CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD

TENDER NO: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

LOAN AGREEMENT NO. ID-P267

JICA FUNDED PROJECT

BIDDING DOCUMENT

FOR

PROJECT FOR CONSTRUCTION OF CHENNAI SEAWATER DESALINATION PLANT (I)

PART-II

(EMPLOYER'S REQUIREMENTS)

Volume 2 of 5

PROCUREMENT OF DESIGN/ENGINEERING, CONSTRUCTION, COMMISSIONING OF 400 MLD SEAWATER REVERSE OSMOSIS (SWRO) DESALINATION PLANT AT PERUR, CHENNAI WITH 20 YEARS OF OPERATION AND MAINTENANCE (DBO BASIS)

INTERNATIONAL COMPETITIVE BIDDING

PROJECT MANAGEMENT CONSULTANTS
SMEC International Pty Ltd.
NJS Engineers India Pvt. Ltd.
Tata Consulting Engineers Ltd.
SMEC India Pvt. Ltd.

SUPERINTENDING ENGINEER
(CONTRACTS & MONITORING)
CHENNAI METROPOLITAN
WATER SUPPLY & SEWERAGE
BOARD

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PART-II- EMPLOYER'S REQUIREMENTS

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8. ELECTRICAL REQUIREMENTS

8.1 INTRODUCTION

This section of the bid proposal shall cover the electrical requirements of the CP1 400MLD Sea water Reverse Osmosis Desalination Plant and its Facilities.

Due to the high salinity and close proximity of the plant to the sea, a Gas Insulated Switchgear (GIS) Substation was envisaged for the project to prevent corrosion of the major electrical equipment.

To meet the power demand load of the 400 MLD Perur Sea Water Reverse Osmosis (SWRO) Desalination Plant (approximately 90MVA), the Gas Insulated Substation shall be fed with a 230kV Power Supply as per Tamil Nadu Electricity Board's latest Codes, Standards, and Regulations.

A Power Receiving Facility / Terminal Point as part of CP1 Contract Package was considered for this project to receive the TNEB 230kV Overhead Transmission Line including its Optical Ground Wire (OPGW).

The 230kV Overhead Transmission Line shall be terminated to the 230kV composite outdoor termination unit and outdoor type lightning arrester by the Overhead Line Contractor under CP5 Contract Package while the Optical Ground Wire (OPGW) provided under CP5 Contract Package shall be terminated to the terminal joint boxes by the Substation Contractor under CP1 Contract Package.

Bonding of the incoming OPGW to the station earthing screen, supply of earthing conductor and connection of the air terminal earth electrodes into the substation earth grid shall be carried out by the Substation Contractor under CP1 Contract Package.

The connection between OPGW joint boxes at 230 kV GIS Substation Receiving Gantry Area and Control Room building via underground optical fibre cables shall be carried out by the Substation Contractor under CP1 Contract Package which shall include supply & installation of fibre optic cable of size similar to OPGW.

The voice communication, tele-protection signaling and main distribution frame (MDF) for optical fiber cable shall be supplied and installed by the Substation Contractor under CP1 Contract Package. Necessary equipment for incorporating the 230/110/11kV GIS Automation System into the SCADA system shall also be supplied and installed under CP1 Contract Package.

8.2 SCOPE OF WORK

The scope of work on this section shall includes Design, Supply, Delivery, Installation, Testing and Commissioning, Operation and Maintenance for 20 years of all electrical equipment for the 400 MLD Sea Water Reverse Osmosis Desalination Plant which include but not necessarily limited to the following schedule of requirements:

1. Power Receiving Facility or Terminal Points of Incoming TNEB 230kV Overhead Line Circuit Connections and Optical Ground Wire (OPGW) with

Composite Outdoor Termination Unit, Outdoor Type Surge Arrester with counter, Steel Structures, and Claustra Block Wall Fencing with stainless steel door, Lightning Protection and Earthing System.

2. 230kV Gas Insulated Switchgear Double Bus Indoor Type 4000A, 50Hz, 3Ph, 50kA/3sec. as per Key Single Line Diagram (Drawing No. 7061563/PMC400MLD/CP1/SLD/001).
3. 230kV Cu/XLPE/AWA/HDPE Cables.
4. 230kV Cable Sealing Ends, Cable Plug-in, Composite Outdoor Cable Termination Unit and Accessories, and Earth Link Boxes.
5. 110kV Gas Insulated Switchgear Double Bus Bar Indoor Type 3150A, 50Hz, 3 Ph, 40kA/3sec. as per Key Single Line Diagram (Drawing No. 7061563/PMC400MLD /CP1/SLD /001).
6. 110kV Cu/XLPE/AWA/HDPE Cables.
7. 33kV and 11kV Cu/XLPE Cables and Cable Termination Accessories.
8. 110kV Cable Sealing Ends, Cable Plug-in, Cable Termination Accessories, and Earth Link Boxes.
9. 2 Nos. 230/110/33kV 150MVA ONAN/ONAF Auto Power Transformers with Vector Group YNa0d1 and 2 Nos. 315kVA 33/0.415kV Earthing Transformers.
10. 4 Nos. 110/11/11kV 50MVA ONAN/ONAF Auto Power Transformers with Vector Group YNd5 and 4 Nos. 315kVA 11/0.415kV Earthing Transformers.
11. Metering, Control and Protection.
12. Substation Automation System (IEC-61850)
13. Digital Fault & Disturbance Recorder (DFDR)
14. Fiber Optic Multiplexer Equipment for Communication and Protection
15. SCADA system for Telecontrol and Telemetering
16. 110V DC & 48V DC and LVAC System
17. Standby Diesel Generator Set
18. UPS System
19. Subgrade Earthing System, Potential Gradient Earthing System, Above Ground Earthing System, Electronic Earthing System and Equipment Earthing System

20. Lightning Protection System
21. 33kV Outdoor Type Vacuum Circuit Breakers (for Earthing Transformers)
22. 33kV Outdoor Type Isolators (for Earthing Transformers)
23. 11kV Outdoor Type Vacuum Circuit Breakers (for Earthing Transformer)
24. 11kV Outdoor Type Isolators (for Earthing Transformer)
25. 33kV Neutral Earthing Resistors
26. 11kV Neutral Earthing Resistors
27. 4000A, 3Ph, 3W, 50Hz, 50kA/3secs. 11kV Switchgears
28. 1250A, 3Ph, 3W, 50Hz, 40kA/3secs. 11kV Switchgears
29. 11/0.433kV Distribution Transformers
30. 11/0.69kV Converter Transformer
31. 11kV Capacitor Banks
32. 11 kV Motors
33. 415V Capacitor Banks
34. 415V Low Voltage Switchgears
35. 415V Low Voltage Busducts
36. 415V Motor Control Centers
37. 690V Variable Frequency Drives / 11kV Soft Starters / 11kV Primary Resistance Starters / 11kV Variable Frequency Drives
38. 415 V Direct Online Starters / Star Delta Starters / Variable Frequency Drives
39. Uninterruptible Power Supply (UPS)
40. Standby Diesel Generator Sets
41. 415 / 240 V AC Distribution Boards
42. 110V DC Distribution Boards / 48V DC Distribution Boards and Batteries
43. Lighting and Small Power System

44. Central Battery System

45. Street Lighting System

46. Area Lighting System

47. Tel/LAN System

48. Low Voltage Power & Control Cables

49. FM200 System

50. Auto Power Transformer Nitrogen Injection Fire Protection (NIFPS) System and Transformer Fast Depressurization System

51. De Luge Water Spray System

Supply of Mandatory Spares, Maintenance Tools & Test Equipment of Power Transformers, Earthing Transformers, Distribution Transformers, GIS Switchgears, Control Equipment, Protection Relays, Meters, 33kV & 11kV Vacuum Circuit Breakers, 33kV & 11kV Isolators, Battery Chargers, UPS, 11kV Switchgears, LV Switchgears, and Motor Control Centers shall be provided and shall be handed over to the Engineer for safe keeping in designated store and warehouse.

Recommended Spare Parts for other equipment shall also be provided to the Engineer for safekeeping.

Manufacturers who have proven experience of manufacturing and supplying the above electrical equipment of similar capacity shall only be considered for this proposal.

The respective equipment should have been manufactured, supplied, installed, tested and commissioned successfully and should be running satisfactorily for the last 5 years continuously. Material approval and certificates from the end users, regarding their satisfactory performances, shall be submitted to the Engineer for verification and approval.

8.2.1 POWER RECEIVING FACILITY / TERMINAL POINTS

230 KV OVERHEAD LINE CIRCUIT CONNECTIONS

The 230 kV Over headline slack spans including overhead earth conductor (OPGW) between the 230 kV terminal tower and the substation gantry structures shall be supplied and terminated by the Overhead Line Contractor under CP5 Contract Package to the composite type outdoor termination unit and the outdoor type surge arrester. All required insulators and hardware shall also be supplied by the Overhead Line Contractor under CP5 Contract Package.

Eyebolts / U-bolts or other suitable fixtures for terminating the slack spans on the substation gantry area shall be provided by the Substation Contractor under CP1 Contract

Package. *All eye bolts, u-bolts, hexagonal bolts and nuts shall be made of stainless steel 304.*

The Substation Contractor under CP1 Contract Package shall provide all the jumpers from the slack span to the composite type outdoor termination unit and outdoor lightning arrester on the substation gantry area by fixing appropriate T-terminals on the slack span conductor or other approved means. The supply of appropriate clamps and the actual termination of the jumper to the substation equipment shall be carried out under CP1 Contract Package.

Bonding of the incoming earth wire to the station earthing screen and supply of earthing conductor and connection of the terminal tower earth electrode into the substation earth grid shall be carried out by Substation Contractor under CP1 Contract Package.

The Substation Contractor under CP1 Contract Package shall terminate the OPGW at the substation gantry in the terminal joint boxes provided by the overhead line Contractor under CP5 Contract.

The connection between OPGW joint boxes at Substation gantry and control room building via underground optical fibre cables shall be carried out by the Substation Contractor under CP1 Contract Package which includes supply & installation of fibre optic cable of size similar to OPGW.

All steel structure foundations at the gantry area shall be protected by zinc sacrificial anode cathodic prevention system to prevent corrossion of the foundation and steel structures under CP1 Contract Package.

COMMUNICATIONS AND SCADA EQUIPMENT

The voice communication, tele-protection signaling and main distribution frame (MDF) for optical fibre cable shall be supplied and installed by the Substation Contractor under CP1 Contract Package. Necessary equipment for incorporating the 230kV, 110kV and 11kV system into the SCADA system shall also be supplied and installed by the Substation Contractor under CP1Contract.

In order to provide the telecontrol & telemetering (SCADA) facilities required at the National Load Dispatch Center (NLDC), all plant supplied under this Contract shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals. All required electrical signals shall be transmitted to the NLDC through the Industrial Gateway of the substation automation system. All GIS HV breakers, motorized disconnectors, tap changer, etc. shall be controlled from NLDC through the Gateway of the substation automation system using IEC 61850 protocol.

Necessary transducer, control & interposing relays, RTU's, etc. shall be used. Necessary interfacing between the Substation Automation gateway and the communication equipment shall also be carried out.

In addition, to realize the complete SCADA system after completion of the Project, modification of the existing software in the master computer of the national load dispatch center, and modification of hardware (installing additional printed circuit cards etc. if required) shall be made under CP1 Contract Package.

8.2.2 FACTORY ACCEPTANCE TEST WITNESS:

The Contractor shall arrange a third-party inspection for the Factory Acceptance Test of the major electrical equipment specified below and the contract price shall be deemed to include all these costs.

Total Sixteen (16) nos. of visit for witnessing of Factory Acceptance Tests by Employer's Engineer (Two Engineers in each visit, and seven days for each visit excluding travel time) is required for the following equipment:

1. 230/110/33kV 150 MVA Auto Power Transformer (2 Nos.)
   110/11/11kV 50 MVA Auto Power transformers (4 Nos.)
2. 315kVA 33/0.433 kV Earthing Transformers (2 Nos.)
   315kVA 11/0.433 kV Earthing Transformers (4 Nos.)
3. 11/0.690 kV Converter Transformers (104 Nos. of different kVA ratings)
4. 11/0.433 kV 630kVA / 2.0 MVA / 2.5MVA Distribution Transformers (12 Nos.)
5. 230kV Gas Insulated Switchgear Equipment
   110kV Gas Insulated Switchgear Equipment
6. Substation Automation System, Control & Protection Equipment Digital Fault & Disturbance Recorder (DFDR) Fiber Optic Multiplexer Equipment for Communication and Protection SCADA system for Telecontrol and Telemetering
7. 230kV, 110kV, 33kV, 11kV Cu/XLPE Power Cables
8. 33kV Outdoor Type Circuit Breakers & Isolators (For Earthing Transformers)
9. 11kV Switchgears
10. 11kV Motors
11. 11kV Soft Starters/Variable Frequency Drives/ Primary Resistance Starters
12. Low Voltage Switchgears
13. 110V DC and 48V DC Battery Chargers and Batteries
14. Central Battery System
15. UPS System and Batteries
16. Motor Control Centers, Soft Starters, Variable Frequency Drives, Wye-Delta Starters, Direct Online Starters.
17. Standby Diesel Generator Sets

Factory Acceptance Test Procedures from the Manufacturers shall be submitted by the Contractor to the Employer's Engineer for approval before commencement of any Site Acceptance Test.

The Contractor shall be responsible to select similar reputable manufacturers for the major electrical equipment listed above to reduce the number of visits and coordination for witnessing the Factory Acceptance Test.

8.2.3 TRAINING

The Contractor shall be responsible for bearing all costs for the Employer's Engineers, including air fares, accommodation, meal, healthcare, laundry, transportation, visa fees etc. together with payment of a daily allowance for each of the Employer's Engineer. All travel and miscellaneous expenses outside Chennai, Tamil Nadu shall be as per JICA's procurement guidelines

The contract price shall also include all costs of foreign and local training for Employer's Engineer.

8.2.3.1 Foreign Training:

Plant visit by the Employer's Engineer as part of Foreign Training shall be arranged to similar projects successfully executed by the Contractor for the past 10 years three months after the award of the Contract.

Overseas training of Employer's Engineer (Three Engineers in each visit and one week for each visit excluding travel time) for each of the following equipment at Manufacturer's Training Institute is required. These trainings can be conducted simultaneously or clubbed together.

1. 230/110/33kV 150 MVA Auto Power Transformer (2 Nos.)
   110/11/11kV 50 MVA Auto Power transformers (4 Nos.)
2. 315kVA 33/0.433 kV Earthing Transformers (2 Nos.)
   315kVA 11/0.433 kV Earthing Transformers (4 Nos.)
3. 11/0.690 kV Converter Transformers (104 Nos. of different kVA ratings)
4. 11/0.433 kV 630kVA / 2.0 MVA / 2.5MVA Distribution Transformers (12 Nos.)
5. 230kV Gas Insulated Switchgear Equipment
   110kV Gas Insulated Switchgear Equipment
6. Substation Automation System, Control & Protection Equipment
   Digital Fault & Disturbance Recorder (DFDR)
   Fiber Optic Multiplexer Equipment for Communication and Protection
   SCADA system for Telecontrol and Telemetering
7. 230kV, 110kV, 33kV, 11kV Cu/XLPE Power Cables
8. 33kV Outdoor Type Circuit Breakers & Isolators (For Earthing Transformers)
9. 11kV Switchgears
10. 11kV Motors
11. 11kV Soft Starters/Variable Frequency Drives/ Primary Resistance Starters
12. Low Voltage Switchgears
13. 110V DC and 48V DC Battery Chargers and Batteries
14. Central Battery System
15. UPS System
16. Motor Control Centers, Soft Starters, Variable Frequency Drives, Wye-Delta Starters, Direct On Line Starters.
17. Standby Diesel Generator Sets

Overseas training on Substation design for Employer's Engineer (Two Engineers in one visit) at an internationally specialized training institute is also required and the duration of training shall be one week excluding travel time.

Training of the Employer's Engineers shall be done first before any Factory Acceptance Test can proceed.

The Contractor shall be responsible for bearing all costs for the trainees, including air fares, accommodation, meal, healthcare, laundry, transportation, visa fees etc. together with payment of a daily allowance for each of the Employer's trainee. All travel and miscellaneous expenses outside Chennai, Tamil Nadu shall be as per JICA's procurement guidelines

8.2.3.2 Local Training:

The Contractor shall be responsible for providing instruction and guidance to Employer's personnel in the operation and maintenance of the substation equipment. During the installation, the Contractor should provide minimum one trainer (Authorized by the Manufacturer) for training of Employer's personnel on site for minimum one week for training of GIS operation & maintenance and for one week for training of substation automation, control & protection system so that they could get a clear idea about operation, inspection and maintenance of the equipment.

The number of trainees for each Training shall be 15 (fifteen) in each Training program. The Contractor shall be responsible for providing lunch and training material to the trainees.

The Contractor shall be responsible for ensuring that all and any items of the electrical works required for the safe, efficient and satisfactory completion and functioning of the works, are included in the Bid Price whether they be described in the specification or not.

The Bid provides for all parts of the works to be completed in every respect for commercial operation to the requirements of the Engineer. All details, accessories etc. required for the complete installation and satisfactory operation of the works not specifically mentioned in this Specification are deemed to be included in the contract price.

8.2.4 SITE ACCEPTANCE TEST (SAT)

Site Acceptance Test shall be performed by the Manufacturer's Testing and Commissioning Engineer and shall be witnessed by the Employer's Engineer for the following equipment :

1. 30/110/33kV 150 MVA Auto Power Transformer (2 Nos.)
   110/11/11kV 50 MVA Auto Power transformers (4 Nos.)
2. 315kVA 33/0.433 kV Earthing Transformers (2 Nos.)
   315kVA 11/0.433 kV Earthing Transformers (4 Nos.)
3. 11/0.690 kV Converter Transformers (104 Nos. of different kVA ratings)
4. 11/0.433 kV 630kVA / 2.0 MVA / 2.5MVA Distribution Transformers (12 Nos.)
5. 230kV Gas Insulated Switchgear Equipment
   110kV Gas Insulated Switchgear Equipment
6. Substation Automation System, Control & Protection Equipment
   Digital Fault & Disturbance Recorder (DFDR)

Fiber Optic Multiplexer Equipment for Communication and Protection
SCADA system for Telecontrol and Telemetering

7. 230kV, 110kV, 33kV, 11kV Cu/XLPE Power Cables
8. 230kV Composite Outdoor Type Termination Unit
9. 230kV Surge Arrester with Counter
10. 33kV Outdoor Type Circuit Breakers & Isolators (For Earthing Transformers)
11. 11kV Switchgears
12. 11kV Motors
13. 11kV Soft Starters/Variable Frequency Drives/ Primary Resistance Starters
14. Low Voltage Switchgears
15. 110V DC and 48V DC Battery Chargers and Batteries
16. Central Battery System
17. UPS System
18. Motor Control Centers, Soft Starters, Variable Frequency Drives, Wye-Delta Starters, Direct Online Starters.
19. Standby Diesel Generator Sets
20. FM200 System
21. Auto Power Transformer Nitrogen Injection Fire Protection (NIFPS) System and Transformer Fast Depressurization System
22. De Luge Water Spray System
23. HVAC System
24. Subgrade Earthing System, Potential Gradient Earthing System, Above Ground Earthing System, Equipment Earthing System and Electronic Earthing System
25. Lightning Protection System

Site Acceptance Test Procedures from the Manufacturers shall be submitted by the Contractor to the Employer's Engineer for approval before commencement of any Site Acceptance Test.

8.2.5 START-UP AND ENERGIZATION

After successful Site Acceptance Test (SAT), Contractor shall submit the Start-Up and Energization procedures to the Employer's Engineer for approval prior to Commissioning.

8.2.6 COMMISSIONING

The Contractor shall be required to prove that the installed system meets the design requirements and Specification to the satisfaction of the Engineer.

8.3 GENERAL CONDITIONS

8.3.1 All electrical works herein shall be carried out by a Professional Electrical Engineer and in strict compliance with the latest edition of International Electrotechnical Commission (IEC), British Standards (BS), European Standards, American Standards, Indian Standards (IS) and Tamil Nadu Electricity Boards (TNEB) Codes, Standards, and Regulations including the latest amendments and rulings. If there is any conflict between Codes, Regulations, and other standards, the most stringent rule shall apply.

8.3.2 All electrical works shall be directly supervised by a Professional Electrical Engineer with minimum 15 years experiences in the Design, Supply, Delivery, Installation, Testing and Commissioning, Operation and Maintenance of 230kV/110kV/11kV Power System and it's Metering, Control, Protection Relays, and Substation Automation System as per IEC-61850 standards and protocol specifically in Gas Insulated Switchgear (GIS) Substations and Sea Water Reverse Osmosis (SWRO) Desalination Plants Electrical Systems.

8.3.3 The works shall be carried out in accordance with the requirements of all authorities having jurisdiction over the works and/or approval required there from. Such notice shall be provided and the application shall be prepared accompanied by such plans and information as may be called for and /or obtain such approvals.

8.3.4 Reference Codes and Standards listed herein are applicable in respect of all materials and workmanship except where in conflict with the provisions of this specification. Where this specification expressly requires standards higher than or different from those applicable under the relevant standard or documents, this specification will take precedence.

8.3.5 Where special conditions exist which would make compliance with these specifications unusually difficult, then details should be submitted in writing to the Engineer, who may grant an exemption. Any such exemption granted shall be obtained in writing from the Engineer by the party seeking the exemption.

8.3.6 Any items of equipment offered and not listed under Preferred Equipment List, must be approved by the Engineer and any such exemption granted shall be obtained in writing from the Engineer by the party supplying the equipment.

8.3.7 The Contractor during the design stage of the plant shall carry out a ***Risk Assessment*** to determine the classification of any hazardous areas within the plant in accordance with Occupational Safety and Health Administration (OSHA) Standards. Classification shall be reviewed by the Engineer and the design and specification of all electrical equipment to be installed in the plant shall be in accordance with any hazardous area classifications determined by the risk assessment.

8.3.8 All permit and electrical fees required for this work shall be obtained by and at the expense of the Contractor. The Contractor shall furnish and transmit to Engineer, copies of Notification of Safety Precaution (NOSP) Certificates, Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) Inspections and Approvals after completion of the work. The Contractor shall prepare all As-Built drawings, plans and all technical user guide documents and paper works required by the approving authorities.

8.3.9 The technical specifications and drawings provided in this Bid Document are indicative and serve as a guidance only. Hence the entire scope of work is not fully reflected in these specifications and drawings. The Contractor shall design and evaluate the sizes and ratings of all the electrical equipment and develop the full set of specifications and drawings to reflect the technical requirements in the scope of works.

8.3.10 Within two months of the signing of the Contract, the Contractor shall submit a program schedule detailing the time required for the Design, Procurement, Factory Acceptance Test (FAT), Delivery, Receiving and Storage Inspection, Construction, Testing and Commissioning and Site Acceptance Test (SAT) for the complete contract.

8.4 REFERENCES, CODES AND STANDARDS

8.4.1 IEC STANDARDS

60034-1	Rotating Electrical Machines - Part 1: Rating and Performance
60038	IEC Standard Voltages
60051	Direct acting indicating analogue electrical measuring instruments
60059	IEC Standard Current Ratings
60072	Dimensions and output series for rotating electrical machines
60073	Coding principles for indicators and actuators
60076-1	Power transformers - Part 1: General
60076-2	Power transformers - Part 2: Temperature rise for liquid-immersed transformers
60076-3	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air
60076-4	Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
60076-5	Power transformers - Part 5: Ability to withstand short circuit
60076-6	Power transformers - Part 6: Reactors
60076-7	Power transformers - Part 7: Loading guide for mineral-oil-immersed power transformers
60076-8	Power transformers - Part 8: Application guide
60076-10	Power transformers - Part 10: Determination of sound levels
60079	Electrical apparatus for explosive gas atmospheres
60085	Thermal evaluation and designation of electrical insulation
60099-4	Metal-oxide surge arresters without gaps for a.c systems
60137	Bushings for alternating voltages above 1000 V
60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
60228	Conductors of insulated cables
60269	Low voltage fuses
60273	Characteristics of indoor & outdoor post insulators for systems with nominal voltages greater than 1000 V
60282	High voltage fuses
60296	Unused mineral insulating oils for transformers & switchgear
60305	Characteristics of string insulator units of the cap & pin type
60332	Tests on electric and optical fibre cables under fire conditions
60364-1	Electrical installation of buildings (Part-1: Scope, object and fundamental principles)
60364-2	Electrical installation of buildings (Part-2: Definitions- Chapter 21:Guide to

	general items)
60364-4	Electrical installation of buildings (Part-4: Protection for safety-Chapter 41: Protection against electric shock)
60376	Specification and acceptance of new sulphur hexafluoride
60383	Insulators for overhead lines with a nominal voltage above 1000 V
60417	Graphical symbols for use on equipment
60423	Conduits systems for cable management
60433	Characteristics of string insulator units of the long rod type
60437	Radio interference test on high voltage insulators
60439	Low voltage switchgear and control gear assemblies
604552-2	Solventless polymersable resinous compounds used for electrical insulation
60480	Guidelines for the checking of sulphur hexafluoride taken from electrical equipment
60502	Extruded solid dielectric insulated power cables from 1 - 30 kV
62052	Electricity metering equipment
60529	Degrees of protection provided by enclosures (IP Codes)
60587	Test methods for evaluating resistance to tracking
60621	Electrical installations for outdoor sites under heavy conditions
60644	Specification for high-voltage fuse links for motor circuit applications
60660	Tests on indoor post insulators of organic mats. between 1 - 300 kV
60672	Specification for ceramic & glass insulating mats.
60898	Circuit Breakers for overcurrent protection for households etc.
60947-1	Low voltage switchgear & control gear-General rules
60947-2	Circuit breakers
60947-3	Switches, disconnectors, switch-disconnectors, etc.
60947-5-1	Control circuit devices and switching elements
60981	Extra heavy duty electrical rigid steel conduits
61035	Specification for conduit fittings for electrical installations
61084	Cable trunking & ducting systems for electrical installations
62271-1	Common clauses for HV switchgear & control gear standards
62271-100	High voltage alternating circuit breakers
62271-200	AC metal - enclosed switchgear & control gear for 1 kV and up to including 52 kV
62271-203	Gas insulated metal-enclosed switchgear for rated voltages of 52 kV and above
62271-209	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 52 kV and above
62271-102	Alternating current disconnectors (isolators) and earthing switches
62271-103	Switches for rated voltage above 1 kV and less than 52 kV
62271-104	Switches for rated voltage of 52 kV and above
60358	Coupling capacitors and capacitor dividers
60071	Insulation co-ordination (Part-1: Definition, principles and rules, Part-2: Application guide)
60815	Guide for the selection of insulators in respect of polluted conditions
60137	Bushings for alternating voltages
60099-4	Metal - Oxide surge arresters without gaps for AC systems
60044-1	Instrument transformers, Part-1: Current Transformers
60044-2	Instrument transformers, Part-2: Voltage Transformers
60282	High voltage fuses.
60269	Low voltage fuses.

60865-1 Short-circuit currents – Calculation of effects (Part-1: Definitions and calculation methods)
61639 Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above
61850 Communication protocols for intelligent electronic devices at electrical substations

8.4.2 BRITISH STANDARDS

BS 29 Spec for Carbon steel forgings
BS 182 Specification for galvanised line wire for telephone & telegraphic purposes
BS 443 Specification for testing zinc coatings on steel wire
BS 499 Welding terms & Symbols
BS 709 Method & testing fusion welded joints
BS 729 Specification for hot dip galvanised coatings on iron & steel articles
BS 970 Specification for wrought steels for mechanical & allied Engineering
BS CP 1014 Tropicalisation
BS 1224 Specification for electroplate coatings of nickel and chromium
BS 1710 Specification for identification of pipelines & services
BS1780 Specification for Bordon tube pressure and vacuum gauges
BS 1858 Specification for bitumen based filling compounds
BS 2011 Environmental Testing
BS 2569 Pt2 Protection of iron & steel against corrosion at elevated temp.
BS 2600 Pt 1 Radiographic examination of fusion welded butt joints in steel
BS 2765 Specification for dimensions of temperature detecting elements
BS 2910 Radiographic examination of fusion welded circumferential butt joints
BS 3858 Specification for sleeves for electric cables & wires
BS 3923 Pt1 Methods of examination of fused welds and butt joints. &Pt2
BS 4211 Specification for ladders for permanent access to chimneys, other high structures, silos and bins
BS 4395-1-2 Specification for High Strength Grip Bolts
BS 4479 Pts 1-9 Recommendations for coatings.
BS 4592 Pt 1-4 Industrial type flooring, walkways and stair treads
BS 4604 Pt 1-2 Spec for high strength friction bolts
BS 4670 Spec for alloy steel forgings.
BS 4800 Schedule of Paint Colours for building
BS 4675 Pt2 Mechanical vibration of rotating and reciprocating machinery
BS 4872 Pt 1 Fusion welding of steel
BS 5395-3 Code of Practice for the design of industrial type stairs, permanent ladders etc.
BS 5493 Code of practice for protective coating of iron & steel structures against corrosion
BS 6072 Method for penetrant flaw detection
BS 6121-1 Specification for metallic cable glands
BS 6121-2 Specification for polymeric cable glands
BS 6121-3 Specification for special corrosion resistant cable glands
BS 6180 Code of Practice for barriers in and about buildings
BS 6231 Specification for PVC insulated cables for switch & control wiring

BS 6443	Method of penetrant flaw detection.
BS 7079	Preparation of steel substrates before application of paints
BS 7354	Design of high voltage open terminal stations

8.4.3 BS EUROPEAN STANDARDS

BSEN 287 -1&-2	Approval testing of welders for fusion welding
BSEN288-1-8	Specification and Approval of welding procedures
BSEN 50172	Emergency Escape Lighting System
BSEN 50171	General Requirements for Central Power Supply System
BSEN 50272-2	Safety Requirements for Secondary Batteries and Battery Installations
BSEN 1838	Emergency Lighting Applications

8.4.4 AMERICAN STANDARDS

IPCEA	: Insulated Power Cable Engineering Association
NEC	: National Electrical Code
NEMA	: National Electrical Manufacturers Association
IEEE std 141-1976	: Protection and Coordination
IEEE std 3004.8-2016	: Recommended Practice for Motor Protection in Industrial and Commercial Power System
IEEE Pub. No. 142	: Grounding of Industrial Power System
IEEE	: Institute of Electrical and Electronic Engineers
NFPA	: National Fire Protection Association
UL	: Underwriters Laboratories, Inc.

8.4.5 INDIAN STANDARDS

Air break switches, MCCBs, etc. for voltage not exceeding 1000 V AC or 1200 V DC	IS 13947
Current transformer	IS 2705 / IEC 60044
Voltage transformer	IS 3156 / IEC 60044, 60186
Electrical Relays	IS 3231, 3842 / IEC 60255
Contactors for voltage	IS 13947 / IEC 60947
not exceeding 1000 V AC Control Switches	IS 6875 / IEC 60947
High Voltage Fuses	IS 9385 / IEC 60282
Low voltage Fuse	IS 13703 / IEC 60269
Electrical direct acting indicating instruments	IS 1248 / IEC60051
AC electricity meters of induction type for voltage greater than 1000 volts	IS 722, 8530 / IEC 60145, IEC 60211
Porcelain post insulators for system with nominal voltages greater than 1000 volts	IS 2544
Specification for copper rods and bars for electrical purposes	IS 613
Specification for low voltage switchgear and control gear	IS 13947 / IEC 60947
Degree of protection provided by enclosures for low voltage switchgear and control gear	IS 13947 / IEC 60947

Marking and arrangement for switchgear, busbars, main connections and auxiliary wiring	IS 5578 / IS 11353
Code of practice for selection, installation and maintenance of switchgear and control gear	IS 10118
Miniature Circuit Breakers	IS 8828 / IEC 60898
Control Switches/ Push buttons	IS 6875

8.5 DEFINITIONS AND ABBREVIATIONS

For the purpose of these requirements the following abbreviations of electrical terms have been used.

