main / single point entry gate of the plant.
2. Biometric sensors be used through a scanning / recording / gate pass entry computerized system that will be controlled by senior security officer - having IT support.
3. System be fool proof and no way an over-ride option be open to security guards until authorized on plant managers pin code over-ride authentication.
4. System will include employer's advised various plant areas / door those will also have biometric control to authorize access to particular fellows only, like PM office, Security Office, Stores, MCR etc.
5. Plant Main Door entry / exit be through the rotate gate packed with automatically reset function
6.

(single man one way single pass through) on biometric authentication of particular individual. Vehicle gate will have a Road Blocker arrangement. Staff Car park which is outside will also open a biometric authentication and reset automatically. Visitors car park will be controlled by reception / security via a remote button to let each visitor car enter and reset automatically. Approach road to plant will have speed breakers, boulders and speed control cameras to check vehicles moving over 50 KMPH. Only Fire Fighting and materials vehicles are allowed inside the plant main gate.

1. System needs be fool proof and must register the entry / exit time of staff against his electronic time sheet towards monthly attendance record.
2. System should be able to generate materials gate pass along with materials / driver and vehicle details.
3. Entry / Exit gates be equipped with metal detector to annunciate and block gate opening on metal detection.
4. Gate passes thus allowed should have a time bart feature asking to renew the gate pass.
5. Gate pass be only authenticated against a high resolution colored picture attached in standard format plus national identity card, passport or plant issued ID card or combination of all .
6. System must be featured to block an unwanted entry of person or materials and pop us such information on subsequent re-attempt.
7. System must keep the data / record saved with unlimited or expandable memory with ability to track from start to end about a particular fellow or material entry.

8. Contractors should have a limited access to enter gate pass request moving immediately to senior security officer, PM , Ops Manager and Maint Manager at the same time for their 1st approval before SSO final approval. So it's a minimum two stages serial authorization.
9. Gate passes can be printed by contractor or an individual requestee.
10. Entry gate must match the photo that was authorized and fellow entering in.
11. System be provided with appropriate software of a famous brand duly warranted for 2 tears. Software license be renewable on yearly bases.
12. System updates shall effect automatically FOC.
13. Back up engg support requested for next 20 years.
14. System be installed and activated soon the entry gate is operational and this must be done on priority.

7.5.12. Work Item no. 41. Met Instrumentation. Lot Delivery be installed and made operational.

Back Ground Discussion

Ensuring gas turbines run at maximum efficiency is a primary goal for operators. In the current economic climate, anything that increases productivity, and hence profit, is clearly welcome. From an environmental point of view, it is also important that turbines run as efficiently – and produce as few emissions – as possible. Fortunately, there are several ways to improve gas turbine output. Controlling the humidity and temperature of air entering the combustion inlet is one of the most important, as it has a direct effect on the turbine's efficiency, emissions, and operational reliability.

Cooler, denser air increases output and efficiency In terms of gas turbine efficiency, the effect of air density is well known: denser intake air increases mass flow rate, which consequently results in improved turbine output and efficiency. Air density is inversely proportional to temperature, meaning that rising temperatures decrease air density and therefore reduce gas turbine efficiency and power. Inlet-air cooling, especially in warm and hot environments, is commonly used to compensate for the efficiency loss caused by high air temperature. Even a small reduction in airtemperature can lead to a significant increase in power output. A 1°C reduction in air temperature can increase output by up to 0.5%. There are several techniques that are used to cool intake air. A common solution is a fogger, a system that injects water into the airflow through nozzles, causing the air to cool as the water droplets evaporate. A secondary benefit of fogging is that the increased humidity of the air reduces the NOx emissions produced by the combustion process. Apart from inlet-air cooling in warm or hot conditions, humidity can also be a critical factor in avoiding icing in cold climates. If humid air is close to freezing, anti-icing systems are needed to protect the compressor from the damage that fast-moving ice particles would cause.

A 1°C reduction in air temperature can increase output by up to 0.5%.

Optimal control needs accurate humidity information.

Given the high speed of air within the air inlet system, water droplets and ice particles must be prevented from entering the compressor and turbine to avoid

costly damage and erosion. In practice, this means that the air humidity needs to be kept below saturation levels. In other words, to avoid condensation, the dew point temperature of the air entering the system has to be below the air and surface temperatures in the system.
The control system has to have a safety margin to allow for measurement uncertainties as well as fluctuations and irregularities in the properties of the air being measured. However, the wider the margins that are needed due to measurement uncertainties, the greater the efficiency potential that is lost. This is where a high level of measurement reliability really pays off.
Accurately measuring the dew point enables cooling and fogging, or even heating, to be performed as close as possible to the condensation or icing limit within the system.

Different ways of expressing humidity.

Depending on the application, different terms are used to express humidity. These include, but are not limited to, relative humidity, dew point temperature, and wet bulb temperature. Relative humidity (RH) is the ratio of the water vapor's partial pressure to its saturated pressure at a particular temperature. RH is expressed as a percentage and is generally used to describe ambient air humidity. The drawback of using RH is that it is heavily dependent on temperature.
For example, if RH is 85% and the temperature 20°C, a decrease in the air temperature of only 2°C changes the RH to 96%. If RH is used to measure air humidity in a turbine inlet, this dependence has to be kept in mind because even without cooling or heating, the air temperature changes in the air inlet system. The main effect is cooling due to the acceleration of air at the compressor bell mouth, which can cause a temperature drop of several °C. Due to this cooling effect there is still a risk of ice formation even when the ambient temperature is above 0°C.

The dew point temperature (Td)

is the temperature at which air, when cooled at constant pressure, becomes fully saturated with water vapor resulting in the formation of liquid water known as condensation. At 100% RH, the ambient temperature is the same as the dew point temperature, but when the dew point temperature is lower than the ambient temperature, the air becomes drier and therefore there is less risk of condensation forming. Two main benefits of using Td are that it is not temperature dependent and it directly provides the margin to condensing conditions. Wet bulb temperature (Tw) is the temperature indicated by a thermometer wrapped in a wet sheath. The wet bulb temperature and ambient temperature can be used to calculate relative humidity or the dew point. Tw is a traditional way to determine humidity but has largely been replaced by direct measurements as accuracy is limited and the method requires some skill to use and maintain. All the above humidity parameters are pressure dependent, but for air intake applications typical drops in pressure are so small that they do not have a significant effect. For example, at 20°C and 1013 mbar, a reduction in pressure of 20 mbar causes a reduction of 1.7% in RH or 0.3°C in Td.

Factors affecting accuracy .

There are many factors that affect humidity measurement accuracy – basic sensing technology being the most obvious one. However thin-film polymer sensors have been proven to satisfy the most critical needs in inlet air monitoring: accuracy, robustness, long-term stability, and low maintenance requirements.
Because air in the inlet may be very close to saturation, and perhaps even forming condensation, the sensor has to maintain accuracy even in these conditions. One challenge for a humidity sensor in condensing air is that if the sensor gets wet, the measurements will continue to show saturated conditions until the sensor dries – even though the air itself is no longer saturated.
To overcome this problem, Vaisala has developed patented heating probe technology. This ensures that the temperature of the probe is kept above the surrounding air temperature in order to avoid condensation on the sensor itself. Depending on the system and exact installation position, direct water splashes may also wet the humidity sensor. Special mounting accessories are available to prevent this from happening.
At power plants and polluted environments,

the intake air may contain contaminants, which can affect long-term sensor accuracy. To overcome this challenge, advanced sensors can be configured with a chemical purge function, which cleans the sensor element automatically by evaporating possible contaminants.

Typical Products suitable for combustion inlet air monitoring:
▪ Vaisala HUMICAP® Humidity and Temperature Transmitter Series HMT330 and Vaisala Combined Pressure, Humidity and Temperature Transmitter PTU300. Both series have a heated probe option, chemical purge function, and Vaisala HUMICAP® thin-film polymer technology. ▪ To check functionality in the field, Vaisala HUMICAP® Hand-Held Humidity and Temperature Meter HM70. ▪ To protect direct water splashes from entering the humidity sensor, Vaisala HUMICAP® Turbine Mounting Kit HMT300TMK.

With all above commentary, Nabisar site is subject to wind storms those have sand and dust pollution effecting air inlet filters performance and efficiency ultimately effecting the CT output.

Temperature effects in the peak summer days and temperature fall during nights in desert especially in winter season along with fog effect will have drastic effects on CT output that needs be monitored and studied on continuous bases through a data analysis module plugged in CT control programme and either regulating the combustion control or depending upon the severity, initiate a warning to the operator for taking additional measures suggested by the EPC contractor.

In order to keep the maximum efficiency maintained of Air Inlet Filter and Compressor, EPC contractor is requested to study the need and type of met measurements required and how to tie with combustion control.

Once EPC contractor have such a proposal tabled and advise how best it's going to add a value towards site testing / measuring performance of AIF / compressor and CT operation through out its life span, employer will review, discuss and come across an agreed action.

7.5.13. Work Item no. 42. Public Address System. Lot Delivery, be Installed and be made operational.

PUBLIC ADDRESS SYSTEM

The voice alarm system shall be the integrated solution for BGI(Back ground Instructions) and EVAC(Emergency Voice Alarm). The voice alarm system shall be designed for public address and emergency evacuation. All the essential EVAC functionality – such as system supervision, spare amplifier switching, loudspeaker line surveillance, digital message management and a fireman's panel interface – shall be combined.

A 24Vdc output shall be available to supply power to external relays, so no external power supply shall be required for that purpose. A LED VU-meter shall allow for monitoring of the master output.

The maximum/rated output power of the internal booster shall be 150 W / 300 W. max mains inrush current shall be 8A @ 230 VAC / 16A @ 115 VAC

The frequency response shall be 60 Hz – 18 kHz (+1/-3 dB, @ -10 dB ref. rated output. The distortion shall not exceed 1% at the rated output, 1 kHz. The controller shall have tone controls to allow for adjustment of the BGI sound. It shall have separate bass and treble controls. The controller shall have two BGI source inputs and a mic/line input with configurable priority, speech filter, phantom power and selectable VOX activation.

The operating temperature range shall be -10°C to +55°C. The storage temperature range shall be -40°C to +70°C.

The system shall comply to the following standards:

- EVAC compliance acc. to IEC 60849
- EMC emission acc. to EN 55103-1
- EMC immunity acc. to EN 55103-2
- Safety acc. to EN 60065

Typically system can be the Bosch Plena Voice Alarm System or equivalent. The matching controller shall be the Bosch Plena Voice Alarm Controller 1990/00, the router be the Bosch Plena Voice Alarm Router 1992/00, the call station shall be the Bosch Plena Voice Alarm Call Station 1956/00 and the call station shall be the Bosch Plena Voice Alarm Call Station Keypad 1957/00

1 - **GENERAL REQUIREMENT**

The design, supply, delivery, installation, testing, commissioning and maintenance of the Public Address System shall include, but not limited to the following:

- Recessed mount (ceiling), surface mount, column and / or horn speakers, sound projectors, box and bi-directional box speakers c/w line matching transformers and volume controls, where applicable;
- Termination of all cables to speakers, power amplifiers, etc.;
- Equipment rack complete with forced air ventilation fan(s), mounting brackets blank panels, terminal boards, etc.
- Main equipment and all associated auxiliary equipment;
- Distribution cabling, including fire rated cables, where applicable, cable ladders, racks and Cable supporting systems (cable trunking and concealed metal conduits)
- All other works and materials necessary for the efficient operation of the whole audio system Complete with power supply requirements and surge arrestors and filters.

The primary objective of the system is to provide clear announcements during public addressing and one-way voice communication during an emergency; the secondary function shall be to provide background instructions where required.

The system shall be capable of fulfilling the following requirements:

- Clear, un-distorted announcements to selected areas during public addressing;
- Clear, un-distorted paging to all zones; either individually or collectively. Selection of groups of zones shall be programmable from time to time; and
- Background instructions to selected areas when the other functions are not selected. (Typically Quranic Recitation, Azan for prayers and set of safety instructions can be played)

The loudspeakers shall be wired up in zones and with supervision; localized volume controls as specified shall be provided so that the desired volume adjustments may be made. Locations of localized volume controls are as indicated in the Schedules and /or drawings.

The zones shall further be grouped according to function so that it shall be possible to make an announcement by depressing just one switch on the call station.

To allow flexibility in the system, it shall be designed to be expandable with easy installation without changes in controller.

When the zones are selected for public addressing, a chime shall first be heard, followed by the announcement. The system shall have a range of tones such that it shall be possible to programme different tones for call stations.
It shall be possible for the system to function with different call stations in operation, provided there is no conflict in the zones being called by the call

stations. An emergency call station shall be provided for emergency.

The controller shall have a system of priorities such that, should a conflict situation arise, the station or user key with the top priority will override the others. This sequence of priorities shall be determined and programmed during the commissioning stage; it shall be possible to change the sequence by on-site as well as off-site re-programming, as and when the need arises.

The system shall comply with country Public Address Evacuation Code of practice or IEC 60849 for the one-way emergency voice communication system in all aspects.

All control and switching equipment shall be centralized and decentralized as specified and located in equipment racks in the FCC and equipment rooms. No other equipment except the volume controls and Cable patch panel shall be located outside the equipment rack.

All equipment supplied shall be from the same manufacturer. Equipment supplied shall strictly be Standard Products from Public Address Product Manufacturer. No tailor- made product shall be acceptable. The tendered shall submit catalogues of all equipment offered and upon delivery; certificate of country of origin, Certificate of Conformity and Certificate of Evacuation for the proposed PA Equipment shall be submitted.

Zoning for the passenger lifts shall be provided as provision and shall complete with the necessary wiring to be terminated in a termination box near the control panel in each lift motor room.Group zoning for the lifts shall be allowed for evacuation announcement.

2 - SYSTEM REQUIREMENT

For general office and public areas, the system shall be capable of delivering a sound pressure level of 85 dB at the listening level.

For Machine & Equipment areas such as plant rooms, etc where the noise level is higher (assumed to be ≤80 dB), the system shall be able to deliver 95 dB at the listening level.

The listening level shall be taken to be 1.5 m above floor level.

The reinforced sound shall be distributed evenly throughout the listening area; the total variation in each area shall not exceed ±4 dB.

An articulation loss of consonants of less than 15% shall be maintained. (Generally, the reverberation time of the various locations shall be assumed to be not more than 1.9 seconds).

Paging announcements shall be possible from any of the microphone call stations, or from the microphone paging station to any zones within the network systems.

Call station shall be using CAT 5 cable with RJ 45 connector to transmit calls.

The main control room microphone paging station shall have the flexibility of selecting any number of user keys (selection buttons) at any one time. It shall be able to program each user key for function.

The central controller shall have a means of monitoring, to continuously monitor the system from the microphone of the call station onwards; any faults shall be displayed on the central unit.

High quality signals shall be maintained at the output of the power amplifiers to compensate for losses in the audio distribution lines.

Each power amplifier with 30% spare capacity shall be provided to drive all loudspeakers during an emergency without overloading.

Each power amplifier shall have a built-in self-restoring protection circuit to guard against hazards of operation such as mis-loading at its input, short-circuiting of its output and connection mistakes.

The power amplifiers shall also have built-in line transformers for 100V loudspeaker matching, DC input of emergency operation. It shall have amplifier monitoring and auto-changeover over circuits & automatic volume control features built-in.

The power amplifiers shall have control inputs and audio inputs for interfacing for fire alarm signals. This control inputs shall be supervised, freely programmable for any system actions and with priorities setting. A built-in amplifier monitoring circuits shall continuously monitor the functioning of the power amplifiers and shall automatically switch in a spare power amplifier in case of failure of any of the amplifiers. Upon detection, the status of the fault shall be indicated in the Central or local Monitoring. The number of spare power amplifiers to be provided shall be ten percent of the total quantity of each range of power amplifiers. All speaker lines shall be supervised for open circuit fault, short circuit fault, and short to ground fault. Upon detection, the status of the fault shall be indicated in the Central Monitoring.

The loudspeakers shall be located such that they meet the necessary requirements. Rooms with on / off volume control units as required are indicated in the schedule of tables. Facilities shall be incorporated to override these volume control units, including those in the “off” position to enable emergency announcements to be broadcast. In general, one ceiling speaker shall be provided for every 25 square meters in each room such as offices and corridors, while a minimum of one ceiling speaker shall be provided for areas less than 25 square meters such as booths, pantry and toilets. Horn speakers shall be provided for all plant rooms, generator rooms and outdoor areas with high ambient noise.

The system shall also have the means to cut-off the instruction sources during emergency paging and shall enable the emergency announcement to be heard in these areas. All volume controls as specified shall be overridden during emergency announcements. There shall be background instructions to selected areas. It shall be possible to pre-program any of the output instructions to any of these zones. Sources provided shall be a continuous cassette player, MP3, an integrated compact disc player with digital tuner.

All equipment such as the central network controller and power amplifiers shall be housed in 19-inch equipment racks.

3.POWER AMPLIFIERS:

It shall meet the following minimum requirements:

The main function of the power amplifier is the amplification of audio signals for the loudspeakers. It shall be possible to select the output voltage between 100V, 70V or 50V by changing output. The power amplifiers are provided with compact 19", 2U & 3U high housing for tabletop use and rack mounting, while the maximum amplifier wattages varies from 120w to maximums 960w.

The amplifiers are protected against overload and short circuits. A temperature-controlled fan ensures high reliability at high output power and low acoustic noise at lower power output. Additionally, all booster amplifiers have an overheat protection circuit that switches off the power stage if the internal temperature reaches a critical limit due to poor ventilation or overload.

Balanced input and a loop-through connector shall be available for easy connection of multiple booster amplifiers to increase the available output power. The power amplifier shall obtain two balanced inputs with priority control, each with a loop-through facility. This allows for easy and automatic switching between e.g. a local music source and a priority announcement from a remote system.

An additional 100V line input is provided to connect the booster amplifiers to a 100V loudspeaker line, for additional output power e.g. on remote locations. Sensitivity or level control is located on the rear of the unit to avoid accidental setting change. A VU-meter with LED-bar shows the output level.

The amplifiers not only provide 70V and 100V outputs for constant voltage loudspeaker systems, a low impedance output for 8 Ohm loudspeaker loads is available for different usage.

The booster amplifiers operate both on mains power and on a 24V battery power supply for emergency back up, with automatic switchover. Amplifier front panel with LED shall shown as an indicator when it operates on the battery or AC supply.

The power amplifier shall be with the following approval: -
• EMC emission acc. to EN 55103-1 • EMC immunity acc. to EN 55103-2

PERFORMANCE

• Frequency response 50 Hz – 20 kHz (+1/-3 dB, @ -10 dB ref. rated output) • Distortion <1% @ rated output power, 1 kHz

INPUTS

• Line input (3-pin XLR, 6.3mm phone jack, balanced) • Sensitivity 1 V • Impedance 20 kOhm • CMRR >25 dB (50 Hz-20 kHz) • Line input 1, 2 (3-pin XLR, balanced) • CMRR >25 dB (50 Hz-20 kHz) • 100V input (Screw, unbalanced) • Sensitivity 100 V • Impedance 330 kOhm

OUTPUTS

• Line loop through output t (3-pin XLR, 6.3mm phone jack, balanced) • Nominal level 1 V • Impedance direct connection to line input • Line loop through output 1,2 (3-pin XLR, balanced) • Impedance direct connection to line input • Loudspeaker outputs (Screw, floating) • Output power @ 24 V • Battery operation -1 dB ref. rated power

ENVIRONMENTAL CONDITIONS

• Operating temperature range -10 to +550C • Storage temperature range -40 to +700C • Relative humidity <95%

4.POWER SUPPLY

The contractor shall make provision for all necessary power supply units, voltage regulators, etc, to ensure that the equipment will perform satisfactorily c/w necessary surge arrestors and filters.