Symbol	**Abbreviations**	**Symbol**	**Abbreviations**
GIS	Gas Insulated Switchgear	LV	Low Voltage
OHL	Over Head Line	ELV	Extra Low Voltage
OPGW	Optical Ground Wire	FLC	Full Load Current
EHV	Extra High Voltage	VCB	Vacuum Circuit Breaker
HV	High Voltage	MCB	Miniature Circuit Breaker
R	red phase	MCCB	Moulded Case Circuit Breaker
Y	yellow phase	ELCB	Earth Leakage Circuit Breaker
B	blue phase	RCD	Residual Current Device
ac	alternating current	MCC	Motor Control Centre
dc	direct current	PFC	Power Factor Correction
A	Amp	PF	Power Factor
mA	Milliamp	CP	Control Panel
V	Volt	LCP	Local Control Panel
W	Watts	LPBS	Local Push Button Station
kW	Kilowatt	UPS	Uninterruptible Power Supply
kWh	Kilowatt hour	PLC	Programmable Logic Controller
MW	Megawatt	SCADA	Supervisory Control And Data Acquisition
MWh	Megawatt hour	LAN	Local Area Network
VA	Volt Ampere	TEL	Telecommunication
kVA	kilovolt amp	I / O	Input / Output
MVA	Mega Volt Ampere	HMI	Human Machine Interface
MVAR	Mega Volt Ampere Reactive	OS	Operator Station
MVARh	Mega Volt Ampere Reactive Hour	R I / O	Remote Input / Output
XLPE	Cross Link Polyethylene	PVC	Polyvinyl Chloride
Hz	Hertz (cycles per second)	PC	Personal Computer
SP	Single Pole	SPD	Surge Protection Device
SPN	Single Pole and Neutral	LED	Light Emitting Diode
DP	Double Pole	UHF	Ultra High Frequency
TP	Triple Pole	HVAC	Heating Ventilation & Air Conditioning
TP&N	Triple Pole and Neutral		
SP&SwN	Single Pole and Switched Neutral		
TP&SwN	Triple Pole and Switched Neutral		
FOC	Fiber Optic Cable		

8.6 TECHNICAL SPECIFICATIONS

8.6.1 EXTRA HIGH VOLTAGE SYSTEM (EHV)

Rated Voltage	230 kV nominal
Highest System Voltage	245kV
Phases	3
Rated Frequency	50 Hz
Rated Short Duration Power Frequency Withstand Voltage (1 Min.)	460kV
Rated Lightning Impulse Withstand Voltage (1.2/50 μs)	1050kV
Rated Normal Current Bus Bar	4,000 A
Rated Normal Current Feeder	4,000 A
Rated Short Circuit Breaking Current (<3 cycles)	50 kA

8.6.2 HIGH VOLTAGE SYSTEM (HV)

Rated Voltage	110 kV nominal
Highest System Voltage	145kV
Phases	3
Rated Frequency	50 Hz
Rated Short Duration Power Frequency Withstand Voltage (1 Min.)	275kV
Rated Lightning Impulse Withstand Voltage (1.2/50 μs)	650kV
Rated Normal Current Bus Bar	3,150 A
Rated Normal Current Feeder	3,150 A
Rated Short Circuit Breaking Current (<3 cycles)	40 kA

8.6.3 MEDIUM VOLTAGE SYSTEM (MV)

Rated Voltage	11 kV nominal
Highest System Voltage	17.5 kV
Phases	3
Rated Frequency	50 Hz
Rated Short Circuit Breaking Current	50 kA
Rated Short Time Withstand Current	50 kA /3 sec.
Rated Short Circuit Making Current	125 kA
Rated Peak Withstand Current	125 kA
Rated Normal Current	4000 A

8.6.4 LOW VOLTAGE SYSTEM

Phase to Phase Voltage	415 V
Phase to Neutral Voltage	240 V
Frequency	50 Hz
Connection	3 Phase 4 Wire
Off Load Transformer Secondary Voltage	433 V
System Earthing	TNS (Neutral Solidly Earthed)
Rated Normal Current	1250A / 4000A
415 V maximum fault level	50kA / 3sec.

8.6.5 CONTROL VOLTAGE FOR 230/110KV GAS INSULATED SWITCHGEARS

Voltage : 110 V DC

8.6.6 CONTROL VOLTAGE FOR SCADA AND TELECOMMUNICATION EQUIPMENT AT 230/110/11KV GIS SUBSTATION

Voltage : 48 V DC

8.6.7 SPACE HEATER POWER SUPPLY

Voltage : 240 V AC (UPS Power)

Phases : 1

Frequency : 50 Hz

8.6.8 INSTRUMENTATION POWER SUPPLY

Voltage : 240 V AC (UPS Power)

Phases : 1

Frequency : 50

8.6.9 PLC INPUT / OUTPUT CIRCUITS

Supply Voltage: 24V DC

8.6.10 CLIMATIC CONDITION

All plant and equipment supplied under the Contract shall be entirely suitable for the climatic conditions mentioned below, and that will prevail over any data in the specification.

The project area and vicinity are close to sea and are in a humid and tropical climate. The ambient shade temperature variation is between 4˚C and 45˚C with periods of high humidity.

The project area is designated a zone of moderate intensity for earthquakes. The seismic factor is 0.05 g to 0. 1 g.

Maximum ambient shade temperature	45˚C
Minimum ambient shade temperature	4˚C
Maximum daily average temperature	35˚C
Maximum annual average temperature	25˚C
Maximum wind velocity	160 Km/h
Minimum wind velocity for line rating purposes	3.2Km/h (110/230kV)

Solar radiation	100mW/sq.cm
Rainfall	2.5 m/annum
Relative humidity, maximum	95%
Relative humidity, average	80%
Altitude	less than 10 m
Atmospheric Pollution	light
Salinity Level	High
Soil type	Sandy / Alluvial
Soil temperature (at 1.1m)	30˚C
Soil thermal resistivity	1.5˚C m/W
Isokeraunic Level (Thunderstorm days/year)	80

All outdoor equipment shall be corrosion proof and shall be fitted with a sunshade cover to provide effective protection against the sun and rain.

8.6.11 230 KV & 110KV GAS INSULATED SWITCHGEAR

This specification shall describe the general technical requirements for the new 230kV & 110kV Gas Insulated Switchgear and shall be read in conjunction with the Schedule of Technical Requirements and Key Single Line Diagram Drawing.

The Contractor shall demonstrate that the switchgear has been designed, built and installed in accordance with the relevant international standards and specifications. It shall also operate and perform on site in accordance with the requirements of the specification and in the environment and climatic condition mentioned in this specification.

The design shall be proven by the submission of test certificates at the time of Bidding covering all specified tests deemed to be pertinent to the plant and to the conditions in which it will operate.

The requirement for switchgear spares, tools and appliances, including test, maintenance and handling equipment shall be as stated in the Bid document. All devices necessary for operation and earthing shall be provided within the Contract Price.

Design, Installation, Testing and Commissioning of the GIS switchgears shall be done by the Switchgear Manufacturer.

Applicable Standards

Except where modified by this specification, the switchgear / accessories shall be designed, manufactured and tested in accordance with following latest IEC Standards and other publications quoted in these Standards. Any international standards referenced in the specifications and are outdated shall be replaced with the corresponding replacement.

List of Standards

IEC62271-1	Common clauses for high voltage switchgear and control gear standards
IEC 62271-100	High voltage alternating circuit breakers
IEC62271-102	Alternating current disconnectors (isolators) and earthing switches
IEC62271-103	Switches for rated voltage above 1 kV and less than 52 kV
IEC 62271-104	Switches for rated voltage of 52 kV and above
IEC 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and upto and including 52 kV
IEC62271-203	Gas insulated metal-enclosed switchgear for rated voltages 52 kV and above
IEC62271-209	Cable connections for gas insulated metal - enclosed switchgear for rated voltages of 52 kV and above
BS7354	Design of high voltage open terminal stations
IEC60376	Specification and acceptance of new sulphur hexafluoride
IEC 60358	Coupling capacitors and capacitor dividers
IEC 60364	Electrical installation of buildings (Part-1: Scope, object and fundamental principles)
IEC 60364	Electrical installation of buildings (Part-2: Definitions- Chapter 21: Guide to general items)
IEC 60364	Electrical installation of buildings (Part-4: Protection for safety- Chapter 41: Protection against electric shock)
IEC 60071	Insulation co-ordination (Part-1: Definition, principles and rules, Part-2: Application guide)
IEC 60815	Guide for the selection of insulators in respect of polluted conditions

IEC 60137	Bushings for alternating voltages
IEC 60099-4	Metal - Oxide surge arresters without gaps for AC systems
IEC60044-1	Instrument transformers, Part-1: Current Transformers
IEC 60044-2	Instrument transformers, Part-2: Voltage Transformers
IEC 60282	High voltage fuses.
IEC 60269	Low voltage fuses.
IEC 60865-1	Short-circuit currents – Calculation of effects (Part-1: Definitions and calculation methods)
IEC 61639	Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above

Technical Requirements

General design, material and manufacturing techniques used shall generally conform to General Technical Requirements.

Quality Assurance

Manufacturers of 230 kV &110kV GIS shall certify on their compliance to ISO 9001:2008 by an organization authorized for certification.

Detailed Ratings

Switchgear and substation equipment shall be suitable for continuous operation on a 3-phase, 50 Hz system of 230 kV & 110kV nominal voltages as per Key Single Line Diagram, Technical Requirements and under the specified climatic conditions. The 230 kV &110kV system shall be effectively earthed.

Type of Switchgear

The switchgear shall be of the SF6 gas insulated metal-enclosed type capable of continuous operation under the climatic conditions existing at the Site. Double busbar switchgear shall be provided. Busbar selector isolators as specified in the Schedules are required to facilitate the changeover of individual circuits from one busbar to the other with the circuit on load and a bus coupler closed. Test report on capability of on load bus transfer shall be submitted for the Engineer's approval.

The arrangement of the switchgear shall be such that all units face in the same direction and particular emphasis is placed on the provision of adequate clearance between chambers and between adjacent bays to facilitate maintenance.

The design of the switchgear shall be such as to enable extensions to be added at either end with the minimum of disturbance to the installed equipment and with one busbar in service. Suitable arrangement shall be provided with the switchgear for H.V. test of future extension part to keep the outage of the existing switchgear to a minimum.

The design shall include all facilities necessary to enable the performance of the specified site checks and tests during pre-commissioning & commissioning tests and after any repair & maintenance. The Contractor shall state the test facilities provided and indicate any attachments or special equipment provided for this purpose.

Design Principles and General Requirements

General

The design and performance of the switchgear shall comply with this Specification and the latest revision of the relevant International Electrotechnical Commission (IEC), if no other standards are specified. Deviations from these specifications and standards shall be stated in the appropriate Schedule.

The Contractor shall submit drawings indicating possible switch room layouts for 230 kV and 110 kV equipment for Engineer's approval.

The switchgear shall be supplied complete with all auxiliary equipment necessary for safe operation, routine and periodic maintenance and repairs with sufficient space between modules.

The normal operations will be carried out from the System Control Centre. The bidder shall take into consideration the unmanned operation of the substation in his design.

Control facilities shall be simple and clearly designated with the respective function and instructions on operation and maintenance and it shall be unambiguous.

The following provisions shall be made for control and indications :

Local control cubicle to equipment - control of circuit breakers, disconnectors and earthing switches which are power operated, complete with electrical indications, mimic diagram, gauges and alarm annunciator.

Remote panel in the control room on the site - control of circuit breakers, disconnectors and line side earthing switches which are power operated with position indication in each instance.

Supervisory control from a system control room centre - provision of control of circuit breakers and disconnectors switches which are power operated, with position indication in each instance.

All necessary local/remote and remote/supervisory control relays, interposing relays and selector switches are to be provided as part of this Contract.

Circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle.

In case of labels not visible when standing on the floor, additional name plate shall be fixed at a suitable location.

A single line diagram shall be marked along each bay showing the location of all items of switchgear.

In the event of leakage from any compartment, equipment shall withstand rated voltage with SF6 at atmospheric pressure.

The insulation levels shall be able to withstand basic test voltages in accordance with the relevant standards for Synchronizing Operation for Breakers.

Busbar connections and enclosures shall be designed to absorb the effects of thermal expansion without application of stress to the supporting structure.

Equipment foundation requirement details complete with floor and structure fixings consistent with the switchgear design offered are to be provided at an early stage in order for these to be incorporated in the civil works design.

Availability for Maintenance, Repair, Extensions, Testing

Maintenance, Repair or Extension (MRE) and HV Testing on one busbar with directly connected apparatuses shall be possible with the other busbar in normal operation.

MRE Testing on one switchgear bay shall be possible with all other switchgear bays in normal operation on one busbar.

MRE Testing on/off bus coupler bay shall be possible with one busbar at the time in normal operation and all switchgear bays in normal operation.

Maintenance access to each module shall be possible without necessitating the outage of adjacent modules.

Gas Compartments

The switchgear units and busbar systems shall be divided into several gas-filled compartments, sealed from each other by gas-tight partitions.

The various gas zones shall be further sub-divided when necessary to restrict any internal arcing damage, particularly within sections of busbars and to enable gas handling procedures to be completed with the minimum of delay. The partitions should confine any internal faults to a respective section of the switchgear.

The number of gas compartments shall be such as to limit the amount of switchgear which has to be isolated and taken out of service as a result of gas leakages, planned maintenance or internal faults.

Proposals for the partitioning of gas zones shall be clearly indicated on the drawings submitted with the bid. Partitioning on the GIS shall be clearly marked with yellow paint on the GIS. Gas volumes and duration of gas handling procedures shall also be indicated in the technical schedules. Each gas zone shall have its own gas monitoring, filling, degassing, re-gassing & gas sampling facility.

Total time for gas evacuation and filling of the largest chamber shall not exceed 10 hours.

Suitable arrangements shall be provided for the thermal expansion and contraction of the busbars and busbar chambers without detriment to the current carrying capacity or gas volume.

Devices shall be provided for each section of switchgear as appropriate to allow for pressure relief. All relief devices shall be located such that operation of the devices shall not endanger personnel working on the equipment or in the vicinity of the equipment.

These devices shall be arranged to give individual compartment alarms in the local control units and initiation of remote alarms. Each gas-filled chamber shall be fitted with static filters to absorb any moisture which may be present. In addition, filters for removal of SF6 decomposition products shall be provided in Circuit Breaker compartments.

For circuits equipped with double cable isolation, provision shall be made to remove the gas from either cable chamber whilst maintaining the other cable in service. i.e., Gas monitoring of the chamber in service shall be maintained at all times.

In chambers equipped for 230kV &110 kV cable sealing ends a disconnecting link must be provided to allow easy isolation between the cable sealing end and the main connections. It must be possible to remove this link without removal/refitting of the main connections alternatively the barrier should be designed for HVAC test of Power Cable.

In order to compensate for any small variations in floor level each compartment shall be fitted with means of adjustment (jacking screws or similar). Such adjustments shall be fully described in the maintenance manuals provided by the manufacturer. In case such arrangements do not exist, it shall be the responsibility of the manufacturer to ensure acceptable floor level tolerance.

Enclosures shall be clearly marked to identify gas compartment zones, disconnectors, circuit-breakers, earthing switches, current transformers, voltage transformers, surge arresters and other primary devices contained therein. The method proposed shall be subject to the approval of the Engineer.

Gas Barrier and Supporting Insulators

Gas barriers shall be gas tight and of sufficient strength and factor of safety to withstand short circuit forces and the maximum pressure differential that can occur under internal fault conditions. The gas barrier withstand pressure shall be more than that of bursting disc. It should be possible to vacuum, any chamber with adjacent chambers having full pressure.

Enclosures

The enclosures for the SF6 gas insulated switchgear shall be of Aluminum Alloy.

It shall be capable of withstanding maximum differential pressure between adjacent gas zone over a considerable period. Evidence shall be provided to verify that enclosures have been designed and tested in accordance with established pressure vessel codes.

Each enclosure shall be tested and stamped by the inspecting authority issuing the test certificate.

Circuit-breakers, isolators, earth switches, VTs, CTs, surge arresters, cable termination chambers, all and any other chambers and components shall have pressure tests on enclosures as per IEC 62271-203 clause 7.101. The withstand pressure of the enclosures shall be well over the bursting disc operation pressure and shall be embossed on all the enclosures at a conspicuous location.

Voltages induced in the enclosures shall not be allowed to exceed reasonable safe limits. All chambers throughout the equipment shall be earthed at an approved number of points. All necessary earthing bars and associated fixings shall be provided. Approved GIS earthing drawings are to be supplied from the manufacturer of the GIS.

Each enclosure shall be provided with lifting points to facilitate maintenance or repair works.

SF6 Gas

(a) SF6 Gas Requirements

All SF6 gas supplied for use in the switchgear shall comply with the requirements of IEC 60376.

Test Reports shall be submitted for review.

(b) SF6 Immersed Insulation

Busbars and items of switchgear shall be supported in the enclosures by insulators of materials compatible with SF6 gas and the products of gas decomposition.

Gas barrier insulators and bushings, including gas-oil and gas-air bushings shall comply with the specified conditions for sealing of enclosures. The Engineer shall be advised of design pressures used and may require test evidence to substantiate performance under extremes of differential pressure and temperature.

SF6 immersed insulation shall otherwise comply with the relevant clauses for insulators and bushings.

Gas Monitors

Gas density monitors complete with alarm and lockout contacts or manometers with pressure switch for alarm and lockout shall be provided. The gas monitor shall be located such that readings can be taken easily standing on the floor. Means shall be provided to enable gas systems to be safely replenished whilst the equipment is in service.

For circuit breaker compartments, a lockout feature shall be provided to prevent operation whenever SF6 gas pressure is less than that permitted by the design for satisfactory operation. Contacts shall be included to initiate alarms to warn of this condition.

Two sets of voltage free electrical changeover contacts shall be provided for every alarm for remote SCADA and repeat alarm facilities in addition to alarm fascias incorporated in the local control panel/marshalling kiosk associated with each primary circuit. Contact multiplying relays may be used.

Position Indicators

Position indicators shall be provided for all circuit-breakers, disconnectors and earthing switches to show whether the main contacts of these switches are in the fully open or closed positions. Position indicator should be directly coupled with shaft drive for all three phases.

Indicators shall be of a reliable mechanical design and be positively driven in both directions by the final drive stage of the contact operating mechanism. Reference marks should be punched or engraved on the main frame for this purpose. Each indicator shall be clearly visible to operating staff at operating control points and access routes provided under this contract.

Temperature Rise

The temperature rise limits shall be in accordance with IEC62271-203. The switchgear shall be capable of carrying the specified rated current at rated frequency continuously in accordance with normal service conditions as defined in IEC 62271-1 as well as site ambient conditions.

The design of sliding type current carrying connectors and joints shall be such that they meet the aforementioned conditions over the full permitted range of movement. Where such joints may be made or adjusted on Site, full details of alignment procedure, together with any necessary alignment tools or gauges shall be described in the maintenance manual and included in the supply of special tools.

Arrangement

The switchgear shall be installed in a building with a cable basement, both being maintained at a slight positive pressure of filtered air such that any SF6 gas released in the building will be discharged externally via pipes from the lowest point.

The Contractor shall supply the necessary permanent type of ladders and galleries for access to all levels of equipment during normal operation or maintenance.

The Contractor shall include in his supply power operated lifting appliances with all accessories as appropriate to the size and weight of component parts of the switchgear which require to be lifted in the course of maintenance or repair. The layout arrangement shall allow for full mobility of the gas handling plant ladders, cat way walks etc. along the switch room.

The offer shall include (a) mobile platform suitable to reach any equipment, (b) Handles of manual operation of D/S, E/S and (c) any special tool required for the operation of the switchgear. 2 nos. of 63A sockets shall be provided in the GIS room at suitable location for the gas handling plant and HV test set.

Mechanical Construction

Components that may require to be renewed and standard assemblies that may be transferred from one circuit to another shall be interchangeable and where required this shall be demonstrated by the Contractor. Flanges shall comply with an appropriate metric standard as regards both dimensions and drilling, where appropriate.

Screwed couplings and fittings shall have pipe threads to ISO Recommendations.

Testing Facilities

Testing flanges/adaptor and associated bushings for 3 phases shall be provided where relevant on each circuit for HV withstand testing of main cables and switchgear. Each testing flange shall be positioned in a separate gas zone compartment which shall be independent of adjacent disconnector and earthing switch gas sections.

HV Cable Testing Facility

A set of single and three-phase cable test bushings and the facility for connection to the switchgear shall be provided which will permit the full AC testing of all cable connected circuits. It shall be possible to connect the test bushings without dismantling other equipment and permit testing three single-core cables at the same time or separately by connecting the test bushing to the AC high voltage test kit fitted at a suitably safe place inside the switchgear room. Adequate precautions shall be taken to ensure that any section of busbars insulated by SF6 gas is not subjected to any cable testing voltage unless able to withstand such voltages. Hence the bidder shall indicate if there is any deviation.

Removal/Insertion of Links for HV Cable Tests and Primary Injection

The Contractor shall be responsible for the degassing, removal of the cable chamber links at the remote ends, and regassing to facilitate HV Cable Tests and Primary Injection. Once the tests are complete the degassing, insertion of the links and regassing shall be completed thus allowing normal operation of the switchgear. This shall include replacement of gaskets as necessary.

Sealing of Enclosures

To prevent ingress of moisture or leakage of gas during the service life of the equipment, the sealing materials used at all joints and interfaces shall satisfy the following requirements:

1. Not affected by SF6 gas
2. Non-hygroscopic, containing no silicon
3. Non-aging and non-shrinking
4. Retain resilience for long periods under stress
5. Stable under all temperature conditions

Seals including those at compartment partitions shall continue to function correctly throughout the temperature and pressure ranges in service and the pressure differentials, including vacuum and test pressures, during erection, maintenance and subsequent revisions.

Expansion bellows and diaphragms, pressure relief devices and inspection windows shall be designed to be free of leakage under the same conditions as stated for seals.

Where the use of cast Aluminium is envisaged the Manufacturer shall submit to Engineer evidence of tests carried out for porosity and extended pressure testing to show the quality of the castings used.

Gas Losses

The Manufacturer should be prepared to guarantee the equipment for a gas loss of not more than 0.5% per annum in any single gas compartment, and not more than 0.5% for the total installation.

Earthing System

All metal parts other than those forming part of any electrical circuit shall be earthed to the earthing system. Any necessary terminals on part of the equipment required for this purpose shall be provided by Contractor. The jointing parts of the earthing conductors/strips are to be properly tinned.

230kV &110 kV cable sheath shall be connected to the earthing grid through the link box.

Gas Handling Equipment

Gas handling plant shall be provided at each installation to permit emergency topping up of gas in the switchgear in the event of leakage and for use during any maintenance works.

The mobile gas handling unit, the size of which shall allow full mobility within the switch room, shall be included for the complete sampling, testing, filtering, drying, extraction and refilling of SF6 gas. This unit shall be self-contained and comprise of a wheeled trolley housing all necessary compressors, vacuum pumps, filter, etc. gauges, piping and controls etc., together with a gas storage tank with usable capacity. The unit shall be capable of evacuating air from the switchgear compartments and replenishing them with gas at the end of a maintenance period. Facilities shall also allow for circulation of the gas from a compartment through filters in order to extract moisture pressure.

Additional mobile or static storage (at least one full cylinder of SF6 gas together with one empty cylinder) shall be provided for use in combination with the gas trolley and to extend storage facilities.

All necessary pipe work, flexible hoses, couplings, valves, pressure and vacuum gauges shall be included to enable interconnection between the switchgear compartments, gas trolley and storage tanks and the cylinders provided by major producers of SF6 gas.

To enable safe maintenance to be carried out on any portion of the switchgear when all electrical supplies to the local control unit are switched off two portable gas alarm units shall be provided. The alarm units shall be self-contained and capable of giving clear audible warning should the gas pressure in any adjoining gas-filled chamber become unsafe. The cost of these equipment shall be included in the GIS price.

Technical Data:

Vacuum Pump

Nominal suction capacity	:	l0m3/h
Achievable final vacuum	:	< 1 mbar Compressor
Theoretical intake volume	:	5.7 m3/h
Suction pressure	:	p = 0.8 to 3 bar (for a short time up to 0.5 bar)
Max. counter-pressure	:	p = 50 bar
Storage performance	:	90 kg
SF6 Filling performance	:	140 kb SF6/h.

An approved portable SF6 gas leakage detector, oxygen analyzer, moisture meter and manual operating handles/tools (for circuit breakers, disconnectors, earth switches) shall be provided for each GIS switchgear room.

Apparatus

Circuit Breakers

Operating Duty and Performance

General

The requirements of IEC 62271-100 in respect of type tests, routine tests, service, operation and the making and breaking of fault currents shall apply to the specified circuit breakers.

Circuit breakers shall be complete with spring or hydraulic operated mechanisms. Where circuit breakers require other services these shall be included in the supply and erection of the common services installation at each substation, and shall include alternative back up facilities.

Offers of circuit breakers shall include proof that a satisfactory period of commercial service experience of not less than three years in climatic conditions similar to Chennai has been obtained with the type and rating put forward; failure to provide this proof may result in rejection of the bid.

Rate of Rise of Re striking voltage

Attention is drawn to the transient recovery voltage (TRV) requirements of the IEC Standards. Where not specifically stated in the test certificates submitted with the Bid, the Bidder shall certify that the TRV to which the Circuit breaker was subjected during the short circuit tests was the most severe condition that could be imposed by the available test plant for a first phase-to-clear factor of 1.3.

Any device incorporated in a circuit breaker to limit or control the rate-of-rise of re striking voltage across the circuit breaker contacts shall likewise be to Engineer's approval and full descriptions of any such device shall be given.

Evidence shall be submitted with the bid to verify that all circuit breakers when interrupting faults on the secondary side of a transformer the transient recovery voltage conditions, that could arise will not exceed the tested interrupting capabilities of the circuit breaker proposed.

Interrupting Duty

In addition to the requirements of IEC 62271-100 for interrupting terminal faults all circuit breakers shall be capable of coping with the interrupting duties produced by the switching of low inductive currents associated with reactors and transformer magnetizing currents and by the switching of capacitive currents associated with overhead lines, cables and capacitors banks as may be applicable. Circuit breakers for these duties shall be of the re strike-free type only.

All circuit breakers shall also be cable of interrupting currents associated with short-line faults and the out-of-phase switching conditions that may occur in service.

The total interrupting time shall be 40ms or less for 245kV CB, 60ms or less for 145kV CB from energization of trip circuit of the circuit breaker to the extinction of the arc. The total closing time shall be less than 65msec from energization of closing circuit of the circuit breaker to closing of the breaker contacts. The operating duty cycle shall be 0 - 0.3 sec - CO - 3 min - CO, with no de-rating for the first re-closure between operations over the voltage range from nominal to rated maximum voltage and from zero to the maximum rated interrupting current without the necessity of intermediate maintenance. The circuit breakers shall be capable of withstanding the transient recovery voltage as per IEC-62271 (values to be determined by the Contractor).

The circuit breaker shall be designed for M2 class as per IEC 62271 under all duty conditions.

Fault Clearance Time

The overall fault clearance time including relay operating time shall be in accordance with the requirements specified.

General Arrangement

Facilities for measurement of circuit breaker contact resistance and timing tests without removal of covers or SF6 gas filling shall be provide. Full details of the testing procedures shall be submitted with the Bid.

Means shall be provided to allow access for the inspection and maintenance of fixed and moving contacts and other enclosed components.

Circuit breakers use the SF6 gas conforming to IEC or other approved standard as the insulating medium as well as for arc quenching.

Circuit breakers shall operate on the principle of self-generating gas pressure within the interrupter for arc extinction. e.g., puffer type. A lockout feature shall be incorporated to prevent operation of the circuit breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with rated duty. A pressure switch (temperature compensator type) operated SF6 low in CB alarm shall be incorporated at LCC, Remote Control Center as urgent feeder alarm at SCC to give indication of falling gas pressure prior to lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by integral filters.

Sufficient nos. of N/O and N/C auxiliary electrical contacts shall be provided for using interlocking circuits and for states indication at the remote and supervisory control centers and any other requirement. At least 10% spare N/O and N/C contacts shall be wired up to LCC for future use.

Operating Mechanisms

The circuit breaker operating mechanism shall be power operated and of the type specified. Operation will normally be from a remote or supervisory position, but facilities shall be provided for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters shall be fitted to all circuit breaker mechanisms.

The mechanism and its control scheme shall be such that, in the event of an electrical tripping pulse being applied to the circuit breaker during the closing stroke, or of the mechanism falling to latch in the closed position, the circuit breaker shall open fully and in such a manner as to be capable of interrupting its rated breaking current.

The mechanism and its control scheme shall be such that the mechanism shall not make repeated attempts to close the circuit breaker when the control switch is held in the CLOSE position in the event of failure to latch on the first closing attempt or in the event of a trip signal being given to the circuit breaker i.e., anti-pumping facility to be provided.

The electrical closing and tripping devices, including direct acting solenoid coils and solenoid operated valves, shall be capable of operation over the ambient temperature range when the voltage at their terminals is any value within the voltage range stipulated in IEC62271-100 and in addition over the range of all operating conditions of the batteries and chargers supplied under this Contract.

The circuit breaker shall preferably be driven by a single mechanism coupled to the three phases.

The circuit breakers shall be provided with the facility for measuring the electrical timing of the contacts.

All circuit breaker operating mechanisms shall be fitted with independent duplicate shunt trip coils suitable for either independent or simultaneous operation.

On feeder circuits Trip Coil 1 (TC1) shall be operated by all circuit protection and inter trips except Main 2 protection. Trip Coil 2 (TC2) shall be operated by Main 2 protection and the local, remote and supervisory control switches.

On Bus Coupler and Bus Section circuits TC1 shall be operative by bus zone protection and TC2 by overcurrent protection and controls.

On Transformer and Generator circuits TC1 shall be operated by all protection and inter trips except REF and TC2 by REF and controls.

Power closing mechanisms shall be recharged automatically for further operations as soon as the circuit breaker has completed the closing operation and the design of the closing mechanisms shall be such that the circuit breaker cannot be operated inadvertently due to external shock forces resulting from short circuits, circuit breaker operation, or any other cause.

Operating mechanisms shall be capable of storing energy for at least two complete closing and tripping operations or one O-C-O operation, local to the equipment and without recharging. Mechanisms shall preferably utilize DC supplies for recharging duties.

Means shall be provided for the CB manual (non-electrical) tripping of the circuit breaker, preferably by a shrouded push button and facilities shall be provided for locking off this means of tripping. It shall not be possible to lock mechanically the trip mechanism so as to render the electrical tripping inoperative.

Facilities shall be provided to permit manual slow closing and slow opening of the circuit breaker for maintenance purposes. It shall not be possible to “slow close" or "slow open" a circuit breaker when connected in the normal service condition.

Spring Charged Mechanisms

Circuit-breakers fitted with power charged spring operated closing mechanism shall also meet the following requirements.

When fully charged the spring mechanism shall have sufficient stored energy to permit the operating sequence O-C-0/2 C-0 to be performed following the loss of supply to the charging motor.

The mechanism shall be charged automatically, for further operations, as soon as the circuit breaker has completed a closing operation. The time required to power charge the spring shall not exceed 30 seconds (as per IEC Standard).

The spring shall be fully charged before it can be released to close the circuit breaker. It shall not be possible for the breaker to close whilst the spring is being charged.

Manual Spring charging facility shall be provided.

A mechanical indicating device shall be provided to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of “spring discharged".

An indicating device shall be provided at the local control panel and the main control room and also over the supervisory system to indicate a spring failing to be charged by a pre-set time after circuit breaker closing.

Circuit Disconnectors and Earthing Switches

General

Circuit Disconnectors and Earthing Switches shall be supplied as shown on the Key Single Line Diagram. Each disconnector and Earth Switch shall be labeled with SCADA numbers as per SLD by providing permanent engraved stickers.

Transformer circuit modules shall be equipped with not less than two maintenance earthing switches, one on either side of the transformer circuit breaker.

Each busbar shall also contain high speed make-proof earthing switch as per the Key Single Line Diagram.

In case of designs incorporating double isolation and interposing earthed metallic screen shall provide similar facilities which enable safe access for testing, inspection, maintenance and extension whilst other parts are in service.

Isolating and earthing switches shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive. Isolating switches shall be arranged for operation while the equipment is alive, but will not be required to break current other than the charging currents of open busbars and connections (including circuit-breaker bushings) or load currents shared by parallel circuits under the conditions of this Specification.

Isolators shall be housed in compartments partitioned from the circuit breakers and the busbars or feeders with which they are associated.