All necessary power supply (s/s/o's etc) required for the operation of the sound equipment shall be designed supplied and installed by the contractor.

5. EMERGENCY OVERRIDE UNIT

The emergency override unit when activated from the Fire Command Center, it will override all incoming signals to allow emergency messages to pass through.

6. SYSTEM TESTING

The contractor shall test the system in the presence of the owner's engineer to show that its performance satisfies the requirement of this specification. All test equipments shall be professional and supplied by the contractor. A sound pressure meter will be required. No claim is allowed for this test. The cost shall be deemed to be included in the schedule of rates for the equipment.

LIST OF APPROVED MAKES.

PUBLIC ADDRESS SYATEM - BOSCH / BOSE / AHUJA

7.5.14. Provisional Sums

Payment work for Items 43, 44 and unforeseen will be made against allocated budget of works and services.

EMPLOYER'S REQUIRMENT FOR MECHANICAL & ELECTRICAL WORKS

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SCHEDULE OF GUARANTEES

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SCHEDULE OF GUARANTEES

8.1. Schedule of Guarantees

1. The Contractor shall guarantee that the Main plant and BOP equipment supplied under the Contract shall be new and in accordance with the Tender including variations/deviations, if any, jointly agreed by the Employer and the Contractor and shall be free from defects and poor workmanship. In the event of any defect or failure in the performance of any component of the Plant or part thereof within the guaranteed period specified in the Tender, the same shall be replaced or repaired by the Contractor to the satisfaction of the Employer free of charge, normal wear and tear accepted.

2. The Contractor shall further guarantee that the performance data given by him in the Schedule of Guarantees shall be complied with by him.

   In the event of guaranteed performance not being attained, the Contractor shall improve the same to the guaranteed level at his own expense within a reasonable time to the satisfaction of the Employer.

3. Parts which as a result of material or manufacturing defects become unusable or the usefulness of which is appreciably decreased, shall he repaired satisfactorily or replaced free of charge by the Contractor on intimation of such defects by the Employer in writing.

   Defective parts shall be property of the Contractor and transport back on his own expense without any obligation to owner from storage / damage point of view while at site, on road, rail or sea or transit or customs custody before or after title transfer.

4. **Objectives of Field Testing of Gas Turbine and Centrifugal Compressor Performance**

• The Contractor is required to verify performance of the gas turbine and compressor to the customer. As the field test provides a baseline for the gas turbine and compressor at the site to compare to the factory performance test, although the field test accuracy may be inherently lower. The field performance test will be the final validation from the contractor to the owner of the guaranteed performance.

• The owner needs to verify performance of the gas turbine and compressor. Baseline performance data is obtained from the initial field performance test. The baseline test will be used for comparing and monitoring the health of the gas turbine-driven compressor package in the future.

• The owner and contractor / manufacturer needs to assess performance of the gas turbine or compressor because of degradation concerns. Based on the field test results, a performance recovery program may be initiated by the contractor / manufacturer or the owner as the case may be.
• The owner requires calibration of an installed historical trend monitoring system. The field test is used to provide initial calibration of the system based on the first performance of the gas turbine and compressor. • The owner needs to determine the operating range of the installed equipment after an outage, upgrade, restage, or physical system change. In this case, the surge point may also need to be re-assessed.
Contractor shall at his own expense will engage a qualified third party to conduct the PT and issue a certificate direct to the owner. PT will be conducted in last week during the one month combined performance Run Test before hand-over.

EPC contractor may please use following guidelines.

1. GTG – Performance Guarantee

a. Typical test parameters include:
b. Combustion Gases (O_2, CO_2, CO, NO_x)
c. Total Hydrocarbons (THC)
e. PM10 Particulate
f. Volumetric Flow Rate to Determine Emission Rates
g. Typical test parameters include: Combustion Gases (O_2, CO_2, CO, NOX and
h. (SO_2), Total Hydrocarbons (THC), PM10 Particulate and Volumetric Flow Rate to determine pollutant emission rates.

2. Overall Power Plant Performance

Electrical Output

Power plant electrical output is one of the most important and critical parameters of an overall plant performance evaluation. Once power plant electrical output has been determined, it can be corrected to reference conditions to provide a comparison of current plant power output to rated output. This is very important so that contract guarantees can be confirmed and/or changes in performance can be tracked over time.

Since this parameter is intimately tied to the revenue generated by the plant, high precision measurements are required in order to ensure the highest accuracy value for this parameter.

EPC Contractor shall bring a certified agency that uses state of the art instrumentation with valid NIST traceable calibration certificates . A certified agency brings these instruments to site to ensure high quality measurements.
Heat consumption is the energy (fuel) consumption of the cycle. The ratio of heat

consumption to electrical power output is commonly known as the heat rate. This relationship is a measure of how efficient the plant is in converting fuel into electricity. This parameter is therefore an indirect relationship of the expense and revenue of plant operation.

Heat Consumption and Heat Rate.

Heat rate is usually corrected to reference conditions – commonly given by the OEM or by the EPC contractor – to validate the performance achieved is in line with the guaranteed performance of the power plant.

A precise heat consumption measurement must be provided so that the calculated heat rate is as precise as possible. In order to provide the highest engineering quality measurements . A certified agency performs overall plant performance tests in accordance with the internationally recognized standards such as ASME PTC46 – Overall Plant Performance

Plant Auxiliary Consumption

The main thermal power generation cycle components will always require auxiliary equipment to operate efficiently and safely.
EPC Contractor shall bring a certified PT agency, that can measure and analyze the auxiliary systems and identify troublesome equipment to ensure optimization of the plant net electrical output.

Error in the measurement of auxiliary power consumption translates into error in the calculated net power output and thus must be minimized. A certified agency can offer advice on what measures to take to improve auxiliary consumption and therefore overall profit margin through net electrical output gains.

GT Performance / Efficiency

The gas turbine compressor is a component that operates under heavy demand. If compressor efficiency is affected, it will consume more energy to compress the gas that is delivered to the turbine and the overall net power output and efficiency of the cycle decreases. The compressor is the first component of the cycle and therefore its effects will carry over to the rest of the cycle.

The turbine efficiency is defined as the ratio between the actual power produced in the turbine over the power that would be produced in an ideal turbine. A decrease in efficiency means that the overall net power output of the cycle decreases (and heat rate increases).

The “PTC22 – Performance Test Code on Gas Turbines” and ISO2314 – Gas Turbines Acceptance Tests are the relevant protocols used by a certified agency to determine the performance of gas turbines.

GT Exhaust Temp / Flow

Control systems need an accurate measurement of gas turbine exhaust to maintain a safe operation and to mitigate the possibilities of “overfiring” or “underfiring” in the combustion chamber. EPC Contractor shall bring a certified 3rd PT agency, typically TGPS can provide high precision instrumentation to measure this parameter and reliable standards to calibrate site instrumentation.

A higher exhaust temperature could be a symptom pointing to compressor or turbine inefficiencies. A certified agency can perform a diagnostic analysis to identify underlying causes for an unexpected gas turbine exhaust temperature or flow variances.

Gas turbine exhaust flow characteristics have added importance when it is used as heat input to a steam cycle. The accurate measurement of mass flow and temperature are needed in order to estimate the performance of the HRSG and the steam cycle.

Startup – Shutdown costs

Every startup and shutdown means additional costs to power plant operators. It is important to understand the costs of these activities to optimize the management of the assets.

A certified agency removes the assumptions out of these parameters by actually measuring the startup – shutdown cycle with actual monetary value that will be specific to each generation group.

Considerations for estimating the costs is that these depend on the type of shutdowns: cold, warm, or hot. A certified agency can help estimate specific costs taking into account critical variables such as the cost of startup fuel input and net electrical power used during these cycles.

Gas Pollution Emission.

Using mobile high precision equipment a certified agency can measure the levels of combustion products such as oxygen, carbon dioxide, carbon monoxide, nitrogen, sulfur dioxide, sulfur trioxide, nitric oxide, nitrogen dioxide, hydrogen sulfide, and hydrocarbons. Testing is conducted in accordance with ASME PTC19.10 – Flue and Exhaust Gas Analyses and all EPA applicable protocols.

Noise Emission.
Noise emissions are accurately measured to ensure power plant noise emissions are compliant with local and contractual noise regulations. For most power plants, the major noise sources during operation are the air-cooled condenser or cooling tower (due to the fans), the gas and steam turbine, and the heat recovery steam generator (HRSG).

Typically a certified agency follows the guidelines set by ASME PTC36 – Measurement of Industrial Sound and ISO 10494 – Measurement of emitted Airborne noise for GT's for the measurement of airborne sound emissions from stationary sound sources and facilities.

SCHEDULE OF GUARANTEES

8.2. MAIN PLANT - CTGs

S.No.	Description	Unit	Tenderer's Guarantees
1	Centrifugal Compressor Flow/Flow Coefficient		Per OEM, to be tested by a certified party
2	Centrifugal Compressor Head/Head Coefficient		
3	Centrifugal Compressor Efficiency		
4	Centrifugal Compressor Power Absorbed		
5	Gas Turbine Full Load Output Power		
6	Gas Turbine Heat Rate (thermal efficiency)		
7	Gas Turbine Exhaust Heat Rate		
8	Turbocompressor Package Efficiency		
9	Generator Package Efficiency		
10			

	Centrifugal Compressor .Ref Data for above parameters		OEM declared performance Guarantees , To be tested by a certified PT agency
	Suction Temperature		
	Suction Pressure		
	Discharge Temperature		
	Discharge Pressure		
	Flow Through Compressor		
	Suction or Discharge Gas Composition		
	Barometric Pressure		
	Speed of Rotation		
	Impeller Diameter		
	Upstream and Downstream Piping arrangement		
	Pipe Diameter (upstream and downstream		

	Gas Turbine. ref data for above parameters		OEM declared performance Guarantees , To be tested by a certified PT agency
	Engine Inlet and Ambient Temperature		
	Barometric Pressure		
	Power Turbine Speed		
	Generator Speed		
	Fuel Flow		
	Fuel Composition		
	Inlet and Exhaust Pressure Loss		
	Relative Humidity of Inlet Air		
	Water/Steam Injection Rate		

	GENERATOR – Each Unit		OEM declared performance Guarantees, To be tested by a certified PT agency
1	Make Serial # Enlist Key Factors and, Speed Terminal Voltage Frequency Power Output at Site Conditions Software Protection IP Class Working Temp / Humidity Obsolete / Upgrade Remote Support MTBF & Consequences on Failure		

S.No.	Description	Unit	Tenderer's Guarantees
2	**8.3. GTG Excitation - Each Unit –** Make – EX 2000 or equal Serial # Enlist Key Factors and, Redundancy Software Protection IP Class Working Temp / Humidity Obsolete / Upgrade Remote Support MTBF & Consequences on Failure Automatic voltage regulator with Reactive current compensator - Volts per hertz limiter - Over-excitation limiter - Under-excitation limiter • Manual field voltage regulator Protection • Volts per hertz, dual level (24EX) • Loss of excitation (40EX) • Bridge ac voltage phase unbalance (47EX) • Generator overvoltage (59EX) • Off/online over-excitation (76EX) The software to include the power system stabilizer (PSS). To enables the generator to produce and transmit more power in a stable manner by reducing low frequency rotor oscillations.. Acceptance on final testing before hand-over	2 Lot	OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance

S.No.	Description	Unit	Tenderer's Guarantees
3	**8.4. PECC, each unit** Enlist Key Factors including MTBF	2	OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance
4	**8.5. MKVI/PLC/SCADA Controls GTG: each unit** Manufacturer Key Factors Redundancy Software Protection IP Class Working Temp / Humidity Obsolete / Upgrade Remote Support MTBF & Consequences on Failure		

S.No.	Description	Unit	Tenderer’s Guarantees
5	**8.6. Unit BOP Control: each unit** Manufacturer Key Factors Redundancy Software Protection IP Class Working Temp / Humidity Obsolete / Upgrade Remote Support MTBF & Consequences on Failure		OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance

S.No.	Description / unit	Tenderer’s Guarantees
6	**8.7.Pump MOTORS** Country of Origin Model Voltage Rating - KV Power Rating – KW Full load current - A Duty point current - AA Starting current - A Efficiency full load - % Efficiency 3/4 load - % Efficiency 1/2 load - % Power factor full load – 0.X Power factor 3/4 load – 0.X Power factor 1/2 load – 0.X Insulation class - H Enclosure protection – IP XX Noise level at duty point dB (A) at 1m – db(A) Bearing type – Single / Double Sealed Moment of inertia – kgm sq Run up time - Seconds Permitted numbers of start per hour - XX Weight - Kg	OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance

S.No.	Description	Unit	Tenderer's Guarantees
	method of cooling		
	Non – reversing arrangement		
7	**8.8. Blank**		
	Manufacturer		
	Country of origin		
	type		
	Diameter of shaft	mm	
	Length of shaft	m	
	Material of construction		
	Type of bearing upper / lower		
	Type of intermediate bearings		
	Numbers of intermediate bearings		
	Guard system		
8	**8.9. Pipe Work:**		
	Manufacturer		
	Country of origin		
	Material		
	Thickness of plate (1800mm diameter)	mm	
	Thickness of plate (800 mm diameter)	mm	
	Thickness of plate (450 mm diameter)	mm	
	Thickness of plate (300 mm diameter)	mm	
	Rating	bar	

S.No.	Description	Unit	Tenderer's Guarantees
	Test Pressure	bar	
	Internal coating		
	External finishing priming		
	External finishing top coat		
9	**8.10.Electric Overhead Gantry Crane:**		OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance. Typically 3rd party block load testing for O/H GR
	Manufacturer		
	Country of origin		
	Type		
	Lifting capacity	tonne	
	Voltage	V	
	Hoist speed high / low	m/min	
	Motor size	KW	
	Motor speed	rpm	
	Travel speed	m/min	
	Motor size	KW	
	Motor speed	rpm	
	Gantry crane speed	m/min	
10	**8.11. Flow meter:**		
	Manufacturer		
	Country of origin		

	Model		
	Pressure rating	bar	
	Diameter	mm	
	Flange rating	PN	
	Body material		
	Internal lining		
	External coating		
	Flow range	m^3/s	
	Control signal	mA	
	8.12.Submersible pumps:		
11	Manufacturer		
	Country of origin		
	Type		
	Model		
	Duty flow	l/s	
	Duty head	m	
	Motor rating	KW	
	Motor protection	IP	
	Speed	Rpm	
	Overall efficiency at duty point	%	
15	**8.13.Butterfly valves (All applications):**		

S.No.	Description	Unit	Tenderer’s Guarantees
	Manufacturer		
	Country of origin		
	Type		
	Working pressure	bar	
	Test pressure	bar	
	Size of bypass	mm	
	Material of construction		
	Body		
	Shaft		
	Seals		
	Rating	PN	
	8.14. Blank		
16	**8.15. Non return valves:**		
	Manufacturer		
	Country of origin		
	Type		
	Diameter	mm	
	Working pressure	bar	
	Test pressure	bar	
	Material of construction		
	Body Disc Body seal Disc facing ring Disc Body seal		

S.No.	Description	Unit	Tenderer's Guarantees
	Seal Valve shaft Bushes Lever arm Lever weight		
17	**8.16. Blank**		
18	**8.17/18. Pressure Relief Valves** Manufacturer		

S.No.	Description	Unit	Tenderer's Guarantees
	Country of origin		
	Type		
	Diameter	mm	
	Test pressure	bar	
	Working pressure	bar	
	Material of construction		
	Seat Spring Body		
19	**8.19.Not Applicable**		

S.No.	Description	Unit	Tenderer's Guarantees
20	**8.20. Main 11 KV Incoming switch board**		OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance.
	Manufacturer		
	Country of origin		
	Type		
	Type Nr		
	Rated normal service voltage	KV	
	Number of mases		
	Frequency	Hz	
	Overall dimensions of switchboard		
	Height	mm	
	Length	mm	
	Width	mm	
	Weight	kg	
	Weight and dimensions per panel		
	Height	mm	
	Length	mm	
	Depth	mm	
	Weight(total)	kg	
	Weight of moving portion	kg	
	Minimum distance required for withdrawal of moving portion	mm	
	Minimum height for removal of voltage transformer	mm	

S.No.	Description	Unit	Tenderer's Guarantees
	Maximum shock load imposed on foundations when operating under fault conditions. (State whether tension or compression)	KN	OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance.
	Switchgear and bus-bars	A	
	Rated bus-bar current		
	Maximum temperature rise at rated bus-bar current above 45^{o}C ambient	^{o}C	
	Bus-bar type test report reference		
	Short time withstand current of switchgear & bus-bar		
	a) One second	rms kA	
	b) Three second	rms kA	
		peak kA	
	Making capacity		
	Constructional features		
	Is an external series break incorporated in breaker		
	Method of closing		
	Method of tripping		
	Closing solenoid coil current and duration at rated voltage	A ms	
	Closing solenoid coil rated voltage	V dc	
	Trip coil current and duration at rated voltage	A ms	
	Trip coil rated voltage	V dc	
	Minimum dc voltage required for	V dc	

S.No.	Description	Unit	Tenderer's Guarantees
	successful closing at make rating	W	OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance.
	Rating of heaters for circuit breakers		
21	**8.21. 11 KV transformer outgoing**		
	Manufacturer		
	Country of origin		
	Type		
	Type Nr.		
	Rated nominal service voltage	kV	
	Number of phases	phase	
	Frequency	Hz	
	Overall dimensions of switchboard		
	Height Length Width Weight	mm mm mm kg	
	Minimum distance required for withdrawal / removal of switchboard components.	mm	
	Bus- bars		
	Rated bus bar current	A	
	Maximum temperature rise at rated bus bar current above 45°C ambient	°C	
	Bus bar fault rating For	kA seconds	
22	**8.22. 11 KV outgoings**		

S.No.	Description	Unit	Tenderer's Guarantees
	Manufacturer		
	Country of origin		
	Type		
	Type Nr.		
	Rated nominal service voltage	kV	
	Number of phases		
	Frequency	Hz	
	Overall dimensions of switchboard		
	Height	mm	
	Length	mm	
	Width	mm	
	Weight	kg	
	Minimum distance required for withdrawal/ removal of switchboard components	mm	
	Bus- bars		
	Rated bus bar current	A	
	Maximum temperature rise at rated bus bar current above 45ºC ambient	ºC	
	Bus bar fault rating	kA	
	For	seconds	
23	**8.23. Transformers**		
	Manufacturer		
	Country of origin		
	Rated Voltage	kV/V	

S.No.	Description	Unit	Tenderer's Guarantees
	Rating Height Length Width Weight Weight (without – oil)	mm mm mm kg kg	
	Fault rating for	kA seconds	
	Protection	IP	
24	**8.24. Cables**		
	11 KV		
	Manufacturer		
	F/R Type		
	400/230 v		
	Manufacturer		
	F/R Type		
25	**8.25. Control and Instruments**		
	Manufacturer		
	Type		
26	**8.26. Earthling Equipment**		
	Manufacturer		
	Earth electrodes	Nos.	
	Inspection covers		
	Cabling		
	Copper earth bar size		

S.No.	Description	Unit	Tenderer's Guarantees
	Thermionic welding material		OEM declared performance Guarantees , To be tested by EPC Contractor subject to owner engineers witness / approval for acceptance.
27	**8.27. LV distribution switchboard for utilities**		
	Manufacturer		
	Bus bar continuous rating	A	
	Bus bar fault rating for	kA seconds	
	Protection	IP	
	Incoming MCCB Manufacturer		
	Rating	A	
	Fault rating for	kA seconds	
27	**8.28. LV distribution switchboard**		
	Manufacturer		
	Bus bar continuous rating	A	
	Bus bar fault rating for	kA seconds	
	Incoming ACB manufacturer		
	Rating	A	
	Fault rating for	kA seconds	
	ACB manufacturer		
	ACB dimensions		

S.No.	Description	Unit	Tenderer's Guarantees
	Height Length Width Weight MCB manufacturer Contactor manufacturer Dimensions Height Length Width Weight	Mm Mm mm kg mm mm mm kg	
28	**8.29. Operating requirements** The following items are to be completed in order to obtain an estimate of operating cost: Electrical loads: 1) Total connected load 2) Maximum running load 3) Average running load 4) Guaranteed average power consumption	 KW KW KWh/day KWh/day	

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CHAPTER 9
CIVIL WORKS - SCOPE OF WORK

9.1 General introduction

This section lays out the requirements of the Employer regarding the Civil Works for the project. The final arrangement of the works shall be developed and construction by the Contractor to best exploit the local physical conditions while maintaining the fitness for purpose inherent in the outline requirements. Nonetheless contractor is responsible to substantiate these requirements to ensure complete functional performance of Power Station and Fulfillment of his obligations under this Contract.