Isolators with double isolations, may be housed into two adjacent compartments. It shall be possible with such partitioning and with the isolator compartments maintained at full gas pressure, to carry out high voltage insulation withstand tests on outgoing circuit cabling or on sections of busbar, without taking adjacent equipment or sections of busbar out of service.

Load making and breaking switches with fault making capability shall be provided which shall be suitable for switching on load without detriment to the equipment and under normal duties up to the circuit rating specified.

Switch mechanisms shall be so designed that the isolator cannot be opened by forces due to currents passing through it and shall be self-locking in both the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Power operated drives shall be provided which shall be suitable for local, remote and supervisory control (supervisory control of earth switches is not required) and should be fitted with a removable emergency manual operation facility. It should be possible to lock-off the manual and local facility and padlock the mechanism in the open and closed positions with the motor automatically disengaged (isolator and earth switch).

Local mechanical position indicators shall be provided on all switches and shall be visible from ground level. Transparent window shall have to be provided as required to see the Disconnector and Earth switch contact status (Close or Open).

For safe earthing of the busbars and feeders, high speed fault making spring driven earth switches shall be provided. The mechanisms shall be electrically operated with provision for local manual operation. The contacts of these earth switches shall have the same fault making capability as that of the circuit-breaker.

Each section of busbar which can be electrically isolated from other sections of busbar by means of isolators or circuit-breakers shall incorporate high speed earthing switches as specified above.

Slow speed maintenance earthing switches shall be manually and electrically operated from the local position only. Positive mechanical and electrical interlocks shall be provided to prevent unintentional use of this earthing equipment.

Selected earthing switches shall be arranged such that, with a minimum use of tools and special fittings, they may be used to facilitate such tests as CT primary injection, contact timing and voltage drop measurement without the necessity to open gas-filled compartments. Detailed means of performing these tests, shall be provided.

Each Isolator/Earth Switch shall have its own separate power and control supply and supplied from the station battery.

Sufficient nos. of N/O and N/C auxiliary electrical contacts shall be provided for using in interlocking circuits and for status indications at the remote and supervisory control centers and any other requirement. At least 10% spare N/O and N/C contacts shall be wired up to LCC for future use by Engineer.

The Disconnector Switch (DS) shall be designed for M1 class as per IEC 62271 under all duty conditions. The Earthing Switch (ES) shall be designed for M0 class (Mechanical endurance) and E1 class (Electrical endurance).

Disconnectors

Disconnectors shall be of the metal enclosed design and shall generally comply with the requirements of IEC 62271-102, 62271-104 and 62271-203.

Disconnectors shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive.

Disconnectors shall be provided with motor driven mechanisms and shall open and close all three phases simultaneously. It shall not be possible for the disconnectors to open or close inadvertently due to forces which may occur in service or under short-circuits.

The mechanisms shall be capable of being locked and secured by padlock in the open or closed position.

In the event of driving motor failure, means for hand operation shall be provided which are operable from ground level or walkways provided.

While doing a hand operation of disconnector, driving motor supply shall be cut off by appropriate means.

All disconnectors shall be fully interlocked with associated circuit breakers, disconnectors and earthing switches to ensure safe operation of the equipment under all service conditions.

The disconnector shall be interlocked with CB is arranged in such a way that CB shall not be allowed to close unless the concerned disconnector is fully closed, i.e. Late make type auxiliary contact shall be used for this purpose.

Electrical interlocking is required for maintenance and operation.

The insulation level for the isolating distance between disconnector contacts shall be at least 15% higher than that for the remainder of the equipment.

Disconnectors shall be capable of switching load currents when shunted by a parallel path (on-load bus transfer) and capacitance charging currents associated with open busbar, bushings and capacitor voltage transformers. Test certificates on the capabilities of on load bus transfer of disconnectors are to be provided.

If the disconnectors are expected to generate fast rising transients during interruption of capacitive currents, adequate protection shall be provided for transient voltage control.

Maintenance Earthing Switches

Earthing switches shall generally comply with the requirements of IEC 62271- 100 and 62271-203.

Earthing switches integrally mounted with disconnectors or separately mounted shall be provided for earthing already isolated sections of gas insulated switchgear in order to provide safety maintenance. Motor operated mechanisms shall be provided but it shall be possible to operate the switch manually in emergency conditions.

The earthing switch, when in the closed position shall have a short-time current withstand as specified for the feeder. No burning or welding of contacts shall occur.

Provisions for testing purposes shall be incorporated in the design of earthing switch to facilitate primary current injection tests and other low voltage checks. Fully insulated designs of earthing shall incorporate removable earth links suitable for the short-time current rating specified. It shall be possible to apply maintenance earths on either side of the test zone for safety reasons.

All earthing switches shall be mechanically interlocked with associated circuit breakers and disconnectors so that it shall not be possible to close an earthing switch onto a live circuit or to make the circuit alive when the earthing switch is closed.

Direct visual indication of the earthing switch position should be provided, with clear markings to show that the device is fully open or closed.

High Speed Earthing Switches

These earthing switches shall be capable of making onto a live circuit and suitable for high speed power operation. It shall be impossible to slow close these earthing switches.

They shall be located at all feeder terminal points and busbars or other location where there is no certainty that the point to be earthed is not energized.

High speed earthing switches shall be capable of interrupting induced currents as may be necessary when opening the earthing switches used for grounding one out of two or more long parallel circuits.

The operating mechanism of high speed Earthing Switches shall be motor wound spring operated type with one of the following features:

The closing spring shall remain in discharged position when the switch contacts are in open position. The closing spring shall be charged only when the closing command is given either electrically or manually and the contacts shall close automatically after the spring is fully charged.

If earthing switch is provided with the design in which closing spring is charged and latched in the open & close position of the switch, then mechanical locking arrangement shall be provided to avoid un-intentional closing of the switch either electrically or manually.

In both the designs, facility for padlocking the mechanism in the open position of the switch shall be provided.

The design of the Earthing Switch shall be approved by the Engineer.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and incorporate a dis-connectable earth strap.

These earthing switches shall otherwise be in accordance with the requirements for maintenance earthing switches.

Current Transformers

Current transformers shall be supplied suitable for the duty specified and comply with the requirements of IEC 60044-1 and BS 3938 as appropriate.

Current transformers, where specified, shall be SF6 gas insulated, shall be compatible with the switchgear and shall preferably not contain any hygroscopic insulating material which could affect the SF6 gas in either the current transformer or in the associated switchgear chamber.

Current transformers shall comply with the requirements of the common sections of this Specification. Where separate terminal boxes are used for current transformer secondary wiring, the identifying labels shall be fitted to the terminal boxes in a conspicuous position but not on removable covers.

Current transformers including primary conductors shall have a short time current rating and duration not less than that of the associated switchgear. All current transformers shall have sufficient overload capacity to permit continuous operation with currents up to 150% of the rated current of the associated equipment.

Secondary windings of each current transformer shall be earthed through a withdrawable link at one point only; in the relay panel for protection circuits and in the control panel for instrumentation.

Current transformers for tariff metering shall not be used for any other purpose. Current transformers for statistical metering may also be used for other instruments and protection.

Where double ratio secondary windings are specified a label shall be provided at the secondary terminals of the current transformer indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams.

CT sizing calculations shall be submitted to the Engineer for approval.

Where double ratios are specified and current transformers with multiple windings are tendered, it shall be possible to select either ratio for each winding without alteration to the number of primary turns.

The characteristics of current transformers used for protection circuits shall include the following requirements.

For overcurrent protection, they shall not saturate, change ratio or produce harmonic voltages in the secondary winding which will affect the accuracy of the relay with primary currents up to 20 times rated the full load current.

For earth fault protection and balanced forms of protection, when connected as in-service, they shall not produce spill currents in excess of half the minimum operating current of the relay but provide stable equipment with primary currents up to 20 times rated full load.

Each protection scheme shall be provided with appropriate current transformers for optimum operation of the scheme. Provision should be made to carry primary injection test of bushing CTs for 100% rating.

Terminal boards shall have shorting/disconnecting links to allow testing with the circuit in service and on load. It shall be possible to carry out primary injection testing of the CTs with 100% rating when the switchgear is fully assembled, or retesting of the CTs during the service life of the switchgear without interruption of supply to adjacent circuits or any part of busbar. The testing facilities provide in the design for site testing shall be stated by the Bidder.

The Contractor should clearly mention the continuous rating of earth switches and their associated cables for the purpose of primary injection tests. The secondary windings of each set of current transformers shall be capable of being open circuited for one minute with the primary winding carrying the rated current. The secondary wiring of all CT's shall be brought to a common terminal block located within the local control cubicle.

The polarity of the primary and secondary windings of each transformer shall be clearly indicated at the respective terminals and in addition labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer winding.

Neutral CT for REF protection and any other CTs which require to be matched with switchgear CTs will be manufactured by switchgear manufacturers and hand over to transformer manufacturer for installation. Suitable mounting arrangement is to be made by the transformer manufacturer.

Voltage Transformers

Indoor voltage transformers, where specified, shall be SF6 gas insulated, shall be compatible with the switchgear and shall preferably not contain any hygroscopic insulating material which could affect the SF6 gas in either the voltage transformer or in the associated switchgear chamber.

Voltage transformers shall comply with the common sections of this Specification, comply with the requirements of IEC 60044-2.

The rated secondary voltage per phase shall be 110/3volts in the case of star connected windings and the rated voltage factor shall be 1.2 continuous; 1.5 for 30 seconds.

Facilities for isolating the primary connections without having to lift the VT from the switchgear shall be provided. This primary isolation shall be without degassing.

It shall not be possible for voltage transformer secondary windings to be connected directly in parallel, except through interposing voltage transformers associated with a synchronizing scheme. To prevent any possibility of back energizing a VT secondary winding via synchronizing circuits, circuit breaker auxiliary contacts which are of the late make-early break type shall be employed.

Voltage transformers shall be capable of carrying continuously, without thermal damage 150% of their rated output.

Voltage transformers on feeder circuits shall be located on the feeder side of the circuit breaker outside the protected zone covered by the busbar protection. They shall however be included in the protected zone afforded by the feeder protection.

Primary connections shall have the same short time current rating as the associated switchgear.

Each secondary winding of the voltage transformers shall be protected by suitable approved fuses and links which shall be located as close as possible to the voltage transformer, preferably within the terminal box. All secondary winding connections, including both ends of the secondary winding shall be brought out to the fuses and links. The fuses and links shall be connected to approved terminal blocks for termination of multicore cables. A metallic label shall be provided and fixed at the voltage transformer clearly indicating the connections required for each winding.

Separate sets of MCBs shall be provided at the VT for:

(a) Each protection scheme
(b) Instruments, disturbance recorder, fault locator etc.
(c) Synchronizing

The circuits for each main protection scheme shall be segregated in separate multi-core cables from the VT to the protection panels. An alarm (VT failure) shall be provided for each set of MCBs.

The neutral point of each voltage transformer secondary circuit shall be earthed at one point only via a separate removable link of approved design. The earth link shall be situated in an accessible position and suitably labeled.

A magnetization curve shall be provided for each voltage transformer for approval by Engineer.

The location of the voltage transformers to be installed on the primary switchgear shall be approved by the Engineer.

Fixed ladders and/or catwalk structures with handrails are to be provided for the VTs for inspection/testing/replacement of fuse, etc.

Mechanical shock indicators shall be fitted to VTs prior to dispatch from the factory, to indicate how the VT was handled during transit and to determine if detailed inspection is required at Site.

Electromagnetic voltage transformers shall be capable of discharging the capacitance of line, cables and switchgear which may remain connected to them during switching operations. The Bidder shall declare any limitations of the equipment for this duty.

The Contractor shall ensure that no disruptive over voltages will be generated due to ferro-resonance phenomena and if necessary, by suitably connecting resistors across the secondary of VT after approval of Engineer. All necessary site tests are to be performed on VTs before commissioning. Details of the test procedures and test formats are to be provided.

Feeder and Transformer Connections

General

SF6 immersed cable sealing end chambers or SF6 gas insulated bus ducts shall be provided as specified for outgoing circuits.

If the Contractor opted to connect the transformer using SF6 gas insulated bus ducts and air insulated bushing, the supply and installation of such gas insulated bus ducts and Air Insulated Bushing shall be included under this contract by the Contractor.

When the circuits are connected via cables directly to the SF6 switchgear terminals the cable and sealing ends shall be as per IEC Standards.

Connections shall be suitable for the specified continuous and short circuit current ratings. Where necessary, expansion joints shall be provided to accommodate differential movements between the switchgear phase terminals and conductors.

The manufacturer of the switchgear is required to coordinate design of SF6 filled enclosures with that of cable sealing ends and transformers supplied by other manufacturers such that the integrity of gas and/or oil pressure compartments is maintained.

Facilities shall be provided for high voltage AC testing and conducting cable fault location measurements of cabled circuits.

To reduce the effect of solar gain all SF6 or other types of insulated bus ducts exposed to direct sunlight shall be covered with metallic sun shielding (If the installation is outdoor partly).

Cable Sealing Ends

Cable sealing ends shall be suitable for terminating the cables specified directly into the GIS switchgear. The dimensions and terminal arrangements, together with details of filling medium of the sealing end shall be submitted for approval by the Engineer before manufacturing.

All sealing ends shall be suitable for filling and shall be designed with joint faces which will ensure leak-free operation and exclude the entry of oil or gas.

Where required to reduce local heating when single-core cables are adopted, non-magnetic gland plates shall be provided or alternatively, non-magnetic inserts.

Design of cable termination equipment must ensure that the following conditions are maintained throughout the life of the equipment.

1. The insulating material, either gas or oil, from inside the cable does not escape and penetrate the switchgear enclosure.

2. The SF6 gas does not enter the cable from the enclosure.

3. The cable sealing end does not introduce moisture into the gas in the sealing end enclosure.

4. The sealing end is capable of withstanding the cable test voltages and differential pressures without damage including overpressure of +30% of normal operating pressure.

Insulating and Earthing

Sealing ends shall be provided with all fittings including flexible connections where necessary. Stress cones or other approved means for grading the voltage stress shall be provided for insulating the cable within the sealing end. (The insulated flange and external casing shall be provided by the cable manufacturer). Glands shall be insulated from the chamber.

The insulation between cable and chamber shall be capable of withstanding a dry high voltage test of 3kV AC for one minute.

Removable links shall be provided close to the GIS to enable sheath tests to be carried out and to prevent arcing to adjacent metal framework during isolator operation.

Material

Porcelain or molded insulators used in the manufacture of cable sealing ends shall be sound, free from defects and thoroughly vitrified so that the glaze or surface treatment is not depended upon for insulation.

The insulators and fittings shall be unaffected by the filling media or rapid temperature changes likely to arise when operating in the Site conditions and shall be designed so as to facilitate cleaning.

Porcelain shall not engage directly with hard metal and, where necessary, an approved resilient material shall be interposed between the porcelain and the end fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

All fixing material used shall not enter into chemical action with the metal parts or cause fracture by expansion during service. Where cement is used as a fixing medium, the thickness of cement shall be as small and even as possible and proper care shall be taken to center and locate the individual parts correctly during cementing.

Each porcelain or molded insulator shall have marked upon it the manufacturer's identification mark and such other mark as may be approved to assist in the representative selection of insulators for the type tests. The mark shall be clearly legible and also visible after assembly of end fittings and shall be imprinted before firing.

When an insulator bearing a certain identification mark has been rejected, no further insulators bearing this mark shall be submitted and the Contractor shall satisfy Engineer that adequate steps will be taken to mark or segregate the insulators which have been rejected in such a way that there shall be no possibility of such insulators being re-submitted subsequently for test or being supplied.

Surge Arresters (Metal Oxide without gaps for A.C. systems)

Indoor GIS surge arresters and outdoor GIS surge arresters shall be of the type metal oxide arresters without gaps complete with surge counters and shall fulfill requirements as per IEC 60099-4, IEC 60099-5 and Engineer's approval.

Control Equipment

Local Control Cubicle

Functions

Each circuit breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously.

Closing of the circuit breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Local control cubicle shall be suitable for installation in a separate place or mounted with the GIS bay. Status indications in the LCC shall be semaphore type or LED type.

Circuit breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

If a disconnector or earth switch is not the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

Local manual release facilities shall be provided for closing and tripping the Circuit breaker. The operation of both releases shall be subject to lockout if insufficient stored energy is available. Local manual releases shall be provided with locking off facilities.

Sufficient electrical terminals shall be provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and local ring main supplies.

Where control cabling between the local control cubicle and the switchgear are connected by plug and socket boxes, the plugs and sockets shall not be inter-changeable.

Hydraulic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breakers, disconnectors and earth switches shall be located in a separate cubicle compartment.

Design

Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles. Local control cubicles shall be provided to be free standing or mounted on the GIS with front access and shall be equipped with anti-condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation.

Cubicles shall be of rigid construction, preferably folded but alternatively formed on a framework of standard rolled steel sections and shall include any supporting steelwork necessary for mounting on the circuit breaker or on concrete foundations. Access to all compartments shall be provided by either removable panels or doors. All fastenings shall be integral with the panel or door and provision made for locking. Doors and panels shall be fitted with weatherproof sealing material suitable for the climatic conditions specified. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen.

The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door operating switch, shall be fitted at the top of each section.

The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus.

All the control switches shall be internal i.e., installed behind a lockable glass door.

Anti -condensation Heaters

Anti-condensation heaters of an approved type shall be provided inside each cubicle. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The heaters shall have individual humidity stat and thermostatic control and shall be arranged to cut off when the cubicle internal temperature exceeds between 30-35°C and humidity less than 30%. A master heater circuit switch shall be provided on the switchboard or panel with an indicating lamp to show whether the supply is on or off. The location of the heater circuit switch and indicating lamp shall be either on a common panel or in such a location that it does not require moving when extensions are provided. The heaters shall operate from the specified single phase a.c. supply. Isolation facilities for a.c. supply shall be provided in each panel.

Auxiliary Switches and Contactors

Auxiliary switches positively driven in both directions shall be provided on all Circuit breakers and isolators for local and remote indication, control and interlocking and repeat relays where necessary. Busbar protection has direct driven auxiliary contacts for CT circuits. With each Circuit breaker, isolating device, and earthing device, there shall be supplied all necessary auxiliary switches, contactors and mechanisms for indication, protection, metering, control, interlocking, supervisory and other services. All such auxiliary switches shall be enclosed in dust free housing. Not less than eight (4 NO + 4 NC) spare auxiliary switch ways shall be provided with each Circuit breaker and not less than six (3 NO + 3 NC) on all other devices. All auxiliary switches shall be wired up to a terminal board in the local control cubicle of the switchgear whether they are in use or not in the first instance and shall be arranged in the same sequence on appropriate busbar coupling and sectioning equipment that sections or sets of busbars cannot be paralleled by means of the busbar isolating devices unless a parallel circuit is already closed through the Circuit breakers of all the equipment.

Switches shall be provided to interrupt the supply of current to the tripping mechanisms of the circuit-breakers directly the operation of the latter has been completed. All such switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism and shall be adequately protected. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Direct acting auxiliary switch make before break contacts shall be used in conjunction with busbar protection schemes.

Auxiliary contactors shall be provided only where the circuit requirement cannot be met by the auxiliary switch arrangements and multiple contactors and relays will not be accepted in lieu of auxiliary switches except as specifically approved by the Engineer.

Interlocking

An interlocking scheme shall be provided which takes into account the following basic requirements.

To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.

To prevent incorrect switching sequences which could lead to a hazardous situation to plant, equipment and personnel.

The interlocking scheme shall be electrical for all operational interlocks but shall be effective when the equipment is being controlled locally, under emergency hand or from a supervisory position.

All electrical interlocks shall so function as to interruption the operating supply and a system of interlocks shall be provided which cover the emergency hand operation of apparatus which is normally power operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

Where key interlocking is employed, tripping of the Circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency tripping device shall be kept separate and distinct from the key interlocking.

Circuit breakers closing shall be possible irrespective of the busbar and circuit isolator position.

Disconnecting switches shall be so interlocked that they cannot be operated unless the associated Circuit breaker is open except that where double busbar arrangements are specified, on-load transfer of feeder circuits from one busbar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

Earthing switches shall be interlocked such that they cannot be operated unless the associated isolator is open.

All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

In double busbar stations where provision for on-load changeover of busbars is specified, the busbar isolating devices shall be so interlocked with the appropriate busbar coupling and sectioning equipment. In all other circumstances, the busbar isolating devices of equipment other than busbar sectioning and coupling equipment shall be so interlocked that their respective Circuit breakers can only be coupled to one set of busbars at a time. It shall not be possible to parallel sections of busbars except through the Circuit breakers of the busbar coupling and sectioning equipment.

For each primary circuit, an interlock bypass switch shall be provided, mounted on the local control cubicle, for use during commissioning of the Switchgear. The switch shall be key operated (common key for each circuit) spring return to normal and provided with sufficient direct drive contacts to enable operation' of the- circuit breaker, isolators and earth switches independent of the electrical interlocking circuitry. By-passing of interlocks shall only be possible in the local (Maintenance) position.

Interlocking philosophy shall be provided by the switchgear manufacturer and shall be submitted for Engineer's approval.

Locking Facilities

Locks and locking facilities shall be provided on each item of substation equipment as detailed below and shall be additional to the mechanical interlocking devices specified in the above clause.

Where a mechanism is to be locked in a specific position, provision shall be made at that part of the mechanism where the operating power is applied and not to remote or ancillary linkages.

The following locking facilities shall be provided with common key operated locks.

a.) Circuit breaker mechanisms in the open position and any associated manual operating device in the neutral position.

b.) Isolating switches in both open and closed positions.

c.) Operating cubicle access doors.

TESTS

Inspection and testing of GIS during manufacture (FAT) and after installation on site (SAT) shall be in accordance with the Specification and IEC Standards.

SCHEDULE OF TECHNICAL REQUIREMENTS OF 230 kV and 110 kV INDOOR TYPE GAS INSULATED SWITCHGEAR (GIS)

SL. No.	Description	Unit	230 kV	110 kV
1.	**Site Condition**			
	Max. Altitude above sea level	m	not more than 150	not more than 150
	Max. Ambient temperature outdoor	℃	+45	+45
	Min. Ambient temperature outdoor	℃	+4	+4
	Max. Ambient relative humidity	%	100	100
	Max. Seismic acceleration at floor level			
	- horizontal	g	0.1	0.1
	- vertical	g	0.1	0.1
2.	**Type Designation**			
	Enclosure			
	- busbar		three phase	three phase
	- bay		single phase	three phase
	Enclosure Material		Al `	Al
	Standards		IEC	IEC
3.	**Electrical Data**			
	Rated Voltage	kV	245	145
	Rated Frequency	Hz	50	50
	Insulation Level			
	- lightning impulse withstand	kV	1050	650
	- 50 Hz withstand 1 minute	kV	460	275
	Rated continuous current at 40℃ Ambient temperature			

SL. No.	Description	Unit	230 kV	110 kV
	- main bus bar and bus coupler	A	3000	3000
	- transformer bay	A	1600	2000 (for Auto Tr.)
				1250 (for 110kV Tr.)
	- line bay	A	1600	1250
	Rated short time withstand			
	- current	kA	50	40
	- duration	sec	3	3
	Rated peak withstand current	kA	125	100
4.	**Secondary Circuit**			
	Auxiliary voltage			
	- for control and signal	V dc	110	110
	- for remote control	V dc	110	110
	- for heating	V ac	415/230	415/230
	- tolerances	%	-15/+15	-15/+15
5.	**Circuit Breaker**			
	Enclosure		**single phase**	**three phase**
	Enclosure material		Al	Al
	Rated short time breaking current	kA	50	40
	Rated peak withstand current	kA	125	100
	Percentage D.C component	%	40	40
	First-pole-to-clear-factor		1.3	1.3
	Rated breaking current			
	- Cable charging	A	250	160
	Switching overvoltage	p.u.	2.5	2.5

SL. No.	Description	Unit	230 kV	110 kV
	Operating mechanism three phase Operating mechanism (for closing/opening)		single/three phase spring	spring
	Number of making coil per Operating mechanism	pcs	1	1
	Number of tripping coil per Operating mechanism	pcs	2	2
	Rated motor voltage	V dc	110	110
	Rated operating sequence		O-t-CO-t'-CO	O-t-CO-t'-CO
	- t	sec	0.3	0.3
	- t'	min	3	3
6.	**Disconnector & Earthing Switch**			
	Enclosure mechanism (for closing/opening)		three/single phase manual & motorised	three phase Operating manual & motorised
	Rated motor voltage	V dc	110	110
7.	**Surge Arrester**			
	Rated voltage	kV	186	120
	Nominal discharge current	kA	10	10
	Discharge class		heavy duty class 3	heavy duty class 3
8.	**CT ratio, class and output**			
	(a) Line bay	A	*	*
	(b) 230/110/33 kV Transformer bay	A	*	*
	(c)110/11/11 kV Transformer bay	A	*	*
	(a) Bus coupler bay	A	*	*

Note :** * **Contractor to design and submit to Engineer for approval.

9. VT ratio, class and output

Ratio	kV	230/√3/0.11/√3/0.11/√3	110/√3/0.11/√3/0.11/√3
Total burden Accuracy class	VA	15(measuring) 30(Protection) 3P & 0.2	15(measuring) 30(Protection) 3P & 0.2

Degree of Protection

for indoor GIS	**IP54**
for outdoor GIS	**IP55W**

TYPE TEST REQUIREMENT:

Type test certificates of Gas Insulated Switchgear (GIS) shall be issued by a *Short-Circuit Testing Liaison* Member testing organisation / laboratory in the manner as mentioned in the STL Guides.

(i) GIS Switchgear

(a) One Complete Switchgear (for 110 kV and 230 kV GIS)

Sl. No.	**IEC 62271-203 Clause**	**Test Name**
i.	6.2	Dielectric tests:
		- Lightning impulse voltage tests
		- Power-frequency voltage tests
ii.	6.4	Measurement of the resistance of circuits
iii.	6.5	Temperature-rise tests
iv.	6.6	Short-time and peak withstand current tests
v.	6.104	Pressure test on partitions
vi.	6.105	Test under conditions of arcing due to an internal fault
vii.	6.106	Insulator tests

(b) Circuit Breaker

Sl. No.	**IEC 62271-100 Clause**	**Test Name**
i.	6.2	Dielectric tests:
		- Lightning impulse voltage tests
		- Power-frequency voltage tests
ii.	6.4	Measurement of the resistance of circuits
iii.	6.5	Temperature-rise tests

Sl. No.	**IEC 62271-100 Clause**	**Test Name**
iv.	6.6	Short-time and peak withstand current tests
v.	6.101	Mechanical and environment al tests
vi.	6.103	Test circuits for short circuit making and breaking tests
vii	6.108	Single-phase and double-earth fault tests
viii.	6.109	Short-line fault tests
ix.	6.110	Out-of-phase making and breaking tests

(c) Disconnector & Earthing Switch

Sl. No.	**IEC 62271-102 Clause**	**Test Name**
i.	6.2	Dielectric tests:
		- Lightning impulse voltage tests
		- Power-frequency voltage tests
ii.	6.4	Measurement of the resistance of circuits
iii.	6.5	Temperature-rise tests
iv.	6.6	Short-time and peak withstand current tests
v.	6.101	Tests to prove the short-circuit making performance of earthing switches
vi.	6.102	Operating and mechanical endurance tests
vii.	6.106	Bus-transfer current switching tests
viii.	6.107	Induced current switching tests

(d) **Current Transformer**

(ii) Short-time current tests

(iii) Temperature-rise test

(iv) Impulse tests on primary winding

(e) Voltage Transformer

(i) Temperature-rise test

(ii) Lightning Impulse test

(f) Gas leakage rate (Per year)

8.6.12 POWER TRANSFORMERS

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076, Parts 1 to 8 & 10 inclusive.

Electrical clearances shall not be less than as stated in the Project Requirements whichever is the greater.

Cooling

The types of cooling shall be as stated in the electrical requirements and the letters relating to the method of cooling used in this Specification and Schedules shall be in accordance with IEC 60076.

Where a combination of three / two methods of cooling is applied to one transformer, as for ONAN/ONAF units for 230/110/33kV transformer and ONAN/ONAF units for 110/11/11 kV transformer, the transformer shall be capable of operating under the ONAN condition as stated in the Schedule of Requirements, after which the cooling equipment is to come into operation and the Transformer will operate as an ONAF unit.

Failure of one fan shall not reduce the continuous maximum rating of the transformer.

Parallel Operation

Transformers supplied against each item shall be designed to operate satisfactory, one with the other, when operating on the same tap position.

Handling on Site

For installation purposes and to permit the moving of transformer, the transformers are to be equipped with castors (rail wheels). A permanent rail transfer track system shall be provided, integrated with the transformer foundations. The castors should be able to swivel in both the longitudinal and transverse directions.

A system of wedges shall be included to stop any unwanted movement of the transformer during its operating life. The distance between rails must be compatible with the transformer dimensions and also the rail gauge prevailing at existing substation sites.

Continuous Maximum Rating

Transformers shall have the rating stated in the Schedule of Requirements and shall comply with the requirements as regards temperature rise and overloads on all tapings, irrespective of the direction of power flow and with the voltage of the lower voltage winding at the normal voltage stated in the Schedule of Requirements. To allow for high atmospheric temperatures, the allowable temperature rises shall be reduced in accordance with IEC 60076-2.

The overload capability shall be in accordance with IEC 60076-7.

Electrical Connections

Transformer windings shall be connected in accordance with the Vector group symbol specified in the Schedule of Requirements and as per IEC 60076.The neutral point of star connected winding shall be brought out for grounding.

All electrical connections within windings shall be brazed but, subject to approval, mechanically crimped joints may be used for round stranded conductors on tapping, bushing or earthing connections and on bundle conductors where design has been proved by type test and application is subject to rigorous quality control.

Ability to Withstand Short Circuit

All transformers shall be capable of withstanding, on any tappings and without damage, the thermal and dynamic effects of external short circuits under the conditions stated in IEC 60076 Part 5. For this purpose, the design short circuit level for each system voltage is stated in the Schedule of Requirements.

Calculations and Tests

Evidence shall be submitted with the Bid as to the extent to which the manufacturer has proved, or is able to prove, either by calculation or test, the ability of the specified Transformers to withstand short circuit.

The Bidder shall provide with his Bid a brief description of those transformers, or parts thereof, which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers tendered but, in the event, this is not so, the Engineer reserves the right to require calculations to prove that the design of transformers tendered will satisfactorily comply with this Clause.

Losses and Evaluation of Losses

Guaranteed values for component losses of the total loss which shall be as low as is consistent with transport restrictions, reliability and economic use of materials, shall be as stated in the Schedule of Particulars and Guarantees.

Bids will be assessed on the basis of the least 'Present Worth' of capital cost plus guaranteed losses, being the sum of the installed Bid Price of the transformers plus a sum which shall be:-

For each unit of the three-phase 230/110/33kV, 150 MVA (ONAN/ONAF) power transformer, Evaluated price of transformer loss = N.a + L.b + M.c

Where N	=	No load loss (core-loss) at rated voltage in kW
L	=	Load loss (copper-loss) at 75 deg. C, 50 Hz maximum continuous rating in kW
M	=	Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
a	=	Cost/kW of no load loss (core-loss) valued at USD
b	=	Cost/kW of load loss (copper-loss) valued at USD
c	=	Cost/kW of auxiliary power valued at USD

For each unit of the three-phase 110/11/11 kV, 50 MVA (ONAN/ONAF) power transformer,

Evaluated price of transformer loss = N.a + L.b + M.c

Where	N	=	No load loss (core-loss) at rated voltage in kW
	L	=	Load loss (copper-loss) at 75□C, 50 Hz maximum continuous rating in kW
	M	=	Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
	a	=	Cost/kW of no load loss (core-loss) valued at USD
	b	=	Cost/kW of load loss (copper-loss) valued at USD
	c	=	Cost/kW of auxiliary power valued at USD

The acceptance of transformers yielding component losses higher than the guaranteed values shall be governed by either of the following:-

Component losses in excess of guaranteed values but within the tolerance permitted under IEC 60076 Part 1.

Transformers shall be acceptable subject to full compliance with all technical particulars, including temperature rises at CMR and subject to the Bidder accepting deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above evaluation rates.

Component losses in excess of guaranteed values and exceeding the tolerance permitted under IEC 60076 Part 1.