The Employer's Requirements have been prepared in consideration of the Conditions of Contract for EPC/ Turnkey Project.

The Contractor will be responsible for all aspects of design and construction of the Project in accordance with the Employer's Requirements, design criteria and specifications furnished herein, and in accordance with additional and supplementary design criteria and specifications prepared by the Contractor and accepted by the Employer.

The scope of the Works will include, but not limited to:

1. Preparation of all detailed design criteria, design analysis, design calculations, design detailing, construction specification, detailed construction drawings and quality control procedures, necessary for the complete construction of the project together with O&M Manuals, and as built record drawings.

2. Additional Site Investigations, survey as necessary to develop a fully functional design for Power Station.

3. The drafting of and adherence to a construction schedule sufficient to meet the requirements of the Project.

   Major Civil Works Include:

   a. Turbine Hall
   b. Fuel Oil Treatment Building
   c. Auxiliaries, Black Start DG, Electrical Sub-Station, Met Instrumentation Tower and Stand Alone Skids
   d. Cable Gallery / Marshalling Areas
   e. Main Control Room
   f. Admin, Security, Car Park, External Works, Internal Streets, External Development, Brick Paving and Curb Stones, Drainage

   External development works including landscaping

   a. All temporary works required to construct the Project, including offices for the Employer and laboratory buildings complete with furnishing and equipment's.
   b. Provision and maintenance of vehicles for the Employer's staff.

c. Conceptual Drawings of the Project are given in Volume-III of this Tender Document.

9.2 General Description of the Project

Site location

The Project is located in general in the vicinity of RO Plant Building at Nabisar, Thar Distt according to following GPS coordinates,

The conceptual Drawings are attached in Volume III showing the location of the project and guide line plan.

GPS Coordinates of THAR Coal Project

RO Plant

S NO:	Easting	Northing	Remarks
1	69.62636	25.06504	
2	69.62724	25.06532	
3	69.62708	25.06585	
4	69.62620	25.06554	

RES-TW

S NO:	Easting	Northing	Remarks
1	69.62541	25.06598	
2	69.62988	25.06727	
3	69.62686	25.07551	
4	69.62225	25.07403	

RES-RW

1	69.62043	25.06261	
2	69.62601	25.06433	
3	69.62225	25.07403	
4	69.61684	25.07231	

Site access

The Access to the site of the project is through Main Road from Mithi.

Climatic data

The Contactor shall take account of the climatic conditions at the Site of the Works. The following information is provided as a guide to the climatic condition likely to be encountered on the site to assist the Contractor, but this shall not relieve him of his responsibility under the Contract.

Altitude. 8 Mtr above sea level

a. Monthly average temperatures:

(1) Maximum 45 ^{o}C
(2) Minimum 18 ^{o}C

b. External temperatures

50 ^{o}C in June
2 ^{o}C in January

c. Annual average rainfall

70 mm per year, the majority falling in the monsoon months of July and August. On average there are 10 rainy days per year. Storm intensities can be high with storm totals reaching 300mm, with normal durations of 1 to 2 days.

d. Monthly Average Relative Humidity

(1) Maximum = 70%
(2) Minimum = 20%

The climatic data given above are based on limited records and their accuracy cannot therefore be guaranteed.

9.3 Design and planning of the works

General

The Contractor shall perform engineering services pertinent to planning and design of the work in accordance with accepted Standards. In addition, the Contractor shall establish & submit to Employer a Quality Control / Quality Assurance program to verify that the Work performed by the Contractor is in accordance with & fully meets the requirement of the Contract.

Design

All Design shall be performed in accordance with the requirement given in the following Section, Basic Design Criteria. The Design of the Works shall be performed during a Detailed Design phase. The Design responsibility of the Contractor shall be as follows:

a. The Contractor shall carry out the Detailed Design and construction drawings of the Permanent Works to be performed under this Contract and the site investigations deemed necessary for the Design.

b. The Contactor shall prepare the Detailed Design and construction drawings of necessary Temporary and Permanent Works to be performed under this Contract

c. The Contractor shall prepare Construction Method Statements and an Implementation Plan, and

d. The Contractor shall prepare the detailed design and Shop Drawings of the components of the project and equipment to be installed under this Contract.

The activities to be performed under the Detailed Design are outlined below:

a. Geological and geotechnical investigations;
b. Topographic investigations;
c. Expansion and clarification of design criteria and parameters;
d. Summary of all tests and investigation planned to be carried out in connection with the Detailed Design;
e. Design Memorandum;
f. Detailed Design;
g. Construction Drawings;
h. Civil Shop Drawings;
i. Manufacture's Shop Drawings to the extent necessary for Employer's design review and operation and maintenance;
a. Plan of the methods of achieving the Construction Requirements;
b. Report on construction methods to be used for all major works;
c. Procurement plan for major equipment;
d. Layout drawings for all temporary works;
e. Principal items of construction planned to be used;

f. Detailed information of site offices and camp facilities;
g. Quality Control and Quality Assurance procedures for Construction; Construction Materials, Material Submittals and RFIs system.
h. Plan for disposal of spoil material;
i. Environmental Management Plan Including measures for rehabilitation of work areas;
j. Construction Security, Health and Safety plans; and
k. Basic outlines of Building Management Systems Operation and Maintenance Manuals including plumbing and drains of all type, and on the Job Training..

For each structure of the project, the Contractor shall prepare Detailed Design documentation to include as a minimum:

a. Description of each structure
b. Design criteria
c. Review of assumptions and design procedures, adopted design criteria, loads and load cases used
d. Codes and books referred
e. Short description of each method of analysis, computer programs used etc.
f. Structure analysis by using latest versions of SAP – 2000, ETAB, SAFE, STAAD or any other.
g. Calculations and principal results of the detailed design analyses
h. Detailed design drawings and specifications for construction and
i. Civil and manufacture's shop drawings.

9.4 General description of Civil Works (scope of work)

The principal elements of the Civil Works are:

a. Provision of construction Materials,
b. Provision of Services;
c. Provision of Temporary Works;
d. Construction of Permanent Works;
e. Demobilization, site rehabilitation, clean up mitigation in accordance with national and local regulations of all environment impacts form construction, and disposal of excess materials and debris.

The descriptions given in the document are outline descriptions only. Such descriptions do not include or give full details of all materials or other items to be supplied or all works and services to be executed by the Contractor in order to fulfill its obligations under the Contract.

9.5 Construction of the permanent works

General

The Permanent Works to be performed by the Contractor are described below;

1.5.1. Met Instrumentation Tower (To be confirmed based on EPC contractor's proposal)

Contractor to review site data and spell out what met parameters like ambient temp, wind speed / direction, quality of atmosphere air, rain, fog etc are to be measured, recorded and be used in plant operation and maintenance besides controlling exhaust and emission limits etc.
Met tower be installed a suitable height Met Tower at a suitable site spot and data be transmitted preferably in the most simple way so to remain ease of maintenance and not to run top time and again.
Met Tower Data acquisition shall be a part of main CR / DCS as best suited and integrated in plant control systems. Contractor is encouraged to spend few days at site and table the best proposal for approval of owner engineer.

Proposed - Power House at Different floor levels:

The ground floor shall have the following facilities:
Turbine hall, Tank Farm Area, Fuel Handling,
PECC / PLC/SCADA control room,
Transformer , switchgear and sub station rooms,
Electrical Distribution Rooms,
FOTP, Stand Alone Skids, WTP, Water Tanks, CEMS, FFS, Water Wash, Cooling Systems, Ventilation and HVAC systems, Waste / Sludge Handling, Incinerator, Inlet Air Filters, Inlet and Exhaust, Stack, Systems, Workshops,
Panel rooms,
Lockers area, Toilets, separate for Ladies and Gents

The first floor shall have the following facilities Office / Conference room, Prayer Hall, Kitchen,
Control room, PA, CCTV, BMS and Security Controls.
Battery room, Store room, IT, Simulator Room,
Library, Fuel Management System,
Toilets, Separate for Ladies & Gents.

Main Features of Plant Construction,

(1) R.C.C columns shall be fair face finish and provided with corbel for gentry crane.

(2) R.C.C floor / slab with openings for lowering the equipment etc. shall have removable covers of aluminum alloy checquered plate of non-slip pattern min. 4.5 mm thick.

(3) Cable trenches / pits shall have fair face finish and provided with aluminum alloy checquered plate steel plate covers/flooring of non-slip pattern. The plate shall be minimum 4.5 mm thick.

(4) The height of the building shall be enough to accommodate the designed GTGs, Inlet, Exhaust with 15 feet clearance on top to accommodate exhaust, louvers, vent units, sun light windows, building lights, over head pipes, cable Trays, cameras, Fire Detectors, Fire

Fighting outlets, ducts and overhead crane.

(5) Finish to the exterior surface of the building shall be as detailed under relevant clauses & as directed by the Engineer.

(6) Plinth protection shall be provided around the building with a semi circular cement concrete lined drain.

(7) Sun – shades shall be provided to the Windows and Ventilators to match external architecture.

(8) Windows and ventilators shall be provided with galvanized steel wire mesh of 20 mm square.

(9) Windows be of Industrial grade aluminum and shall be tilt opening type.

(10) Doors and Windows in the office will be of Industrial grade aluminum and be provided with double glazing unbreakable glass.

(11) Windows in the Turbine hall shall be provided with mechanism for opening / Closing.

(12) Proper sewerage and drainage arrangements from the building shall be provided. HDPE -100 Pipe shall be used.

(13) Plumbing works shall be complete using HDPE-100 pipe and fixtures of the best quality . Pipe Fittings be PVC coated, Industrial grade threads, non corrosive, non rustable materials – subject to owner's engineer approval.

9.6 Plant at Basement level

The basement shall be an R.C.C structure having fair face finish. The design shall conform to the standard codes and requirement as given out under the relevant clauses for the intended use.

Basement level to accommodate ware house, labs, Fuel Management System (partly), Vaults, Key management system, access Control, Biometric Access Control, security, Health & Safety Control, Drawings, Drafting, Autocad, Blue Printing, Chemical Storage, Cylinder Room, Waste Handling Management, External Phones / Local Exchange Rooms, Truck Bay, Auto Workshop, Car Wash, CMMS, Call Up Card, Work Permit. All these will be computerized, internet sported or house net communicated for fast / tracked movement. etc.

9.7 Blank

9.8 Sub-station

The building shall be as per approved drawing of typical WAPDA Substation .

9.9 Site drainage

Site drainage shall be properly designed and provided with HDPE-100 or suitable drainage pipes, road crossings and precast covers wherever required. Details be submitted for employers approval.

9.10 External sewerage

External sewerage shall be designed and provided with HDPE -100 or suitable pipes and C.C manholes of standard size into R.C.C septic tank and soak away as required. Details be submitted for employers approval.

9.11 Access road and parking areas:

Existing road / walkways where dismantled shall be restored to its original condition. New roads and parking areas shall be made in cement concrete and should be of adequate dimensions. Cross drainage structures shall be RCC type & to be provided at suitable location along the alignment and elsewhere deemed necessary.

Site approach road shall have speed breakers to allow max 60 KPH. Security Staff and visitors car park will be outside the plant main entrance. Main entrance shall have security / reception / Fire Brigade building. Free access to plant main entrance will be blocked by road blockers and access will be only through biometric entry control meant for material vehicles. Personnel entry / exit will be through 3 X rotating gates controlled biometrically. Plant premises located buildings will also have access control biometrically as decided by the employer.

Plant boundary / peripheral wall , internal , external roads will have pole mounted lights / security cameras.

9.12 Site development:

Site development around the power house and ancillary structure including culverts, leveling, grading, landscaping and grass & shrubs areas shall be minimum 2000 sq. meters as per approval of the Employer.

9.13 Provision of camp and office facilities

General

Provision of Office and Camp facilities shall be made by the Contractor. The Contractor shall design, install, operate, provide all consumable items, spares, replacements and fuel and shall maintain throughout the execution of the work office facilities required for the Works.

9.14 Temporary site installations

The Contractor shall design, install and maintain throughout the execution of the Works all temporary facilities required for the work.

On completion of the Project, the Contractor shall remove all temporary facilities, including their foundations that are not handed over to the Employer, and restore the area.

9.15 Temporary facilities to be handed over to the Employer

At the expiry of time of completion, selected temporary facilities or part of it, if and as described in Employer’s Requirements, shall be handed over to the Employer in good, and serviceable conditions, so that these can be utilized by the Employer without any further treatment, renovation or repair.

9.16 Power and water supply for construction

The Contractor shall be responsible for the design and provision of temporary power supply for site during construction of the works.

The Contractor shall be responsible for the supply of potable water as well as disposal and treatment of wastewater and reuse. If water is supplied by the Employer, the cost thereof shall be deducted from contractor bills at the rate fixed by the Employer and which will be the commercial tariff.

9.17 Health and Safety

The Contractor shall be under an obligation to take all reasonable safety measures in relation to the type of services undertaken and shall conduct itself and all personnel assigned to the Work and perform the Work in such a way as to comply at all times with its obligation and duties under laws, regulation, rules, order and other enactments in force from time to time relating to health and safety matters, including the Employer's safety requirements. EHS shall be a well established computerized system that owner will adopt to monitor the employs health record and plan.

9.18 Quality assurance / quality control

The Contractor will instigate a QA/QC programmed in accordance with the relevant Clause of the EPC Contract and section 2 of this volume.

9.19 Environmental Compliance

Reference is made to the environmental requirements given in:

a. The law and Regulation of Government of Pakistan arid Government of Sindh.

b. Employer's Requirements for Environmental Protection given in this Volume.

c. Sub-Clauses 4.18 [Protection of environment], 4.22 [Security of the Site], 4.23 [Contractors Operation at Site], 4.24 [Fossils], 6.6 [facilities for staff and Labour], 6.7 [Health and Safety], 7.3 [Inspection], 14.5 [Plant and Material Intended for the Works], 16.3 [Cessation of Work and Removal of Contractor Equipment] of General Condition of Contract and any other clause or sub-clause having any relevance to Environment.

d. **Local traditions and customs of Sindh.**

e. The Contractor shall within one month of receipt of Notice to Proceed, appoint an Environmental Inspector for the Works, whose broad responsibilities are to guide the construction personnel on environmental matters, to communicate and to make liaison with the Employer, Government of Sindh and local elders.

f. The Contractor shall provide Environment Management Plan of the Site as defined in this Volume.

9.20 Training Programme

The Contractor shall provide a training program in operation and maintenance for the Employer's O&M personnel generally to meet the requirements stated in Volume II of Bid Documents.

9.21 Setting out of works

Setting out data such as BENCH MARK, DATUMS and original setting out points shall be provided by the Employer.

EMPLOYER'S REQUIRMENT
FOR
CIVIL WORKS

CHAPTER 10
CIVIL WORKS - EMPLOYER'S REQUIREMENTS

CHAPTER 10
CIVIL WORKS - EMPLOYER'S REQUIREMENTS

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CHAPTER 10
CIVIL WORKS - EMPLOYER'S REQUIREMENTS

10.1 Scope of Work

General introduction

This section lays out the requirements of the Employer regarding the Civil Works for the project. The final arrangement of the works shall be developed and construction by the Contractor to best exploit the local physical conditions while maintaining the fitness for purpose inherent in the outline requirements. Nonetheless contractor is responsible to substantiate these requirements to ensure complete functional performance of Pumping Station and Fulfillment of his obligations under this Contract.

The Employer's Requirements have been prepared in consideration of the Conditions of Contract for EPC/ Turnkey Project.

10.2 Contractor's responsibilities

The Contractor shall perform or cause to be performed all works and services necessary for the design, engineering, procurement, construction start-up demonstration and testing of the Works, and remedying of defects in the Works. The Contractor shall provide all materials and equipment, machinery, tools, labour, transportation, administration and other services and items required to complete the Works on a turnkey basis and otherwise in accordance with the Contract (defined as the "Services").

The Contractor shall perform for the Services and other work hereunder in accordance with Good Industrial Practices, all applicable laws, sound engineering and construction practices, and the safety precautions. Each part of the Works shall be designed and constructed by the Contractor so as to be fit for use for their respective purposes and when completed the works shall be fit for the purposes for which the Works are intended.

The parameters and criteria for the design specified herein shall be used to develop a series of design briefs, tender drawings, data and construction specifications to be submitted by the Contractor. These memoranda, drawings, data and specifications shall be developed from information provided by the Employer, additional studies and field investigations carried out by the bidder and other requirements of these contract documents. The Contractor shall be responsible for ascertaining the validity of all informations made available by the Employer. The detailed design shall be performed by the Contractor based upon the basic design criteria stated herein, the design memoranda submitted with this bid, and additional design memoranda and design analyses as necessary to complete the design of the works. The referred documents, design parameters, loads and similar items given herein are to be considered minimum standards to which the works are to be designed. The contractor shall use a more conservative approach to the design where in his professional judgment as appropriate.

Temporary works shall be designed to be safe, reliable, adequate for all loads and uses, and where they are to be incorporated into the permanent works, temporary works shall be designed in strict compliance with the criteria adopted for permanent works.

Without limiting the foregoing, the Services shall include those described in the following Sub-sections.

10.3 Engineering and design

The Contractor shall provide all engineering and design services necessary for completion of the Works in conformity with the Contract, including but not limited to site investigations and research, conceptual design engineering and design necessary to describe and detail the Works, provision of criteria for the detailed design by suppliers of equipment, material and systems for incorporation into the Works, and preparation of drawings, plans, bills of materials, schedules and estimates. The Contractor shall review and be fully responsible for and will co-ordinate and integrate engineering and design services provided in relation to the Works by Sub-Contractors and suppliers.

The Contractor shall be solely responsible for the interpretation of the data contained in the Employer's various Preliminary Design Documents.

10.4 Basic design criteria and applicable codes

The design of all structures shall be carried out preferably based on BS Standards and Codes of Practice. The design standards adopted should, as far as possible, be from a single authority and be available in the language of the Contract.

Structure shall be designed and constructed in accordance with latest issues of following British Codes of Practice and Specifications:

a. ACI & BS 8110: The structural use of reinforced concrete
b. BS 8007 : The structural use of reinforced concrete
c. CP 114.0 : The structural use of reinforced concrete
d. CP 3 : Code of basic data for design of buildings Chapter-V Loading, Chapter-IX Durability

The analyses shall determine the critical load case for each structure and structural member, verify the structural member verify the stability of each structure and calculate the critical loads to be borne by each of the member within the structure. The design shall size each structure and structural member to safety and economically to carry the required load using the prescribed materials.

The allowable stresses for concrete and steel shall be in accordance with accepted international and local codes and standards.
Seismic Factor: Seismic design and detailing shall be applicable in design of all structures as per criteria prevailing in the project region and as published by Sindh Building Control Authority.

All building such as office block, Power House, FOTP, Tank Farm Area, Met Tower, H.T. Panel room, switch room, Power sub-station etc. and the like shall have RCC foundations and RCC construction with RCC framed structure, cement concrete Block Walls, etc. complete.

Depending on soil investigation or if during construction of foundation works of buildings and structures any soft soil or treacherous soil is encountered, foundation design shall be carried out to demonstrate the safety / stability of structure with adequate factors of safety.

Any variation on this account shall be deemed to be included in the contract price.

The design of civil works shall at least meet the following requirements.

a. The structures shall remain stable during and after construction with appropriate factors of safety under all probable loads and load combinations.
b. Factor of buoyancy shall also be considered for all water retaining structures.
c. All water, chemical, liquid fuel retaining structures shall be leak proof and water tight.
d. Internal stresses shall not exceed recognized limits.
e. Foundation materials shall not be overstressed.
f. Properly designed expansion and construction joints with suitable water stops and anchored covering shall be provided.
g. Basement structure shall be water proof (from subsoil water)

The Contactor shall be responsible for safety and stability of the structure and water tightness of the water retaining structures.

10.4.1 Design load & load combinations

All building structure shall be designed for the loads to which they will be subjected.

a. Dead load
b. Live load
c. Impact or dynamic effect of the live load
d. Wind load
e. Horizontal forces due to water current

f. Earth Pressure
g. Earth quake stresses

Compliance to authorities

In addition to the basic design criteria, the design shall also conform to the requirement of all relevant local, provincial and federal authorities where approval for that section of works is needed from the relevant authorities.

Mix design of concrete

Method of concrete mix design of strength requirement adopted for the design shall be specified by the contractor.

10.5 Units of measurement

All units of measurement shall be SI (Kg m.) units.

10.6 Economic life of works

The design of civil works shall be based on useful economic life of 50 years.

10.7 Bid submissions

Design brief

a. General

Clause 7.1 of Material & Workmanship defines the scope of work. The Employer requires that each bidder be prepared to define in detail, the elements of his offer during the tendering process. This shall be done through a design brief covering all elements to be designed by Contractor. Through this brief the contractor shall provide evidence that consideration has been given to all other items. The design brief is to be supported by drawings and are intended to represent the type and quality of information required to evaluate the bids and to highlight;

(1) Design parameters and methodology
(2) Design criteria of the project and its components parts.

Construction Specifications

All designs, equipment materials and construction methodology not completely detailed in referenced or proposed documents or design criteria shall conform to acceptable industrial practice. During the evaluation period, the Employer may request to submit Construction Specifications for the purpose of clarifying and defining the bid. The format of the Specifications shall be as follows:

a. General
b. Detail Description
c. Related Works
d. Reference Specifications

e. Submittals
f. Design Requirements

Contractor staff qualification

All staff must be proficient in the English language.

The Project Manager, Project Design Manager, Quality Assurance Manager and Project Design Engineer should be graduates of recognized colleges.

The Bidders shall submit with their Bids the name of the nominees for each of the designated positions together with detailed resumes of their experience and qualifications.

10.8 Detailed design submission

Design Programme

The Contractor shall submit to the Employer a Design Programme showing the order and procedure in which he proposes to carry out the Design and Engineering services with a schedule of submission of design documents and drawings for completing the Works within 28 days after the “Notice to Commence”, and also to match with the Work Programme (Sub-Clause 8.3 of the Conditions of Contract). Such Design Programme shall be subject to review and revision by the Contractor in Consultation with the Employer in order to achieve completion of the Works within the time for completion.

The number of copies of the report and other documents to be submitted to the Employer by the Contractor is specified in Sub-Clause 2.8.

Detailed design submission

The Contractor shall carry out structural analysis of the structures and its foundations to confirm the stability under site specific seismic loads.

Detailed reinforcement drawings and bar bending schedules shall be prepared for all concrete structures. Where the structural design for earthquake loading relies in ductile behavior of structural elements then anchorage, splicing of bars and shear provision shall comply with current earthquake detailing practice.

The design works shall cover determining the site & sub soil water reactive conditions relevant for long term operational efficiency and safety in the approach to through all water conveyance elements.

Within 2 (two) months of commencement date and prior to beginning any construction work, the Contractor shall submit to Employer for consent a Detailed Project Report (DPR). The DPR shall define all finished structural dimensions and / or performance characteristic of all elements of the project except those dependent on subsurface geotechnical conditions. Geotechnical investigation report is enclosed. The bidder however shall ensure that the estimates are based on the Contractor's own confirmatory investigations and / or interpretations. The results and interpretations of the geotechnical investigations shall be presented in the DPR.

The DPR should include at least the following:

- **a.** The result and interpretations of the geotechnical investigations (including construction materials.)
- **b.** The results and interpretations of the hydrological investigations.
- **c.** The results and interpretations of topographic surveys.
- **d.** The geotechnical, sub soil and structural design including design standards, criteria and calculations.
- **e.** Drawings to a detail sufficient to show all significant structural and plant features.
- **f.** Justifications supported by calculations and drawings.
- **g.** Details of specifications to be adopted.
- **h.** Quality Control plan for construction stage.

Drawings & documents

As part of the Design Documentation, the Contractor shall provide a complete and clear set of stability check calculations, specifications and drawings of all construction works, service utilities, and materials as well as of his temporary works design.

The Contractor shall successively submit structural design, documents and drawings for the review, comment and consent of the Employers in accordance with the schedule of submission of design documents and drawings in the Contractor's Work Programme as stipulated in above. The Employer shall give his consent / Comments on all design and drawings referred to him within 15 days for submissions prepared by the Contractor and submitted to the Employer at Site, and 28 days of the date of receipt in the Employer main design office for submissions prepared by the Contractor and reviewed by the Employer from the main design offices.

Submission Drawings

The details of drawings / documents which will be submitted for the Employer review and consent or for information are as below:

(1) Detailed technical specifications wherever necessary.
(2) General arrangement and layout drawings.
(3) Concrete outline drawings.
(4) Assembly drawings.
(5) Foundation design and treatment drawings.
(6) General reinforcement arrangement for structures.

The drawings in the following category will be submitted only for information and record of the Employer:

a. Detailed Reinforcement drawings.

b. Design Calculations.
c. Sub-assembly Drawings.

In case of consent of a submission of drawings / documents by the Employer, one set of drawings / documents will be returned to the Contractor within the stipulated review period, marked “Consented”.

In case the drawings / documents are accepted in principal, but minor comments are made, the drawings / documents will be marked “consented with comments” and the comments shall be explained in a covering letter and / or clearly marked in the drawings / documents, which will be returned to the Contractor within the stipulated review period. Further design construction shall proceed, considering the comments. Amended drawings / documents will be submitted after completion of the works.

In case of substantial disagreement with the drawings / documents, these will be marked “returned for review” and will be returned to the Contractor within the stipulated review period with the reasons for disagreement spelt out in detail in the covering letter. Technical discussions shall, if required, be held thereafter without delay to address the concerns of the Employer. The drawings / documents will be reviewed, appropriately revised and resubmitted for information with the response, explanation or action to the comments of the Employer.

Approved drawings

In case consent or comments of the Employer have not been communicated within the stipulated review period then the drawings shall be deemed to have been consented to and the Contractor can then act on them and shall inform the Employer accordingly.

The Contractor shall furnish to the Employer the following number of copies of approved drawings, reports and other technical documents:

a. One transparent copy and 3 paper copies of drawings, which are submitted for information only.
b. One transparent copy, three paper copies A1 size and three paper copies of minimum A-3 size of drawings, which are submitted for consent. One paper copy shall be returned to the Contractor with consent or comments.
c. Consent drawings in sets of two transparent copies and ten paper copies of minimum A-3 size.
d. As-built drawings in sets of one transparent copy, and ten paper copies of minimum A-3 size.
e. Report and other documents in five copies and approved manual in ten copies for Employer’s reference and records.
f. Progress reports in five copies.

Amendment / revision of drawings

No comment, amendment or revision to a report or design or its redesign made or requested by the Employer which is for reasons caused by an error or mistake by the Contractor or is deemed necessary for the proper fulfillment of the Scope of the Works defined in the Contract shall not be grounds for additional time or payment. Any request of the Employer that can be shown to be a requirement outside of the scope of the Works of the Contractor shall be notified as such by the Contractor and the Employer will decide whether such additional work will be required. If outside the scope of the works and required by the Owner this shall imply that such additional works shall constitute a Variation.

Defect

If either the Contractor or the Employer become aware of an error or defect of a technical nature in a document which was prepared for use in executing the Works, which has any effect on the execution of the Works and needs to be clarified, prompt notice shall be given to the other party of such error or defect, if errors are found in the documents produced by the Contractor, the documents and the Works shall be corrected at the Contractor's cost, not-withstanding any consent by the Employer.

The Contractor is responsible to liaise and co-ordinate his design with that of the different disciplines and subcontractors / suppliers, including incorporating the interface requirements,

Consent or approval

Consent or approval of the Employer to any or all of Contractor's documents, programme, schedules, designs and drawings etc. shall not relieve the Contractor of design and construction responsibilities / liability or obligations to complete and commission the Works as per provisions of the Contract.

10.9 Construction and construction management

The contractor shall manage and carry out the construction of the works and ensure the expeditious construction thereof in accordance with the terms and provisions of the Contract. The Contractor shall inspect or cause to be inspected all material and equipment to be incorporated in the Works and shall reject those items determined to be not in compliance with the Contract.

The Contractor shall establish and maintain works management control systems and provide construction management services in accordance with the requirements of the Contract and otherwise necessary for the achievement of the Contractor's obligations under the Contract.

The Contractor will co-ordinate and integrate the construction of the Works including those performed at interfaces between the engineering disciplines responsible for the construction services provided by him and the construction work carried by Subcontractors.

10.10 Procurement

The contractor shall procure and pay for, in the Contractor's name as an independent contractor and not as agent for Employer, all the Contractor and Subcontractor labour, materials, equipment, supplies, manufacturing and related services (whether on or off the site) for construction of an incorporation into the Works which are required for completion of the works in accordance with the Contract. The Contractor warrants that all such items shall be new and of the quality, reliability and performance, where no express requirements are set out in the Contract, of a quality reliability and performance consistent with best engineering practices.

10.11 Standards of design and works

All the design and construction of all permanent works shall comply with codes referred in the Contract.

The works shall be executed in a neat, controlled and workmanlike manner, shall be designed to the codes referred in the Contract for the class of duly specified. All materials shall be of good quality and approved by Employer. The specified service life is 50 years for Civil Works.

10.12 Testing

All materials, related to or intended for incorporation in the works shall be, while in the process of procurement subjected to such tests and inspections as may be necessary, to prove compliance with the requirements of the Contract Documents.

Acceptance of pertinent test certificates, or waiving of inspections and tests, shall in no way relieve the contractor of his contractual obligations for furnishing the works in accordance with the provisions of the Contract.

The contractor shall upon reasonable notice, grant the Employer, at all time, free access to the factories and workshops, both local and overseas and afford full facilities for unrestricted inspection and witnessing of assembly and tests and shall furnish him with such information as may be required.

10.13 Design control

The Contractor's design shall be checked and consented by the Employer. The verification procedure shall establish that the design meets the Employer's Requirements, the applicable standards and best Engineering practices.

Design verification may require qualification tests of components or assemblies. Qualification tests shall provide testing under the most adverse design conditions for the features being verified or enable results to be extrapolated to such condition. Procedures for such testing shall be prepared by the Contractor and agreed with the Employer prior to testing.

10.14 Contractor’s tests

The Contractor shall provide the services of competent Engineering staff to test all items of Material and Plant in a safe and efficient manner.

The Contractor shall establish, along with his detailed design, procedures for testing of all Materials and Equipment in accordance with specified standards and shall promptly produce certificates of such testing including all test certificates for proprietary materials. Testing procedures shall be in accordance with those give in the General Conditions.

At site the Contractor shall set up a laboratory for testing of construction materials. The tasks, which cannot be performed at the site laboratory, will be done by the Contractor at other laboratories approved by the Employer.

The participation of the Employer or his Representative in any inspection and test activity will not relieve the Contractor of his responsibility for ensuring that the requirements of the specifications are met.

10.15 General description of Civil Works (scope of work)

The principal elements of the Civil Works are:

a. Provision of Materials;

b. Provision of Services;

c. Provision of Temporary Works;

d. Construction of Permanent Works;

e. Demobilization, site rehabilitation, clean up mitigation in accordance with national and local regulations of all environment impacts form construction, and disposal of excess materials and debris.

The descriptions given in the document are outline descriptions only. Such descriptions do not include or give full details of all materials or other items to be supplied or all works and services to be executed by the Contractor in order to fulfill its obligations under the Contract.

10.16 Construction of the permanent works

10.17 General

The Permanent Works to be performed by the Contractor are described below;

10.18 Fuel Inlet Piping, FOTP, Tank Farm Area Foundation works

These works shall be R.C.C structure having fair face finish. The design shall conform to the standard codes and requirements as given out under the relevant items.

10.19 Power House at Ground floor level:

(i) The ground floor shall mainly have the following facilities:

1. Turbine hall,
2. Tank Farm Area,
3. Fuel Handling,
4. PECC / PLC/SCADA / control room.
5. Transformer , switchgear and sub station rooms,
6. Electrical Distribution Rooms,
7. FOTP,
8. Stand Alone Skids,
9. WTP, Water Tanks,
10. CEMS, FFS, Water Wash,
11. Cooling Systems,
12. Ventilation and HVAC systems,
13. Waste / Sludge Handling,
14. Incinerator,
15. Inlet Air Filters, Inlet and Exhaust,
16. Stack,Systems,
17. Workshops,
18. Panel Rooms
19. Toilets, Separate for Ladies and Gents
20. In Plant Training
21. Janitors Room
22. Met Instrumentation Tower

a. The first floor shall have the following facilities

(1) Office / Conference room
(2) Kitchen
(3) Control room
(4) Battery room
(5) Store room

(6) Prayer Hall,
(7) PA, CCTV, BMS and Security Controls.
(8) Solar Systems,
(9) IT Support,
(10) Plant Simulator Room,
(11) Library,

(12) Fuel Management System,
(13) Toilets, Separate for Ladies & Gents + Janitors Room
(14) LOTO and Plant Tagging System

Construction work shall not limited to but shall have following main features as a minimum, R.C.C columns shall be fair face finish and provided with corbel for gentry crane.

1. R.C.C floor / slab with openings for lowering the pumps etc. shall have removable covers of aluminum alloy checquered plate of non-slip pattern min. 4.5 mm thick.

2. Cable trenches / pits shall have fair face finish and provided with aluminum alloy checquered plate steel plate covers/flooring of non-slip pattern. The plate shall be minimum 4.5 mm thick.

3. The height of the building shall be enough to accommodate the designed GTGs and 20 ft clear height to accommodate piping, cabling, ducting, FFS, Cameras, HVAC, Ventilators, blowers and overhead crane.

4. Finish to the exterior surface of the building shall be as detailed under relevant clauses & as directed by the Engineer.

5. Plinth protection shall be provided around the building with a semi circular cement concrete lined drain.

6. Sun – shades shall be provided to the Windows and Ventilators to match external architecture.
7. Windows and ventilators shall be provided with galvanized steel wire mesh of 20 mm square.

8. Windows shall be Industrial Aluminum grade, non-breakable double glazed glass and tilt opening type.

9 Doors and Windows in the office will be of Industrial Aluminium Grade, provided with double glazing non breakable glass.

8. Windows in the motor hall shall be provided with mechanism for opening and closing.
9. Proper sewerage and drainage arrangements from the building shall be provided. HDPE -100, non corrosive, leak proof threads , PVC coated Pipe shall be used.

10. Plumbing works shall be complete using HDPE-100 pipe and fixtures of the best quality, non corrosive, leak proof industrial grade PVS coated type.

10.21. basement level

The basement shall be an R.C.C structure having fair face finish. The design shall conform to the standard codes and requirement as given out under the relevant clauses for the intended use.
Basement level to accommodate ware house, labs, Fuel Management System (partly), Vaults, Key management system, access Control, Biometric Access Control, security, Health & Safety Control, Drawings, Drafting, Autocad, Blue Printing, Chemical Storage, Cylinder Room, Waste Handling Management, External Phones / Local Exchange Rooms, Truck Bay, Auto Workshop, Car Wash, CMMS, Call Up Card, Work Permit. All these will be computerized, internet sported or house net communicated for fast / tracked movement. etc.

10.20 Blank.

10.21 sub-station:

The building shall be as per typical WAPDA approved type .

10.22 External site drainage:

Site drainage shall be properly designed and provided with HDPE-100 drainage pipes road crossings and precast covers wherever required.

10.23 External sewerage

External sewerage shall be designed and provided with HDPE -100 pipes and C.C manholes of standard size into R.C.C septic tank and soak away as required.

10.24 Access road and parking areas:

Existing road / walkways where dismantled shall be restored to its original condition. New roads and parking areas shall be made in cement concrete and should be of adequate dimensions. Cross drainage structures shall be RCC type & to be provided at suitable location along the alignment and elsewhere deemed necessary.

Site approach road shall have speed breakers to allow max 60 KPH. Security Staff and visitors car park will be outside the plant main entrance. Main entrance shall have security / reception / Fire Brigade building. Free access to plant main entrance will be blocked by road blockers and access will be only through biometric entry control meant for material vehicles. Personnel entry / exit will be through 3 X rotating gates controlled biometrically. Plant premises located buildings will also have access control biometrically as decided by the employer.
Plant boundary / peripheral wall , internal , external roads will have pole mounted lights / security cameras.

10.25 Site development:

Site development around the power house and ancillary structure including culverts, leveling, grading, landscaping and grass & shrubs areas shall be minimum 2000 sq. meters as per approval of the Employer.

10.26 Civil Works Requirements (General)

10.27 Excavation

This section covers excavation both surface and underground, required for the foundation of structures, the extraction of material for borrow areas and underground excavation works, in soil rock, including loading, transportation and disposing for all parts of the works.
Disposal of material is classified either to be transferred for further processing and subsequent as for concrete aggregates, to construct embankments and roadfills, disposal of surplus and / or unsuitable materials in permanent deposits.

The Contractor's excavation equipment shall be of recent type and shall be provided and kept in good operating condition.

10.28 Clearing Site

The Contractor shall clear the ground on which the works are to be erected, by removing trees and roots, bushes, grass and other superficial obstructions. The material cleared shall be disposed off by the Contractor by controlled burning or in some other approved manner.

The Contractor shall clear the ground on which the works are to be erected, by removing trees and roots, bushes, grass and other superficial obstructions. The material cleared shall be disposed off by the Contractor by controlled burning or in some other approved manner.

10.29 Exploration of Borrow Areas and Quarries

Borrow or quarry material shall be obtained from the areas designated by the Contractor in his design investigations. Borrow areas and quarries shall be exploited only in so far as the suitable materials cannot be obtained from required excavations.

All negotiations with the owners of property outside the right of way (RoW) provided by the Employer to the Contractor on which any borrow or quarry pit will be situated, and obtaining the relevant licenses for exploiting such areas will be undertaken by the Contractor. The contractor will also obtain licenses, if required for exploiting the RoW for stone, gravel, sand and other materials.

The Contractor shall carry out sufficient tests on the material being excavated from borrow or quarry pit in order to satisfy the specified requirements for the particular purpose for which it is to be used.

If there is any doubt concerning the quality of borrows or quarry material being excavated at any time the Contractor shall notify the

Employer immediately, and in any case before such material is processed. The results of all tests carried out by the Contractor shall be submitted to the Employer at timely intervals.