The acceptance of transformers shall be entirely at the discretion of the Employer and subject to the Bidder accepting the deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above loss evaluation rates.

In the event of transformers yielding component and total losses which are either equal to or below the guaranteed values, the Bidder will not be entitled to any premium in respect of reduction in losses below the guaranteed values.

Impedance

The value of impedance measured on various tapping's shall be as stated in the Schedule and minimum and maximum values where stated in the Schedule of Requirements shall be guaranteed by the Contractor.

Noise

The transformer noise levels shall be measured as a type test and in accordance with IEC 60076-10. The acceptance level of the transformers shall be as stated in the Schedule of Requirements.

Harmonic Suppression

Transformers shall be designed with particular attention to the suppression of harmonic voltages, especially the third, fifth and seventh harmonics, and to minimize the detrimental effects resulting there from.

MAGNETIC CIRCUIT AND WINDINGS

Magnetic Circuit

The core winding structure and major insulation shall be such as to permit an unobstructed flow of cooling oil over the core and through the core cooling ducts to ensure efficient cooling of the core and where required of flux shunts and tie rods/bars.

The magnetic circuit shall be insulated from core bolts and supporting framework and be capable of withstanding a test voltage to core bolts and to the frame of 2.5 kV r.m.s for one minute. Two separate insulated removable bolted earthing links shall be provided for earthing of the core and of the core-supporting framework to the exterior of the tank. These links shall be located in a covered box at the top of the transformer and arranged so they are accessible for testing purpose without opening up the transformer. Alternatively, connection to both the core and the frame may be made via two externally bolted links within an access box fitted with an oil tight cover near the base of the tank.

The core shall be earthed via copper straps inserted in each group of core packets separated by oil ducts or other insulating materials: and at a minimum of four (4) points distributed evenly across the width of the core.

Flux Density

Cores shall be constructed from cold rolled grain oriented steel sheets. Design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, and that when operating under the most onerous conditions envisaged in IEC 60076 and IEC 60354, flux density in any part of the magnetic circuit does not exceed 1.9 Tesla.

Windings

Construction of Windings

Transformer star connected windings shall have graded insulation as defined in IEC 60076. For 33 kV and below they shall have uniform insulation as defined in IEC 60076. All neutral points shall be insulated to withstand the applied test voltage specified in the Schedule of Requirements.

The windings shall be located in a manner which will ensure that they remain electromagnetically balanced and that their magnetic centers remain coincident under all conditions of operation.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure for such length of time as will ensure that further shrinkage will not occur in service.

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 conditions including external short circuit.

If the winding is built up of sections or of disc coils separated by spacers, the clamping arrangements shall ensure that equal pressures are applied to all columns of spacers.

Tertiary Windings

The tertiary winding of 230/110/33kV power transformer shall be adequately rated for the specified load and its average and hot spot winding gradients at the specified load shall not exceed the specified temperature rise for winding average and winding hot spot when added to the mean oil and top oil temperature rises measured during the temperature rise test on the HV and LV temperature rise tests.

The tertiary winding shall further have adequately conductor cross sectional area and mechanical strength to withstand a through fault on the tertiary terminals and the fault current present in that winding during line to ground fault on the HV and LV phase terminals and without exceeding the maximum permitted current density and temperature rise limits calculated in accordance with IEC 60076-5 Clause 4.1.4.

Internal Earthing

All metal parts of the transformer, with the exception of the individual core laminations, core bolts and associated individual clamping plates, shall be maintained at some fixed potential.

Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom main core clamping structure shall be earthed by one or more of the following methods:

1.) by connection through vertical tie rods to the top structure;

2.) by direct metal-to-metal contact with the tank base maintained by the weight of the core and windings;

3.) by connection to the top structure on the same side of the core as the main earth connection to the tank.

Earthing of Magnetic Circuits

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath an inspection opening in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2.5 kV. The link shall have no detachable components and the connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

All insulating barriers within magnetic circuits shall be bridged by means of Aluminium or tinned copper strips, so inserted as to maintain electrical continuity.

Earthing of Coil Clamping Rings

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the Transformer as the main earth connection.

Size of Earthing Connections

Main earthing connections shall have a cross-sectional area of not less than 80 sq.mm but connections inserted between laminations may have cross-sectional areas reduced to 20 mm2 when in close thermal contact with the core.

TANKS AND ANCILLARY EQUIPMENT

Transformer Tanks

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable structural steel of an approved grade to BS EN 10029. The final coat colour of transformers shall be to Munsell 5Y-7/1. The On-load tap changer tank shall be separated from the main tank of the transformer.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Each tank shall be provided with at least four jacking lugs, and where required, with lugs suitably positioned for transport on a beam transporter. Haulage lugs should also be provided to enable a cable to be used safely for haulage in any direction.

The transformer tank shall be capable of withstanding a full vacuum when empty of oil, without any significant permanent deformation or damage.

All joints, other than those which may have to be broken, shall be welded.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Where cooling tubes are used, each tube shall be of heavy gauge steel welded into the tank sides, top and bottom.

Each tank cover shall be of adequate strength, must not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. Inspection openings shall be provided to give access to the internal connections of bushings, winding connections and earthing links. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection covers shall be provided with lifting handles.

Pockets shall be provided for a stem type thermometer and for the bulbs of temperature indicators where specified. These pockets shall be located in the position of maximum oil temperature and it must be possible to remove any bulb without lowering the oil level in the tank. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

A ladder shall be provided on one side of the tank as a means for inspection and access to the top of the transformer. The lower section of the ladder shall be equipped with a barrier complete with provision for locking with a padlock.

Conservator Tanks, Breathers and Air Dryers

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system. Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservator tanks shall also be provided with a cleaning door, filling cap, drain valve with captive cap and an oil level indicator with minimum and maximum levels indicated. The normal level at an oil temperature of 25 deg. C shall be indicated and the minimum and maximum levels shall also be correlated with oil temperature markings. The temperature markings shall preferably be integral with the level indicating device.

The pipe work between the conservator and the transformer tank shall comply with the requirements of this specification and a valve shall be provided at the conservator to cut off the oil supply to the tank.

The conservator shall be fitted with an air cell which shall be connected to a silica gel breather of a type which permits the silica gel content to be removed for drying. Due to the climatic conditions at site, this breather shall be larger than would be fitted for use in a temperate climate. All breathers shall be mounted at a height of approximately 1400 mm above ground level.

A completely separate conservator shall be provided for the OLTC. This conservator shall be fitted with: an oil level gauge, a desiccant breather, isolating valves shall be provided for connection from OLTC conservator connection pipe to OLTC and to connection breather, an oil sump drain valve for sump, a filling cap and a removable end plate for inspection and repainting.

Valves

Each transformer shall be fitted with the following valves as a minimum requirement:

Main Tank

A.) One 50mm bore filter valve located near to the top of the tank.

B.) One 50 mm bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against (A). Where design permits, this valve may be combined with item (C).

C.) One 50mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable. This valve shall also be provided with an approved oil sampling device.

D.) One valve between the main tank and gas actuated relay, complete with bypass facility to facilitate removal of relay and maintain oil flow.

Conservator

A.) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank complete with bypass pipe work for Buchholz relay to facilitate maintenance of the relay.

B.) One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer

A.) 50mm filter and 50mm drain valve where selector switches are contained in a separate tank.

Diverter Switch Tank

A.) One drain valve to be fitted to each tank.

Radiators and Cooler Banks

A.) Valves at each point of connection to the tank

B.) The two valves arrangement across the gas actuated relay are to be connected with an oil pipe work bypass facility to facilitate removal of the relay, due to failure etc., and still maintain the oil flow system between the conservator and main tank.

Blank flanges, plates or captive screw caps shall be fitted to all valves and pipe ends not normally connected in service.

The omission of any, or the provision of alternative arrangements to the above requirements, will not be accepted unless approved in writing by the Employer before manufacture.

Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil resisting synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork, or similar material, or where metal inserts are provided to limit compression.

Gaskets shall be as thin as possible consistent with the provision of a good seal and full details of all gasket sealing arrangements shall be shown on the Plant drawings.

Pressure Relief Device

An approved pressure relief device of sufficient size for the rapid release of over pressure that may be generated in the tank, and designed to operate at a static pressure lower than the hydraulic test pressure, shall be provided. It shall be of the spring operated valve type and shall be provided with one set of normally open signaling contacts which will be used for trip alarm purposes.

The relief device is to be mounted on the tank cover and is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation. Discharge of oil shall be directed away from the transformer top cover and clear of any operating position.

Earthing Terminals

Two substantial steel flag type terminals having two 14mm diameter holes on 55mm centers shall be located one on either side and near to the bottom of the transformer to facilitate connection to the local earthing system.

Rating, Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to each transformer tank at an average height of 1500mm above the ground level:

1.) A rating plate bearing the data specified in IEC 76 Part 1. This plate shall also include the short-circuit current rating and time-factor for each winding.

2.) A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 76 Part 1 with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct physical relationship of the terminals.

3.) A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.

Plates are to be of stainless steel or other approved material capable of withstanding the rigours of continuous outdoor service at site.

Nuts & Bolts of Transformer Tanks

All nuts & bolts of transformer shall be stainless steel grade 304.

COOLING PLANT

Radiators and coolers shall be hot-dip galvanized, designed so that all painted surfaces can be thoroughly cleaned and easily painted in situ with brush or spray gun. The design shall also avoid pockets in which water can collect and shall be capable of withstanding the pressure tests specified in for the transformer main tank.

The clearance between any oil or other pipe work and live parts shall be not less than the minimum clearances stated in the Schedule of Requirements.

Radiators Connected Directly to Tank

Where built-on radiators are used, each radiator shall be connected to the main tank through flanged valves. Plugs shall be fitted at the top of each radiator for air release and at the bottom for draining.

A valve shall be provided on the tank at each point of connection to the tank.

Cooler Banks

Each cooler bank shall be provided with:

A. A valve at each point of connection to the tank.

B. A valve at each point of connection of radiators.

C. Loose blanking plates for blanking off the main oil connections.

D. A 50mm filter valve at the top of each cooler bank.

E. A 50mm drain valve at the lowest point of each interconnecting oil pipe.

F. A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.

G. Air release and drain plugs on each radiator.

The omission of any or the provision of alternative, arrangements to the above requirements will not be accepted unless approved in writing by the Engineer before manufacture.

Forced Cooling

The type of forced cooling shall be as stated in the Schedule of Requirements.

Forced cooling equipment for transformers of similar rating and design shall be completely interchangeable, one with the other, without modification on Site.

Oil Pipes and Flanges

All oil piping necessary for the connecting of each transformer to its conservator, cooler banks etc. shall be supplied and erected under this Contract.

The oil piping shall be of approved material with machined flanged joints. Copper pipe work is to comply with BS 61.

Dimensions of steel pipes shall be in accordance with BS 3600 and the drilling of all pipe flanges shall comply with BS 4504.

An approved expansion piece shall be provided in each oil pipe connection between the transformer and each oil cooler bank.

All necessary pipe supports, foundation bolts and other attachments are to be provided.

It shall be possible to drain any section of pipe work independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

Air Blowers

Air blowers for forced air cooling shall be of approved make and design and be suitable for continuous operation out-of-doors. They shall also be capable of withstanding the stresses imposed when brought up to speed by the direct application of full line voltage to the motor.

To reduce noise to the practical minimum, motors shall be mounted independently from the coolers or, alternatively, an approved form of anti- vibration mounting shall be provided.

It shall be possible to remove the blower, complete with motor, without disturbing or dismantling the cooler structure framework.

Blades shall be of material subject to approval.

Blower casings shall be made of galvanized steel of thickness not less than 2.6mm (14 S.W.G.) and shall be suitably stiffened by angles or tees.

Galvanized wire guards with mesh not exceeding 12.5mm shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts cannot be touched by test fingers to IEC 60529.

Cooler Control

Where forced cooling using multiple small single-phase motors is employed, the motors in each cooling bank shall be grouped so as to form a balanced three- phase load.

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this Contract for automatic starting and stopping from contacts on the winding temperature indicating devices as specified. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor, or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totaling more than 15kW simultaneously, either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts which may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk, together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors, shall be included in the Contract.

An alarm of indicating "Transformer Cooling Fault" is to be provided and initiated in the event of any ventilation/cooling motor trip, or failure of either main or control supplies.

VOLTAGE CONTROL

Transformers shall be provided with tap changers for varying the effective transformation ratio. Control schemes of on load tap change shall utilize 110V ac centre tap earthed voltage derived from the 415V, 3 phase, 4 wire system. Phase failure relays shall be provided to ensure a secure supply.

Number and range of taps shall be as called for in the Schedule of Requirements.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.

Tap positions shall be numbered consecutively, ranging from one upwards. The tap positions shall be numbered so that by raising the tap position the LV voltage is increased.

On-Load Tap Changers

On-load tap changers shall be MR Germany, ABB Sweden, or equivalent make and shall comply with IEC 60214 and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with these standards will be accepted.

Current making and breaking switches associated with the tap selectors or otherwise where combined with tap selectors shall be contained in a tank in which the head of oil is maintained by means completely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, detection of oil surges and provision of alarm or trip contacts will be dependent on the design of tap-changer and be to the approval of the Engineer.

Mechanisms

The tap change mechanism shall be designed such that when a tap change has been initiated, it will be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement not being completed an approved means shall be provided to safeguard the transformer and its auxiliary equipment.

Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions. For on-load tap change equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

Thermal devices or other approved means shall be provided to protect the motor and control circuit.

A permanently legible lubrication chart shall be provided and fitted inside the tap change mechanism chamber.

Local and Remote Control

Equipment for local, manual and electrical operation shall be provided in a cubicle. A thermostat controlled anti-condensation heater is to be provided in the cubicle. Electrical remote control equipment shall also be supplied.

The following operating conditions are to apply to the on-load tap changer controls:

1.) It must not be possible to operate the electric drive when the manual operating gear is in use.

2.) It must not be possible for two electric control points to be in operation at the same time.

3.) Operation from the local or remote control switch shall cause one tap movement only, unless the control switch is returned to the off position between successive operations.

4.) It must not be possible for any transformer operating in parallel with one or more transformers in a group to be out of step with the other transformers in the group. Any deviation in the position of tap changers has to stop further function of the AVR. (Out of step protection)

All electrical control switches and local manual operating gear shall be clearly labeled in an approved manner to indicate the direction of tap changing, i.e.: raise and lower tap number.

Emergency stop push-button at local and remote-control positions.

Indications

Apparatus of an approved type shall be provided on each transformer:

To give indication mechanically at the transformer and electrically at the remote-control point of the number of the tapping in use.

To give electrical indication, separate from that specified above, of tap position at the remote supervisory point.

To give indication at the remote-control point and at the supervisory control point that a tap change is in progress; this indication to continue until the tap change is completed.

To give indication at the remote-control point and at the supervisory control point when the transformers operating in parallel are operating out of step.

To indicate at the tap change mechanism the number of operations completed by the equipment.

Automatic Voltage Control

Automatic Control shall be suitable for control of transformers in parallel.

In addition to the methods of control the following methods shall also be provided.

1.) Automatic Independent - It shall be possible to select automatic independent control for each transformer irrespective of the method of control selected for any other of the associated transformers.

2.) Automatic parallel - It shall be possible to select any transformer for master or follower control.

3.) It must not be possible to operate any tap changer by supervisory, remote or local electrical hand control while the equipment is switched for automatic operation.

Voltage Regulating Relays

Automatic voltage control shall be initiated by a voltage regulating relay of an approved type and suitable for flush mounting. The relay shall operate from the nominal reference voltage stated in the Schedule of Requirements derived from a circuit mounted LV voltage transformer having Class 1.0 or 0.5 accuracy to IEC 60186 and the relay voltage reference balance point shall be adjustable.

The relay bandwidth shall preferably be adjustable to any value between 1.5 times and 2.5 times the transformer tap step percentage, the nominal setting being twice the transformer tap step percentage.

The relay shall be insensitive to frequency variation between the limits of 47Hz and 51Hz. The relay shall be complete with a time delay element adjustable between 10 and 120 seconds. The relay shall also incorporate an under voltage blocking facility which renders the control inoperative if the reference voltage falls below 80 percent of the nominal value with automatic restoration of control when the reference voltage rises to 85 percent of nominal value.

On each transformer the voltage transformer supply to the voltage regulating relay shall be monitored for partial or complete failure. The specified indicating lamp and alarm will be inoperative when the circuit- breaker controlling the lower voltage side of the transformer is open and also that when the tap changer is on control other than automatic control.

Parallel operation and Master/follower facilities shall have to be provided in the AVR relay. The AVR relay shall be fully integrated into the substation automation system and all AVR related operations shall be securely performed from the Substation Automation System. The Substation Automation supplier shall be responsible for integrating the AVR relay.

Remote Control Panels

The remote control panels specified in the Schedule of Requirements shall be floor mounted sheet steel cubicles of approved type, layout and colour to Munsell 5Y-7/1 and shall be provided for each transformer. Each shall form a complete enclosure with lockable rear doors and shall be fitted with interior lamp, door switch, heaters, cable gland plates for bottom entry of cables and all other equipment to provide the features specified, the standard requirements (which may be varied to suit manufacturer's design) being as follows:

Instruments:

Voltmeter (voltage at the low voltage terminals of the transformer).

Tap position indicator with integral or separate scale to indicate the no-load LV voltage in kV appropriate to each winding tap.

Relays:

Automatic voltage control.

Controls:

Automatic/Non-automatic voltage control selector switch, Remote/Supervisory tap change control selector switch, Pistol grip selector switch with centre zero, Independent/Master/Follower selector switch, AVR voltage reference adjuster.

Indications and Alarms:

Tap change in progress - white lamp

Tap change out of step - amber lamp

Tap change incomplete - amber

Tap change control on "local"

Tap change control on auto/manual

Group 1 Air forced cooling equipment running - white

Group 1 Air forced cooling overcurrent alarm - amber

Group 2 Air forced cooling equipment running - white

Group 2 Air forced cooling overcurrent alarm - amber

Forced cooling failure-amber lamp

VT Fail alarm - amber

Supply voltage to OLTC failure - amber lamp

Remote control schemes shall be entirely suitable for operation with the distance between the transformer and remote control panels.

Off-Load Tap Changers

The off-circuit tapping's for Auxiliary transformer shall be provided on the higher voltage windings for variation of no-load primary voltage as specified in the Schedule of Requirements.

Off-load tap-changing shall be carried out by means of an external hand-operated tapping switch mounted on the side of the tank. All phases of the tapping switch must be operated by one hand wheel.

The tapping switch shall have a spring-loaded captive bolt or other approved means on the moving part which positively locates the switch correctly at each tapping position. This bolt must be lockable at each tapping position and shall be provided with a suitable padlock and keys. Moving the switch from one tapping position to another shall require that the bolt be withdrawn by hand from its locating socket on the transformer tank against the spring pressure.

Tap-position numbers corresponding to the tapping switch bolt-locating sockets shall be cast or engraved in a metal indication plate fixed to the tank and a keyed metal pointer on the tapping switch operating handle shall show clearly at which tapping number the transformer is operating.

All tap-position indicators shall be marked with one integer for each tap position, beginning at number 1. Adjacent taps shall be numbered consecutively in such a manner that when moving a tap to a new tapping position which has a higher number, the no-load output voltage of the untapped winding increases.

SUPERVISORY CONTROL

Requirements

Transformer tap change control will be affected from the substation control room with facilities for remote control from the National Load Dispatch Centre. All necessary connections, indications, auxiliary switches, relays and changeover switches to meet supervisory control requirements shall be provided and connected under this Contract to terminal blocks in the remote-control panels. The supply and installation of the multicore control cables between the remote-control panels and the Plant/Telecontrol Interface Cubicle shall be provided under the Contract.

The following supervisory facilities are required:

Controls:

Supervisory selection of auto/non auto voltage control.

Tap change raise/lower by direct operation of tap changer.

Tap change blocking on/off.

Remote/Supervisory selection "Override".

Parallel/Independent control.

Indications and Alarms:

Tap position indication

Tap change out of step alarm

Buchholz and winding temperature non-trip alarm

Tap change control on Local/Supervisory

Parallel/Independent, master/follower

Tap change blocking on/off

Tap change control on Automatic/Manual

All contacts for supervisory alarms and indications shall be potential free.

HV & LV TERMINALS AND CONNECTIONS

Primary and Secondary Terminals

Auto Power Transformers are to be provided with Cable Termination Modules (instead of porcelain insulators) which act as a link between the Power Transformer and the High voltage cables complying with IEC 62271-209. The cable termination module shall have the inspection hole with connecting flange for the high voltage cable testing set. During high voltage cable testing, the primary conductor between the cable sealing end and the switchgear can be removed.

Neutral for the power transformer shall be terminated to the Earth thru the porcelain bushing.

Tertiary and Neutral Terminations

Terminations of delta connected tertiary windings and neutral ends of windings shall be as follows:

Delta Connected Tertiary Windings

Delta connected tertiary windings for local AC distribution shall be terminated with cable termination modules and will act as a link between the Power Transformer and the High Voltage cables complying with IEC 62271-209.

Where current transformers are specified in the Schedule of Requirements or on the Drawings, these shall be included in this Contract.

Neutral Ends of Windings

Neutral ends of the three phase windings shall be connected at a point accessible from a hand hole at the transformer tank top cover. Where current transformers are specified at the neutral ends before the neutral connection of the windings, to be used in conjunction with a protection, they shall be installed such that access is possible through the same hand hole and maintenance of these CT, if need be, can be carried out without lowering the transformer oil below the core and winding.

The star connection shall then be brought out via one outdoor bushing insulator capable of withstanding an AC power frequency test.

Mounting of Bushings

Transformer cable termination modules shall be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Neutral bushings shall be mounted in a position from which a connection can be taken to a neutral current transformer mounted on a bracket secured to the transformer tank.

The clearances from phase to earth must not be less than those stated in the Schedule A of Requirements.

A flexible pull-through lead suitably sweated to the end of the winding copper shall be provided for the bushings and is to be continuous to the connector which is housed in the helmet of the bushings.

When bushings with an under-oil end of a re-entrant type are used the associated flexible pull-through lead is to be fitted with a suitably designed gas bubble deflector.

The bushing flanges must not be of re-entrant shape which may trap air.

Clamps and fittings made of steel or malleable iron shall be galvanized and all bolt threads are to be greased before erection.

Bushing Current Transformer (BCT)

BCT particulars are stated in the Schedule A of Requirements.

AUXILIARY POWER AND CONTROL CABLES

Scope of Supply

This Contract includes the supply, installation and termination of the necessary auxiliary power and control cables within items of the substation supplied under the Contract.

The Contractor shall produce, during the currency of the Contract and in any case before shipment of the material commences, detailed cable core schedules for each transformer.

Auxiliary power and control cables shall have copper conductors, PVC insulated, armoured and PVC sheathed overall. The cable design shall generally be in accordance with BS 6346:1989.

All cables installed under the Contract shall utilize compression glands of type E1 to BS.6121 or otherwise designed to secure armour wires and bond them to earthed metal and to provide seals between sheath and gland and between inner sheath and threaded fixing component.

The Contractor shall supply and fit the compression gland and make off individual cores on to the terminal boards, including the supply and fitting of numbered markers on each core.

TEMPERATURE AND ALARM DEVICES

Temperature Indicating Devices and Alarms

The transformers shall be provided with approved devices of Kilhstrom or equivalent for indicating the top oil temperature and hottest spot winding temperatures. The devices shall have a dial type indicator and, in addition, a pointer to register the highest temperature reached. Each winding temperature device shall have three separate contacts fitted, one of which shall be used to control the cooling plant motors, one to give an alarm and one to trip the associated circuit-breakers.

To simulate indication of the hottest spot temperature of the winding the device shall comprise a current transformer associated with one phase only and a heating device designed to operate continuously at 130 percent of transformer CMR current and for 30 minutes at 150 percent of CMR current, associated with a sensing bulb installed in an oil tight pocket in the transformer top oil.

The winding temperature indicators (WTI) shall be housed in the marshalling cubicle. The tripping contacts of the winding temperature indicators shall be adjustable to close between 80 deg C and 150 deg C and to re-open when the temperature has fallen by not more than 10 deg C.

The alarm contacts and the contacts used to control the cooling plant motors on the above devices shall be adjustable to close between 50 deg C and 100 deg C and to re- open when the temperature has fallen by a desired amount between 10 deg C and 15 deg C.

All contacts shall be adjustable to a scale and must be accessible on removal of the relay cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 volts and 250 volts AC or DC and of making 500 VA between the limits of 110 and 250V DC. Cooler motor control contacts shall be suitable for operating the cooler contactors direct or, if necessary, through an interposing relay.

The temperature indicators in the marshalling kiosk shall be so designed that it is possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.

The working parts of the instrument shall be made visible by the provision of cut- away dials and glass-fronted covers and all setting and error adjustment devices shall be easily accessible.

Connections shall be brought from the device to terminal boards placed inside the marshalling cubicle.

Terminals, links and a 63mm moving iron ammeter shall be provided in the marshalling kiosk for each WTI for:

Checking the output of the current transformer.

1. Testing the current transformer and thermal image characteristics.

2. Disconnecting the bulb heaters from the current transformer secondary circuit to enable the instrument to be used as an oil temperature indicator. Links shall be provided.

Gas and Oil-Actuated Relays

Each transformer shall be fitted with gas and oil-actuated relay equipment having alarm contacts which close on collection of gas or low oil level, and tripping contacts which close following oil surge conditions.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

Each relay shall be fitted with a calibrated glass window for indication of gas volume.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1400mm above ground level, where it shall be terminated by a cock which shall have provision for locking to prevent unauthorized operation.

The design of the relay mounting arrangements, the associated pipe work and the cooling plant shall be such that maloperation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps, whether by manual or automatic control under all operating temperatures.

The pipe work shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipe work shall be avoided.

For two conservators piped separately to the transformer, one Gas and Oil actuated relay shall be installed in the main tank and an Oil-flow relay shall be installed in the OLTC conservator.

SHIPMENT AND DRYING OUT

Shipment

Each transformer, when prepared for shipment, shall be fitted with a shock indicator or recorder which shall remain in situ until the transformer is delivered to site. In the event that the transformer is found to have been subjected to excessive shock in transit, such examination as is necessary shall be made in the presence of the Engineer.

Where practicable, transformers shall be shipped with oil filling to cover core and windings but, when shipped under pressure of gas, shall be fitted for the duration of delivery to site and for such time thereafter as is necessary, with a gauge and gas cylinder adequate to maintain internal pressure above atmospheric.

Drying Out

All transformers shall be dried out by an approved method at the manufacturer's works and so arranged that they might be put into service without further drying out on Site.

Clear instructions shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barriers or tank cover) which must be taken before the specified vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand the treatment shall be provided with each transformer.

TRANSFORMER OIL AND TREATMENT

Transformer Oil

The Contractor shall supply the first filling of all insulating oil required for the operation of the Plant and, after treatment, a test shall be made in the Engineer's presence to prove that the breakdown voltage is at least 60kV at 2.5mm electrode gap. The transformer oil shall be new, inhibited, naphthenic based mineral oil, free from additives. It shall be acid-refined and pre-treated and shall have properties complying with IEC 60296-class II.

Oil Purifier Equipment

The oil purifier equipment is to be mounted on a steerable trailer equipped with pneumatic types, over-run and parking brakes and weatherproof canopy. The equipment shall be capable of purification of oil to IEC 60296 and IEC 60422, shall be of the replaceable paper filter type and shall have the following facilities:

1.) Oil treatment rate not less than 6000 litres per hour.

2.) Water extraction capability down to 5 ppm.

3.) Reduction of dissolved gas content to 1% by volume or less.

4.) Filtration level less than 1 micron.

5.) Oil transfer, vacuum pumps and heaters suitable for 415V, 3 phase 50Hz, 4 wire, supply.

6.) Vacuum capability approximately 1 Torr.

7.) Facility to apply vacuum to transformer tank during oil filling.

8.) Two 15m lengths of wire reinforced hose coloured differently for clean and dirty oil.

9.) Facility for "closed loop" operation.

10.) One 20m length of power supply cable with plug and socket at the filter end only.

Oil Storage

Contractor shall supply the first filling of transformer oil. It is envisaged that the oil will be supplied to site in 200kg drums and filtered by use of the plant described in the preceding paragraph into a storage tank prior to transfer again via filter plant into the transformer.

Storage tanks shall be painted internally and externally and shall be equipped with:

1.) 50mm top inlet and bottom outlets with blank flanges

2.) 50mm drain valve

3.) Oil level indicator

4.) Hand hole

5.) Silica gel breather

6.) Collapsible Oil Containers

This section covers the design, manufacture and supply of 9000 litre and 18000 litre capacity two collapsible oil container suitable for on-site storing, transferring and transporting transformer oil associated with the transformers being supplied under the Contract.

Each container shall be made up of one or several layers (and securely bonded together) of tough polymer and textile material which can be folded with ease for transportation purposes. The outer surface of the container shall be coated with a tough abrasion resistant compound and on the inner face with a polymer compatible with the transformer oil.

The containers shall be provided with the following fittings:

1.) Controllable inlet and outlet valves constructed from brass or Aluminium alloy and a gun metal outlet plug.

2.) Air vent plug(s) for air release during oil filling and located at the centre and top of each container.

3.) Two sets of special tools, gauges and spanners necessary to operate and maintain the valves, plugs etc.

The guarantee period is 36 months from the date certified in the Final Acceptance Certificate.

The following details are to be submitted with the proposal to supply the oil container.

1.) Descriptive literature and technical specification of the container design.

2.) Manufacturer's production capability and supply record for at least 5 years service experience.

3.) Test certification record.

4.) Type reference number, capacity, weight and dimensions (laid flat unfilled and maximum filled height).