On completion of borrow operations remaining final slopes shall be prepared to be kept in stable conditions as consented by the Employer.

10.30 Excavation in Soil

The excavations may be widened and flattened beyond the lines and levels shown on the Contractors drawings as necessary to ensure the stability of the slopes associated with the excavation. Where the excavation is for a structure, the nominal excavation profile will allow space for the placing and bracing of formwork.

10.31 Shoring of Existing Structures

The area (site) of construction generally lies in open land, with existing structure / water supply line, etc. The Contractor / Bidder shall shore up the structures / water supply lines the stability of which is liable to be endangered by the execution of the work. The Contractor shall be fully responsible for all damages to persons or properties resulting from any accident to structures / water supply lines etc.

10.32 Slips, fall and Excess Excavation

The Contractor shall prevent slips and falls of material from the sides of the excavation and embankments.

In the event of slips or falls occurring in the excavations, and where excavations are made in excess of the dimensions of the permanent works, the voids so formed shall be filled by the Contractor. When such voids, in the opinion of the Employer, may affect the stability of the ground for the support of the works, or of the adjacent structures and services, the Contractor shall fill the void soil with concrete 10 / 20. In other cases the Contractor shall fill the voids with selected excavated material placed and compacted to the approval of the Employer. This shall be at no extra cost to the Employer.

Particular care shall be exercised by the contractor to ensure that over excavation beyond specified levels is not carried out. In case of over excavation the volume excavated shall be replaced by Concrete of class 10 / 20 at his cost. Filling of voids due to over excavation shall be in accordance with relevant Para hereof.

10.33 Dewatering

The Contractor shall keep each structure and pipeline excavation clear of water during construction and, in the case of structures being constructed in saline groundwater for such further period as may be necessary to avoid the submersion of concrete within 3 days of it being placed. The method of keeping excavation clear of water, dewatering, and disposal of water shall be subject to the approval of the Employer. The Contractor shall ensure that sufficient standby plant is on Site at all times to avoid any interruption or discontinuity of the dewatering process.

In vicinity of the existing conduit and other structures, dewatering shall be carried out by establishing control points, lowering of the groundwater level to below the required excavation level and maintaining the same till concrete is cast and minimum 3 days old.

Sump well points for dewatering shall be located at safe distance from the foundation of the existing conduit to avoid any settlement or other damage to the same.

The contractor shall submit his dewatering plan with details of equipment, for approval of the Employer minimum 28 days in advance of excavation.

10.34 Excavation of Foundation

Use of jack hammers and vibratory tools in proximity of the existing structure shall not be allowed. No blasting is permitted within the limits of site. The vertical sides of all excavations shall be excavated to the specified excavation limits.

Excavated surfaces which will remain permanently exposed on completion of the Works shall be cleared of all loose material, pieces of rock, debris, rubbish and shall be left neat and tidy.

10.35 Disposal of Surplus Material

Surplus excavation material shall be disposed off in the areas as directed by the Employer.

10.36 Preparation of Foundations

After an area has been excavated and cleared the Contractor shall clean, the foundations surface so that the foundation surface can be inspected by Employer for any faults, cracks, and other defects in the rock if encountered.

When any excavated surface is ready for concreting the Contractor shall request the Employer for inspection via RFI system and formal approval to proceed the next step.. No foundation will be covered before this consent has been given.

10.37 Concrete and Reinforcement

This Clause specifies basic and minimum standards for materials and workmanship for preparing, transporting, placing, compacting, and finishing of concrete.

Concrete shall be composed of SR cement, potable, chloride and nitrate free water, water, fine and coarse dirt free / washed aggregate and no admixtures to prolong concrete set timing, rather concrete be

mixed at site and must be placed within 15-30 minutes after mix and must use vibrator for few seconds in entire area while placing concrete. Segregation be avoided and curing of concrete must started after 1-2 hrs after placing - using triple burlap layer and applying sufficient quantity of drinkable (chloride and nitrate free) water. Chemical curing is not allowed at this site.
The design of concrete mixtures shall be based upon securing a plastic, workable mixture suitable for the specific conditions of placement and, when properly cured, a product having durability, impermeability, and strength in accordance with all the requirements of the structures.
In case concrete is mixed at a batching plant, batching plant ticket be presented before placing the batch.
Looking on site conditions, concrete must be mixed placed before sunrise and if required, cold or ice water be mixed to increase the setting time.

The Contractor shall submit for review all detailed concrete mix designs complete with mix proportions, slump, gradations, specific gravities, absorption, unit weights, compressive strength at all specified ages, water cement ratio, slump, air content, air temperature at the time of mixing and placing temperature of the concrete.

10.38 Materials

a. Cement

Cement for concrete mortar and grout shall be Sulphate Resistant Cement and shall conform to the standards specified in the Contractors design. Cement shall be free from lumps, ungrounded clinker, and other foreign materials.

Transportation of cement to the batching plant shall be accomplished in adequately designed weather tight trucks or other means which will protect the cement completely from exposure to moisture.

Cement shall be stored separately of other aggregates. The amount of cement stored shall meet the requirement for at least 20 days of concrete placement. Immediately upon receipt at the Site of the Works, cement shall be stored in a dry weather tight and properly ventilated structure with adequate provisions for the prevention of absorption of moisture.

b. Admixtures

Admixtures, only if approved by owner engineer for any specific reason and that should be in writing, shall be delivered to site in suitably labeled containers and stored and used in accordance with the manufacturer’s specifications and recommendations.

c. Water

The water used for making and curing concrete shall generally be of drinking water quality and shall be from a source approved by the

Employer and at the time of use shall be free from polluting matter in any quantity and shall not have the following characteristics:

(1) Pollutants affecting the initial setting time of the cement by more than 30 minutes or reduces the compressive strength of test cubes by more than 20% when tested in accordance with BS 3148.

(2) Prevents the achievement of the specified test cube strengths at 28 days for the appropriate class of concrete.

(3) Produces discoloration or efflorescence on the surface of the hardened concrete.

(4) The water shall be free from hydrocarbons and from suspended organic matter. Inorganic matter in solution shall not exceed 500 mg/l by weight and in suspension shall not exceed 50 mg/l by weight.

The water must be chloride and nitrate free as much as possible, which the Contractor proposes shall be tested to the approval of the Employer before use in the permanent works.
Regular tests of the water shall be made during construction of the Works. The water shall be sampled at the point of discharge into the mix and the frequency of sampling shall be as approved by the Employer. The Contractor shall supply two copies of each test result to Employer.

10.39 Aggregates

Aggregate shall consist of hard, tough durable, clean, and uncoated particles suitable to produce the required concrete grades and tested for alkali reaction.

The area of the deposit or quarry from which aggregates are to be produced shall be carefully cleared of trees, roots, brush, sod, soil, unsuitable material and other objectionable matter. Materials including stripping, removed from deposits or quarries within the project limits and not used in the Project shall be disposed of in a manner not to form unsightly places. The Contractor shall arrange the spoil area at his cost.

Fine Aggregate

Fine aggregate shall be well graded from fine to coarse and the gradation shall conform to the following requirements as delivered to the mixer:

Sieve Size	Percentage of total mass passing Sieve
9.5 mm	100
4.75 mm	95 – 100
2.46 mm	80 – 100
1.18 mm	50 – 85
0.60 mm	25 – 60
0.30 mm	10 – 30
0.15 mm	2 – 10
0.074 mm	0 – 8

Fine aggregate shall be stored and maintained in such a manner as to avoid the inclusion of any foreign materials in the concrete.

Storage of aggregates shall be such that it prevents segregation or contamination. Sufficient aggregates shall have been produced before the start of concrete operations to permit continuous placement of concrete.

Coarse Aggregate

Coarse aggregate shall be separated into nominal sizes.

The grading of the aggregate within the separated size groups as delivered to the mixer shall be as follows:

Nominal Size Range	Min. Percentage retained in sieve indicated
4.75 to 9.5	NA
9.5 to 19.0	25 on 16.0 mm
19.0 to 37.5	25 on 31.5 mm
37.5 to 75.0	25 on 63 mm

The particle shape of coarse aggregate shall be generally rounded or cubical.

Coarse aggregate storage piles shall be such that it avoids the inclusion of any foreign material in the concrete and prevents segregation and excessive breakage.

10.40 Batching and Mixing

a. Plant

The Contractor shall provide a modern and dependable batching and mixing plant. Dust control equipment on all batching plants and cement silos shall be provided or a drum type mixer if quantity of batch is small.

The equipment shall be capable of combining the concrete components into a uniform mixture within the time limit required for such operation and of discharging this mix without segregation.

b. Measuring

Cement shall be weighed separately on an individual scale. Water shall be weighed separately on an individual scale or may be measured by volume.

All other ingredients shall be measured by mass except admixtures which may be measured by mass or volume.

Standard test weights and other auxiliary equipment required for checking the operating performance of each scale or other measuring device from zero to full capacity of the scale or device shall be provided. Scale accuracy shall be within 1.0% of the scale capacity.

c. Mixing

The mixing plant may be located at or away from the aggregate and cement, batching plant. The mixing plant shall consist of batch type mixers. The mixing plant shall be equipped with suitable devices for obtaining representative sample from each mixer and delivering samples to a test area at ground level.

The mixing plant shall include a device for counting and automatically recording the number of batches mixed.

The batching and mixing plant shall have arrangements for reading wastage of any material or concrete that is improperly batched, mixed or held in the mixers too long.

d. Testing and inspection facilities

Facilities shall be provided by the Contractor at the Contractor's batching plant and mixing plant for concrete control testing. The facilities shall include a plant inspector's enclosure with desk and platforms for obtaining handling and testing samples of aggregates and plastic concrete.

e. Conveying

The method of transporting concrete from the batching plant to the position of placing shall be such that segregation does not occur.

f. Placing

No concrete shall be placed in any location until all transport and placing arrangements, formwork, installation of reinforcement and embedded parts and preparation of surfaces against which the concrete is to be placed have been prepared and checked in accordance with the Contractors control procedures.

Surfaces upon which concrete is to be placed shall be free from standing water mud debris, oil and loose or unsound fragments.

Concrete shall be worked readily into the corners and angles of the forms and around all reinforcement and embedded items without permitting the component concrete materials to segregate.

The Contractor shall provide equipment adequate for handling and placing concrete containing the maximum aggregate size and low slump concrete mixes.

Concrete shall be placed, in all cases, as nearly as practicable, directly in its final position and shall not be caused to flow such that the lateral movement will permit or cause segregation of the coarse aggregate, mortar, or water from the concrete mix.

Once placement of concrete has commenced in a location, placement shall not be interrupted by diverting the placing equipment to other locations.

All concrete that can be properly placed within specification requirements for slump and temperature, and can be properly consolidated without re-tempering, shall be classified as being placed within the time limit.

g. Concreting during Hot Weather

During the placing of concrete during hot weather the Contractor shall comply with the recommendations contained in the Manual of Concrete Practice Part 2 1989, "Hot Weather Concreting – American Concrete institute 3058 77". Looking on site condition, best practice would be to place concrete before sun rise and use as cold water as chilled or ice water.

h. Joint Spacing

The joint spacing including construction, control and contraction joints shall be as shown on the Drawings or as otherwise consented by the Employer.

i. Lift in Concrete

The maximum permissible depth of concrete placed in one lift or course shall be as shown on the Drawings for each structure or as otherwise consented by the Employer.

j. Consolidation of Concrete

Concrete shall be compacted with the aid of mechanical vibrating equipment and may be supplemented by hand spading, tamping and rodding as required and consented to by the Employer. Consolidation of concrete shall be by electric or pneumatic drive immersion type vibrators or form or surface vibrators of sufficient power and capacity to consolidate the concrete effectively and quickly.

The duration of vibration shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation.

k. Placing concrete in Conduit

Concrete in the conduit shall be placed by pumping or other non-pneumatic methods. If pumped, the end of the discharge line shall be kept well buried in the concrete during placing to assure complete filling, after the concrete has been built up to the crown. Special care shall be taken to force concrete into all irregularities and to completely fill the corners.

10.41 Construction Joint Treatment

Construction joint shall be clean and wet when covered with fresh concrete. Construction joint shall be prepared by cleaning with high pressure water blasting. The operation shall be continued until all loose or defective concrete and all surface skim of mortar, laitance, coatings, stains, debris, and other foreign materials are removed.

10.42 Water Stops

Water stops shall be installed as per BS8007 where required and in joints as shown on the Contractor's Drawings.

All Water Stops shall be installed so as to form a continuous watertight diaphragm in each joint. Adequate arrangement shall be made to support and completely protect the water stops during the progress of the work. Water Stops punctured or otherwise damaged shall be replaced or repaired.

Particular care shall be taken to ensure that concrete in the vicinity of water stops is adequately compacted whilst avoiding damage to the Water stop.

10.43 Forms

Forms shall be used wherever necessary, to confine the concrete and shape it to the required lines. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall be maintained rigidly in correct position. Forms shall be sufficiently tight to prevent loss of mortar from the concrete.

Forms for exposed surfaces or water passages shall be constructed so as to produce a uniform and consistent texture and pattern on the face of the concrete. The forms shall have Formica cladding.

The forms shall be constructed so that the structure components will be true to line and grade. The forms shall be checked before concreting to produce structures within specified tolerances. Tolerances shall be indicated, in the Contractors Drawings.

At the time concrete is placed in the forms, the surfaces of the forms shall be free from encrustation of mortar, grout, or other foreign materials that would contaminate the concrete or interfere with the finish of formed surfaces.

Before concrete is placed the surfaces of the forms shall be oiled with a commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces

Forms shall be removed carefully, so as to prevent damage to the concrete.

10.44 Curing and Protection

All concrete shall be moist cured for a period of not less than 14 consecutive days by an approved method or combination of methods applicable to local conditions. All equipment needed for adequate curing and protection of the concrete shall be available and ready to apply before actual concrete placing of each placement begins.

The Contractor shall protect all concrete against damage until final acceptance.

10.45 Finishes and Finishing

The class of finish shall be to suit the Contractors Design and shall be indicated on the Contractors Drawings.

Class F1: General for unexposed surfaces such as those against which backfill or further concrete will be placed. The surface shall be free from void and honeycombed areas.

Class F2: For surfaces permanently exposed to view but where the highest standard of finish is not required. Finish is intended to be left as struck. Minor blemishes and discoloration will be permitted.

Class F3: Formwork shall be lined with Formica or a material that produces a smooth finish of uniform texture and appearance. The lining material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes.

Class U1: The concrete surface shall be uniformly leveled and screeded to produce a plain even uniform surface to the profile shown on the, Construction Drawings. No further work shall be carried out to the surface unless it is used as the first stage.

Class U2: Floated Finish After the concrete has hardened sufficiently the Class U1 surface shall be floated by hand or machine sufficiently only to produce a uniform free from screed marks.

Class U3: Trowelled Finish. When the moisture films have disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, the Class U3 surface shall be steel trowelled under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.

Class U4: Brushed Finish. The surface shall be treated as U2 and then lightly brushed with a stiff brush to produce a textured finish.

10.46 Steel Reinforcement

a. General

All steel reinforcement including rods, wire fabric, and anchor bars shall be detailed, furnished cut bent and placed as shown on the Drawings. All reinforcement shall be free from loose flaky rust and scale, and from oil, grease, mud, mortar, or other coatings which might destroy or reduce its bond with concrete or grout.

b. Cutting and Bending

Steel reinforcement may be mill or field bent. All bending shall be in accordance with standard approved practice and shall be performed by approved mechanical methods. Heating of reinforcement for bending will not be permitted. Bars with kinks or bends not shown on the Drawings shall not be used.

c. Type

Steel reinforcement shall conform to the standards defined in the Contractors Design and consented by the Employer. As a minimum the reinforcing coated steel shall comply with the requirements of ASTM A615M, Grade 300 or 420. However, reinforcing steel for earthquake resisting frames shall comply with the requirements of ASTM A706M. The use of

Epoxy coated reinforcing steel meeting the requirements of this section is acceptable. Each delivery of reinforcement delivered to site shall be individually identifiable by suitable tags and accompanied with the associated test certificates confirming the test results.

d. Splicing

All splices in reinforcement shall be as shown on the Drawings. Adjacent sheet of mesh reinforcement shall be spliced by lapping as shown on the Contractor's Drawings.

e. Supports

All reinforcements shall be secured in place by use of approved metal or concrete supports, or ties. Such supports shall be of sufficient strength and of sufficient number to maintain the reinforcement in place throughout the concreting operation. The supports shall be used in such a manner that they will not be exposed or contribute, in any way, to the discoloration or deterioration of the concrete.

f. Quality Control

The Contractor shall control the quality of his work. To this end the Contractor shall submit his quality control and quality assurance procedures to the Employer for consent. Inspection during concerte placing and after must be via an RFI for each step and formal approval to proceed on next step.

10.48
Fill Scope

This section covers all work for the construction of fills including backfill behind structures and protective layers.

Drawings

Selection of fill material for the Permanent works shall be as required by the Contractors Design. Fill shall be placed in positions as shown on the contractor's drawings.

The Contractor Design shall specify the classification and type of compaction to be employed.

Compaction of fill

Wherever a density requirement of a soil or gravel layer is specified in terms of a percentage density the Contractor shall be at liberty to employ any type of compaction equipment the he may choose in order to achieve such density over the full specified depth of the layer, provided that the equipment employed is adequate and suitable for the purpose and is in no way detrimental to any part of the Works and the successive layers bind together all to form an integral mass.

The dimensions of fills shall be in accordance with the type of cross section details shown on the Contractor's Drawings.

The thickness of individual layers shall depend on the type of material used and the maximum size of the particles in such material.

Where the material can generally be broken down to a maximum size of 200 mm, the layer thickness shall not exceed 250 mm after compaction except in the case of cohesion less sands where layer thicknesses of up to 400 mm may be employed. Surface compaction test be proven to 100% compaction on each layer using CBR and seeking formal consent of owner engineer raising RFI for each compacted layer before applying consecutive top layer. Over compaction be avoided in any case.

In the case of material that cannot be reduced to a maximum size of 200 mm or less after removal of the oversize material, thicker layers shall be constructed but the thickness of the loose layer shall not be more than is necessary to ensure that the maximum particle size is generally not more than the completed layer thickness. Fill shall be placed in successive horizontal layers parallel to the final fill surface, and the construction of tapered layer shall be restricted to the bottom layers of fill where it may be unavoidable due to cross fall or tapering out of fills.

Rock material containing rock particles greater than 200 mm in size shall not be used at a depth of less than 150 mm below the top of fill level unless consented by the Employer.

Finishing of Slopes

Fill slopes shall be finished to neat lines with all lose rocks and uncompacted material removed. The degree of finish required shall depended on the nature of the material used for the fill slopes but-it shall be as smooth as is consistent with the material involved and good workmanship.

Protection of Fills

All permanent drains shall be constructed as soon as possible plus sufficient additional temporary drains as may be necessary to protect the fill, and they shall be maintained in good working order. Ruts and potholes developing in the fill after completion shall be repaired, and damaged sections of the fill shall be reshaped and re-compacted.

All fill slopes shall be maintained by the Contractor until acceptance of the fill. All erosion and floor damage to slope shall be promptly repaired.

10.47 Architectural Finishing

General

This Clause covers the architectural finishing and works required under the Contract.

The Contractor shall develop a schedule of finishes and associated specifications for the Employer consent. Types of Finishes and fittings shall be shown on the Contractor's Drawings and shall be consistent with the agreed schedule.

The Contractor shall submit, to the Employer for his consent, specimens of materials for colour and finish for the items requiring the Employer Consent, at least 28 days prior to the date he wishes to place order.

All building construction and finishing work shall be performed by experienced skilled labour duly inducted for and practicing 100% site safety practices including but PPE as a minimum..

Finishing Works shall not commence until the area concerned is arid, such adjacent areas which may affect the finishing work have been weatherproofed, and the concrete or other materials have dried out sufficiently.

Permanent openings shall be finished neatly and the Contractor shall furnish and cut as required such special shapes of materials as are required for neat finishing at edges. Where required in suspended ceilings access openings neatly finished at edges shall be formed by the Contractor and fitted into the openings in such a manner as to blend with the ceilings.

Where walls, floors or ceiling are to receive a plastered, tiled or painted finish, the Contractor shall prepare for consent of Employer, trial panels, approximately one meter square, be erected in the locations where the particular types of finish are required. The trial panels will be required to demonstrate the final appearance of the finish which may be required at a particular location.

The Contractor shall provide and maintain adequate protection from damaging of the finishing throughout the Contractor period.

Concrete Work

Reinforced or SR Cement Concrete.

Concrete in structures and chambers etc. shall be in all circumstances fair faced finish and in no case repair shall be allowed. Any fins shall be removed and finished smooth with a rich cement slurry.

Edges where exposed shall be chamfered to a size of 1-1/2” x 1-1/2”

Block Work

Block work shall confirm BS 6073 Part 1. Type B with average compressive strength not less than 7.0 N/mm^2.

Block shall be solid, hollow or cellular, beded and jointed in mortar average 10 mm thick. Cellular blocks shall be laid with cavity downwards.

Internal faced work for painted finish shall have flush jointing as BS 5628, and be left fair clean face ready decoration.

Internal wall shall be solid block 150 mm thick.
External walls shall be 600 mm thick in cavity design.

Where block work is to be rendered or plastered joints shall be raked out to a depth of 12 mm.

Metal anchors for fixing block work to concrete shall be stainless steel conforming to BS 1449, min: tensile strength of 400 N/mm^2, 4.5 mm thick x 35 mm min: width length to such cavity.

Stainless steel butterfly wall ties shall be built into cavity.

Plastering

Internal plastering shall be 12.5 mm thick carried out in accordance with BS 5492 using cement mortar in the ratio of 1:4.

External rendering shall conform to BS 5262 and the surfaces shall have 18.75 mm thick cement plaster with mechanical spray plaster finish in white cement with colour pigment and white marble chips of zero “0” No. in the ratio 1:2. Panels 900x900 with engraved separation joints (visual) shall be made.

Stainless steel angle bead conforming to BS shall be fixed at all external angles.

Floor Finishes

The floor finish shall be over the base course in case of ground floor or directly on reinforced concrete slab. The floor finishes shall be either cement concrete, Marble or Industrial Grade PVC / Terrazzo / granite tiles, to suit the requirements of the location and as approved by the Employer. The Contractor shall be responsible for ensuring that the background or sub base to which the specified finish is to be applied, has properly cured and is properly finished and is completely adequate to receive the specified finish per owner engineer written approval and consent on RFI to move.

All materials likely to reduce adhesion of the finish shall be removed prior to the application of the specified finish and the surface left dust free and clean and protected from contamination until time of laying finish.

Surfaces to receive adhesives and fixatives shall be thoroughly dry.

Surfaces that are to receive cement mortars shall be roughened and dampened prior to the application of the mortar;

All traffic and loads shall be kept off completed work at least until bonding has set. If possible, areas shall be locked up on completion of finishing work.

Plain Cement Concrete Floor

Plain cement concrete floor shall be laid in the ratio of 1:2:4 of minimum thickness 75 mm over the base concrete. Floor of the Transformer Room shall be in cement concrete.

Terrazzo Floor

Terrazzo floor shall be laid in the Turbine Hall and Store Room in grey cement. Marble chips shall be No. 1 to 4 of approved colour having an abrasive hardness of min: 16 as determined by National Bureau of Standard Report BMS 98. The flooring shall be laid in panels using 25 mm thick plate glass strips for separation.

Butecena Marble Tiles

Butacena Marble floor Tiles of approved colour shall be laid in office, control rooms and SCADA room. The size of the tiles shall be 450 x 450 mm laid over min: 37.5 mm thick CC 1:2:4 base.

Acid Resistance Tiles

Acid Resistance , non skid Tiles flooring shall be laid in Battery room, Labs, Stores and Fuel Buildings.

Non-Skid Ceramic Tile

Non-skid Ceramic Tile flooring shall be provided to Bath rooms and open areas exposed to rain or water. The tiles shall conform to BS 1281 and of colour and size 300 mm x 200 mm as approved by the Employer.
Areas not specifically mentioned here like WTP and stand alone skids should comply with vendor recommended flooring or as approved by owner engineer.

Wall Finishes

The Contractor shall ensure that the background or sub base to which the specified finish is to be applied has properly cured and is properly finished and is completely adequate to receive the specified finish.

Surfaces which are to receive finishes shall be cleaned free from loose materials fines, encrustations, oil, paint, dirt and any other material that might percent satisfactory bond.
Surfaces to receive adhesives or fixatives shall be thoroughly stained with Masking tape where necessary to prevent staining of adjoining work such as windows and door frames.

a. Tiling / Dado / Skirting

In general it shall conform to BS 5385

The Contractor shall submit to the Employer for his consent, loose samples of each type of tile or other unit finish required. Samples shall be sufficient in number to illustrate the extremes and average of the ranges of colour, size and texture.

Only whole tiles are to be used, where practicable equal margins of cut tiles larger than half a tile.

Joints in all tiled panels shall be set out to the manufacturer's recommendations.
Tiles shall be kept free of traffic for a minimum period of 72 hours after laying.

Protection following laying shall be adequate to withstand all damage.

The Contractor shall furnish additional spare materials of the same type, quality and colour equal to 1 per cent of quantity of each type laid. These tiles and skirting's shall be packed and labeled suitable for storage.

Tiling shall be glazed granite or marble wall tiles conforming to BD 1281 and will be provided in Bathroom's upto 2100 mm height.

Skirting shall be in Butacena brown marble tiles and provided to office room upto 150 mm height.

Dado in glazed brown marble tiles 400 x 400 smoke colour shall be provided in Machine Hall, SCADA , simulator, fuel management, IT, Exchange, stores, admin, security, prayers room and control room upto 2100 mm height. The tiles in addition to normal procedure for fixing with chemical bond shall be fixed with galvanized iron screws and surface finished smooth to match.

b. Stairs

Stairs to basement from ground floor shall be RCC and have chequered surface finish.

Stair treads and risers to from finished ground shall be 1875 mm thick non skid Terrazzo / PVC tiles laid over 37.5 mm thick CC 1:2:4 bases.

c. Doors

Frames for the doors shall be of steel conforming to BS 1245 and BS 4737 Part 1 and galvanized in accordance with BS 729. Frames shall be built in as work proceeds with the fixing camps securely bedded into the clock work courses without disturbing any damps proof course. Frames shall be painted externally with on approved gun applied butye or poly sulpine non-setting mastic and finish to match with the finish of the doors.

Doors shall by double or single leaf Industrial Aluminum grade for offices and of steel for stores, workshops & machine halls approved by the Employer
Steel door where required shall be of an approved type. These shall be manufactured from steel sheet conforming to BS 1449, part 1 and of all welded construction with internal angle reinforcing grid. Facing sheets shall be minimum 1.6 mm thickness cold rolled leveled sheets. External doors shall be 44 mm thickness and internal doors 35 mm thick with all necessary reinforcement for hangers, locks and other furniture.

Plant Main Entrance and rotatable staff gates are to be security grade. Vol III gives conceptual sketches.

d. Roller Shutter Doors

Roller shutters shall be sliding type installed in accordance with the manufacturer’s requirements and from minimum 18 gauge steel employing convex type lath.

Unless otherwise shown in the Contractors Drawings and consented to by the Employer, roller shutter shall be manually operated on the inside of the building. The mechanism shall be lockable.

Not less than 28 days before proceeding with fabrication the Contractor shall submit shop drawings of the roller shutter to the Employer showing sections, dimensions, fixings and other information as may be required by the Employer for his consent.

e. Door Furniture

All hardware shall be manufactured to a strong, durable and secure pattern. The Contractor shall submit to the Employer for consent samples of door furniture to be used in the works.

Unless otherwise shown in the Contractors Design, iron or steel for building into brick, stone or concrete masonry shall be hot dip galvanized or coated with 2 coats of aluminum paint. All other iron and steelwork shall be given two coats of rust inhibiting paint before fixing.

f. Windows and Ventilators

Minimum 20% area of the wall surface exposed to the outer atmosphere shall be provided with fully double glazed aluminum windows and ventilators. The windows and ventilators will be of aluminum. The Contractor shall submit to the Employer for consent samples of windows to be used in the works.

Prior to installation, all items of windows and ventilators shall be protected from the weather, stored level on the ground and stacked in the way that allows free air circulation around the items. Installed windows and ventilators shall be protected from mechanical damage as required.

The frames shall be accurately set out and assembled square arid true. All necessary accessories and fixings for the proper completion of the Works shall be provided.

Window and ventilators shall be plumb, Square and level and firmly fixed by approved devices.

The frames shall be from an approved manufacturer and fabricated from H9 aluminum alloy in accordance with BS 4873. They shall be of the type and to the dimensions shown on the Drawings, fully weather stripped. Surface finish shall be anodizing to BS 3987 to provide an anodic coating of 25 micron average thickness over mechanical stain finish.

Fittings shall be manufacturers standard type. All windows and ventilators should be provided with 20 mm square galvanized steel wire mesh.

Pre-finished surfaces shall not be allowed to rub or slide against each other and shall be well protected during transportation and storage.

Glazing shall comply generally with BS 6262. Glass shall unless otherwise shown be 5 mm thick clear ordinary glazing quality complying with BS 952 except where required to be thicker minimum 12 mm in accordance with BS 6262.

Reinforced glass shall be 12 mm 6 mm thick with straight wires both ways to form 13 mm squares in accordance with BS 952.

Glass panels for offices and Panel room shall be reinforced glass min 12.0 mm thick with aluminum framework as approved by the Employer.

Putty shall be approved metal casement type of approved colour for metal and hardwood frames and linseed oil type complying with BS 544 for softwood frames. Rebates shall be sealed before glazing with primer for softwood frames and the finish varnish for hardwood frames.

All glass shall be left clean inside and out free from all scratches or other blemishes on completion.

g. Plumbing Fittings & Fixtures

HDPE - 100 pipe, High-density polyethylene and fittings shall be used in all plumbing works.
The pipes in the wall shall be encased or ducted and in the floor in covered ducts only. Fixtures shall be of Master or equivalent make and as approved by the Employer.

The whole of the plumbing fittings, fixtures and their installation complete shall be in accordance with all relevant regulations of the appropriate local Authority or Government Authority.

Generally all pipework shall be embedded in walls, placed in wall chases to be provided and tiled in or taken up in ducts and concealed from view.
Surface mouthed pipework shall be adequately and suitably fixed in position in accordance with the best practice and in accordance with the applicable specifications.
The Contractor shall furnish and install the fittings and features in the locations as shown on Contractor's Drawings.

Wash basins and toilet pans shall be scratch proof, shining glazed, large size, heavy duty commercial / industrial grade defined in the Contractor Drawings subject to approval of owner engineer. .

Wash Basins toilet pans shall be white vitreous china of the best quality.

Bath Rooms for the office shall be provided with European type pan toilet pan and wash basin mirror and rack.

Bath Rooms for the staff shall be provided with variety of Asian type toilet pan and European type. The two pans shall be further provided with partitions and separate doors. Wash basin shall be common.

Contractor's Facilities
Contractor's Site office

The Contractor shall provide the Site office and other facilities for its own use at a place approved by the Employer.

Contractors Laboratory Facilities

The Contractor shall, for the duration of Contract, supply, maintain and operate a materials testing laboratory at site necessary for sampling preparing and testing materials as specified. The Contractor may also use an off-site testing laboratory to perform certain of the specified tests Both the laboratory and the test shall be to the approval of the Employer such approval shall not be given if significant delays in obtaining results are likely, or if the results may be unreliable. The Contractor shall make all the necessary arrangements and provide all transport and labor for conveying the samples to the Employer promptly. The Employer approval will be withdrawn if the service proves in any way unsatisfactory.

The Contractor shall provide trained and experienced Material Engineer technician and skilled labor to carryout specified tests to the satisfaction of the Employer. The Material Engineer and technicians shall be approved by the Employer. In case of unsatisfactory performance such approval will be withdrawn and the Contractor shall arrange for suitable replacement for approval by the Employer.

The Employer and his supervisory staff shall have access to the laboratory to supervise testing and to witness verification tests ordered by the Employer or his staff.

The Contractor shall keep record of all tests he conducts in connection with compliance with, and as, required by the Specifications, and shall supply copies of the results of such tests to the Employer as soon as practicable after each test is made.

.
Employer have a geo testing laboratory already established at site which will be serve the purpose.

10.48 Security, health and safety

The Contractor will provide the Employer with a security, safety and health manual within one month of Notice to Proceed, covering all aspects mentioned in sub-clauses and other relevant clause of the EPC Contract, Laws and Regulations of Government of Pakistan and Government of Sindh relevant international standards, tradition & customs of Sindh and in accordance with relevant section of this Volume.

10.49 Furniture and equipment for the office

The Contractor shall supply the steel furniture, fittings and equipment listed below and installs them in the Employer offices within the pump house. They shall be for the sole use of the Employer and his staff and employees of the Employer. All furniture, fixtures and equipment shall be supplied new, and manufacturer’s description or sample shall have been approved by the Employer before any item is ordered. The Contractor shall keep insured all furniture, fitting and equipment supplied to the Employer to their full local value (including duty) until the end of the Defects Liability Period when the same will be handed over to the Employer in satisfactorily working condition and shall remain Employer’s property.

The offices shall be adequately furnished equipped and maintained for proper use and functioning, all to the satisfaction of the Employer. The furniture and equipment listed herein is the minimum and may be varied or substituted by the Employer with other or additional items to meet his requirements.

a) Furniture:

All furniture will be made from stainless steel metal work, best quality lock, and polish on the wood work of high quality, all as approved by the Employer.

1	Officers table 5½’x 3’ with 4 drawers and glass top along with attached side rake 3’x½’ also glass top	4 Nos

2	Table 5’x3’ with 3 drawers on each side	4 Nos
3	Conference Table 21’x5’	1 No
4	Central Table 3½’X3½’ with glass top	4 Nos
5	Officers chair revolving with arms and upholstered	4 Nos
6	Upholstered chair with arms.	4 Nos
7	Upholstered chair with arms for conference room	25 Nos
8	Reclining easy chairs	2 Nos
9	Steel filing cabinets with locks & suspended filing system	4 Nos
10	Steel racks for tools with lockable drawers -6’x4’x1.5’	4 Nos
11	Plane chest 5’X3’ deep X 4’ high	4 Nos
12	Waste paper baskets	10 Nos
13	Glass Ash trays	10 Nos
14	Sundry office items like letter tray, punch, paper, stapler, pencil holder, pencils, sharpeners and erasers	10 sets

b). Kitchen items

1	No frost refrigerator -8 cft	1 No
2	Tea cattle stainless steel – 1 Litre	2 Nos
3	Electric cattle -1 litre	1 No
4	Tea mugs china ware	12 Nos
5	Tea cups with saucers china ware	24 Nos
6	Half plates china ware	24 Nos
7	Quarter plates china ware	24 Nos
8	Sugar pot china ware	6 Nos
9	Milk pot china ware	6 Nos
10	Table spoon stainless steel	24 Nos
11	Tea spoon stainless steel	24 Nos
12	Sauce pan stainless steel	2 Nos
13	Cess-rolls stainless steel	2 Nos
14	Spoons for item 12 & 13	4 Nos
15	Cooking range with 4-burners with gas cylinder	1 No
16	Service cabinet 6’x2½’x3’	2 Nos
17	Medium size serving dishes	6 Nos
18	Medium size service bowl	6 Nos
19	Forks stainless steel	12 Nos
20	Service trays	4 Nos

21	Water glasses	12 Nos
22	Water jugs	4 Nos

The Kitchen to be provided with suitable fittings and fixtures.

b) Wash rooms & Toilets

Wash rooms/toilets to be provided with best quality fittings and fixtures but with prior approval of the Employer. English w/c and Asian w/c both are to be provided, with Muslim and telephone type showers. Wash basin and Mirror to be provided in the Bath rooms with approval of owner engineer.

10.50 Surveying Instruments and Surveyors

The Contractor shall provide and maintain the following survey equipment on site for the sole use of the Employer and his staff for the duration of the Contract.

a. Total Station (One second Accuracy)
b. Automatic Level
c. Level Staff
d. Ranging Rods
e. Tripod Stan
f. Prism
g. Prism Holder
h. Measuring Steel Tape 100 meter

The contractor shall provide a competent and experienced surveyor with two assistants and necessary labour along with transport for the survey work. The survey staff and transport for surveyors shall be maintained with driver consumables, POL, spares and insurance and shall be solely at the disposal of the Employer and his staff.

On completion of the work, the survey instruments and the transport will be returned to the contractor.

10.51 Transport for the Employer

The Contractor shall provide new approved vehicles as listed in the Schedule of Prices, for the use of the Employers and his staff and Employer.

Vehicles shall be equipped with 1st aid kits, spare water container and where possible the double fuel tank, roof rack and be suitable for tropical use. Kerb weight and tyre pressures shall be stated on each vehicle and the vehicles shall conform in all respects to the regulations of the appropriator registration authority.

The Contractor shall provide competent drivers to the approval of the Employer for the vehicles used on site. The Contractor shall provide all fuel, lubricants, etc and shall license, insure (as detailed below), servicer and maintain the vehicles in a roadworthy state. The Contractor shall be obliged to have ready access to spare parts appropriate to the number, type and duty of the vehicles supplied. If in the opinion of the Employer the Contractor should default in this respect and deprive the Employer of use of vehicle(s) made unserviceable by normal use in the conditions and demands of the Site, the Contractor shall provide suitable alternative transport to the approval of the Employer. If the Contractor fails to provide this service the Employer shall be entitled to withhold the issue of a Payment Certificate until the service is resumed.

Insurance for vehicles must be comprehensive and include:

Cover for the Employer and his staff driving the vehicle;

Liability to third parties (including passengers whether the Employer his staff or others) for an unlimited indemnity in respect of death or personal injury and for the maximum indemnity reasonable obtainable in respect of loss, destruction or damage to property.

The vehicles shall be handed over to the Employer at the end of the Defects Liability Period or earlier if order by the Employer and transferred in the name of the Employer.

For a site movement of Employer Supervision staff for inspection of Contractor’s works or in connection with the works, the Contractor shall make available suitable transport as required. No direct payment shall be made for this and the cost thereof is deemed to be included in the contract price.

10.52 Telephones

The Contractor shall provide following communication facilities for the sole use of the Employer and his staff.

The Mobile telephone (3 nos.) shall be portable hand held cellular type as Motorola Model Vader, manufactured by Motorola Inc. or similar approved by the Employer, with all charges to be paid by the Contractor to keep the phones working throughout the Contract period.

Three landline telephone shall be provided in the site office of Employer and on Fax machine of approved make. The Contractor shall bear the cost of installation, instruments and payment of telephone bills regularly to keep telephone in service continuously until the end of Defects Liability Period. The Contractor shall maintain the Fax machine with provision of all consumables until the end of Defects Liability Period.

One completion of work, the telephone (other than mobile phone) and Fax machine will be the property of the Employer and will be handed over to him.