SCHEDULE OF TECHNICAL REQUIREMENTS OF 230/110/33 kV POWER TRANSFORMER

Sl. No.	**Description**		
	RATING AND PERFORMANCE		
1	Maximum continuous rating (MCR)	MVA	150
2	Number of Phases		3
3	Number of windings		Auto plus stabilizing
4	Normal ratio of transformation at no load and at principal tap - HV/LV/TV	kV	230/110/33
5.1	Corresponding highest system voltages	kV	245/145/36
5.2	Corresponding lowest system frequency	Hz	48
6	Minimum withstand voltages: - Full wave impulse withstand of windings of line terminal bushings	kVp	By Manufacturer

Sl. No.	Description		
	- Induced over voltage - Power frequency withstand of neutral	kVp kV rms kV rms	
7	Type of cooling		ONAN/ONAF
8	Minimum continuous rating	MVA	150
9	Rating of tertiary windings	KVA	315
10	Service conditions:		
	- External cooling medium	-	Air
	- Altitude not exceeding	m	150
	- Air temperature not exceeding Average air temperature in any one year not exceeding:	^{0}C	45
	- In any one day - Average in one year	^{0}C ^{0}C	35 25
11.1	Maximum temperature : - Top oil rise normal - Average ONAN winding rise - Average ONAF winding rise	 ^{0}C ^{0}C ^{0}C	 50 55 55
11.2	Maximum hot spot temperature at maximum continuous rating at yearly average ambient temperature	^{0}C	98
11.3	Winding hot spot temperature on emergency overload not exceeding	^{0}C	140
12	Phase connections: - HV winding - LV winding - TV winding		 Star Delta Delta

Sl. No.	Description		
	- Vector group - HV/LV/TV		YNa0d1
13	Short circuit withstand fault level at terminals of: - 230 kV busbars - 110 kV busbars - 33 kV busbars	kA kA kA	50 40 31.5
14	Impedance voltage at 75□C and at normal tap and MCR between windings (% on HV Base): - HV & LV % on HV base	%	By Manufacturer
15	Delta connected tertiary winding - Nominal voltage - External load	kV kVA	33 315kVA
16.1	Total range of variation of on load transformation ratio (on HV side) as sl. no. 4: -Ratio - Size of steps	% %	±10 1.25
16.2	Type of control		On load local, remote and supervisory electrical and hand operation
17	Line drop compensation		Yes
18	Whether automatic control required and referenced voltage		Yes, 110V, 50Hz
19	Whether separate remote control panel required		Yes
20	DC supply: - Nominal - Maximum float voltage	V V	110 125

Sl. No.	Description		
21	Whether provision for supervisory control required, including AVR setting		Yes
22	Whether marshalling kiosk required		Tank side Cubicle
23	Number of transformers for which automatic control is to be suitable		2 (and provision for future 3rd)
24	**TERMINATIONS** Bushing insulators or cable boxes on line and neutral terminals: i) HV line ii) Neutral iii) LV line iv) Tertiary winding		Cable Termination Modules
25	**BCT PARTICULARS** i) HV (230kV) Side: Core 1 Core 2		
	ii) LV (110 kV) Side: iii) Core 1, Core 2 & Core 3		matched with WTI
	iv) Tertiary Side : Core 1, Core 2 & Core 3		Ratio & burden matched with WTI and OLTC
	v) Neutral Bushing (core 1):		Ratio & burden matched with WTI

Sl. No.	Description		
26	Pollution category of bushing insulators		25 mm/kV of system rated (highest) voltage
27	**COOLING** i) Number of cooler banks required per transformer		To suit transformer design
	ii) Rating of each cooler bank as percentage of total loss at CMR iii) Standby cooling requirement	%	50 One fan in each group
 28 29	**GENERAL** Type of oil preservation system Maximum acceptable noise level		Air Cell 78 dBA

SCHEDULE OF TECHNICAL REQUIREMENTS OF 110/11/11 kV POWER TRANSFORMER (50 MVA)

	RATING AND PERFORMANCE		
1	Maximum continuous rating (MCR)	MVA	50
2	Number of Phases		3
3	Number of windings		2
4	Normal ratio of transformation at no load and at principle tap - HV/LV/TV	kV	110/11/11
5.1	Corresponding highest system voltages	kV	145/36
5.2	Corresponding lowest system frequency	Hz	48
6	Minimum withstand voltages:		
	- Full wave impulse withstand of windings of line terminal bushings - Induced over voltage - Power frequency withstand of neutral	kVp kVp kVrms kV rms	By Manufacturer
7	Type of cooling		ONAN/ONAF
8	Minimum continuous rating	MVA	50
9	Rating of tertiary windings	KVA	315
10	Service conditions:		
	- External cooling medium - Altitude not exceeding - Air temperature not exceeding Average air temperature in any one year not exceeding: - In any one day - Average in one year	- m ^{0}C ^{0}C ^{0}C	Air 150 45 45 35
11.1	Maximum temperature :		

	RATING AND PERFORMANCE		
	- Top oil rise normal - Average ONAN winding rise - Average ONAF winding rise	^{0}C ^{0}C ^{0}C	50 55 55
11.2	Maximum hot spot temperature at maximum continuous rating at yearly average ambient temperature	^{0}C	98
11.3	Winding hot spot temperature on emergency overload not exceeding	^{0}C	140
12	Phase connections:		
	- HV winding - LV winding - TV winding - Vector group - HV/LV/TV		Star Delta Delta YNd5
13	Short circuit withstand fault level (one sec.) at terminals of: - 110 kV busbars 11 kV busbars		40 kA 50 kA
14	Impedance voltage at 75ºC and MCR (50 MVA) between windings (% on HV Base) at Nominal tap at maximum tap at minimum tap		By Manufacturer
15	Not used		

	RATING AND PERFORMANCE		
16.1	Total range of variation of on load transformation ratio (on HV side) as sl. no. 4: - Ratio Size of steps		±10 1.25
16.2	Type of control		On load local, remote and supervisory electrical and hand operation
17	Line drop compensation		Yes
18	Whether automatic control required and referenced voltage		Yes, 110V, 50Hz
19	Whether separate remote control panel required		Yes
20	DC supply: Nominal Maximum float voltage		110 125
21	Whether provision for supervisory control required, including AVR setting		Yes
22	Whether marshalling kiosk required		Tank side Cubicle
23	Number of transformers for which automatic control is to be suitable		4
24	TERMINATIONS Bushing insulators or cable boxes on line and neutral terminals:		Cable Termination Modules

	RATING AND PERFORMANCE		
	i) HV line ii) Neutral LV line		
25	BCT PARTICULARS i) HV (110kV) Side Core 1 Core 2		Ratio, burden and accuracy class shall be matched with WTI meter
	ii) LV (11 kV) Side Core 1 Core 2 Core 3		for WTI meter for Tap changer
	iii) Neutral Bushing (core 1 & 2):		
26	Pollution category of bushing insulators		25 mm/kV of system rated (highest) voltage
27	COOLING i) Number of cooler banks required per transformer ii) Rating of each cooler bank as percentage of total loss at CMR Standby cooling requirement	%	i)To suit transformer design ii)100% iii)One fan in each group
27	GENERAL Type of oil preservation system Maximum acceptable noise level		Air Cell 78 dBA

8.6.13 EARTHING /AUXILIARY TRANSFORMERS

Earthing transformers shall comply with IEC 60076-6 and shall be of the oil immersed ONAN type suitable for outdoor installation. They are to have a main interconnected star winding brought out via oil/air terminal bushings, which will be directly connected to the lower voltage terminals of the associated system transformer.

The neutral point of the interconnected star winding shall be brought out of the tank through a bushing insulator. This point maybe isolated or connected to earth directly or through a resistance in order to provide an earthing point for the neutral of the system.

The earthing transformers shall have a secondary winding to supply the substation auxiliary load. The voltage ratio shall be 33/0.415kV. The star-connected secondary windings shall be arranged to give a three-phase, four wire supply with the star point solidly earthed. The secondary winding shall have a continuous rating as stated in the Schedule of Requirements and shall conform to IEC 60076.

Electrical and Short Circuit Characteristics

Earthing transformers will normally have their neutral points connected to earth via a resistance which limits earth fault current to the full load current at the associated power transformer. However, provision is made for solidly earthing the neutral points and, under this condition, the earthing transformers shall be capable of withstanding, both thermally and mechanically without damage, for a period of 5 seconds the application of normal three phase line voltage to the terminals of the interconnected star winding with one line terminal earthed. The current density of the winding under this condition shall not exceed $50A/mm^2$.

In addition, the interconnected star winding of each earthing transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for 10 seconds without injurious heating an earth fault current in the neutral connection as specified. The current density under such conditions shall not exceed $23A/mm^2$.

Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

1.) Conservator vessel with removable end cover and prismatic oil gauge.

2.) Buchholz relay.

3.) One thermometer pocket with captive screw cap.

4.) Silica gel breather of the oil seal type.

5.) Pressure relief device.

6.) Filter valve and combined filter and drain valves.

7.) Oil sampling device.

8.) Rating plate.

9.) Tank earth terminals.

10.) Lifting lugs.

Secondary Windings

The three-phase, four-wire secondary windings shall be terminated at a three-pole MCCB unit with bolted neutral link and gland entry for a four-core solid dielectric cable. This shall be accommodated in a lockable, fully weatherproof compartment together with a neutral earthing link. The purpose of the neutral earthing link is to connect the 415V system neutral to earth. It shall be connected between the transformer winding end and a suitably located earthing terminal to which the system earth can be connected.

The windings shall be fitted with off-load tap changer to vary the voltage ±5 percent of the nominal open circuit value in 2.5 percent steps.

Terminal Connections

The 33 kV / 11kV side of the earthing transformers shall be fitted with cable termination modules. The earth point connection to the neutral earthing resistor shall be via a 33 kV / 11 kV conductor.

Inspection and Testing

Inspection and testing of transformers during manufacture and after installation on site shall be in accordance with this Specification.

SCHEDULE OF TECHNICAL REQUIREMENTS OF 33/0.415 kV EARTHING (STATION SERVICE) TRANSFORMER

	EARTHING TRANSFORMER		
1	Nominal rating	kVA	315
2	Number of phase		3
3	Frequency	Hz	50
4	No-load voltage ratio	kV	33/0.415
5	Corresponding highest system voltage	kV	36/1.1
6	Type of cooling		ONAN
7	Coolant		Mineral Oil
8	Type		Core, Conservator Type

9	Installation		Outdoor, High Salinity, Tropical , high rainfall and humidity
10	Earthing		Neutral solidly earthed in interconnected star winding Neutral earthed in LT 3 phase, 4 wire system
11	Windings		Double wound of high conductivity copper
12	Test voltage		Impulse test voltage (1.2/50 μs) kV 170/10 (HT/LT) Power frequency withstand voltage kV 70/2.5 (HT/LT) for 1 min
13	Vector group		ZNyn11
14	Neutral to be brought out		HT: Yes, LT: Yes
15	Neutral insulation		Full insulation and 100% loading capacity
16	HV/LV Terminals		Cable Termination Modules
17	Impedance voltage	%	5
18	Tapping range		Off load tap changer ±5% in the step of 2.5
19	Tap changer control		Manual
20	BCT Particulars: HV side Neutral(core-1) LV side (core-1)		 100/1A 600/1A

SCHEDULE OF TECHNICAL REQUIREMENTS OF 11/0.415 kV EARTHING (STATION SERVICE) TRANSFORMER

	EARTHING TRANSFORMER		
1	Nominal rating	kVA	315
2	Number of phase		3
3	Frequency	Hz	50

4	No-load voltage ratio	kV	11/0.415
5	Corresponding highest system voltage	kV	12/1.1
6	Type of cooling		ONAN
7	Coolant		Mineral Oil
8	Type		Core, Conservator Type
9	Installation		Outdoor, High Salinity, Tropical, high rainfall and humidity
10	Earthing		Neutral solidly earthed in interconnected star winding Neutral earthed in LT 3 phase, 4 wire system
11	Windings		Double wound of high conductivity copper
12	Test voltage		Impulse test voltage (1.2/50 μs) kV 75/10 (HT/LT) Power frequency withstand voltage kV 28/2.5 (HT/LT) for 1 min
13	Vector group		ZNyn11
14	Neutral to be brought out		HT: Yes, LT: Yes
15	Neutral insulation		Full insulation and 100% loading capacity
16	HV/LV Terminals		Cable Termination Modules
17	Impedance voltage	%	5
18	Tapping range		Off load tap changer ±5% in the step of 2.5
19	Tap changer control		Manual
20	BCT Particulars: HV side Neutral(core-1) LV side (core-1)		 100/1A 600/1A

8.6.14 PROTECTION, CONTROL AND METERING

The protection and control facilities shall be suitable for the power system arrangement as shown in the Key Single Line Diagram Drawing of this Technical Specifications.

From operational experience, including system stability, protection coordination, integration with existing protection and control equipment, capitalizing of staff experience and familiarization with equipment, protection settings calculation mechanism and methodology of operation, standardization of operation performance, facilities and spare requirements, the protection relays, control& automation systems including complete panel are being rationalized to specific types.

The system operator is making every effort to avoid serious system mal-operation and as such the types of relaying to be supplied on this project shall comprise equipment from the following manufacturers countries of origin:

1.) Alstom (France/UK)

2.) ABB (Switzerland/Sweden)

3.) Siemens (Germany)

4.) Schneider Electric (France/UK)

Acceptance of any other relays with similar characteristics shall have to undergo substantial field trials of at least one year to the satisfaction of the Engineer to ensure satisfactory operation.

The protection shall be sufficiently sensitive to cater for the minimum fault level condition. The protection shall also be suitable for a system fault level equal to the switchgear rating as specified in this specification. All current transformer design shall be based on these fault levels.

All relays shall operate correctly within system frequency limits of 47Hz to 51Hz.

FAULT CLEARANCE TIMES

230 kV, 110 kV, 33 kV and 11kV systems overall fault clearance times (i.e. from fault initiation to arc extinction) shall not exceed the following:

Type of Fault Maximum Fault Clearance Time

Nominal system voltage between phases	kV	230	110	11
Substation and Transformer fault	msec	100	120	160
Line fault				

(a) Up to 72% of the line length (i.e.. 90% of a distance relay Zone 1 reach setting of 80% of the line impedance)	msec	100	120	160
(b) 72% to 100% of the line length where, plus protection signalling time	msec	130	150	190

These requirements must be fulfilled under all system conditions including maximum dc current offset and any time delay. Clearance within these times shall be achieved for all types of faults except high resistance earth faults detected by DEF protection or under circuit breaker failure conditions.

ARRANGEMENT OF FACILITIES

Control and relay equipment shall be mounted on panels and cubicles as specified and shall be installed in permanent buildings on the substation sites. The order of the panels shall follow the sequence shown on the drawings.

Control panels shall incorporate all necessary control and indication facilities for the operation of the plant and equipment at the associated substation. In addition, the plant may be remotely controlled and supervised from the National Load Dispatch Centre (NLDC).

The Gateway system for communication to the NLDC shall be supplied under this contract including all necessary items like auxiliary switches, relays and changeover switches, etc. Where specified for the mounting of, and connection to, interposing relays and transducers, links shall be provided to enable transducers to be isolated for test purpose and shortening facilities shall be provided where transducers are used in the secondary of the current transformers. All circuits provided under this contract whether or not they are subject to the system control requirements at the present time, shall be designed and constructed so that the standard facilities specified can be readily provided as required in the future.

The employer will be responsible for carrying out system protection calculation and determine relay setting value for the new substation including remote end substation. The Contractor shall review the protection setting calculation given by the employer and shall be responsible for implementation of protection setting that will be provided by employer including configuration, testing, commissioning etc. The employer's Engineer shall witness the protection setting & testing of the same. In case, the proposed Protective relay is not suitable for the proposed application the Contractor shall change to a suitable relay as recommended by the manufacturer without any cost implications to the Employer.

MULTICORE CABLE DIAGRAMS

This Contract includes the preparation of cabling schematic diagrams, showing the approved routing of cores in the various cables, and detailed cable schedules and connection diagrams for all the cables associated with each item of equipment.

TEST AND EARTHING FACILITIES

Each control or relay panels shall be provided with a copper earth bar of not less than 150 sq. mm cross-section and arranged so that the bars of adjacent panels can be joined together to form a common bus.

The common earthing busbar of control and relay panels shall be connected to the main station earthing system via a copper earthing connection of not less than 150 sq. mm.

Software for testing the protection & control devices shall be included in the scope of supply. In addition, for secondary injection testing of the protection & control devices, provision shall be made in the panel for current & voltage injection using standard test set and disconnecting type terminal blocks with facility for short circuiting of current transformer secondary circuit etc. by means of movement of links from their normal operating position, or any other testing arrangement approved by the Employer.

PROTECTION DEVICES

Simplified arrangements of the main connections and protection for the various items of plant are shown in the Key Single Line Diagram Drawing of this Technical Specifications.

Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits. All equipment are to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

Current transformers, where possible, are to be located so as to include the associated circuit breaker within the protected zone and shall be located generally as indicated on the schematic drawings included in this Specification.

Transformer Buchholz, winding temperature and tap changer protective devices are to be supplied under this contract, and all necessary interposing relays, tripping relays and cabling associated with these devices shall be supplied and mounted under this Contract.

RELAYS

Relays shall conform to IEC 61850 standards, be of approved types complying with IEC 60255 or BS 142 and 5992, parts 1, 2 and 3 as appropriate, fully tropicalized, and shall have approved characteristics. Relays designed identical to relays with a minimum of five years proven field experience will only be accepted. Supply record of proposed relays shall be furnished for the last five years. The Employer will reject any design he considers unsatisfactory or having insufficient field experience. All the Protective relays shall be numerical type. Numerical relays shall be configured in such a way that at least two (2) nos. relays shall be provided for each feeder.

The protection relays, shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases and of the draw out type with rear connections. The panel front side shall be covered by a transparent glass door.

Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Electrically reset tripping relays shall be provided where necessitated by the system of control, such as for those circuits subject to remote supervisory control.

Relay contacts shall be suitable for making and breaking the maximum currents which, they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved auxiliary contacts, relays or auxiliary switches shall be provided. In such cases the number of auxiliary contacts or tripping relays operating in tandem shall be kept to the minimum in order to achieve fast fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate, shall be provided with LCD, LED or flag indicators, phase coloured where applicable. LCD, LED or Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element.

All Relay settings shall be visible and readable without having to remove the relay front cover. It shall not be possible to amend relay settings with the front cover in place; other than over a serial link, if provided.

If a connector for local use is provided, this shall be accessible only after removing the front cover. Where a port is provided for permanent connection to a modem or other peripheral equipment, remote access shall be password protected.

Relays which rely for their operation on an external DC supply shall utilize for this purpose the trip supply of the associated circuit-breaker trip coil. This supply shall be monitored and an alarm provided in the event of failure.

Any auxiliary supplies needed shall be drawn from the main station batteries and not from separate internal batteries in the protection equipment.

Relays, whether mounted in panels or not, shall be provided with clearly inscribed labels describing their function and designation in addition to the general purpose labels.

Attention is practically drawn to the tropical climate and relay designs should be entirely suitable for duty under full tropical conditions.

To minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energized from the positive pole of the battery.

Relay shall be suitable for operation on 110 V nominal, 121 V float DC systems without the use of voltage dropping resistors or diodes.

Numerical protection shall be designed in such a way that in case of a failure of DC auxiliary infeed, the full information need to be maintained at least 24 hrs. After a recovery of DC auxiliary infeed the last information and alarms will be displayed and the alarm "failure of DC auxiliary infeed" released. The relay reset shall not erase the relay memory.

The Numerical protection functions shall be in the form of software such that additional or different functions, application specific logic, etc. can be readily implemented without changes to the existing hardware. It shall be possible to program/ parameterize by a portable computer (PC) all the numerical protective relays and the entire relay operating and configuring software and the portable computers and other accessory equipment needed to communicate with the relays shall be provided.

All numerical relays shall be adequately protected against damage from incoming surge and shall meet relevant IEC, BS and ANSI SWC test standards. Relays shall utilize a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation.

In addition to all equipment and components, the Contractor shall supply documents and calculations to prove the correct functioning of the equipment and he shall ensure and demonstrate that the setting range of relays and the operating limits of all equipment are suitable for the intended applications.

Electromagnetic Compatibility

In certain cases, e.g., distance protection, current differential etc., electronic relays, or devices utilizing microprocessors are specified and electromagnetic devices will not be accepted.

Where such devices are required, they and the ancillary circuits connected to them, such as power supplies, current and voltage transformer secondary's, status, tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an EHV substation.

Adequate steps, by means of suitable design, shall be taken to prevent Electromagnetic

Interference (EMI) generated by sources such as circuit breakers, disconnectors, lightning, radio or radar emissions, switching contactors in dc circuits, etc. or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.

All relays offered must therefore have been type tested to meet the current requirements of IEC 60255 with respect to High Frequency disturbance, Fast Transients, Electrostatic Discharge, Radio Frequency Interference testing, etc.

OVER HEADLINE PROTECTION

230 kV Overhead Line Protection

230kV Overhead Line shall be protected by Distance relay both for main 1and main 2 and Directional Earth Fault relay as a backup under this Contract.

Only the backup protection can be incorporated in the bay control unit and not the main 1 and main 2 protection. Main protections shall be provided separately.

Both main protections and directional earth fault protection operating in conjunction with tele- protection channels over optical fibre or power line carrier circuits to form a permissive under reach scheme of distance protection.

Each set of protection will be energised from separate current transformers and shall have facilities for independently tripping duplicated circuit-breaker tripping coils and initiating auto-reclosing, breaker failure protection, inter-tripping, alarms, fault location equipment, disturbance recorders etc. The Contractor shall ensure that the relay contacts used for initiation of auto reclosing shall have the same dwell time as the main tripping contacts to avoid any problems arising from contact racing with the auto reclose relay.

Two sets of protection shall consist of different types of relays either from the same manufacturer or from different manufacturers. Separate elements shall be provided for phase and earth fault measurement. Separate elements shall also be provided for each zone. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of fault and to allow for variation in the path of earth faults on the system.

Distance as Main-1 & Main-2 Protection and Directional Earth Fault Protection as Backup

The main protection (First and Second main) shall be of numerical type and shall be provided by distance relays for use with a signalling channel.

The relay scheme offered shall be suitable for use in the permissive under-reaching, permissive overreaching, blocking and unblocking modes. All these options shall be contained and selectable in the standard relay scheme. The relay should be applicable to all neutral ground possibilities and should be suitable for the protection of long or short overhead lines or cables, double circuit lines, heavily loaded lines, lines with weak in feeds etc.

The permissive over reach scheme shall operate in a permissive under reach/overreach transfer tripping mode with under reaching zone I elements and overreaching zone 2 elements and suitable logic to achieve fast tripping at the sending end in the event of a weak infeed at the receiving end. The weak infeed logic shall comprise a zone 3 element set to look in the reverse direction, which 'echos' back the received signal to the sending end if the reversed zone 3 comparator does not operate.

To provide high speed tripping when a line terminal is open a 'signal echo feature' shall be provided, which is initiated when either the feeder disconnector is open, or when the associated circuit breakers are open.

The Zone 1 elements will normally be set to approximately 80 per cent of the line impedance. They shall trip the local line circuit-breaker.

The Zone 2 elements will be set to over-reach the remote substation and in the case of permissive over-reaching mode operate in conjunction with teleprotection signalling channels to form a permissive over-reaching scheme. They shall also act as a back-up time delayed zone which trips the local circuit-breaker. In the case of permissive under-reaching mode protection the overreaching Zone 2 unit will be used as the permissive element to permit instantaneous tripping of the local circuit.

The Zone 3 elements shall provide a further time delayed back-up zone.

Distance protection back-up zones shall also trip the remote end circuit breaker(s) via a direct intertripping channel.

Partially cross polarised mho or polygonal impedance characteristics relays are preferred for Zones 1 and 2 for 3-phase and 2-phase faults but other characteristics will be considered. Quadrilateral characteristics with adaptive reactance measurement to avoid overreach or under reach for resistive faults with pre fault load are preferred for earth faults. The relays shall operate for faults in the direction of the protected line only. Under no circumstances shall they operate for reverse faults even when the voltage supplied to the relay falls to zero on all three phases nor shall they operate due to the transient response of the capacitive voltage transformers following reverse close-up faults. Details of methods used for polarising the relays to deal with faults close to the relaying point shall be provided. Zone 3 shall be capable of being set as either directional or non-directional and shall be capable of being independently off set in both directions.

The reach of each zone and reverse element shall be individually adjustable by means of a multi-tap voltage transformer or other approved method. The characteristic angle shall be adjustable between approximately 40 and 80 degrees.

Where used in a permissive overreach transfer tripping scheme with weak infeed tripping the zone 3 unit may be set looking in the reverse direction. The reverse looking impedance/directional elements shall detect all reverse faults capable of being detected by the Zone 2 relay at the remote substation. Bidders shall explain how this is achieved.

Single pole tripping and auto-reclosing are being employed and the auto-reclosing scheme requirements. The distance protection shall be suitable for such a scheme and the Contractor shall substantiate by calculation or other means that phase selective tripping will be achieved under the system conditions anticipated in the daily operation.

The Contractor may request whatever information he requires for carrying out the necessary calculations.

Auto reclosing shall be capable of being blocked for any three phase fault any Zone 2 or Zone 3 time delayed trip carrier channel out of service DEF aided trip DEF back up time delayed trip Switch on to fault.

The necessary circuitry shall be incorporated to inhibit the Zone 1 and Zone 2 phase fault elements when necessary during single phase to earth faults and during the single phase auto reclose dead time. These features shall be selectable by links or switches. Provision shall also be made to ensure that the earth fault elements reset during the single phase dead time.

The protection sensitivity shall be shown to be adequate for the minimum fault level conditions. These will be advised to the Contractor at a later stage.

Where fault resistance may be significant, the Contractor shall illustrate that the distance protection can cover such values taking fault current distribution and load conditions into account.

The operating time of each distance protection zone shall be substantially independent of fault current magnitude. The operating times shall be stated in the Schedule of Particulars and, in addition, curves shall be provided showing the effect of line and source impedance, fault position and operating current.

Under no circumstances shall any line protection operate because of normal system switching including de-energisation of the line.

A feature shall be incorporated to ensure instantaneous tripping in the event that the circuit-breaker is closed onto a fault on a previously de-energised line.

Distance protection back-up Zone 2 and Zone 3 time delay setting ranges shall be 0.2 to 1.0 seconds and 0.5 to 3.0 seconds respectively.

A carrier receive signal extension timer with a delay on reset of 100 msecs shall be provided to ensure that relays at both ends of a parallel feeder circuit have sufficient time to trip for faults occurring in the end zones of the protected line.

A monitoring system shall be provided to supervise the voltage transformer supply to each set of distance protection. In the event of loss of one, two or three phases, the monitoring system shall inhibit relay operation and initiate an alarm. The VT supervision unit associated with the distance relay shall also inhibit the DEF protection in the event of VT fuse failure.

All relays shall incorporate indicators to show the relay tripped, zone indication and the phase or phases faulted. Indication must not be lost in the event of a supply failure.

Directional earth fault protection operating in a permissive overreach scheme shall be provided to cater for high resistance faults which cannot be detected by the distance protection. The same teleprotection signalling channel shall be used for the directional earth fault scheme and the distance protection scheme. An echo feature shall be included with the DEF Scheme and shall be subject to approval by the Engineer.

The directional relays shall be dual polarised i.e., polarised with zero sequence voltage and current. The relay sensitivity shall be adjustable between approximately 5 and 10% of rated current. A relay characteristic angle of 60 degrees is preferred but alternative angles will be considered. It is appreciated that because the 230kV system zero sequence source is an auto transformer with a delta tertiary winding, that current polarising of a dual polarised relay is unreliable without careful analysis. The Contractor shall be responsible for determining whether such a current signal can be taken from the auto transformer neutral and safely used for polarising the relay within three months of being advised of all transformer impedance parameters.

The directional earth fault protection shall initiate three pole tripping. It must therefore include a short time delay to permit single pole tripping by the distance protection. Initiation of three pole reclosing following operation of a DEF aided trip shall be selectable by means of a switch.

Directional earth fault relays shall incorporate a back-up stage in addition to the aided tripping unit. The time delay range shall be 0.2 to 5.0 seconds or inverse time delayed with a characteristic to IEC 60255.

Neither the distance protection scheme nor the directional earth fault scheme shall mal-operate due to fault current reversal during sequential clearance of a fault on the parallel circuit.

The effect of zero sequence mutual coupling between the double circuit lines on the protection shall be described, together with any measures considered necessary to overcome this effect.

The distance protection time delayed back-up Zones 2 and 3 and the directional earth fault back-up stage shall intertrip the remote station circuit-breakers over direct intertripping channels.

Auto reclosing shall not be initiated on receipt of direct intertripping signal. Direct intertripping shall also be initiated in the event of a 3 phase fault in any zone, or following a switch on to fault trip.

Distance relays shall be supplemented by power swing blocking relays. Power swing blocking relays shall be compatible with their appropriate distance relays, and for distance relays having offset mho zone 3 characteristics or starters shall comprise an offset mho characteristic which encompasses and is concentric with the distance relay impedance starter or zone 3 characteristic. Similarly, where it is possible to shape the zone 3 or starter characteristic the power swing blocking relay characteristic shall also be capable of similar shaping. Where zone 3 is set reverse looking the power swing blocking characteristic shall be set such that it encompasses the forward looking zone 2 characteristic.

Facilities shall be provided to block zones 1, 2 and 3 of the distance relay from the power swing blocking logic as required.

Blocking logic shall be derived by determining the time taken for the apparent impedance of the power swing locus to pass from the characteristic of the power swing relay to the appropriate distance relay characteristic. Blocking shall not take place until the apparent impedance has passed through the two power swing characteristics and the set time delay has expired. The associated time delay relay shall have a setting range of 50-250 ms.

Relays shall be of numerical or static design. Electromechanical relays will not be accepted. The Numerical relays shall be design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Distance to fault indication, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Man Machine Communication (MMC) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection. A separate communication port shall be provided so that the distance relays can in future communicate with the Station monitoring system as well as easily be integrated into Station Control Systems. A PC with a Man Machine Communication (MMC) software for setting of the relay shall be included in the scope of supply.

Reset times shall be low to ensure the associated distance relay reverts to its normal role as soon as possible following a power swing.

Power swing blocking shall be inhibited during the single pole dead time of an auto reclose cycle so that if a power swing develops during this period the distance protection can give an immediate three phase trip. The bidder shall advise whether it is possible to extend the inhibition of the power swing blocking to cover a period immediately following auto reclosing so that if a power swing develops on reclosing onto a permanent fault a 3 phase trip would be permitted. The bidder shall also advise whether power swing blocking can be inhibited if an earth fault occurs during a power swing.

If the associated VT supplies are lost due to VT fuse failure the power swing blocking relay shall not operate.

Where protection is supplied from multi-ratio current transformers, the lowest ratio will be used for the initial system configuration, when fault levels are low. The working ratio will be increased when the system expands and the fault levels and load transfers increase.

Differential as Main-1 & Main-2 protection and Directional Earth Fault Protection as Backup

The protection shall be of numerical type line differential relay and shall be suitable for short underground or over head line protection (single or double circuit) in solidly or low impedance grounded systems.

The relay shall incorporate a facility to compensate for different CT ratios at each line terminal.

A tripping signal for a fault shall be given within 30 ms of fault occurrence (including main tripping relay).

The differential protection shall measure the currents of three phases independently and the tripping shall take place should the comparison of the values in both the terminal stations result in a differential current above a set level. The relay shall incorporate methods for ensuring protection stability for external faults with allowance for CT transformation errors. The minimum CT requirements for the protection must be clearly stated. The protection shall offer phase-selective tripping, if required.

For digital communication between relays at each line terminal, the protection shall be suitable for direct interfacing to the available communication link according to the particular application. This may be a pair dedicated optical fibres, or a digital interface card of a multiplexed communications link. Where the multiplexer forms part of an overall communications system, the relays shall incorporate the necessary algorithms to ensure stability with load current during communications path route-switching.

Upon detection of a communications channel failure and following a time delay of less than 10 seconds, an alarm shall be given. In the event of signalling channel failure the protection must not trip due to load or emergency load currents.

The protection system shall incorporate at least one zone of directional under impedance protection, to provide time-delayed remote back-up tripping in the even of a fault in an adjacent remote circuit not being cleared by its main protection. This protection function shall be blocked in the event of VT signal failure.

The protection system shall offer standby directional protection elements that can automatically or manually (as selected) be brought into service in the event of data communications link failure between the relay terminals. The alternative protection shall, preferably be one zone of high-speed under reaching distance protection and one zone of time-delayed overreaching distance protection.

In addition to the tripping contacts the protection shall provide all necessary contacts for initiating phase-selective auto re-closing, breaker failure protection, disturbance recorder, signaling and alarms.

For overhead lines, the relay shall be compatible with the external single and three phase auto reclose system which is to be common for the Main-1 and Main-2protection.

The protection system shall include a secure integral inter-tripping facility, which can be used as a secondary inter-tripping path by external breaker fail protection.

The relay shall be equipped with self-supervision of both its software and hardware (including VT signal supervision). Detection of a failure shall result in the affected part(s) of the protection system being blocked, so that no incorrect tripping will occur.

In the event of a relay failure an alarm contact must operate and the nature of the failure should be indicated where possible.

The trip output contacts of the relay must either be suitable for switching the breaker trip coil currents directly, or an interposing trip relay with heavy duty contacts must be provided. In the event of breaker failure, where the circuit breaker auxiliary contact may not interrupt the trip coil current, the trip contacts within the differential relay should not be damaged if the relay resets following breaker fail protection clearance.

Coupling Bay Protection

The Coupler bay shall be provided with over current instantaneous trip relay protection and over current time delay relay protection and instantaneous trip relay protection.

In case of main & transfer bus arrangement all trip-signal of line and transformer feeder protection shall be transferred to the coupling breaker in case the feeder breaker is bypassed and the feeder is protected by the coupling-bay circuit breaker. This shall be provided by auxiliary relay, not by auxiliary contacts of the circuit breaker by-pass isolator.

BUSBAR PROTECTION

The busbar protection (double scheme) shall be low impedance type numerical relay. The protection shall be extensible to cover the final substation arrangements and Bidders shall state what extra material is required.

The busbar protection shall have the following features:

Two independent measurement & tripping criteria. One based on stabilized current differential algorithm and the other on directional current comparison and shall be capable of detecting three phase, phase-phase and phase to earth faults, under all system generation plant conditions. They shall meet the fault clearance time of 100ms under all conditions.

Two independent hand or electrically reset busbar protection trip relays shall be associated with each circuit-breaker. These trip relays may also be employed for circuit breaker failure. Operation of either of these relays shall block closing of the associated circuit breaker.

Each trip relay shall trip the circuit-breaker via both trip coils. Both relays on the 230kV or 110 kV transformer circuits shall trip the associated circuit-breakers.