10.53 Health and Safety

The Contractor shall provide for the health and safety of its employers, any employees of Employer and any other persons who are at any time directly or indirectly effected by the performance of the Work by an application of a suitable or acceptable health and safety policy that ensures attention to the safety of work sites, to safe methods of working, to the suitability of personnel by training or placement and by adequate supervision.

The Contractor shall be under an obligation to take all reasonable safety measures in relation to the type of services undertaken and shall conduct itself and all personnel assigned to the Work and perform the Work in such a way as to comply at all times with its obligation and duties under laws, regulation, rules, order and other enactments in force from time to time relating to health and safety matters, including the Employer's safety requirements.

The Contractor shall in addition observe and follow all guides, codes and recommendations issued or made by the government, professional or trade organization or other official or responsible organization relating to health and safety at work as applicable to the project.

At every site where the work is being performed under this Contract the Contractor will appoint a safety who will be responsible for all personnel engaged in the performance of the work under this contract including those of the Contractor's sub-contractor. The contractor will draw up and ensure compliance with safety regulations commensurate with the hazardous nature of work.

10.54 Quality assurance / quality control

The Contractor will instigate a QA/QC/RFI programmed in accordance with the relevant Clause of the EPC Contract.

10.55 General

a. Description

The Contractor shall be completely responsible for implementing a Quality Assurance Plan covering all the Works contained in the Contract including the design. The Quality Assurance Plan will be prepared by the Contractor and reviewed and authorized by the Employer and will be implemented by the Contractor. It will be especially managed by the Contractor's Resident Quality Assurance Manager. The contractor's Quality Assurance Plan means by which the Contractor ensures the control and quality of all design function, all fabrication by his vendors and sub-contractors and all construction activities carried out by his sub-contractors.

10.56 The Contractor's Quality Assurance Plan

The Contractor's Quality Assurance Plan shall meet all the requirements of the International Standards Organizations known as ISO 9001. As appropriate the Contractor will impose on his designers, Vendors, fabricators and sub-contractors the requirements of ISO 9002, ISO 9003 and ISO 9004.
The Quality Assurance Plan will be prepared and presented in three different volumes namely:

- Volume 1 Quality Plan
- Volume 2 Quality Assurance Procedures
- Volume 3 Quality Control Procedures

Collectively the three Volumes will comprise of the Contractor's Quality Assurance Clan. Each volume will address the issues enumerated in the following Articles of this Section.

The Quality Assurance Plan shall recognize the necessity for revision during the project at which time reauthorization shall be sought from the Employer.

Within twenty-one (21) days of the date of the Notice to Proceed the Contractor shall produce and submit to the Employer an outline of the QA Plan. Within a further 28 days of the above submittal date the Contractor will submit the detailed QA Plan incorporating the comments made by the Employer. The authorized detailed QA Plan will be supplemented by comprehensive details for specific work activities at least 28 days prior to their commencement.

The Contractor's Quality Assurance Plan will be managed and directed by a dedicated Resident Quality Assurance Manager who will be physically on the project Site throughout the implementation and will report directly to both the Contractor's Site Project Manager and independently and directly to the Contractor's Home Office Senior Management.

10.57 Requirements of the Contractor's Quality Assurance Plan

Volume 1 : Quality Plan

This section of the Contractors Quality Assurance Plan will address the following topics:

(1) Purpose and Scope Policy
(2) Organization and Responsibilities
(3) Project Manager Review
(4) Applicable Standards
(5) Definitions

The purpose scope and policy chapters will establish the general philosophy and parameters that the Contractors Senior Management require for the Quality Assurance Plan.

Organization and responsibilities will clearly present the detailed Contractor's Organization as it pertains to Quality Assurance and Quality Control activities. A description of assigned responsibilities is required.
Project Management Review will address the Contractors procedures for addressing quality issues raised by the Resident Quality Assurance Manager to the Site Project Manager and Head Offices Senior Management.

The standards that will be used to support the Contractors Quality Assurance Plan are required to be listed. This will include all applicable industry codes, standards and practices and specifically those referenced in the contract Document and Employer's Requirements.

For clarity in the use of the Contractor's Quality Assurance Plan document by Contractor's personnel it is required that a glossary of specific terms used in the documents be itemized (Definitions).

Volume 2 : Quality Assurance Procedures

This Volume will present clearly the procedures developed by the Contractor to provide a planned and disciplined approach for the achievement of project quality objectives. The procedures, in general require the prompt detection and correction of deviations, which are or may be detrimental to quality and generate documentation necessary to provide objective evidence of achievement of quality objectives during design, fabrication, construction and commissioning phases of the project.

As a minimum the QA procedures will include but not limited to:

(1) Contractors procedures addressing the requirements of ISO standards.
(2) Plant Management Procedures.
(3) Construction Schedule Management and RFI system.
(4) Progress Reporting Procedures.
(5) Design Procedures.
(6) Procedures for selecting and appointing sub-contractors and vendors.
(7) Procedures for obtaining, reviewing and approving sub-contractors and vendors quality procedures.
(8) Procedures for auditing sub-contractors and vendors.
(9) Contractors Method Statements for all work activities.
(10) Document Control Procedures.
(11) Environmental Management Procedures.
(12) Health and Safety Procedures.
(13) Audit and Surveillance Program and Schedule by Resident QA Manager.

(14) Non-Conforming Reporting (NCR) and Deviation Report (DR) procedures.
(15) Training Procedures.
(16) Interim Payment Procedures.
(17) “As-Built” drawings and information procedures.
(18) Operation and Maintenance Manual Procedures Change Control of Project Quality Procedures.

Volume 3 : Quality Control Procedures

This volume is dedicated solely to the procedures and systems that the Contractor will perform to maintain an effective Quality Control (QC) program. In general the Contractor will perform sufficient checks, inspection and tests on all items of the work including:

(1) The Design Engineer
(2) Vendors
(3) Sub-contractors
(4) Contractor’s Site Work Activities

And so ensure conformance with respect to the design, materials, workmanship, construction, finish and functional performance.
The Contractor’s QC system shall be implemented by a separate QC organization headed by a full time QC Manager who will report to the Resident QA Manager. The QC organization will include personnel trained, specialized and qualified to inspect and test all the categories of the work. This work will include the Design Operations. Vendors and Subcontractors Consortiums operations as well as the Contractor’s own off-site and on-site operations.

The quality Control Plan shall include adequate provision for access by the Employer to inspect any and all facilities of the project and facilities such as laboratories etc required to implement the plan.

Specifically Volume 3 will address the following items as a minimum:

(1) The QC organization.
(2) The number and qualifications of personnel to be used.
(3) Authority and responsibility of QC personnel.
(4) Methods and procedures of QC control for all the Work including design vendors and sub-contractors.
(5) Inspection and Testing Plan.
(6) Details of the site laboratory including the physical layout stalling and proposed on-site testing equipment.
(7) Details of any off-site laboratory testing.
(8) Details of the physical site tests and laboratory tests proposed for all the construction materials with emphasis on cement, concrete, soils and rock testing Frequency of Testing shall be included.
(9) Method of documenting and procedures to be followed for QC operations, inspection and testing for each section of the technical provisions. Details of proposed forms are to be included.

(10) Off site testing of manufactured items and type testing.

(11) Procedures that will ensure that the latest applicable Drawings, Shop Drawings, Specifications and instructions required by the Contract Documents, as well as authorized changes, are used for fabrication, construction, and inspection and testing.

(12) Procedure for the issuance, tracking and close-out of Non-Conforming Reports (NCR's) and Deviation Reports (DR's). This procedure shall prioritize the NCRs and ensure the closeout of such matters in a timely manner to the satisfaction of the Employer.

10.4.1 Employer's Quality Assurance Program

It is intended that the Employer will establish his own Quality Assurance Programme, which will be independent of the Contractor's QA/QC programs.

The Employer's QA program will be under the control of the Employer's Site Resident QA Manager who together with his staff will have the responsibility to evaluate and verify the Contractor's QA/QC operations.

Observations, inspection, tests or approvals by the Employer's Resident QA Manager or any other person shall not relieve the Contractor from his obligations to perform the Work in accordance with the Contract Documents.

The Employer has the right to visual inspection of all Contractor's Work. If Work is to be covered, Contractor shall notify Employer's Resident QA Manager of Work completion and Employer's Resident QA Manager must inspect within reasonable time. If any Work is covered without such notification, it must, if requested by Employer's Resident QA Manager, be uncovered for observation. Such uncovering shall be at Contractor's expense unless Contractor has given Employer's QA Manager reasonable notice of Contractor's intention to cover such Work and Employer's Resident QA Manager has not acted with reasonable promptness in response to such notice. "Reasonable Notice" shall never be less than 24 hours, excluding Sundays and holidays.

The Employer also has the right to carry out any physical testing of the Contractor's Work. Samples of Site work (e.g. concrete, soils, cement, rock, reinforcing steel etc) will be supplied by the Contractor at no charge. Furthermore, the Employer will have the right to utilize the site laboratory and staff (if necessary) to carry out verification testing, at no charge. Such verification testing by the Employer's Resident QA Manager will be performed in an efficient and timely manner so that the Contractor's QA/QC program is not disrupted.

The Employer will also have the right to perform any offsite testing of materials. Samples for such testing will be supplied at no cost by the Contractor. Should any off-site testing indicate materials not meeting

Contract requirements, the costs of the Employer off-site testing will be charged to the Contractor.

10.60 Environmental Compliance

General

Reference is made to the environmental requirements given in:

a. The law and Regulation of Government of Pakistan arid Government of Sindh.

b. Employer’s Requirements for Environmental Protection given in this Volume.

c. Sub-Clauses 4.18 [Protection of environment], 4.22 [Security of the Site], 4.23 [Contractors Operation at Site], 4.24 [Fossils], 6.6 [facilities for staff and Labour], 6.7 [Health and Safety], 7.3 [Inspection], 14.5 [Plant and Material Intended for the Works], 16.3 [Cessation of Work and Removal of Contractor Equipment] of General Condition of Contract and any other clause or sub-clause having any relevance to Environment.

d. Local traditions and customs of Sindh.

e.

Miscellaneous

a. The Contractor shall within one month of receipt of Notice to Proceed, appoint an Environmental Inspector for the Works, whose broad responsibilities are to guide the construction personnel on environmental matters, to communicate and to make liaison with the Employer, Government of Sindh and local elders.

b. The Contractor shall provide Environment Management Plan of the Site as defined in this Volume.

Environmental management

a. The Contractor shall comply with all legal duties and obligations regarding the protection of the environment as laid down laws and Regulations of Governments of Pakistan and Sindh. Where there is any conflict between laws and Regulations, and clause in this specification, the more stringent requirement shall be adopted.

b. Within fourteen (14) days of the date of the letter of Acceptance the Contractor shall submit to the Employer an outline of the Contractors environmental management plan for complying with the environmental management requirements, especially as described here in this Specification. Within twenty-eight (28) days thereafter the Contractor shall submit for the Employer’s approval a detailed environmental management plan that consists of proper account of all comments made by the Employer on the outline environmental management plan. The management plan shall include, but not be limited to, the Contractors proposed arrangements for abatement and mitigation measures for environmental protection and reporting, and his organization chart showing how he delegates environmental management responsibilities on the site.

Air Quality

(i) Burning of waste will not be permitted either on or off the site.

(ii) Dust shall be kept to a minimum on the Site and at the residence area by appropriate water spray at all times.

Noise

(i) The Contractor shall take all reasonable precautions to minimize nuisance caused by noise and vibration. This may require the modification of plant where noise emissions are excessive, the construction of screens or a restriction on working hours. Where appropriate, the contractor shall provide ear protectors for staff working in the vicinity of noisy plant on site.

(ii) The Contractor will be responsible for complying to ensure the noise levels at the boundary of the project site, the worker and staff's camp should not exceed 65 dB(A) during day time and 55 dB(A) during night times. Where the noise levels exceed those recommended, the Contractor shall propose measures that he intends to take to improve the noise levels and when approved by the Employer shall implement the proposals at no additional cost and without delay.

Waste Management

(i) The Contractor is fully responsible for the day-to-day management on waste collection and disposal. The Contractor must make arrangements for waste management for the collection and the disposal of domestic and industrial refuse, by handling, transporting or storage of schedule wastes outside the premises and its safe disposal at a location approved by the Employer.

(ii) The Contractor must ensure that all the necessary utensils such as proper storage containers or bins for refuse and kitchen wastes, special storage containers for scheduled wastes, temporary sewerage plants or toilet facilities are provided at the premises.

The Contractor must also comply with the following environmental conditions throughout the construction stage:

(i) Temporary sewage treatment for toilet facilities in accordance with the specifications as prescribe by the Law and Regulation must be provided at the Contractor's site office and worker's camp before the commencement of any works;

(ii) Open burning of solid waste including biomass waste and construction debris is strictly not permitted;

(iii) Handling and disposal of scheduled wastes must comply with the requirements of the laws and regulations of Government of Pakistan

Avoidance of Nuisance

(i) The Contractor shall take all reasonable precautions to avoid causing a nuisance with dust, noise or vibrations arising from his operations. This provision is in addition to but not in substitution for the provisions of the Conditions of Contract.

(ii) The Contractor shall not obstruct as far as possible, the normal rights of way of the users of the public roads and where this is necessary and unavoidable, he shall provide barriers, roads signs, warning lights, etc. required for proper traffic control including getting the necessary permits from the Police Department and other local authorities and paying all fees in connection therewith.

(iii) The Contractor shall be liable and shall indemnify the Employer in respect of any claims or proceedings arising out of his neglect in taking care to avoid creating a nuisance when carrying out the Works.

(iv) Necessary Noise level controls shall be exercised by the Contractor in accordance with the limits said in this section subject to the approval of the Employer.

Prohibition of Advertising

(i) The Contractor shall treat the contract and everything written as private and confidential in particular, the Contractor shall not publish any information, advertisement, drawing or photograph relating to the Works and shall not use the Site for advertising purposes, except with the written consent of the Employer and subject to such conditions as he may prescribe.

10.61 Training Programme

General

With reference to item 5.5 of the Conditions of Contract, the Contractor shall provide the services of competent staff (prior to the details of qualifications shall be submitted) who shall train Employer’s staff or other as the Employer may nominate in the operation, servicing and maintenance of the Plant, including items of Plant supplied by sub-contractor. Training shall cover start-up, shutdown, normal and exceptional operation. Plant shall cover all electrical and mechanical equipment, all hydraulic steel structures and all instrumentation and control equipment and structures.

The Contractor shall provide a training program in operation and maintenance for the Employer’s O&M personnel generally to meet the requirements stated in Volume II of Bid Documents.

Setting out of works

Setting out data such as BENCH MARK, DATUMS and original setting out points shall be provided by the Employer.

Plant, materials and services

All materials used in the Permanent Works and workmanship shall generally be of standard quality available in Pakistan and except where otherwise specifically instructed or where specific standards are referred to, comply with any of the latest issues of the relevant Standards and Codes of Practices.

Statutory requirements

The Contractor shall comply with the pertinent statutory requirements. Concerning explosives, the Contractor shall provide suitable bunkers at approved locations for the storage of all explosives. Storage, transportation, handling, charging, etc. shall be performed by experienced personnel using approved equipment in accordance with the relevant statutory regulations and to the satisfaction of the Employer. The Contractor shall obtain the requisite permission and diligences from the concerned agencies for transportation, use and storage of explosives.

Photographs

The Contractor shall take photos in digital camera during progress of work, which shall be attached to the monthly progress report. Each of these photos shall be submitted in 6-fold as paper copies in colour and two CD’s. The sizes of the photos shall be 10 x 15 cm. Every month at least ten colour photos for each report shall be supplied.

The Contractor shall supply unmounted colour prints of photographs, not less than 200 mm by 225 mm, of each portion of the Works in progress and completed, as may be directed by the Employer and specified herein. The digital CDs shall be the property of the Employer and shall be delivered to the Employer with the prints. No prints shall be supplied to anyone without the written permission of the Employer.

The photographs shall be of two categories:

a. Progress photographs;
b. Record photographs;

Both categories of photographs shall be properly referenced to the approval of the Employer. Each print shall have the recorded date of the photographs, the direction in which the camera was facing and identifying description of the subject and the reference.

Photographs taken for record purposes as ordered by the Employer shall be supplied with two prints, having on the reverse of one print the signatures of the Contractor and the Employer (or their authorized representatives) for the purpose of attestation. If required, the Contractor may at his own cost have an additional print.

The Contractor shall supply the CD and two prints of each progress photograph ordered by the Employer. He shall supply sets of four additional prints of progress photographs selected by the Employer for incorporation in albums. He shall supply albums, mount the prints and title the prints and albums all to the approval of the Employer.

The contractor shall make available a digital camera with 8 MB smart Ram and accessories for the role use of the Employer for the purpose of the project, all at his cost. At the end of the contract the camera & accessories shall become the property of the Employer.

Office for the Employer

Office spaces prepared and provided for the Employer shall be maintained for the duration of the Contract and serviced as specified. For the purpose of this Chapter the office space provided shall be known as the Employer’s site office. On completion of the Contract all fixtures fitting, furnishings and equipment shall be handed over to the Employer and will continue to remain Employer’s property.

Area of offices

The building for the site office block shall be made suitable for the climate with air-conditioning, all to the approval of the Employer.

The floor area of the office block shall be about 250 Sq.m as directed by the Employer.

The office block shall be furnished.

Servicing and maintenance

The Contractor shall service and maintain all ancillary works, Employer’s site office, furniture, fixtures and equipment including provision of security janitorial services and refuse disposal services, until the end of the Defects Liability Period. The Contractor shall replenish consumable items and all office supplies, stationery, copying paper and miscellaneous items of office use as and when required. In addition, at the end of the Defects Liability Period, the furniture, fittings and equipment shall be cleaned, repaired or replaced, as necessary, to bring them into good condition, and they shall remain the property of the Employer at the conclusion of the Contract.

Assistance to the Employer

The Contractor shall provide following competent office staff and workers approved by the Employer continuously as may be required by the Employer, to assist him in running his site office, in connection with the Works.

Office Secretary for SRE	1
Word Processors / Typist	2
Office Assistants	2
Messengers	2
Tea Boys	2
Cleaners / Janitors	4

The messengers shall be provided with conveyance by the Contactor to deliver messages and mail to the offices of Employer, Contractor and the Employer etc. the contractor's rates shall include for any overtime work.

In case the performance of any of such staff is considered by the Employer as unsatisfactory, the Contractor shall replace the same forthwith with acceptable personals.

Drainage and Sewerage System

The Contractor shall design, execute and maintain a sewerage system to the approval of the Employer.

HDPE-100 conforming to ISO standard shall be used for the sewerage system.

Access Roads and Development of Site Area.

The contractor shall provide access roads (cement concrete or bituminous over a Sub Base) to all building and parking areas including crossings structures. The parking areas shall be paved with cement concrete of designed mix over the under bed of lean concrete. The work shall be executed to the satisfaction of the Employer.

Automatic Door Closers

Automatic door closer shall be face fixing type suitable for the weight of door to which attached, hydraulically operated with steel arms and steel or aluminum body capable of door opening to 180 degree and having adjustable hydraulic check.

a. Venetian Blinds

Canvas venetian blinds of the vertical type of the best quality shall be provided for office and control room windows and glass panels/partitions. Colour and quality shall be as approved by the Employer.

b. Ladders & Railings

Non Skid Industrial Grade Aluminum or Galvanized iron ladders and railings shall be provided in halls and at places as shown in the drawings or indicated by the Employer and essentially required.
It shall be of approved size, and suitable for location and strong enough to with stand the stresses and strains of movement.

Galvanized iron ladder shall conform to BS code.