The operating time of the measuring relays shall not exceed 30 msecs at five times the relay current setting.

The busbar protection will be supplied from multi-ratio current transformers. The working ratio will be selected on the basis of maximum load transfer in the same manner as the line current transformer ratios.

The overall fault setting shall be between 10% and 30% of the minimum fault current available for any type of fault, unless otherwise specified. The minimum fault current for busbar faults will be advised at a later stage.

The rated stability limit of the protection shall not be less than the switchgear short circuit rating.

Automatic and continuous supervision of current transformer circuits shall be provided to give an alarm when the out-of-balance current reaches an undesirable value. Operation of current transformer supervision equipment should take the defective protection zone out-of-service.

The Contract shall include for all necessary current transformers, relay panels, marshalling boxes, isolating and shorting links, etc. A lockable Busbar protection ON/OFF switch shall be provided.

Current transformer secondary bus wiring should be suitably dimensioned to reduce current transformer burdens to a minimum.

Suitable voltage limiting devices shall be provided as necessary, including across the unused part of the CT secondary when tapings are employed.

Full details of the scheme offered, together with performance figures for stability and sensitivity, shall be provided.

The numerical busbar protection shall be multi-processor in structure, with extensive self-supervision, 16-bit analogue to digital converters, together with appropriate algorithms to provide phase segregated measuring principles and multi criteria evaluations before initialization of trip commands. The busbar protection shall be of decentralized type and the bay units shall be fixed as close to the CT' s as possible reducing the copper wiring to a bare minimum and thereby also reducing the CT burden and CT dimension.

If the intercommunication between the bay unit and central unit by fiber optic cables, the required fiber optic cable and all necessary items shall be supplied, connected and commissioned by the Contractor.

Conditions of Acceptance of Busbar Protection Systems shall be Submitted on the Basis of Calculated Performance.

The Engineer is prepared to accept Calculated Performance data for differential busbar protection systems in lieu of heavy current tests, subject to the following:

The rated stability limit shall be no less than the three-phase symmetrical breaking capacity of the associated switchgear.

The overall fault setting for any type of fault shall be between 10% and 30% of the minimum fault current available. The minimum fault current available for a busbar fault will be advised later.

Current transformer knee point voltages shall not be less than twice the relay circuit setting voltage.

The maximum peak voltage across current transformer secondary wiring shall not exceed 3kV under maximum internal fault conditions.

Associated current transformers shall be 5P20, low reactance type. Split core type current transformers will not be accepted.

The Contractor shall submit for the Engineers approval a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burdens between current transformers and relays, details of the relay circuits and performance calculations.

CIRCUIT BREAKER FAILURE PROTECTION

Breaker failure protection shall be fitted to all 230kV & 110kV GIS circuit breakers. The breaker failure protection on a circuit-breaker shall be initiated by all the other protection devices which normally initiate tripping of that breaker including the receipt of a direct intertripping signal from a remote line end. In the event of the circuit-breaker failing to open within a pre-selected time, the breaker failure protection shall initiate tripping of all adjacent circuit-breakers. It shall also incorporate provision for initiating tripping of any remote infeeds, via direct intertripping channels over optical fibre communication link or power line carrier circuits.

The position of each circuit-breaker shall be monitored by a current check relays fed from the protection current transformers as shown on the drawings. The relay outputs shall be connected in series in a "two out of two" arrangement. The relays shall have an operating time of approximately 10msec. and a consistent reset time of less than 15msec. The relays shall be capable of remaining in the operated position continuously and of carrying twice the circuit rated current continuously.

The scheme provided shall be suitable for use in a single pole and three pole tripping and auto reclosing schemes as appropriate.

The operating time from initiation to back tripping output shall be selected by means of duplicated timers with a setting range of 50-500 msecs. The two timers per circuit breaker in the case of the 230 kV scheme shall be connected in series in a two-out-two basis and shall energise both trip coils of all adjacent circuit breakers via two back tripping circuits from separate d.c. supplies.

The timers shall be of a modern design to minimise over travel. With the approval of the Engineer the busbar protection trip circuits may be employed for circuit breaker fail back tripping.

In the event that a circuit breaker is unable to trip due to low gas pressure, low hydraulic oil pressure etc. the associated alarm shall be arranged to by-pass the breaker fail time delay. The breaker fail relay/scheme shall be designed to accept this input.

Operation of the breaker fail protection shall block manual and automatic reclosure of the associated circuit breaker. Breaker failure protections inbuilt in distance / transformer relays will not be accepted.

AUTO RECLOSING SCHEME

Three pole and/or single pole, single shot repetitive auto-reclosing equipment, shall be provided for the 230kV overhead line circuit-breakers.

Reclosure shall be initiated following tripping by either main protection operating in Zone 1 or in conjunction with a teleprotection receive signal. Selection facilities shall also be provided to enable or block three pole delayed auto-reclosing following operation of the directional earth fault protection aided trip output. Reclosure shall not be initiated in the event of a three phase fault, nor any type of fault in the second or third back-up zones, nor when a direct intertripping signal is received, nor when the circuit-breaker is closed onto a fault on a previously de-energised line, nor when the DEF back-up protection operates nor if the carrier channel is out of service.

The following modes of operation shall be selectable by means of a switch or switches or programmable.

Single pole, high speed, auto-reclose: Auto-reclosure shall only be initiated in the event of a single phase to earth fault. All other types of faults shall result in three phase tripping without auto-reclosing.

Three pole delayed reclosing: Delaying reclosing shall only be initiated in the event of a single phase or two phase fault. Three phase faults shall result in tripping without auto-reclosing.

Single pole, high speed and/or three phase delayed, auto-reclosing as appropriate.

Single pole, high speed auto-reclosing shall be initiated only in the event of a single phase-earth fault and delayed reclosing initiated in the event of a two phase fault. Three phase tripping without re-closing shall take place for three phase faults.

No auto reclosing: Three phase tripping without auto-reclose shall take place for any type of fault.

If a second earth fault occurs during the single pole auto-reclose dead time, and the selector switch is in the single and/or three pole reclosing mode three phase tripping with subsequent delayed three pole auto-reclose shall take place. If the auto-reclose selector switch is in the single pole reclose mode, three phase tripping with lockout should follow. Any auxiliary relays required to meet this logic shall be deemed to be included.

The high speed and delayed reclosing dead times have to be coordinated with the equipment being provided at the remote substation. Tentative ranges are, as follows:

High speed single pole reclose dead time	:	0.3 to 3 seconds.
Delayed three pole reclose dead time	:	3 to 30 seconds.

Bidders shall state available ranges.

The reclaim time i.e. the time period following the automatic reclosing of the circuit-breaker, during which any further fault results in three phase tripping and lockout, shall be chosen to match the duty cycle of the circuit-breakers, assuming the shortest available dead time is chosen. The reclaim time shall not, however, be less than five seconds, and the reclaim timer range shall extend to 180 seconds. (The reclaim time commences at the instant the reclose command is given to the circuit-breaker and, therefore, includes the circuit-breaker closing time).

The closing command shall be limited to two seconds, after which time the reclosing equipment shall be automatically reset without resetting the reclaim timer. The reclosing equipment shall also reset if dead line check or synchronism check conditions are not satisfied within a predetermined time of the check relays being energised.

A counter shall be provided to record the number of reclosures and lockout after a pre-selected number of reclosures has been reached.

The rated duty cycle of the circuit breaker as defined in IEC 60056 (and subsequent amendments) states that following an initial trip and auto reclosure a further reclosure is not permitted for a further 3 mins.

Reclosing schemes shall include voltage monitoring and check synchronising relays as appropriate.

Dead line check relays shall monitor the condition of the line and busbar and permit three pole reclosing only when the line is de-energised and the busbar is energised. The line is considered to be de-energised when the voltage is less than twenty percent of rated voltage, and the busbar is considered to be energised when the voltage is greater than eighty percent of rated voltage.

(A signal shall be provided from the dead line check relays for interlocking of the line earth switches to prevent the switches being closed onto a live line).

When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall monitor the magnitudes of the two voltages across the open circuit-breaker, and the phase angle and slip frequency between these voltages. Closing shall only be permitted when these are within prescribed limits.

Check synchronising relays shall comply with the requirements of this specification. The same relays may be used as for manual closing.

OVERCURRENT AND EARTH FAULT PROTECTION

The overcurrent and earth fault relays shall be fully Numerical and have multi characteristics (inverse, very inverse, extremely inverse) to IEC 60255.

Over current relays shall have a current setting range from at least 50% - 200% in 25% setting steps. Earth fault relays shall have a current setting range from at least 20% - 80% in 10% setting steps.

Time multiplier settings shall be continuously adjustable from 0 to 1 or, as an alternative in steps of 0.025 from 0.05 to 1.0.

In the case of transformer circuits relays shall be provided with high set instantaneous units which can be set to 1.25 times the fault current in the HV winding for a fault on the LV terminals computed using the transformer minimum impedance and assuming negligible source impedance. The instantaneous unit shall have a low transient overreach (less than 5% for system X/R ratio of 10) and an operating time of less than 40 msec at two times the current setting.

In the case of underground line circuits relays should have a reset ratio greater than 95% to enable settings to be made which are close to the circuit emergency rating. The relay contacts must close at a current equivalent to 110% of the setting and relay overshoot must not exceed 50 msecs.

Over current and earth fault relays shall trip via the CB duplicate trip coils and initiate duplicated direct intertripping to the remote line end CB.

Relays shall be thermally rated such that the operating time of the relay at the highest practical current levels on any combination of current and time multiplier settings shall not exceed the thermal withstand time of the relay. The Contractor shall provide copies of type test reports to show that this requirement has been met.

Directional back up over current and earth fault relays shall be provided for underground Cable feeders and the directional elements shall be voltage polarised.

Directional units for directional over current protection shall be quadrature connected with a relay characteristic angle setting of 30° or 45° current leading voltage.

Directional units for directional earth fault back up protection shall employ residual voltage quantities and the relay characteristic angle be variable 0°, 45° and 60°, current lag.

The nominal operating boundary shall be ±90° from the relay characteristic angle and the operating time of the directional unit shall not exceed 20 ms at the relay characteristic angle.

The relay shall be capable of operating correctly when both the operating current and polarising voltage quantities are 1% of rated values at an angle equal to the relay characteristic angle.

The residual polarising voltage for earth faults may reach 190.5 volts and therefore it should withstand this value continuously. The continuous withstand current should be no less than twice rated current.

TRANSFORMER PROTECTION

Biased Differential Protection

The transformer differential protection shall be fully numerical design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Trip indications, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Human Machine Interface (HMI) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection.

Overall differential protection shall be of the biased differential type and capable of detecting phase and earth faults.

Separate facilities shall be provided to enable bias and operating settings to be adjusted. The minimum operating setting shall not be greater than 20 per cent of the rated full load current of the transformer.

The protection shall be designed to ensure stability on any transformer tap position under maximum through fault conditions with maximum d.c. offset. An infinite source is to be assumed and the through fault current calculated using the transformer impedance only.

Correction for matching transformer vector groups and main CT ratio’s for Transformer Differential protection shall be performed within the relay without the use of external interposing-transformer.

The relays shall have magnetising inrush current restraint of the second harmonic or other approved means. All necessary interposing current transformers shall be provided under the contract.

Where specified in the drawings two separate biased transformer differential protection relays shall be provided for each transformer.

Restricted or Balanced Earth Fault Protection

Where specified, or shown on drawings, transformer windings and connections shall be protected by restricted earth fault protection. Delta connected windings shall be protected by balanced earth fault protection. Relays shall be of identical numerical design as the main protection and of the low impedance type with necessary protection against over voltages. For reliability reasons the Restricted earth fault relay shall be separate from the main-1 transformer differential relay, but in case of two biased differential relay the Restricted earth fault relay can be incorporated in main-2 differential relay.

Relays shall have maximum sensitivity and minimum operating times consistent with stability for faults outside the protected zone and on magnetising inrush surges.

The rated stability limit shall not be less than the maximum current available for an external fault. This shall be taken as 16 times the rated current of the protected winding of the power transformer, or any other value agreed by the Engineer.

For the purpose of calculations, it shall be assumed that any neutral earthing impedance is short circuited.

The Engineer is prepared to accept calculated performance for instantaneous high impedance restricted earth fault protection in lieu of heavy current tests, subject to the conditions of this specification except:

The rated stability limit shall be as specified above.

The fault setting shall be as specified below.

When the transformer winding is connected to a solidly earthed power system, the fault setting shall be between 10% and 60% of the rated current of the winding. When the transformer winding has more than one rating, the setting shall be based on the lower rating.

When the protected transformer is not connected to a solidly earthed power system the fault setting shall be between 10% and 25% of the minimum current available for an earth fault at the transformer terminals.

230/110kV Transformer Back-up Overcurrent Protection

Three pole inverse time back up over current and earth fault protection shall be provided as shown on the drawings. This shall comply generally with the specification but in addition the over current elements shall also be a two stage device. Stage 1 shall be arranged to trip the 110kV circuit breaker and stage 2, the 230kV circuit breaker. Stage 1 will comprise the inverse time unit and stage 2 will comprise an additional definite time unit with a setting range of 50 msec - 5 secs.

Gas Pressure (Buchholz) Protection

Power transformers and earthing transformers shall be fitted with Buchholz devices under this contract. The Buchholz device will be of the two element type giving operation under gassing and under surge conditions.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be provided, mounted and connected under this Contract.

Oil and/or Winding Temperature

Transformers will be provided with oil and/or winding temperature protection under this contract. These will be of the two stage type with adjustable settings giving alarm and trip facilities.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be supplied and connected under this Contract.

Low Oil Level and Pressure Relief Devices

Transformers shall be provided with low oil level with contacts for the purpose of providing remote alarm. Transformers shall also be provided with a pressure relief device with contacts for purposes of remote alarm and trip function.

The alarm relays associated with these devices shall be supplied and connected under this Contract.

Tap Changer Oil Surge

Transformers will be provided with an oil surge or pressure operated device having contacts for purposes of remote alarm and trip.

A relay associated with this device shall be supplied and connected under this Contract.

All necessary flag indication, tripping and alarm relays associated with tap change oil surge shall be provided.

Standby Earth Fault Protection

Standby earth fault protection shall be provided for all earthing transformers/resistors, fed from a current transformer in the transformer/resistor neutral connection.

The operating current shall be adjustable between 10 and 40 per cent of the resistor value. The time delay shall be adjustable between 1 and 10 secs. As an alternative to a definite time relay, a long inverse time relay may be offered.

Tripping Relays

All tripping relays, where specified shall be of the heavy duty type suitable for panel mounting. The trip relays of the offered numerical protections shall be directly capable of tripping the breaker coils. It shall not be required to add additional trip relays

Trip relay contacts shall be suitably rated to satisfactorily perform their required duty and relay operating time shall not exceed 10 ms from initiation of trip relay operating coil to contact close.

Where specified latching type relays shall have hand or electrically reset contacts and hand reset flag indicators. Resetting of the flag indicator and the contacts shall be possible without having to open the relay case.

Tripping relays shall operate when the supply voltage is reduced to not higher than 30% of nominal battery voltage. It shall not operate for wiring leakage currents and discharge of wiring capacitance

230kV and 110 kV circuit breakers are equipped with two trip coils. One tripping relay shall initiate tripping via one trip coil and the other tripping relay via the second trip coil.

DC AUXILIARY VOLTAGE OPERATING RANGE

DC operated relays, coils, elements, etc. will be operated from a 110V rated DC. battery, which under float charging conditions operates at about 125V DC. operated relays coils elements etc. shall be suitable for operation over a voltage range of 66V to 143V. i.e. 110 - 40% + 20%.

TELEPROTECTION SIGNALLING

Details of protection initiation and various permissive and direct intertripping signals shall be submitted by Contractor to the Engineer for approval.

Proposed Fiber Optic Multiplexer equipment system layout Drawing of this Technical Specifications shall also be submitted by Contractor for approval.

TRIPPING RELAYS

All tripping relays, where specified shall be of the high speed, (less than 10ms), high burden, heavy duty (greater than 150W) type suitable for panel mounting.

Relays shall comply with the requirements of this specification.

PROTECTION SETTINGS

Relay settings with calculation for all unit type protective schemes shall be submitted to the Engineer prior to commissioning of any plant for approval. Settings shall also be provided for those relays and other equipment provided under this Section of the Contract which do not require an intimate knowledge of existing relay settings e.g. circuit-breaker fail relays. Detailed calculations shall be provided supporting all recommended settings.

8.6.15 SUBSTATION AUTOMATION SYSTEM

This specification covers the design, manufacture, inspection, testing at the manufacturer's works, erection and commissioning of a Substation Automation System, as described in the following sections, to control and operate the substation.

This describes the facilities required to provide the control of plant and system within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

The Substation Automation System (SAS) shall comprise full station and bay protection as well as control, monitoring and communication functions, and provides all functions required for the safe and reliable operation based on IEC 61850 standards supplied in cubicles. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package and perform the necessary system control and data acquisition functions. It shall include communication gateway to NLDC, inter-bay-bus, intelligent electronic devices (IED) for bay control and protection. Contractor shall design the Substation Automation System general system architecture drawing as part of their scope of work.

The communication gateway shall secure control from and information flow to remote network control centers. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer and trip/close coils in the switchgear without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Engineer.

The Contractor will have option to choose different type of communication network for bay level and process level based on IEC 61850. But network topology and access mode shall be clearly indicated. The availability shall be maintained with suitable topology of ring, star or bus. The physical medium of those shall be glass fibre optics.

The IED's for protection and control functions shall maintain high availability and reliability together with bay independence through extensive self-supervision and state-of-the-art technology. All IED's shall be directly connected to the IEC 61850 bus and shall use only IEC 61850 protocol for communication. No proprietary protocols shall be used.

The system shall be capable of having its computing power increased in the future by the addition of additional computing systems.

The system design life shall be not less than 20 years.

The capacity of the SA system shall be sufficient for the ultimate development of the substation as set out in the project requirements.

The SA supplier shall demonstrate that the system proposed has been designed, installed and commissioned in accordance with IEC 61850 standards and shall provide evidence of satisfactory service experience during the past 5 years.

Compliance with standards

For design and type testing of the protection and control equipment, the following standards shall be applicable:

General List of Specifications

IEC 60255: Electrical Relays

IEC 60038: IEC Standard voltages

IEC 68068: Environmental testing

IEC 60664: Insulation co-ordination for equipment within low-voltage systems

IEC61850: Standard for Substation integrated protection and control data communication

Detailed List of Specifications

IEC 255-6: Measuring relays and protection equipment

IEC 255-7: Test and measurement procedures for electromechanical all-or- nothing relays

IEC 68-2-3: Test Ca: Damp heat steady state

IEC 68-2-30: Test Db and guidance: Damp heat, cyclic

IEC 255-5: Insulation tests for electrical relays

IEC 255-22: Electrical disturbance tests for measuring relays and protection equipment:

IEC 255-22-1: 1 MHz burst disturbance test

IEC 255-22-2: Electrostatic discharge test

IEC 255-22-3: Radiated electromagnetic field disturbance test

IEC 255-22-4: Fast transient disturbance test

IEC 255-11: Interruptions to and alternating component (ripple) in D.C. auxiliary energising quantity to measuring relays

IEC 255-6: Measuring relays and protection equipment

IEC 255-21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment

IEC 255-21-1: Vibration tests(sinusoidal)

IEC 255-21-2: Shock and bump tests

IEC 255-21-3: Seismic tests

IEC 255-0-20: Contact performance of electrical relays

IEC 870-3/class 2: Digital I/O, Analogue I/O dielectric tests

IEC 801-5/class 3: Digital I/O Surge withstand test

IEC 870-3/class2: Radio interference test

IEC 801-4/4: Transient fast burst test

IEC 801-2/4: Static discharge

IEC 801-3/3: Electromagnetic fields

Design and Operating Requirements

General

The SA shall be suitable for operation and monitoring of the complete substation including future extensions. The supplier shall provide a high quality SCD file (System Configuration Description file) complete with ICD files (IEC device capability files) and substation topology which will enable easy extension of the substation in future. The offered products shall be suitable for efficient and reliable operation and maintenance support of the substations.

The SA system shall be state-of-the art design suitable for operation in high voltage substation environment, follow the latest Engineering practice, ensure long term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

Protection shall be an integral part of the SA system and protective relays shall be directly connected to the inter-bay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote control location.

Failure behavior of the hardware and software functions shall be addressed and related diagnostic and rectification working instructions shall be provided. The system performance, if failure of communication to NLDC, main and redundant computer based work stations, central functions, data model, control and protection IED's, station and bay level communication shall also be clearly addressed.

Modes of Operation

The operator stations and specified remote users shall have following operational modes, each password protected.

Monitoring Ability to select graphic displays and lists for viewing only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.

Control Selection of graphic display and lists. Able to acknowledge station and SA alarms, complete controls, dressing, etc. associated with normal real time of the control of the substation.

SA Engineering provides all the SA monitoring functions, together with online facilities for program/database/format modifications and checking without the possibility of executing power system controls.

System Manager Provides access to all system functions, including assignment of passwords and system maintenance activities.

In addition, a facility to provide access to the numerical Protection relays including AVR, change/modify relay settings & AVR parameters and fault and disturbance data shall be provided.

A series of passwords shall be personally assigned to operators in each of the above categories.

It shall be possible for substation operators to log on either of the substation workstation and to be allocated the appropriate mode of operation relevant to the password. SA System Engineering work and access to the protection relays and fault and disturbance recording information shall generally be carried out at the Engineering workstation or remote master station.

All the workstation and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

Similarly, an operator manual entry applied at a workstation shall be immediately displayed at other workstations where this data is presented.

Project Specifications

Specific functions required and boundary conditions of the SA shall be detailed by the Contractor for approval by the Engineer.

Vendor's Experience and Local Support

Only experienced and technically capable manufacturers with minimum 15 years experience in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred manufactures will be those who have experience in deliveries of the full scope of substation automation systems and services. This experience has to be substantiated by means of reference installations being in service under similar environmental conditions for at least 10 years. In order to assess the vendor's experience with similar projects, the vendor is required to submit the following with his bid:

1. Technical design specifications and description of Substation Automation
2. Catalogues and brochures of equipment and devices offered

Reference list

The vendor shall assure for long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SA equipment (not less than10 years).

Quality Assurance and Inspection

Quality Assurance of design and development, production, installation and servicing of material and workmanship shall be governed by ISO 9001. Supporting documents to prove ISO 9001 third party approvals shall be provided with the offer.

The SA system shall be pre-assembled and tested at the vendor's workshop before shipment and should be witnessed by the Third Party Inspector and by the Employer's

Engineer.

General System Design

The system shall be so designed that personnel without any background in microprocessor based technology can operate the system easily after they have been provided with some basic training.

System control from the substation control room will be with the help of an Industrial Computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

Acquisition and plausibility check of switchgear status

Control of switchgear

1. Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays
2. Display of actual measured values (U, I, P, Q, f)
3. Display of events
4. Display of alarms
5. Display of trends
6. Sequence control functions
7. Dynamic busbar coloring
8. Disturbance records and fault location
9. System self-supervision
10. Hard copy printing

The offered SA shall support remote control and monitoring from NLDC centre via an industrial grade gateway with redundant CPU as well as redundant DC/DC converters. PC based gateways which contain moving parts will not be accepted. The gateway should be designed for a life of at least 20 years. The gateway shall provide for communication to/from remote control centers via IEC60870-5-101 protocol. Even if the Station PC is not available, it shall be possible to control the station from NLDC center as well as from the backup control panel in the individual bays with all interlocks. Interlocking in case of emergency (i.e. if bay controller fails) should be waived locally by means of a switch with key lock by the Maintenance Engineer for all the switchgear.

Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimizing maintenance time to repair.

The Substation Automation System shall be structured in two levels - station level and bay level. The data exchange between the electronic devices on both levels shall take place via an inter-bay bus as per IEC 61850 standards. The entire station shall be controlled and supervised from the station level PC. It shall also be possible to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay should fail. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz., NLDC, station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level. Each bay control and protection unit shall be independent of each other and its functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station.

The Substation Automation System shall contain the following main functional parts:

1. Human Machine Interface (HMI) with process database
2. Gateway function for remote control via an industrial grade hardware
3. Dial in facility / laptop workstation for protection relay parameterization, disturbance analysis and SA system fault analysis.
4. Data exchange between the different system components via high speed bus
5. Bay level devices for control, monitoring and protection
6. Bay oriented local control and protection panels with mimic inserts
7. Facility for emergency operation of all the switchgear, if bay controller fails. (Key / master key system)

The main process information of the station shall be stored in distributed databases. The system shall be based on a de-centralized concept with bay oriented distributed intelligence for safety and availability reasons. Functions shall be decentralized, object oriented and located as close as possible to the process.

The substation monitoring/protection system shall supply data for maintenance, repair and remote parameter setting of protection and control devices in the switchyard.

In the event of a fault in the electrical network, the substation monitoring shall provide a quick means for collecting the relevant and critical data of the fault.

The monitoring system shall be suitable for the supervision and monitoring of all the secondary (IED) and primary devices in a substation including future extensions.

Maintenance, modification or extension of components shall not cause a shut-off of the whole station monitoring system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

It shall be possible to access all protection and control devices for reading the terminal parameters (settings). The setting of parameters or activation of parameter sets shall be restricted by password to the protection Engineer.

One remote computer should be provided with the access to SMS with different access levels. The required SMS software and application specific firmware (for relay parameterization) shall be provided with associated tools and equipment. The required Engineering tools analyzing software also shall be provided/installed both in the station PC and the remote Master Analysis station. A backup copy of all the software shall be provided in CDs.

Flexibility and Scalability

The offered SA system concept shall be flexible and shall permit future extensions to be realized easily as per IEC 61850 standards. Preference will be given to those suppliers who are in a position to provide protection and control devices which can be freely adapted to the application functions required.

System Hardware

Operator Station

The main operator station shall be based on an industrial PC hardware and high- resolution full-graphics screen with manufacturers' standard type tested software operating under Windows environment. A black & white printer and a Hard Copy color printer shall be connected via LAN to the operator station.

Dual station computers shall control the SA system and drive the work stations and other peripherals. One of the station computers shall operate the system in the "on line" state while the other acts as a "redundant hot standby". The standby computer shall be continuously updated and shall immediately take over the SA system duties without interruption or transfer mechanism should the on-line operator workstation fail. The Industrial computers shall be supplied in cubicles of protection class IP54 or better along with the GPS clock & switches as required.

Disturbance Records shall be analyzed using the installed Disturbance Record Analysis programs. The Disturbance Records will be collected, over the inter-bay bus, from the connected IED's by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of Disturbance data or upload them in a pre-programmed manner. The Event printer shall print events spontaneously as they arrive in the main operator station.

Each uploaded data report file shall be reported on one line that shall contain:

1. The event date and time
2. The name of the event object
3. A descriptive text
4. The state or value of the object

The information fields above shall be structured in columns for maximum readability.

The hard copy printer shall permit printing of any picture (or part thereof) from the station level PC's using easily accessible commands from the window menus.

The main Station PC`s shall be supplied by the station DC battery and a UPS system with a supply duration of not less than 30 minutes shall be provided to supply the monitor and the printers.

At least 32 window annunciator unit shall be directly connected to the main Station PC`s to monitor the same and also to annunciate common station abnormal/fault conditions.

Station Inter-bay Bus

The LAN connecting the industrial computer-based operator workstations, printers shall be Ethernet 802.3 LAN, Protocol TCP/IP (10 Mbits/ sec or higher) and the physical medium shall be thin Ethernet or fiber optic bus, provided this LAN is kept within the confines of the control room.

The bay control and protection units shall be connected via glass fiber optic cables to a station inter-bay bus using industrial grade Ethernet switches. The station bus according to IEC 61850-8 is today mapped to MSS / Ethernet (with priority tagging and with 100 MS/s). The standard is not making any provision on the Ethernet communication infrastructure. To at least ensure a certain level of quality, performance and availability at least the following described criteria's have to be fulfilled concerning the Ethernet switches and topology.

Industrial grade Ethernet switches that fulfill the hardened requirements concerning temperature, EMC and power supply (110 V DC from the station battery) suitable to be installed in substations shall be provided, i.e., the same data as common for numerical protection. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g., for later system extension utility has not to rely on one switch supplier only. External switches shall be supplied as they have the advantage that there is no interruption or reconfiguration of the Ethernet ring if one or several bay devices are taken out of service. To increase reliability the Ethernet Switches shall have redundant power supply & shall be powered from two different station batteries.

Protection and Control IED's and Local Back-up Control Mimic on 230 kV & 110 kV Level

The bay control IED's, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as protection, commands, bay interlocking, data acquisition, data storage, event and disturbance recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear without any need for separate interposing equipment or transducers.

The numerical bay control IED shall be provided with a minimum of nine (9) configurable (current or voltage) analogue input channels and adequate number of binary input & output channels which are galvanically isolated from the SA system. The channels shall also be individually separated from each other. HV switchgear and instrument transformers shall be directly connected to the bay level IED without any interposing equipment.

The devices shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 255 to conform to the high requirements for operation on the secondary system of HV switchgear.

The 230 kV &110 kV bay control & protection IED shall have the following features:

1. A minimum of 9 configurable analogue channels
2. At least 32 binary inputs, 24 signal relays and 2 command relays
3. 16 nos. LED's on the front of the unit for indication
4. Synchro check function
5. Power function which can be configured to measure forward or reverse, active or reactive power.
6. Four (4) independently settable parameter setting groups, settable/selectable locally or remotely via the HMI programme.
7. 4 line Local Display Unit (LDU or front HMI) on the front of the relay which can display both input as well as measured quantities: frequency, phase currents, phase voltages, active power, reactive power, etc.
8. High speed bus serial communication port as per IEC 61850 standards.
9. Sequence of Events Recorder with a buffer for 256 events and a resolution of 1 msec. The events that are to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to optocoupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.
10. Disturbance Recorder function which can record 9 analogue values, 16 Binary signals and 12 analogue channels for internal measurement values. It shall be possible for the Disturbance Recorder function to be triggered by any internal or external binary signal or internal protective function.

Comprehensive self-supervision

1. Battery-free memory back-up of Event and Disturbance Records
2. Logic functions (AND, OR, bistable flip flop, etc.)
3. Delay/Integrator function

The numerical bay control IED's shall be mounted together with all the relevant bay protective relays in cubicles of Protection Class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LEDs shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the substation.

The distributed backup mimic for Local Control shall be installed next to the bay controller IED, which can be used in case of maintenance or emergency or if bay control IED fails. Local bay control via the back-up control mimic on the Control & Protection cubicles shall incorporate the same user safety measures e.g., bay interlocking, synchro check, interlock override user guidance, etc. as the station HMI. Local bay control shall be key-locked and the control either from GIS local control panel or station HMI or from remote shall be disabled if the local/remote selector switch on the back-up control mimic is in the 'local' position.

The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function.

Faults in the bay control IED shall be indicated on a front HMI and a message shall be sent to the station level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criteria must be maintained in worst case scenarios also. Further, a single failure must not have any effect on the primary system, which is monitored and controlled.

Only the backup protection can be incorporated in the bay control unit and not the main protections. Main protection shall be provided separately.

All IED`s shall have at least 5 years of successful proven experience in HV applications.

Software Structure

The software package shall be structured according to the SA architecture and strictly divided in various levels. It shall be possible to extend the station with the minimum possible effort. Maintenance, modification or extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the bid.

It shall be the responsibility of the Contractor to obtain any license required for the operation software. The Contractor shall indemnify the client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

Station Level Software

Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SA functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, Engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. The System shall contain a library with standard functions and applications.

Operating System

Windows Workstation operating system shall be used for the operator station as it supports several standard system features, e.g., support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardized, user-friendly look & feel HMI.

Bay Level Software

System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. Its lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance Engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage.

Application Software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They shall form part of a library.

The application software within the control/protective devices shall be programmed in a functional block language.

System Testing

The supplier shall submit a testing procedures for Factory Acceptance Test (FAT) and testing procedures for Site Acceptance Test (SAT) of the station automation system for approval. For the individual bay level IEDs, applicable Type Test certificates shall be submitted.

The manufacturing phase of the SA shall be concluded by a Factory Acceptance Test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system. The bids should prove that they have the required testing tools to test the IEC 61850 based SA system and such tools shall be used and shown to the Engineer at FAT.

If the complete system consists of parts from various suppliers, the FAT shall be limited to sub-system tests. In such cases, the complete system test shall be performed at site together with the Site Acceptance Test (SAT).

The different high voltage apparatus within the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:

1. Commands from different operator places, e.g. from the associated control centre (NLDC), station HMI, or local control panel according to the operating principle
2. Select-before execute commands
3. Operation from only one operator place at a time.
4. Operation depending on conditions from other functions, such as interlocking, synchrocheck, operator mode, or external status conditions.

The control function shall also include:

1. Prevention of double operation
2. Command supervision
3. Selection of operator place
4. Block/deblock of operation
5. Block/deblock of updating of position indications
6. Manual setting of position indications
7. Overriding of the interlocking function (Second key switch)
8. Switchgear run time supervision
9. Status Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in cases when spontaneous position changes have taken place.

Each position of an apparatus shall be indicated using two binary auxiliaries normally closed (NC) and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralized so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall be hard wired/take place via inter-bay bus.

An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

Measurements

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

Event and Alarm Handling

Events and alarms shall be generated either by the switchgear, by the control devices and by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time tagged with a time resolution of 1 millisecond. The time tagging shall be done at the lowest level where the event occurs and the information shall be distributed with the time tagging.

Time Synchronization

The time within the SA shall be set via a GPS Clock Receiver connected directly to the Bay Level LAN. The time shall then be distributed to the control/protective devices via the high-speed optic fiber bus. An accuracy of ±1 millisecond within the station is required.

Synchronism and Energizing Check

The synchronism and energizing check functions shall be distributed to the control and/or protective devices and shall have the following features:

1. Adjustable voltage, phase angle, and frequency difference.
2. Energizing for dead line - live bus, or live line - dead bus.

3. Settings for manual close command shall be adaptable to the specific switchgear.

Voltage Selection

The voltages, which are relevant for the synchro-check functions, depend on the station topology i.e., on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

HMI Functions

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log. The Alarm List shall indicate persisting and fleeting alarms separately.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

Following standard pictures shall be available from the HMI:

1. Single line diagram showing the switching status and measured values
2. Control dialogues
3. Measurement dialogues
4. Blocking dialogues
5. Alarm list, station / bay oriented
6. Event list, station / bay oriented
7. System status
8. Checking of parameter setting

HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

Object status shall be indicated using different status colors for:

1. Selected object under command
2. Selected on the screen
3. Not updated, obsolete value, not in use or not sampled
4. Alarm or faulty state
5. Warning or blocked

6. Update blocked or manually updated
7. Control blocked
8. Normal state
9. Busbar coloring to show live & dead bus.

Process Status Displays and Command Procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap changers are displayed in the station single line diagram.

In order to ensure a high degree of security against unwanted operation, a special "select – before - execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen and all other switchgear shall be blocked. After the "execution" of the command, the operated switch symbol shall blink until the switch has reached its final new position.

The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated, the interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

System Supervision Display

The SA system shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication links, and printers at the station level, etc.

Reports

The SA shall generate reports that provide time related information on measured values and calculated values. The data displayed shall comprise:

Trend reports:

1. Day (mean, peak)
2. Month (mean, peak)
3. Semi-annual (mean, peak)
4. Year (mean, peak)

Historical reports:

1. Day
2. Week
3. Month
4. Year

It shall be possible to select displayed values from the database on-line in the process display. Scrolling between e.g., days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

Trend Display (Historical Data)

A trend is a time-related follow-up of process data. The analogue channels of all the connected bay level devices on the 230 kV &110 kV level shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

Event List

The event list shall contain events, which are important for the control and monitoring of the substation. The time has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer. The information shall be obtainable also from printed event log.

The chronological event list shall contain:

1. Position changes of circuit breakers, isolators and earthing devices.
2. Indication of protective relay operations
3. Fault signals from the switchgear
4. Violation of upper and lower limits of analogue measured value.
5. Loss of communication

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

1. Date and time
2. Bay
3. Device
4. Function
5. Alarm class

Alarm List

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control center. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. Date and time of occurrence shall be indicated.

The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

1. The alarm date and time
2. The name of the alarming object
3. A descriptive text
4. The acknowledgement status

The operator shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example, due to bad contacts or intermittent operation.

Filters for selection of a certain type or group of alarms shall be available as for events.

Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as the following shall be displayed.

1. Type of blocking,
2. Authority
3. Local / remote control
4. NLDC/SA control
5. Errors,
6. Etc.

Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

User Authority Levels

It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to a certain user authorization group. Each user shall then be given access rights to each group of objects, e.g.:

Display only

1. Normal operation (e.g.: open/close apparatus)
2. Restricted operation (e.g.: by-passed interlock)

System administrator

For maintenance and Engineering purposes of the station HMI, the following authorization levels shall be available:

1. No Engineering allowed
2. Engineering/configuration allowed
3. Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the substation shall be according to the levels specified below:

Function	Typical Values
Exchange of display (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s
Presentation of an analogue change in the process display	< 1 s
From order to process output	< 0.5 s
From order to update of display	< 1.5 s

System Reliability

The SA system shall be designed to satisfy very high demands for reliability and availability concerning:

1. Solid mechanical and electrical design
2. Security against electrical interference (EMI)
3. High quality components and boards
4. Modular, well-tested hardware
5. Thoroughly developed and tested modular software
6. Easy-to-understand programming language for application programming
7. Detailed graphical documentation, according to IEC 1131-3, of the application software
8. Built-in supervision and diagnostic functions
9. After sales service
10. Security
11. Experience of security requirements
12. Process know-how
13. Select before execute at operation
14. Process status representation as double indications
15. Distributed solution
16. Independent units connected to the local area network
17. Back-up functions
18. Panel design appropriate to the harsh electrical environment and ambient conditions
19. Panel grounding to provide immunity against transient ground potential rise

Configuration Tools

The configuration of the station HMI shall be made using the operator station working in Windows NT environment. The various functions shall be customized by easy to use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process database and adaptations of the communication configuration data.

A portable Personal Computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

The PC based service & support system shall be used for the following purposes:

1. System configuration
2. System testing
3. Help functions
4. Program documentation

5. Down- and up-loading of programs
6. System commissioning
7. Data base management
8. Changing peripheral parameters

The service & support system shall be able to monitor data in the running substation control system and to present changing variables on the display screen in graphic representation.

Documentation

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

1. List of Drawings
2. Control Room Lay-out
3. Assembly Drawing
4. Single Line Diagram
5. Block Diagram
6. Circuit Diagram
7. List of Apparatus
8. List of Labels
9. Functional Design Specification (FDS)
10. Test Specification for Factory Acceptance Test (FAT)
11. Logic Diagram
12. List of Signals
13. Operator's Manual
14. Product Manuals
15. Calculation for uninterrupted power supply (UPS) dimensioning
16. High quality SCD file

Indicating Meters in Local Back-up Control Panels

Each circuit shall be equipped with Indicating meter for measurement of three phase currents, voltages, frequency, power factor, active and reactive power. Repeat pulse outputs are to be provided from all energy meters, where specified.

Trip Circuit and Power Supply Supervision

Trip circuit supervision relays shall be provided to monitor each of the trip circuits of circuit-breakers in the relay panel and each relay shall have sufficient contacts for visual/audible alarm and indication purposes.

The trip circuit supervision scheme shall provide continuous supervision of the trip circuits of the circuit-breaker in either the open or closed position and independent of Local or Remote selection at the local operating position. It shall be suitable for use in single and three pole tripping schemes as appropriate.

Relay elements shall be delayed on drop-off to prevent false alarms during faults on DC wiring on adjacent circuits, or due to operation of a trip relay contact.

Series resistances shall be provided in trip circuit supervision circuits to prevent mal-tripping of a circuit-breaker if a relay element is short circuited.

Relay alarm elements should be equipped with self-resetting flag indicators.

Where specified, time delayed power supply supervision relays shall be provided to monitor the duplicated DC power supplies for tripping, closing, CB fail, busbar protection etc. within a relay panel. An alarm shall be given if either supply voltage falls below 70% of nominal voltage for a period in excess of 3 secs. The relay shall be equipped with a self-resetting flag indicator, and shall be suitable for continuous operation at 125% of nominal DC voltage.

BUSBAR VOLTAGE SELECTION

Where required, selected voltage references, one for each busbar, shall be employed for all indications, metering, protection and synchronizing where appropriate. The correct voltage selection for the requirements of each circuit according to the busbar to which it is connected shall be obtained by direct use of auxiliary contacts on busbar selector switches.

Availability Calculations

The Contractor shall submit availability calculations for the offered substation automation system.

DIAGRAMS

The Contractor shall submit schematic diagrams for consideration of the Engineer within six months of the Contract commencement date. Prior to preparation of schematic diagrams, the Contractor shall provide single line, block and logic diagrams in order to agree the circuit schemes and operating modes.

The Contractor shall provide set of drawings for the 230/110kV GIS Substation as soon as possible after award of Contract. As part of the Contract documentation, the Contractor shall provide integrated sets of complete drawings (schematic and wiring diagrams, cable schedules, etc.).

CURRENT TRANSFORMER CALCULATIONS

The Contractor shall submit to the Employer detailed calculations substantiating the parameters of the current transformers he proposes to provide. They shall be presented within six weeks of the Contract commencement date.

SCHEDULE OF TECHNICAL REQUIREMENTS OF SUBSTATION AUTOMATION SYSTEM

1. General Requirement

Standards to be complied with Substation Automation system

Test Ca. Damp heat steady state	IEC 60068-2-3
Test Db and guidance; Damp heat	IEC 60068-2-30
cyclic Digital I/O, Analogue I/O	IEC 60870-3 class 2
dielectric Tests Digital I/O, Surge	
withstand test	IEC 60801-5/Class 2
Radio interference	
test Transient fast	IEC 60870-3/Class 2 IEC
burst test	60801-4/4
Static Discharge	
Electromagnetic fields	IEC 60801-2/4
	IEC 60801-3-3
Temperature range	°C 0/50
(min/max) Relative	% 93
humidity	Yes
Intelligent Electronic Devices (IED's)	Yes
- Serial communication interface included?	Yes
- Protection & Control IED's connected same bus?	Yes
- Self-monitoring	Yes
- Display of measured values	Yes
- Remote parameterization	Yes
- Disturbance record upload and analysis	Yes
Availability Calculation shall be furnished for each equipment as well as for the entire system	

2. Detailed Requirements:

Number of years of proven field experience of offered system.	10Yrs.
(Note: proof of experience should be furnished. The components used in the offered system and those with field experience should be the same)	
Design life of Substation Automation	20 Yrs
System Manufacturers quality assurance	ISO 9001/9002 or equivalent
system Dimensions of cubicle	
- Width	mm
- Depth	mm
- Height	mm
	N/m^2 max.600

- Floor load

3. Station Level Equipment:

Station Controller
MTBF (Mean time between Failures) MTTR (Mean time to repair)

Industrial PC Hrs
Hrs

Dual Station Computers Provided in redundant hot standby	Yes
Hot standby take-over time	Seconds
Annunciator for Station PC system software	16 Windows
Number of years of proven field experience of offered	5 Yrs
software	Windows
Operating	Yes
System	Yes
All standard picture as per spec included	Yes
in HMI Process Status Display &	Yes
Command Procedures Event processing	Yes
as per spec	Yes
Alarm processing as	Yes
per spec Reports as per	Yes
spec	Yes
Trend Display as per spec	
User Authority levels as per spec	
System supervision & monitoring as per spec Automatic sequence control as per spec	

4. Gateway to National Load dispatch Center

Number of years of proven field experience of offered unit	5Yrs
Insulation tests	IEC 60255-5
Fast disturbance	IEC 61000-4-4, Class 4
tests Industrial	EN 50081-2 Class A
environment	Yes
Industrial grade hardware with no moving parts (PC based gateway is not accepted)	20 Yrs
Design life of offered	Yes Yes
equipment Redundant	Yes Hrs
communication channel	Hrs
Redundant CPU	
Redundant DC/DC Supply	
MTBF (Mean time between	

Failures) MTTR (Mean time to repair)

5. Station Bus:

Physical Medium — Glass fibre optic

6. Interbay Bus

Physical Medium — Glass fibre optic

7. Printer server

MTBF — Hrs

8. Event Printer

MTBF — Hrs

9. Hard Copy colour Printer

MTBF — Hrs

10. Master Clock – GPS (Global Positioning System) Receiver:

MTBF — Hrs

11. Bay control Unit - HV

Number of years of proven field experience of offered — 5 Yrs
unit
Yes
Separate Bay controller unit provided for each
bay & feeder
HV
Type of bay controller offered HV/MV
Yes
Select Before Operate with Open Execute
& Close Execute
No
Single bit dependence
Yes
Interlocking, bay &
Station wide — Specify range
Synchrocheck function — Specify range
- Maximum Voltage difference — Specify range
Yes
- Maximum Frequency difference
4
- Maximum Phase
Yes
difference Double command
blocking Independent settable
256
parameter groups Local
1 ms
Display Unit — Yes
Sequence of event recorder — Yes
- Events — Yes
IEC 60255-5
- Time resolution
IEC 61000-4-4, Class 4
Disturbance recorder
Hrs
function
Hrs
Comprehensive self-
supervision
°C -10 to +50
Battery free backup of events and
°C -10 to +50
disturbance records

Insulation tests	%	93
Fast disturbance tests MTBF	%	93
MTTR		
Temperature range: IED's		
- Operation		
- Transport and storage		
Relative humidity:		
- Operating max./min		
- Transport and storage		

12. Back up control mimic -HV

Control functionality:	
Control of breaker as well as all isolators/earthing switch	Yes
(Control functionality should not be affected if bay controller fails)	Yes
Key-Locked	Yes
Interlock override function	Yes
Separate backup control mimic provided for each bay & feeder	

13. Bay Control Unit - MV

Number of years of proven field experience of offered unit	5 Yrs
	Yes
Separate Bay controller unit provided for each bay & feeder	
Control functionality implementation in software: Select before Operate with Open	Yes
Execute & Close Execute	Yes
Interlocking, Bay & Station	
Wide Synchrocheck	Specify range
function	Specify range
- Maximum Voltage difference	Specify range
- Maximum Frequency difference	Yes
- Maximum Phase	Specify
difference Local	1 ms
Display Unit	Yes
Sequence of event recorder	Yes
- Events	IEC 60255-5
- Time resolution	IEC 61000-4-4, Class 4
	Hrs

Disturbance recorder function Comprehensive	Hrs	
self-supervision	℃	-10 to +50
Insulation tests	℃	-10 to +70
Fast disturbance		
tests MTBF	%	93
MTTR	%	93
Temperature range: IED's		
- Operation		
- Transport and storage		
Relative humidity:		
- Operating max./min		
- Transport and storage		
14. Back up control mimic - MV		
Control functionality:	Yes	
Control of breaker as well as all isolators/earthing switches	Yes	
Separate backup control mimic provided for each bay & feeder		
15. System Performance:		
Exchange of display (First reaction)	< 1 S	
Presentation of a binary change in the process display	< 0.5 S	
Presentation of an analogue change in the process display	< 1 S	
From order to process output	< 0.5 S	
From order to updated of display	< 1.5 S	

8.6.16 DIGITAL FAULT AND DISTURBANCE RECORDER [DFDR]

For standardization of operation performance, facilities and spare requirements, the Digital Fault and Disturbance Recorder [DFDR] to be supplied under this project shall be from Siemens, ABB, GE, or Approved Equal.

The DFDR shall have the following features:

The equipment shall be an independent stand-alone system to monitor analogs and digital signals from all 230kV and 110kV feeders including transformer and bus-coupler bays that requires to be monitored.

The manufacturer shall prove the system reliability of good site performances by providing substantial evidence of the systems already installed and commissioned for at least a duration of 5 years, accompanied by the customer recommendations and type test reports from internationally acclaimed laboratories.

The DFDR system shall be modular in design for easy expansion, upgrade and easy maintenance.

The acquisition system or it's storage unit shall not be based on a PC platform.

System shall be equipped to monitor, detect and record simultaneously Fast transient faults (short term) and Slow phenomena disturbances (Long term) like power swing, frequency variation, voltage drop, etc. covering all the required feeders.

All input signals shall be able to scan and record simultaneously at least 2 or 3 user programmable sampling rates from 500Hz to 6kHz for Fast (Short terms) transient monitoring and from 1Hz to 500Hz for Slow phenomena (Long terms) monitoring in order to detect and record Fast (short terms) and Slow phenomena (Long terms) events.

At least 25 Sec of memory for transient fault data recording (at 6 kHz – sampling rate) and over 1000 Sec for Slow (at 30 Hz) phenomena recording shall be provided in addition to the auto maintained inbuilt Hard Disk unit which shall be installed for data storage. The inbuilt Hard Disk Unit shall be managed and operated by the identical industrially proven operating system of the DFDR.

The graphical data should be recorded in respect of all feeders simultaneously (snapshot image). The recording should contain the data prior to the event, post event including the dynamic length of the event / fault without any alterations.

The system should possess a library of sensors (triggering criteria), which should be selected by the user and able to detect and record various type of incidents. The system shall be able to detect incidents by the selected starting criteria and should be able to produce a record.

The recordings shall contain the graphical data of Physical inputs (voltage, currents, digitals) and virtual inputs. [e.g. Frequency, dp/ dt , dq/dt (3 Phases / Single Phase), RMS values etc..]

The DFDR shall be able to communicate with Local and / or Remote Master Station using Master communication and Analysis software. This software should permit the user either locally or remotely to download the recorded data, to ascertain the system operational status, change parameters etc.

Master communication should be able to communicate via RS 232 (Direct connection), through modem (dial up telephone line) and LAN [Ethernet (TCP / IP) – IEEE 802.3] networking.

The following functions shall be performed by the DFDR, Fault Location, (including impedances and report), Graphical display of data, Phase measurement & display, Transient Fault Recording, Dynamic swing recording, Harmonics measurement & display, Integrated SER function, Calculated channels etc.

System shall be able to calibrate at site, and the required menu driven software and other required accessories shall be supplied along with a Notebook computer and color printer etc.

The systems shall be equipped for time synchronization by the external GPS clock receiver for real time synchronizing (including Antenna).

Local printing facility shall be provided with the system.

Master station (a latest version of PC) and relevant software shall be supplied with the equipment for analysis and communication.

Provision for Power Quality monitoring or continuous monitoring (periodical recording) shall be made available for at least 4 feeders.

Energy Meter (Tariff Metering) :

Meter requirement:

Programmable meter

Adjustable different tariff

110-400V flexible input voltage setting

1(10) A current rating

Accuracy class to be ±0.2 for kwh and ±0.5 for kVArh

RS232/485 Port for Modem interface

Standard metering protocol for remote interface

Data storage of 16 channel@30min interval and of 90days

Optical head and software to upload and download of meter data

Password protection for programming and for configuration

Configurable display, including meter ID, Power quadrant display etc.

Provision for quick reading scroll, reset etc. (Programmable)

Additional requirement:

Online test facility of meter (with TTB) and with Security Sealing Provision.

TTB's should be at the suitable accessible panel front location with meter

Meter cabinet should be exclusive for tariff metering only and have sufficient Security Sealing provision, provided with 220V, 5A two pin socket outlet for modem power, Auxiliary bias power, Testing Equipment power etc.

All main metering CT, VT should be terminated to metering panel directly including star point (4 wire).

Backup metering circuit may be shared for other purpose.

VT MCB (both main and backup) should be located in the metering panel. Downstream VT MCB rating should be less than that of upstream.

All CT & VT terminals should have Security Sealing provision.

Normal display list:

Scroll order Display Item Name

Complete LCD Test

Present date

Present time

Current billing total kWh-Del

Current billing total kWh-Rec

Current billing total kVARh-(Q1+Q4)

Current billing total kVARh-(Q2+Q3)

Current billing maximum kW-Del

Current billing maximum kW-Del Date

Current billing maximum kW-Del Time

Current billing cumulative kW-Del

Current billing maximum-Rec

Current billing maximum kW-Rec Date

Current billing maximum kW-Rec Time

Current billing cumulative kW-Rec

Phase A Voltage

Phase B Voltage

Phase C Voltage

Phase A Current

Phase B Current

Phase C Current

Phase A Voltage angle

Phase B Voltage angle

Phase C Voltage angle

Phase A Current angle

Phase B Current angle

Phase C Current angle

System PF-arithmetic

Line frequency

Alternate Mode Display list:

Scroll order Display Item Name

Complete LCD Test

Present date

Present time

Current billing total kWh-Del

Current billing total kWh-Rec

Current billing total kVARh-(Q1+Q4)

Current billing total kVARh-(Q2+Q3)

System PF-arithmatic

Line frequency

Load profile (Cumulative meter reading) and Instrumentation profile Data in the following format should be stored in each 30 min interval for at least 100 days.

Interval Data (Load profile):

Interval Data Mode: Cumulative Engineering Units

Time kWh-Del kWh-Rec kVARh-(Q1+Q4) kVARh-(Q2+Q3)

Date: 1/31/2015

Interval Data (Instrumentation):

Set-1

Time End Phase A Voltage End Phase A Voltage End Phase A Voltage Average System kW

Date:1/31/2015

13:45 0.0008 0.0004 0.0004 -0.7002

Self Read Feature for at least 12 month's billing history.

SCHEDULE OF TECHNICAL REQUIREMENTS DIGITAL FAULT AND DISTURBANCE RECORDER [DFDR]

Sl.	**ITEM**	**UNITS**	
(A)	**GENERAL**		
1	Manufacturer's name & address		
2	Type		
3	Power Supply -Power supply for printer	VDC VAC	110 230
(B)	**ANALOGUE INPUTS**		
1	Number of Channel -Expandability		216 Min. 336
2	Nominal Current	Amp	1A/5A

Sl.	ITEM	UNITS	
3	Nominal voltage - Current	Vac/Vdc mA/Amp	
4	Frequency response		
5	Cut-off frequency		
	(a) Bandwidth	dB	
	(b) Attenuation at	dB	
	(c) Auto adjusted anti-aliasing filters for chosen sampling rate	Yes/No	Yes
d	Simultaneously programmable sampling rate for all feeders/inputs -Locally Changeable -Remotely Changeable	Yes/No Yes/No	Min 2 for FAST and SLOW Recording Yes Yes
e	Possible sampling rates	Samples/sec Samples/sec Samples/sec	3 different sampling rates: Slow. 1Hz-500Hz fast: 0.5 kHz – 6kHz continuous (variable rate)
6	DC coupled inputs	Yes/No	Yes
7	Resolution	bits	12 or better
8	Accuracy	%	Min 0.5
9	Burden 1. Current Circuit at IN 2. Voltage Circuit	VA VA	
10	Overload 1. Current 2. Voltage circuit	% In % Vn	100% In continuously, Min 600 % in for 1 Second 2Vn and max.

Sl.	ITEM	UNITS	
			350 Vn
(C)	DIGITAL INPUTS		
1	Number of Channel -Expandability (Without and time skew)		648 min. 1008
2	Selectable input level	Vdc	N/O or N/C, 110 VDC
3	Type		Potential or potential free
4	Resolution	ms	contact
(D)	MEMORY		
1	Size	MB	64 MB or Higher
2	Type		Solid State
3	Pre-fault time (fast scanning rate)	sec	0.1-2 user programmable
4	Post-fault (fast scanning rate	sec	0.1-2 user programmable
5	Pre and Post-fault time (slow scanning rate)	sec	min. 180 user programmable
6	In-Built hard disk (auto-maintained	GB	min. 4 GB
Sl.	ITEM	UNITS	
(E)	SENSORS/ TRIGERRING CRITERIA		
	All sensors/triggers are preferable Programmable and Virtually recordable	Yes/No	Yes
1.	Logical combination sensor	Yes/No	Yes
2.	Three phase over or under Voltage / Current	Yes/No	Yes
3.	Mono phase over or under Voltage / Current	Yes/No	Yes

Sl.	**ITEM**	**UNITS**	
4.	***du/dt, dp/dt, dq/dt, [Single/3 Phases], df/dt. etc.	Yes/No	Yes
5.	RMS [Voltage / Current]	Yes/No	Yes
6.	Zero Sequence	Yes/No	Yes
7.	Negative, Positive Sequence	Yes/No	Yes
8.	Frequency	Yes/No	Yes
9.	DC Step	Yes/No	Yes
10.	Pendling / Swing	Yes/No	Yes
11.	Digital level and edge	Yes/No	Yes
12.	Sensor trigger	Yes/No	Yes
13.	Event Trigger	Yes/No	Yes
14.	Manual Trigger	Yes/No	Yes
15.	Remote Trigger	Yes/No	Yes
(F)	**CLOCK SYSTEM**		
1.	Internal Clock	Yes/No	Yes
2.	Accuracy		
3.	External Synchronization	Yes/No	Yes
4.	Time resolution between 2 synchronized pulses		
(G)	**OUTPUT ALARM RELAY CONTACT**		
1.	Max. operation Voltage DC/AC	Vac / Vdc	250 Vac or above, 60 Vdc or above
2.	Make and carry for 0.5 sec	A	Min 8A
3.	Carry Continuously	A	Min 5A
4.	Break (DC) – resistive	W	
(H)	**INTERFACE FOR DATA COMMUNICATION**		
1.	Full definition compression	Yes/No	Yes
2.	Maximum transmission rate	bits / Sec	
3.	Standard serial port (EIA-232-D)	Yes / No	Yes

Sl.	ITEM	UNITS	
4.	Printer Port	Yes/No	Yes
5.	Dedicated serial port for modem	Yes/No	Yes
(I)	**PRINTER DATA**		
1.	Printer amplitude (scaling peak to peak)		
2.	Time Scale (mm / s)		
3.	Printer resolution	mm	
4.	Auto printing	Yes/No	Yes
(J)	Fault Priority transmission	Yes/No	Yes
(K)	Fault location (distance calculation)	Yes/No	Yes
(L)	Test certificates from internationally recognized Laboratories	Yes/No	Yes
(M)	**COMMUNICATION AND REMOTE ANALYZING UNIT**		
	1. Processor Pentium	(MHz) Yes/No	Yes, at least 450 MHz Pentium
	2. Co-Processor Pentium	Yes/No	Yes
	3. Main memory capacity	(Mb) Yes/No	Yes, at least 64 MB
	4. Color graphics board S-VGA	Yes/No	Yes
	5. Screen S-VGA	Yes/No	Yes
	6. Hard disk unit	Yes/No	Yes, at least 40 GB
	7. Printer	Yes/No	Yes
	8. Modem	Yes/No	Yes.

*Note: du/dt=Change of voltage, dp/dt=Change of active power, dq/dt=change of reactive power, df/dt=Change of frequency.

8.6.17 FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND PROTECTION

This specification describes the communication requirements for the transport of voice, data and protection signals, including Engineering, configuration, testing, installation and commissioning.

For standardization of operation performance, facilities and spare requirements, the Fiber Optic Multiplexer Equipment for Communication and Protection to be supplied under this project shall comprise of equipment which can totally be integrated into the existing Telecommunication system in TNEB Network including the Telecommunication Network Management System.

Contractor shall provide a drawing that shows the planned arrangements of fiber optic multiplexer equipment for communication and protection. All materials and equipment offered shall be brand new, from the manufacturer's normal and standard construction, designed and manufactured according to the latest technological methods.

Summary of Standards

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

The Equipment shall comply with the latest ITU-T recommendations for the plesiochronous and synchronous hierarchies.

The equipment shall be independent type tested.

In particular the mentioned recommendations shall be covered:

The PDH interfaces shall conform to the following recommendations: ITU

ITU-T G.702: General aspects of digital transmission systems – Terminal equipment - Digital hierarchy bit rates

ITU-T G.703: Digital transmission systems – Terminal equipment – General Physical/electrical characteristics of hierarchical digital interfaces

ITU-T G.704: Digital transmission systems – Terminal equipment – General Synchronous frame structures used at 1544, 6313, 2048, 8448 and 44 736 kbit/s hierarchical levels

ITU-T G.706: General aspects of digital transmission systems – Terminal equipment - Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in recommendation G.704

ITU-T G.711: Pulse code modulation (PCM) of voice frequencies

ITU-T G.712: Transmission performance characteristics of pulse code modulation channels

ITU-T G.732: General aspects of digital transmission systems – Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s

ITU-T G.735: Characteristics of primary multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s

ITU-T G.736: General aspects of digital transmission - Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s

ITU-T G.737: Characteristics of external access equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s

ITU-T G.823: The control of jitter and wander within digital networks, which are based on the 2048 kbit/s hierarchy.

ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

The architecture of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 147: Synchronous digital hierarchy multiplexing structure.

ETS 300 417: Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment

ETS 300 417-1-1 / EN 300 417-1-1 V1.1.2: Generic Processes and Performance

ETS 300 417-2-1 / EN 300 417-2-1 V1.1.2: SDH and PDH Physical Section

Layer Functions

ETS 300 417-3-1 / EN 300 417-3-1 V1.1.2 : STM-N Regenerator & Multiplex Section Layer Functions

ETS 300 417-4-1 / EN 300 417-4-1 V1.1.2 : SDH Path Layer Functions

ITU

ITU-T G.707: Network node interface for the synchronous digital hierarchy

ITU-T G.783: Characteristics of synchronous digital hierarchy (SDH): equipment functional blocks

ITU-T G.803: Architecture of transport networks based on the synchronous digital hierarchy (SDH)

ITU-T G.805: Generic functional architecture of transport networks

ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

ITU-T G.841: Types and characteristics of synchronous digital hierarchy (SDH) network protection architectures

ITU-T G.957: Optical interfaces for equipment and systems relating to the synchronous digital hierarchy

ITU-T G.958: Digital line systems based on the synchronous digital hierarchy for use on optical fibre cables

ITU-T M.2101.1:Performance limits for bringing into service and maintenance of international SDH paths and multiplex section

ITU-T T.50: International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange

The synchronization and timing of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 417-6-1 / EN 300 417-6-1 V1.1.2: Synchronisation Layer Functions

ETS 300 462-1 / EN 300 462-1-1 V1.1.1: Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 1: Definitions and terminology for synchronization networks

EN 300 462-4-1 V1.1.1: Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 4-1: Timing characteristics of slave clocks suitable for synchronization supply to Synchronous Digital Hierarchy (SDH) and Plesiochronuous Digital Hierarchy (PDH) equipment

ETS 300 462-5 / EN 300 462-5-1 V1.1.2: Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 5: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment

ITU

ITU-T G.813: Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC)

Abbreviations

ADM Add-drop multiplexed ALS Automatic Laser Shutdown BIP (Bit Interleaved Parity)

CAS Channel Associated Signalling CAP Carrier-less Amplitude and Phase CRC Cyclic Redundancy Check DTMF Dual Tone Multi-Frequency

EN European Norm

EOW Engineering Order Wire

ETS European Telecommunications Standards GPS Global

HDSL High Density Subscriber Line

IEC International Electrical Commission ITU International Telecommunication Union IP Internet Protocol

ISDN Integrated Services Digital Network MCMI Multi Coded Mark Inversion

MS Multiplex Section

NE Network Element

NMS Network Management System LAN Local Area Network

OS Optical Section

OSPF Open Shortest Path First

PDH Plesiochronuous Digital Hierarchy PPP Point-to-Point Protocol

RS Regenerator Section

SDH Synchronous Digital Hierarchy

SNMP Simple Network Management Protocol SOH Section Overhead

STM Synchronous Transport Module TCP Transmission Control Protocol TTI Trail Trace Identifier

VC Virtual Container

VF Voice Frequency

General requirements

The digital multiplex equipment shall be universal, software-controlled, and provide various interface cards to connect tributary interfaces signals such as voice, teleprotection and data to aggregate interfaces. On aggregate level 2Mbit/s and 8Mbit/s electrical interfaces complying with ITU-T recommendations G.703 / G.704 and 2Mbit/s HDSL interfaces shall be available. In addition, optical STM- 4 aggregate interfaces on 620Mbit/s shall be available. All modules shall form an integrated part of a shelf.

The multiplexer shall provide means to drop and insert individual 64 kbit/s signals and allocate them to determined time slots in the 2Mbit/s streams. Path protection on 64 kbit/s and 2Mbit/s shall be supported.

It shall be suitable for operation in substation with harsh environment with high electromagnetic interference, be highly reliable and provide secure communication for real time signals such as voice, SCADA, tele protection and status/control signals.