Non Skid Industrial Grade Aluminum or Stainless steel ladders & railings in office and first floor passage shall be provided

c. Gauge Measure

Calibrated magnetic or Metallic strip water / fuel depth measuring gauge shall be provided and fixed with tanks. The figures shall be visible in the night darkness. Along with the calibration table (chart) or graph shall be designed to indicate the rate volume
The metallic strip shall be of rust proof and unbreakable material. The figures shall be written in an indelible material. The strip shall be fixed in a recessed space.

10.62 Project Meetings
General

a. Description

The Contractor shall schedule and administer throughout the progress of the works:

(1) Pre-design meetings
(2) Periodic design progress meetings
(3) Preconstruction meetings including safety review
(4) Periodic construction progress meetings including safety review, and
(5) Specially called meetings

In addition the Employer may call extraordinary meetings as necessary. Pre design, preconstruction and progress meetings shall be held during both the design and construction phases on a schedule satisfactory to the Employer, but at least on a monthly basis at a minimum.

b. The Contractor shall:

Prepare agenda for meetings. Proposed agenda for all meeting shall be submitted to the Employer at least 7 days prior to each meeting.

Distribute written notice of each meeting 14 days in advance of meeting date.
Make detailed graphically supported presentations regarding the status of the Work.

Record the minutes include all significant proceedings, decisions, and action requirements.
Reproduce and distribute copies of minutes within 3 days after each meeting.

To all participants in the meeting.

(1) To all parties affected by decisions made at the meeting.

(2) Representatives attending the meeting from the Contractor, the Contractor's design engineer, sub-contractors and suppliers shall be qualified and authorized to act on behalf of the entity each represents.

(3) Employer will attend meetings to monitor progress of the Work and shall be given the opportunity to confirm and sign the minutes of the meeting before distribution.

a. Design Meetings

Pre-Design meeting agenda shall include, but not limited to:

(1) Distribution and review of design progress schedule.
(2) Proposed additional investigations.
(3) Contacts with regulatory agencies
(4) Equipment supply contracts
(5) Procedure for submittal and review of design documents
(6) Quality assurance procedures
(7) Project Configuration
(8) Technical Matters

b. Design Progress Meetings

The design progress meeting's agenda shall be held at a minimum quarterly and the agenda shall include but not limited to:

(1) Review and approval of previous meeting minutes
(2) Review of progress since previous meeting
(3) Status of submittals and approvals
(4) Problems which impede design progress schedule
(5) Corrective measures to regain projected progress schedule
(6) Revisions to progress schedule
(7) Proposed progress during succeeding work period
(8) Status of review by regulatory agencies
(9) Status of Equipment supply contract

c. Construction Meetings including Safety Review

(1) Pre-Construction Meeting

The pre-construction meeting agenda shall include discussion of:

(i) List of major sub-contractors and suppliers.

(ii) Progress Schedule.
(iii) Critical work sequencing.
(iv) Major equipment deliveries and priorities.
(v) Project Coordination.
(vi) Designation of responsible personnel.
(vii) Procedures and processing of:
(viii) Field decisions.
(ix) Proposal Requests.
(x) Submittals
(xi) Application for payment.
(xii) Adequacy of distribution of Contract Documents.
(xiii) Procedures for maintaining Record Documents.
(xiv) Use of site and Site Installation:
(xv) Office, work and storage areas.
(xvi) Employer's requirements.
(xvii) Construction facilities and controls.
(xviii) Quality control / Quality Assurance / RFI procedures.
(xix) Temporary utilities.
(xx) Safety, first-aid procedures and handling safety voialations
(xxi) Security procedures.
(xxii) Field observation by regulatory agencies.

d. **Construction Progress Meetings including Safety Review**

The construction progress meeting shall occur once per calendar month which shall address an agenda including but not limited to:

(i) Review and approval of minutes of previous meeting.
(ii) Review of work progress since previous meeting.
(iii) Field observations, problems, conflicts,
(iv) Problems which impede Progress Schedule.
(v) Review of off-site fabrication delivery schedules.
(vi) Corrective measures and procedures to regain
(vi) Projected schedule. Safety effectiveness review.
(vii) Revisions to Progress Schedule.
(viii) Plan progress and establish schedule for succeeding work period.
(ix) Review submittal schedule expedite as required.
(x) Maintenance of quality standards.
(xi) Review proposed changes for effect on progress Schedule and on completion date.
(xii) Status of periodic field observation by regulatory agencies.

10.63 Schedule & Construction Progress Record General

a. Schedule

The Contractor shall submit the proposed Schedule for the design and execution of the Works in a format and media approved by the

Employer. The proposed programme shall be in two levels of details as follows:

The Overall Programme which shows the major work items of the Works.
The detailed Working Programme which shows further breakdown of the major work items into activities involved in the sub-items.

The Contractor shall use Critical Path Analysis (CPA) to analyze and identify critical activities and key dates and shall present the programme in bar chart form and network diagram indicating activities and dates critical to completion of the work on time.

The Contractor shall produce all schedules using the latest revision of the Primavera scheduling software and form one data-base so that the programmes are inter-linked and fully coordinated. The programme shall show increasing detail, each succeeding programme level sub-dividing activities in the preceding level.

The Contractor shall submit an explanatory report covering any aspect of the chart or network that the Contractor cannot show on the chart. The Contractor shall agree with the Employer on the work section, activities, sub-activities, interface and other critical dates which the Contractor has to identify in the programmes. This shall become the Overall Works Programme based on which the Contractor shall complete the Work in time. This Overall works Programme shall not be changed unless agreed with the Employer.

The Overall Works Programme shall show every significant activity required for the completion of the contract including:

(1) Contractor’s own detail design
(2) Supplies design and manufacturing plans
(3) The submittal of drawings and information to and reviewed by the Employer.
(4) Approval required from statutory authorities and agencies.
(5) Appointment of major sub-contractors and suppliers.
(6) Mobilization, time on site and removal of major items of Contractors Plant and temporary facilities.
(7) Procurement and off-site testing, and delivery of major equipment and material to the site.
(8) Construction and installation of the works on the site.
(9) Off-site activities such as prefabrication of components.
(10) Inspection, testing and commissioning.
(11) Forecast labour plants and equipments requirements.

The major work items of the works to be shown on the overall work Programme shall consist of, but not limited to the following:

(1) General
(2) Mobilization
(3) Site Office & General Items
(4) Site Installations

10.64 Detailed Engineering Design

Civil works for Power house, BOP and Infrastructure:

(1) Mechanical & Electrical Works
(2) Procurement of equipment, mechanical and electrical
(i) Imported
(ii) Local
(3) Power Station, Electro-Mech and Control Rooms
(4) Excavation of foundations
(5) Concreting works
(6) Basement of Pump Station
(7) Ground floor of pump station and associated facilities
(8) Finishing works
(i) Block Masonry
(ii) Plaster and Dado
(iii) Doors, windows & ventilators
(iv) Flooring
(v) Painting
(vi) External Plan protection
(vii) Miscellaneous
(9) Plumbing and Sanitary Fittings and Fixtures (Internal & External)
(10) External development work
(11) Sub-Station
(12) FOTP
(13) Stand Alone skids and Met Tower
(14) All Miscellaneous Works
(15) Admin and security
(16) Erection and puch List
(17) Testing and Commissioning
(18) Initial Running Maintenance
(19) Final Handing-Over
(20) Cleaning-up Work
(21) Final Documentation
(22) Demobilization

Each activity in the Overall Works Programme shall have the following information:

(1) Activity code, description, duration and the sequence with other activities.

(2) The earliest and latest start finish dates with available float.
(3) The party responsible for each activity e.g Contractor, Sub-Contractor, Employer, etc.

(4) The cost weighing for each activity by the Contractor with respect to the total cost of all the activities must add upto 100%.

(5) The installation Quantities and forecast man-hour.

(6) The relevant price breakdown item shown in the contract shall be easily identified in the work Programme.

(7) The Detail Working Programme shall contain the items, which are breakdowns of the major items. The Programme shall identify any interface requirements affecting the work. The main quantities of material and other agreed relevant information.

(8) The Contractor shall provide a concise master network diagram. The Contractor shall analyze the CPM network using the precedence diagram method. The work breakdown structure (WBS) will be the same as that for the Overall Works Programme, and each major activity shall relate to the price breakdown headings.

(9) The activities presented in the programme shall be capable of indicating the required information stated above.

10.65 Detailed Progress Report

Each month the Contractor shall report on a day in a format and media approved by the Employer the progress and financial status of the works of the previous month. The report shall accurately estimate the work completed on each activity including the design activities shown on the accepted Overall Works Programme and the Working Programme. The contractors progress report shall include relevant progress photographs. The Contractors shall agree with the Employer and shall implement progress control procedures.

The Contractor’s progress report shall identify

a. **Detailed Progress Report**

(1) Total work progress as of the end of previous month with a progress chart showing progress achieved in % against scheduled progress.
(2) Activities re-scheduled or re-estimated since previous progress.
(3) Activities added or deleted since the previous report.
(4) Works progress achieved during the previous month.
(5) Major activities undertaken in the previous month with photos attached.
(6) Major activities to be carried out in the next period, and the effect on the programme on the latest available information.
(7) Areas of concern, Punch List
(8) Actions to be taken to solve the problem(s)
(9) Forecast completion dates and milestone dates.

b. **Resources**

(1) Staff returns
(2) Labour return
(3) Plant return
(4) Construction Material and PPE delivered to site

c. **Commercial**

(1) Schedule of information required

(2) Material on site

d. **Financial**

(1) Anticipated cash flow forecast

(2) Schedule of Guarantees

(3) Schedule of Insurance

(4) Particulars of Sub-contractor and Suppliers

(5) The Contractor’s execution of the construction work shall not deviate from the sequence shown in the approved Overall Work Programme without prior written permission from the Employer.

10.66 Weekly Progress Meeting

Within four (4) weeks of the Commencement Date the Contractor and the Employer will agree on a programme schedule for weekly progress meetings covering the total duration of the Works. The Contractor shall make himself available for any other meetings called for by the Employer outside the schedule.

The Contractor shall prepare the following programme with increasing detail to demonstrate the Contractor’s shorter-term and detailed planning of the execution of activities

a. Detailed Working Programme

b. Weekly Detailed Working Programme

The Detailed Working Programme shall be submitted to Employer for approval monthly to cover the period for the next following month’s planned work. The hard copy of the programme must also include the previous one (1) month progress. The electronic copy of the programme must also include progress for the period from the beginning of the Contract.

The Weekly Detailed Working programme shall be submitted to the Employer for approval weekly and must show at least previous week’s progress and the future two (2) week’s planned work.
The Weekly Detailed Working Programme shall contain details of all critical activities in delay and any delays the contractor can foresee to future critical activities. The Contractor shall report the likely effect on the programme and the remedial action, the Contractor proposes to rectify the delay such as but not limited to:

a. Increase resources

b. Increasing the worked hours

c. Carrying out activities in parallel

The Contractor shall issue relevant short-term programmes with the method statements required in the Contractors project Quality

Assurance Plan. To accurately reflect the status of the Works, the Contractor shall monitor, update, revise the programmes, and submit them to the Employer in the regular progress meetings or at such other time as instructed by the Employer. All the programmes submitted to the Employer shall be in electronic format and in hard copy.

10.67 Explosives

a. The Employer shall have the power to regulate restrict or prohibit the use of explosives, explosive powered tools, or the like in the Works if in his opinion it is necessary to do so for the safety of persons or property or to safeguard the Works.

b. No blasting shall be carried out in any part of the Works without the written permission of the Employer. Such permission shall not absolve the Contractor from any of his obligations or liabilities under the Contract and he shall take all necessary precautions including the use of blasting nets or mats to avoid damage, loss or injury to persons and to public or private property.

c. The Contractor shall keep the Employer fully informed at all times when blasting is proposed to be carried out and of any details that may be required by the Employer concerning strength of charges and their positions.

d. Explosives shall not be used within 50 ft, or such greater or lesser distance as the Employer may direct, of concrete placed in the Works, of any existing structure, pipeline electric cable or overhead power or telephone lines etc.

e. The Contractor shall obtain at his own expenses the necessary licenses for the use, handling, transporting and storage of explosive and shall comply at all times with the requirements of the Police Department, and other authorities having jurisdiction in the area of the works, as may be conditional upon the granting of such licenses.

10.68 Project Signs

General

a. Project Signboard

The Contractor shall design, supply, erect and maintain one solar power illuminated modern signboard, approximately 10 ft wide by 7 ft high, at the entrance of the Site or at a location to be agreed by the Employer. The Employer shall review and agree the Contractor's design. The Contractor shall employ an experienced sign- writer to prepare the signboard.

The Contractor shall remove the signboard and associated footings on completion of the Works and leave the site in the specified condition.

The Contractor shall not display any advertisements within or around the Site without the prior written approval of the Employer.

Taking Over
General

a. Substantial Completion

(1) When Contractor considers the work is substantially pursuant to Clause 10, the General Conditions of EPIC, he shall submit to Employer,

(i) A written notice that the work, or designated portion thereof, substantially complete and a letter of certification stating the Project has been constructed in accordance with the Contract Documents; and,

(ii) Punch list of items to be completed or corrected.

(iii) With in a reasonable time after receipt of such notice. Employer will determine the status of completion on the basis of his On-site observations.

- Should Employer determine that the work is not substantially complete:

(i) Employer will promptly notify the Contractor in writing giving the reasons thereof;
(ii) Contractor shall remedy the deficiencies in the work and send a second written notice of substantial completion to the Employer; and
(iii) Employer will re-evaluate the work.

- When Employer concurs that the work is substantially complete, Contractor will:

(i) Prepare a Taking Over Certificate for Mechanical, Electrical & Civil works accompanied by:

- Contractor's punch list of items to be complete or corrected, as verified and amended by the Employer;
- Complete list of As-Built Drawings
- List of detail specifications of As-Installed plant and equipment
- Details of the As-constructed civil works
- List of As-supplied spare parts, tools and equipment
- List of O&M manuals

And

(ii) Submit the Certificate to Employer and Contractor for their written acceptance of the responsibilities assigned to them in the Certificate.

(iv) **Move-Out of Site Installation**

(1) After completion of the Works, the Contractor, with prior approval of the Employer, shall:

(i) Remove all buildings, installation and temporary facilities. The Contractor shall fill with earth all basements and underground areas, clean up and restore the terrain to its quasi-original condition. The Contractor shall also treat the excavations executed for his own convenience, such as temporary roads, in a way acceptable to the Employer. If the Contractor refuses to remove the buildings, plant, equipment and installations or if the operation is not made as specified within 2 months from completion of the Works, such buildings, plant equipment and installations may be removed by the Employer and the removal costs shall be deducted from the Contractor's final payment.

The Employer shall have the right to take over a part or all of such buildings and installations at no extra cost. All buildings and installations shall be handed over in good condition.

Prior to Taking-Over of the Works, roads and access branches whose construction and maintenance was an obligation of the Contract shall be left in good condition of service. With regards to provisional roads constructed for the Contractor's use, the Employer shall indicate in which condition the areas shall be left, and the Contractor shall establish this condition at his own cost.

(v) **Final Inspection**

(1) When Contractor considers the work is complete, he shall submit written certification that:
(i) Contract Documents have been reviewed;
(ii) Work has been inspected for compliance with Contract Documents;
(iii) Work has been completed in accordance with Contract Documents;
(iv) Equipment and systems have been tested in the presence of the Employer and are operational; and
(v) Punch List Work is completed and ready for final inspection

(2) Employer will make an onsite visit to verify the status of completion with reasonable promptness after receipt of such certification.

(3) Should Employer consider that the work is incomplete or defective:

(4) Employer will promptly notify the Contractor in writing, listing the incomplete or defective work:

(5) Contractor shall take immediate steps to remedy the stated deficiencies, and send a second written certification to Employer that the work is complete; and

(6) Employer will re-evaluate the work.

(7) When the Employer finds that the work is acceptable under the Contract Documents, he shall request the Contractor to make closeout submittals.

10.69 Final Application for Payment

Contractor shall submit the final Application for Payment in accordance with procedures and requirements stated in the conditions of the Contract.

10.70 Taking Over Submittals

a. **General**

(1) Project Record Documents and Samples

(i) Contractor shall maintain one record copy of:

- Contract Drawings
- Specifications
- Addenda
- Change Orders and Other Modifications to the Contract
- Reviewed Shop Drawings, Product Data and Sample
- Field Test Records
- Inspection Certificates
- Manufacturer's Certificates

(ii) Record Documents and Samples shall be stored in Field Office apart from documents used for construction. Files, racks and secure storage for Record Documents and samples shall be provided

(iii) Record Documents shall be maintained in a clean, dry and legible condition. Record Documents shall not be used for construction purposes.

(iv) Record Documents and samples shall be available for inspection by Employer.

(2) Recording

(i) Contract Drawings: On a daily basis, the Contractor shall legibly mark in ink or indelible pencil, to record actual construction, the following information:

- Location of internal utilities and appurtenances concealed in construction referenced to visible and accessible features of structure.
- Field changes of dimensions and details
- Changes made by Change Order or Employer's Supplemental Instructions.
- Details not on original contract drawings

(ii) Specifications and Addenda: The Contractor shall legibly mark up each Section to record.

- Manufacturer, trade name, catalog number and supplier of each product and item of equipment actually installed.
- Other matters not originally specified.

(iii) Shop Drawings: The Contractor shall maintain as record documents and legibly annotate the following drawings to record changes made after review:

- Mechanical submittal
- Metal fabrications

(3) Submittal

(i) At completion of project, Contractor shall deliver Record Documents to Employer including the Contract Drawings in reproducible ink-on-mylar sheets that match the contract documents (size, sheet content and title block).

(ii) Accompany submittal with transmittal letter, in duplicate containing:

- Date
- Project title and number
- Contractor's name and address
- Title and number of each record document
- Certification that each document as submitted is complete and accurate
- Signature of Contractor, or his authorized representative

(4) As-Built Documents

The Contractor shall consider the preparation of As-built Documents and operation and maintenance manuals as part of his site installation. The "As-built" Documents shall be prepared in a way to satisfy the requirements of the Employer. The drawings shall be in digital copies in AutoCAD 14 Format and six (6) blue prints, indicating the accurate location and dimensions of all structures with reference to a permanent survey network. Before establishing the "As-built" Documents the Contractor shall submit an advance copy to the Employer for approval.

(5) Operation and Maintenance Data

(i) Submit two sets prior to final inspection, bound in 8-1/2" x 11" text pages, three D size ring capacity expansion binders with durable plastic cover.

(ii) Prepare binder covers and edge with printed title Operation and Maintenance Instructions, title of project, and subject matter of binder when multiple binders are required.

(iii) Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab tiling clearly printed under reinforced lamina led plastic I, bs.

(iv) Contents: Prepare a Table of Contents for each volume, with each Product or system description identified type on 24 pound white paper

Part 1: Directory, listing names, addresses and telephone numbers of Construction Manager, Contractor, sub-contractors and major equipment suppliers.

Part 2: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of sub-contractors and suppliers. Identify the following:

(i) Significant design criteria
(ii) List of equipment
(iii) Parts list for each component
(iv) Operating instructions
(v) Maintenance instructions for equipment and systems
(vi) Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

Part 3: Project documents and certificates, including the following:

(i) Shop drawings and product data
(ii) Certificates
(iii) Photocopies of warranties

(v) Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Employer comments. Revise content of documents as required prior to final submittal.

(vi) Submit six copies of final volumes revised, within ten days after final inspection

(6) Warranties and Bonds

(i) Provide duplicate notarized copies
(ii) Execute and assemble documents from sub-contractors, suppliers, and manufacturers
(iii) Provide Table of Contents and assemble in three D side ring binder with durable plastic cover
(iv) Submit prior to final application for Payment
(v) For items of Work delayed beyond, Taking-Over, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.