The equipment offered shall already be working successfully in telecommunication networks operated by power utilities. It shall comply to the latest ITU-T standards and be able to be interconnected with telecommunication equipment.

Any equipment in the network shall be manageable from a control centre and there shall be means to supervise external/existing equipment as well.

As a minimum module for the following user signals shall be available as plug- in units for the digital multiplexer:

Analogue subscriber interface: subscriber and exchange side

4-wire E&M voice interface

G.703, 64kbit/s data Interface

X.24/V.11 (RS-422), Nx 64kbit/s data interface

Alarm collection interface

Teleprotection command interface

Binary signal (status and control) interface

2Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704.

Additionally, the equipment shall provide the following aggregate interfaces:

STM-4 (620 Mbit/s) optical 1+1 interface for medium and long distances, with automatic laser shut down.

STM-4 (620 Mbit/s) optical add-drop interface for medium and long distances, with automatic laser shut down

STM-4 (620 Mbit/s) electrical interface

2 Mbit/s HDSL interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

General Conditions

The same equipment shall be used as a terminal, for through connections (transit, repeater) and as add-drop multiplexer (ADM) with integrated optical line modules.

First order multiplexing (2048 Mbit/s), second order multiplexing (8448 Mbit/s/s) and STM-4 multiplexer shall be integrated.

Conference for voice channels and point-multipoint function for data signals shall be possible.

The equipment shall be of fully modular design, based on a single shelf.

Channel capacity: Digital Cross Connection

The equipment shall be equipped with a redundant cross connection function with decentralized cross connection functions on each board.

The cross connect capacity shall be minimum 40x2Mbit/s, or 200x64kbit/s non- blocking.

Redundant centralised functions

The equipment shall be equipped with redundant circuits for all centralised functions.

Power Supply

The multiplex equipment shall operate at 48VDC +/- 15%. Redundant power- supply shall be supported.

ITU Compliance

The Equipment shall comply to the latest ITU-T recommendations for the plesiochronous and synchronous hierarchies, such as:

G.702-704, G.706, G.711-714, G.732, G.735-737, G.742, G.826, G.823, Q.552

Electromagnetic compatibility and safety regulations

The equipment shall comply with the EN50022, EN50082, IEC 801-2, IEC 801-6 and shall be conformant with CE.

Ambient Conditions

Storage and transport: -40 ... +70°C; 98% (no condensation) Operation: -5 ... +45 °C, humidity of max. 95% (no condensation)

Mechanical construction

The equipment shall be of robust design. All tributary and aggregate units shall be integrated in the same shelf.

All connectors shall be accessible from the front.

Network management system

The equipment shall be software programmable, either by a local craft terminal - preferably notebook - or a centralized Network Management System (NMS).

Traffic through the multiplexer shall under no circumstances depend on Network Management System, i.e. the multiplexer has to operate without being connected to any management system.

The Network Management System shall be used to supervise the PDH and SDH network.

Path protection

The equipment shall provide means to protect 64kBit/s channels. The protection shall be end to end from one interface (telephone or data) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm.

The switching shall be done within the multiplexer without using the Network Management System.

Section protection

The equipment shall provide means to protect 8Mbit/s and 155 Mbit/s connections. It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed.

The switching shall be done within the multiplexer without using the Network Management System.

Network Topology

It shall be possible to build point to point - , linear-, ring-, T, and meshed networks.

Synchronisation

The equipment shall be synchronisable with an external clock, with connected 2048 Mbit/s signals and/ or with internal oscillator. The synchronization shall be configurable and it shall be possible to distribute the synchronization to other equipment as well.

The system shall have means to switch to select the synchronisation source as well as means to prevent the system from switching synchronisation loops. The equipment shall be capable select the synchronisation source by means of the SSM (Synchronisation Status Messaging) feature according to ITU-T G.704 or priority based.

Alarms

Each module shall supervise its functions and shall have an alarm-indication LED on its front. All alarms shall be collected by the NMS.

Each node shall be capable to collect up to 50 external alarms.

Test Loops

The equipment shall provide means to loop signals on 64kBit/s level as well as on 2Mbit/s level. It shall indicate an alarm if a loop is activated. It shall have the possibility to determine the time after which an activated loop is switched back.

Maintenance facilities

Every Network Element shall have a built-in Signal Generator and Analyser to analyse communication paths. It must be possible to cross connect the Generator and Analyser to transmission channels and terminate the signal in other Network Elements. The configuration must be possible locally with the craft access terminal and remotely with the NMS or the craft access terminal.

It must be possible to loop-back signals locally and remotely using the craft access terminal or the NMS.

Requirements for Transport Level 13.6.1SDH Aggregate Units

The interface shall be designed for use on single mode fiber at 1310nm and 1550nm. The optical connectors shall be E2000.

The following main functions shall be supported: Termination of the OS-, RS-, MS- and VC-4 layer

Extraction and insertion of the SOH communications information Through connections of VC-12 and VC-3

The following maintenance functions shall be supported:

Status indications

Loops

Restart after ALS TTI monitoring BIP Error Insertion

The following SDH interfaces shall be available:

6 × STM 4 optical port interface 4 × STM 1optical port interface 2× STM 4 electrical port interface

2× STM 1 electrical port interface

13.6.2 HDSL Aggregate Units

2Mbit/s HDSL interface

The HDSL interface shall provide means to interconnect the multiplexer over two pairs of copper wire up to 12km using CAP modulation (Carrier-less Amplitude and Phase). It shall communicate either with another interface of the same type or with a remote desktop terminal.

2Mbit/s HDSL Desktop Terminal

This Terminal shall provide a HDSL interface to transmit 2Mbit/s over two pairs of copper over a distance up to 12 km. It shall be housed in a metallic indoor case. The following interfaces shall be available:

- G.703, 2Mbit/s, 75 ohm

- G.703, 2Mbit/s, 120 ohm

- X.21/V11, Nx 64kBit/s (N = 1 .. 32)

- V.35, Nx 64kBit/s (N = 1 .. 32)

- V.36 / RS449, Nx64kBit/s (N = 1 .. 32)

LAN connection:

10/100 Base T Ethernet connection for e.g. router supporting LAN protocols: IP, IPX; Routing Protocols: RIP; WAN protocols: HDLC, PPP, Frame Relay (including RFC 1490). It shall inter-operate with Cisco, Wellfleet, 3Com etc. and be manageable locally, remotely, and with Telnet and SNMP. Two such Desktop Terminals shall be connectable to provide a 2Mbit/s link over two pairs of copper.

HDSL Repeater:

An HDSL repeater solution for distances longer than 12km shall be offered including a remote powering solution.

HDSL Line Protection:

The HDSL equipment shall (where necessary) be protected against influences of induced voltages up to 10 kV.

Tributary Units

4-Wire Interface (VF interface)

This interface shall provide 8 voice channels with a bandwidth of 300 Hz .. 3.4 kHz and 2 signaling channels (M => E, M' => E') per voice channel.

Each interface shall be configurable to operate with or without CAS. With CAS it shall use the a and b bits for the two signaling channels.

The level shall be software adjustable within the following range: Input: +7.5 .. -16 dBr

Output:+7.0 .. -16 dBr

Modules where each interface can be individually configured with 1+1 path protection shall be available.

Analogue Subscriber Interface

An interface with at least 10 subscribers as well as high-density analogue subscriber card with 60 subscribers shall be available. The ringing generator shall be integrated in the subscriber module interface. The ringer frequency shall be adjustable for 20Hz, 25Hz, and 50Hz.

The following main functions shall be supported:

Downstream signaling:

Ringing

Metering Polarity reversal

Reduced battery

No battery

Upstream signaling: On/off-hook

Pulse and DTMF dialing Flash impulse

Earth key General:

Constant current line feeding Line test

Permanent line checks

CLIP (On-hook VF transmission) Metering after on-hook

Exchange Interface

This interface shall provide 12 interfaces to connect remotely connected analogue subscribers to an exchange. It shall provide the following functions:

pulse dialing

tone dialing (DTMF) earth key function

metering function(12 kHz or 16 kHz) flash impulse

polarity reversal indication of busy lines

The following parameters shall be configurable by software: input voice level –5 .. +4 dBr

output voice level –7.5 .. –1 dBr metering pulse enable/disable signaling bit definition

loop back of voice to the telephone

Party line Telephone System (Engineering Order Wire)

An Engineering order wire (EOW) facility shall be provided at each multiplexer. The EOW shall be configured as a party line and use in band DTMF signaling to call another EOW-Terminal. The Terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (1..4 digits), and two group call numbers (1..4 digits each).

V. 24/V.28 RS232 Interface

It shall support the following bit rates: 0 .. 0.3 kbit/s transp. (V.110)

0.6 .. 38.4kbit/s synchronous / asynchronous (V.110).

Modules where each interface can be individually configured with 1+1 path protection shall be available.

V.11/X.24 Interface

This interface shall comply to the ITU-T X.24 recommendation for signal definition and to V.11 for electrical characteristics.

It shall support the following bit rates:

48, 56, Nx 64 kbit/s (N = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous (X.30)

Modules where each interface can be individually configured with 1+1 path protection shall be available.

V.35 Interface

This interface shall comply with the ITU-T V.35 and V.110 recommendations. It shall support the following bit rates:

48, 56, Nx 64kbit/s (Nx = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

V.36 / RS 449 Interface

This interface shall comply with the ITU-T V.36 and V.110 recommendations. It shall support the following bit rates:

48, 56, Nx 64kbit/s (N = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

64 kBit/s Co directional Interface

This interface shall comply with the ITU-T G.703 part 1.2.1 for co directional data transfer.

A module shall have at least 8 interfaces.

Modules where each interface can be individually configured with 1+1 path protection shall be available.

LAN Interface

There shall be a 10/100 Base T interface available with Router Bridge and FRAD Function available. The following specification shall be covered:

Ethernet connection: 10/100 Base T LAN protocols: IP, IPX

Routing Protocols: static IP route, OSPF2 V2

WAN protocols: PPP, Frame Relay (including RFC 1490)

The interface shall be manageable locally, remotely, with the management system of the platform.

The LAN interface shall support linear-, ring- and star-configurations. The WAN side shall support link capacities Nx64kBit/s and 2Mbit/s.

Alarm Interface

This interface shall provide means to collect various alarms, which will be displayed, on the Network Management System. It shall be used to manage non- PDH equipment with the PDH Network Management System.

It shall have at least 24 binary inputs and at least 4 outputs, which can be switched by the Network Management System.

It shall be possible to connect an input to an output so that if an alarm occurs, the output contact will be switched.

It shall be possible to label an alarm. The label-text shall be read from the interface module so that it can be indicated on the Network Management System as well as on the local craft terminal.

Teleprotection Interface

The protection of the lines shall be arranged as detailed in Section 5.Teleprotection equipment shall be provided for permissive tripping and direct tripping on the lines.

The permissive tripping signals are required to operate circuit breaker trip relays in conjunction with the distance protection and directional earth fault relays.

The direct tripping signals are required to operate remote circuit breaker tripping relays.

Technical Requirements:

This interface shall provide means to transmit four bi-directional command channels.

The signals shall be adjustable from 24 to 250VDC by means of software.

All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

Security, Dependability and Transmission speed shall be selectable and programmable.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The interface shall support T-nodes.

The Teleprotection interface shall provide an integrated non volatile event- recorder which shall be synchronizable either internally or by GPS or a command counter which counts trip commands.

The teleprotection interface shall provide means for signal delay measurement. 1+1 protection must be available; the switching shall be done within less than 10ms.

The interface shall do automatic loop test every 60s.

Under no circumstances shall the interface cause trip-commands in case of power supply failure or when put in or out of service.

It shall be possible to synchronize all teleprotection interfaces with one GPS in one station. The GPS time shall be distributed over the teleprotection channel.

An 8-bit command addressing shall be used to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.

Optical Protection Relays Interface

This interface shall have an optical port to connect protection relays for teleprotection to the multiplexer. It shall operate on 1300nm use MCMI line coding and be suitable for teleprotection relays.

Optical amplifier

In case of long distance communication, which cannot be covered by a standard optical interface, optical amplifier shall be applied.

The amplifier shall provide a power budget of at least 48dB for bit rates from 8 Mbit/s up to 622 Mbit/s

on a pair of single-mode fibre for single wavelength (single channel) have no dispersion limits for STM-4 applications up to 250km.

Binary Contact Interface

This interface shall provide means to transmit binary signals. The inputs and outputs shall be isolated.

The inputs shall be suitable for 24VDC .. 60VDC. Outputs shall be solid state relays.

The interface shall provide a 24VDC short circuit proofed auxiliary power supply.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The Teleprotection interface shall provide an integrated event recorder, which shall be synchronizable either internally or by GPS.

2Mbit/s G.703 / G.704 Interface

This interface shall comply with the ITU-T G.703 and G.704 recommendations.

The interface module shall have at least four interfaces to be activated individually. It shall be possible to have 128 interface modules a multiplexer.

In order to connect different equipment, the interfaces shall be available with the impedance of 120 ohms and 75 ohms.

The interface shall support CRC-4 multi-frame according to ITU-T G.704 (enabled and disabled by software).

The CAS signaling according to ITU-T G.704 table 9 shall be activated optionally.

The interface shall be able to extract the 2.048 MHz clock, which can be used to synchronize the multiplex equipment.

The interface module shall support 2Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals.

OPERATIONAL TELEPHONE SYSTEM

There are two separate telephone systems under NLDC, that is, Operational Telephone System (IP based) and Administrative Telephone System (Traditional circuit switch based).

An IP Phone facility shall be provided at the CP1 230/110kV GIS substation. The IP Phone shall be incorporated by IP connection from upstream substation through IP network in the Operational Telephone System which is controlled from the existing call manager at NLDC.

At least three telephone sets proper to the above-mentioned Administrative Telephone System shall be provided at each new substation.

The Contractor shall consult the Employer and confirm whether more additional telephone sets/instruments for the systems need to be provided including their types and specifications.

SCHEDULE OF REQUIREMENTS FOR FIBER OPTIC MULTIPLEXER

EQUIPMENT

SL.NO.	DESCRIPTION	UNIT	REQUIRED
1.0	GENERAL:		
1.1	Type of multiplexer		SDH: ADM
1.2	Complying to ITU-T rec.		Yes
1.3	Transmission Capacity	Mbit/s	STM-4: 620
1.4	Access capacity on 64 kbit/s	channels	Minimum 200
1.5	Access capacity on 2 Mbit/s	channels	Minimum 40
1.6	Redundant central processor		Shall be available
1.7	Digital cross connect function		Fully non-blocking
2.0	Available AGGREGATES:		
2.1	Optical aggregates (ITU-T G.957)		L-1.1, L-1.2
3.0	Available TRUNK INTERFACES:		
3.1	HDB3, 2 Mbit/s interfaces per module	No.	Minimum 8
3.2	Complying to ITU-T rec.		G.703, transparent G.704, selectable
3.3	HDSL, 2Mbit/s interface: no of copper wires	No. ch ch / pair of wire	4 or 2 30 or 15 30 / 2 pairs 30 / 1 pair

SL.NO.	DESCRIPTION	UNIT	REQUIRED
			15 / 1 pair
4.0	Available USER INTERFACES		
4.1	Voice interfaces for trunk lines:		
4.1.1	1 + 1 com path protection, available for all		yes
4.1.2	Analogue, 4wire with E&M: Input level Output level	dBr	+7.5 .. –16 +7.0 .. –16.5
4.1.3	Analogue, 2wire with E&M: Input level Output level	dBr	+6.5 .. –12.5 –1.0 .. -20
4.1.4	Digital, 2Mbit/s CAS or PRI		yes
4.2	Voice interfaces for remote subscriber:		
4.2.1	2wire, subscriber side	dBr	-5 .. +4 / -7.5 .. -1
4.2.2	2wire, PABX side	dBr	-5 .. +4 / -7.5 .. -3
4.3	Integrated teleprotection		
4.3.1	Interface for Commands:		
4.3.1.1	Number of independent commands	No.	4
4.3.1.2	Transmission time max.	ms	6
4.3.1.3	Signal voltage	Vpeak	250
4.3.1.4	1 + 1 com path protection		yes
4.3.2	Interface(s) for Differential Protection:		
4.3.2.1	Electrical interface: G.703	kbit/s	64

SL.NO.	DESCRIPTION	UNIT	REQUIRED
4.3.2.2	Optical Interface	kbit/s	Minimum 64
4.4	Data: channels per module		
4.4.1	1 + 1 com path protection, available for all		yes
4.4.2	V.24/V.28 (RS-232): up to 38.4kbit/s	No.	4
4.4.3	V.11/X.24 (RS-422): 64kbit/s	No.	4
4.4.4	V.35: 64kbit/s	No.	4
4.4.5	V.36 (RS-449): 64kbit/s	No.	2
4.4.6	G.703: 64kbit/s	No.	8
4.4.7	Ethernet: 10/100 Base T WAN capacity Protocols	No. Mbit/s	1 Min: 2x 2Mbit/s Min.: IP
4.5	Integrated alarm gathering module:		
4.5.1	Number of external alarms per module	No.	Min. 20
4.5.2	Auxiliary power supply for ext. contacts		Yes
4.6	Network Management System		
4.6.1	Type/Name of configuration tool		
4.6.2	For fault / configuration management		Yes / yes
4.6.3	For local / remote operation		Yes / yes
4.6.4	Data communication network (DCN)		Ethernet / IP or Ethernet / OSI
4.7	Ambient Conditions:		

SL.NO.	DESCRIPTION	UNIT	REQUIRED
4.7.1	Storage: ETS 300 019-1-1, class 1.2	°C / % hum	-25 .. + 55 / class 1.2
4.7.2	Transport: ETS 300 019-1-2, class 2.2	°C / % hum	-25 .. + 70 / class 2.2
4.7.3	Operation: ETS 300 019-1-3, class 3.1E	°C / % hum	-5 .. +45 / class 3.1E
4.8	Power Supply		
4.8.1	Operation	VDC	48 / 60 (-15/+20%)
4.8.2	Fully redundant power supply		yes

8.6.18 230kV OUTDOOR SURGE ARRESTERS

General

Surge arresters shall be of the type employing non-linear metal oxide resistors without spark gaps. The Contractor shall demonstrate by calculations that the surge arresters will adequately protect the switchgear arrangement proposed.

Operating Duty and Performance

The protective characteristics and discharge duties shall be determined by the Contractor. The arresters shall give consistent protection to their associated equipment against over voltages produced by lightning, switching, station internal or external faults, and other system disturbances.

The arresters shall be rated and tested such that they are able to discharge a specified maximum energy due to the application of temporary voltages of form and magnitude which can occur in service as determined by insulation coordination studies to be carried out by the Contractor, without coming into the temperature region where thermal runaway could result upon subsequent application of maximum transient and steady state voltage conditions.

Particular attention shall be given to the high discharge currents which some of the arresters may experience in service due to the requirements to discharge the energy of the shunt capacitors and reactive compensating equipment or in other circumstances.

The design of the arresters shall take into account and shall maximize the degree of current sharing between complete arresters. Similarly, the design shall also take into account and shall maximize the degree of current sharing between parallel columns of the same arrester.

The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage. The Bidder/Contractor shall furnish the values and supporting calculations along with the Bid. The arresters shall be fully stable thermally under site conditions and shall take care of the effect of direct solar radiation.

Constructional Features

Surge arresters shall be housed in porcelain insulators designed to withstand extremes of the environment described. The insulation shall have a minimum creepage distance of 25 mm/kV rated system phase to phase voltage. The method of sealing against the ingress of moisture shall be of a type well proven in service and the manufacturing procedures shall include an effective leak test which can be demonstrated to the inspecting Engineer if required.

The internal components of arresters shall be arranged to minimize radial voltage stresses, internal corona and to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the porcelain housing. Except where approved, organic materials are not permitted.

Good electrical contact shall be maintained between resistor blocks taking account of any thermal expansion and contraction of the block or mechanical shock during transport and erection, by installing a well proven clamping system.

Metal oxide arresters installed outdoors shall be able to dissipate, when new, twice the energy generated in the resistor blocks when energized at their maximum continuous operating voltage immediately having been subjected to the discharge duties specified in IEC 60099-4 and assuming that the porcelain housing and the surrounding air is at least 5˚C higher than the maximum ambient air temperature specified.

Good quality control of the manufacturing process of the resistors shall be ensured by rigorous testing procedures. The procedures shall ensure that the characteristics of the blocks are, and will remain, within the specified limits when new and throughout the anticipated life of the arresters. Samples may be selected at random by the Engineer for special tests to be agreed with the manufacturer.

All surge arresters shall be fitted with a pressure relief diaphragm which shall prevent explosive shattering of the porcelain housing in the event of an arrester failure and the arrester shall have been tested according to the high and low current tests specified in IEC 60099-1.

Fittings and Accessories

Arresters shall be supplied complete for installation in an outdoor switchyard, including insulating bases and surge counters, one per phase, and, if applicable, grading rings. The material used for terminals shall be compatible with that of the conductors to which they are to be connected.

Each arrester shall be identified by a rating plate in accordance with the requirements of IEC 60099-4. In addition an identification mark shall be permanently inscribed on each separately housed unit of a multi-unit arrester so that units can be replaced in the correct position in the event of them being dismantled.

Surge counters shall have an internal assembly which is matched to the line discharge capability of the arrester and shall include a leakage current meter with a bi-linear scale for ease of reading. Auxiliary contacts are to be provided to signal remote indication of counter operation.

Tests

Arresters shall be designed and tested in accordance with the requirements of IEC 60099-4. Any departure shall be the subject of agreement between the Engineer and the Contractor. Routine tests shall be carried out in accordance with the Specification.

8.6.19 33 kV & 11kV OUTDOOR TYPE OFF-LOAD ISOLATOR

Installation	:	Outdoor (Corrosion-Proof)
Type	:	Air
Construction	:	Housed In Metal Clad Cubicles
Operation	:	Gang
Operating Mechanism	:	Manual
Mounting Position	:	Vertical or Horizontal on supporting structure as required
Number of Pole	:	3 (Three)
Frequency	:	50 Hz

Nominal System Voltage	:	33 KV / 11 KV
Rated System Voltage	:	36 KV / 12 KV
Power frequency voltage withstand to earth	:	70kV(rms) / 28kV
Power frequency voltage withstand across open contacts	:	70kV(rms) / 28kV
Lightning impulse withstand to earth(1.2/50μs)	:	170 kV peak /75kV
Lightning impulse withstand across open contacts(1.2/50μs)		170 kV peak / 75kV
Rated Normal Current	:	630A
Rated Short Time Withstand Current	:	31.5 kA (3 sec.) / 20 kA (3 sec.)
Material of Contact Surface	:	Silver plated copper
No. of Auxiliary switches	:	6 NO + 6NC
Standard	:	Performance, design & testing shall be in accordance with the latest edition of applicable IEC – 62271-102.

Features

Single – Break Pattern [Vertical break or Horizontal break, OFF load type.

Channel type mounting base insulator, blast.

Coupling tubes for gang operation and adjustable operating rod with insulating link and intermediate guide for operating rod.

Auxiliary switch, operated by the phase coupling tube, to control circuits for operating indicators, alarms, electrical inter-locking with the respective breaker to ensure that the isolator can only be operated when the breaker is in "OFF' position etc. with at least 100% spare contacts.

Earthing steel pads with provision for earth lead.

Glands for multi-core control cables.

Provision for pad locking in “ON” & “OFF” position.

Provision of key interlocking.

Stainless Steel 304 Nuts, bolts & all accessories for mounting on structures.

Interlocking magnet for electrical interlocking.

All ferrous parts shall be hot dipped galvanized with three coats of powder epoxy after completion of machining.

Galvanizing shall be in accordance with BS-729.

All control devices shall be suitable for operation on 110 V DC supplies from Sub- station.

Operating mechanism shall be fully tropicalized and housed in corrosion proof housing. Complete supporting steel structure. All supporting steel structure shall be hot dipped galvanized with three coats of powder epoxy after completion of fabrication.

Isolating devices shall be accordance with IEC-62271-102. They shall be complete with supporting steel work and installed to maintenance of any section of the sub-station plant when the remainder is alive and shall be so located that the minimum safety clearances are always maintained.

The air gap between terminals of the same pole with the isolator open shall be of a length to withstand a minimum impulse voltage wave of 115 Percent of the specified impulse insulation rating to earth.

Isolating switches shall be designed for life operation and isolators shall be hands operated. Where used for feeders they shall be capable of switching transformer-magnetizing currents. Main contacts shall be of the high-pressure line type and acing contacts provided shall be to the Engineer’s approval.

Service conditions require that isolating switches shall remain alive and in continuous service for periods of up to 2 years in the climatic conditions specified without operation or maintenance. These contacts shall carry their rated load and short circuit currents without over heating or welding and at the end of the two year period the maximum torque required at the operating handle to open 3-phase isolator shall not exceed 350 NM.

All feeder isolators shall be fitted with approved three phase link earthing devices, mechanically coupled or interlocked with the main isolator so that the earthing device and main isolator con not be closed at the same time.

Isolating devices shall be interlocked with circuit breakers and isolators as necessary to prevent the possibility of making or breaking load current.

Isolator operating mechanisms shall be of robust construction, carefully fitted to ensure free action and shall be un-effected by the climatic conditions at site. Mechanism shall be as simple as possible and comprise a minimum of bearing and wearing parts. Approved grease lubricating devices shall be fitted to all principal bearings. The mechanism shall be housed in weather proof, rain and watertight enclosure complete with auxiliary switches, terminal blocks and cable gland plates. All steel and malleable iron parts including the supporting steelwork shall be galvanized as per BS-729.

8.6.20 INSTRUMENT TRANSFORMERS

Conventional inductive voltage and current transformers according to IEC 61869-1/61869-2/61869-3 shall be used and shall be acceptable. Current & voltage Sensors are not acceptable. Terminal and polarity marks shall be indelibly marked on each PT & CT on the associated terminals and these marks shall be in accordance with relevant standards.

Secondary terminals of each potential and current transformer shall be brought out in a weather-proof terminal box. Facility shall be provided for shorting and Grounding the CT secondary at the terminal box. The star point, whenever required, shall be formed at the terminal box only.

Each PT and CT shall be provided with a rating plate showing the particulars required by the relevant standard.

Potential Transformers

Potential Transformer shall be according to the IEC:61869-1/618693. Potential transformers shall be of single core type the metal enclosed gas - insulated inductive/electromagnetic type mounted directly on the high voltage enclosure.

The secondary terminals must be located in accessible grounded terminal boxes on the PT enclosure itself. The secondary terminals must be wired to the terminal strip in the respective bay marshalling cubicle. PT should be in segregated compartment and not forming a part of bus bar.

In case of ungrounded potential transformers both the terminals of the primary winding shall be brought out through bushings rated for full line voltage. In case of Grounded potential transformers, the end of the primary winding intended to be grounded shall be brought out through a bushing and Grounding connection shall be made outside.

The secondary terminal box for the potential transformers shall also include necessary HRC fuses/ MCBs for protecting the secondary circuit. Further, for the purpose of fuse supervision both terminals of fuse shall be brought out to the terminal box. MCBs shall be provided with auxiliary contacts for interlocking, Trip and alarm purposes.

Whenever a PT secondary winding is used for both measurement and protection application it shall have dual accuracy class of 0.5/3P, unless otherwise specified. However, for revenue class metering applications the accuracy class shall be 0.5/3P for that core.

The Potential Transformer shall be so designed to avoid ferro-resonance effects and shall be provided with adequate ferro-resonance-suppressor (if required) on the secondary windings. An electrostatic shield shall be employed between the windings of PT to prevent coupling of the transients generated in the GIS high voltage conductors with the control wires.

Potential Transformers shall not be mounted on the same compartment/Gas section as the Cable Feeder termination compartment in order to test the Cable feeder independent of the Potential Transformer.

Current Transformers

The current Transformer shall confirm to the IEC61869-1/IEC 61869-2. The current transformers shall be toroidal-core type current transformers and shall be located outside the Gas Compartment.

CT Primary Current shall be (*) Amp. CT Secondary Current shall be (*) Amp. Accuracy class 0.5 for metering and class X for protection.   Burden shall be (*) VA. Note: (*) - means Contractor shall do the sizing calculation of the CTs.

For the purpose of polarity checking, the position of each primary terminal in the current transformer SF6 gas section shall be clearly marked.

In the case of multi core CTs, it shall be possible to adjust the ratio taps on any core independent of the setting on the other cores, for which purpose these tapping shall have to be provided on the secondary windings only. The CT cores shall be of low reactance type.

8.6.21 GIS SURGE ARRESTERS

The surge arresters shall fully comply with IEC-60099-4

Gap-less ZnO arrestors shall be provided before the termination to the transformer. Surge arrestor shall be of the hermitically sealed, Gapless Metal Oxide, suitable for use with gas insulated switchgear. They shall have adequate thermal discharge capacity for sever switching surges, long duration surges and multiple shocks.

Normally isolable surge arrestors on the Bus Bar shall be used. This will facilitate quick isolation and coupling whenever bus bars are required to be exposed to high voltage test.

Self-contained discharge counter shall be provided for each single pole unit. A leakage current detector as an integral part of the discharge counter shall be supplied. A counter along with detector shall be so arranged that it will be possible to read the leakage current values from the outside cubicle. The value of leakage current beyond which the operation is abnormal shall be clearly marked in red colour on the detector.

8.6.22 33 KV / 11 KV OUTDOOR TYPE VACUUM CIRCUIT BREAKER

1	Type	Outdoor type VCB
2	Standard	IEC 62271-100
3	Rated voltage	36 kV / 12 kV
4	No. of poles	Three (3)
5	Rated short-duration power frequency withstand Voltage (1 min.)	70 kV rms / 28 kV rms
6	Rated lightning impulse withstand voltage	170 kV peak / 75 kV peak
7	First pole to clear factor	1.3
8	Rated current	630 A
9	Rated short circuit breaking current	31.5 kA rms / 25 kA rms
10	Rated short circuit making current	80 kA peak / 50kA
11	Short time withstand current for 1 sec.	25 kA rms / 20 kA rms
12	Total closing time	<150 ms
13	Total breaking time	<100 ms
14	Operating mechanism	Motor spring stored energy
15	Rated duty cycle	O-0.3S-CO-3min-CO
16	Number of closing coils	1
17	Number of tripping coils	2

18	Number of auxiliary contacts for:	
	Making Breaking Middle position	Min. 8 Min. 8 0
19	Creepage Distance	25mm/kV (Min)
20	Protection class	IP55
21	Standard	Performance, design & testing shall be in accordance with the latest edition of applicable IEC – 62271-100, 60694 .

Features:

Grading terminal connector.

All current carrying parts shall be made of copper.

Externally visible circuit breaker position indicator.

Electrically remote controlled operating mechanism.

Shall be capable of the interrupting duties produced by the switching of transformer magnetizing current and the switching of line charging current. Tests certificate demonstrating this ability of the circuit breakers shall be submitted with the offer.

Circuit Breaker closing mechanism shall be 230 volt AC motor wound spring- operated type such that the closing speed is independent of the operator.

Shall be two tripping coils and one closing coil.

Hand closing and tripping shall be done through manual levers.

Trip free mechanism i.e. tripping is independent.

Local “Close” and “Trip” controller.

Operation Counter.

Supporting Steel Structure.

Bushing Insulator as Specified in IEC-60137.

Corrosion Proof sheet steel control kiosk, with hinged door on three sides and necessary multi-core cable glands. Controls from this position will normally is used under maintenance and emergency conditions only. AC 230V lighting system inside the door of control kiosk shall be provided.

ARC suppression type contacts.

Manually operating devices for slow closing for inspection and maintenance. It shall not be possible to slow close a breaker when in normal services.

Earthing pad with provision for earth leads.

Standard sundries like anti-condensation heaters, MCBS wiring board etc.

Evidence of prototype tests together with test certificate from a recognized institution covering the equipment shall be furnished with the offer. The test duty shall be as per the requirements of relevant IEC standards.

All bolts and nuts shall be made of stainless steel 304.

All steel structure supports shall be hot dip galvanized with three coats of epoxy powder.

8.6.23 TERMINATION POINT CONDUCTOR AND JUMPERS

Installation	:	GIS Substation Gantry Area, Outdoor.
Type	:	Aluminum Conductor Steel Reinforced (ACSR)
Code Name	:	As required.
Conductor Size	:	As per Current carrying capacity.
Standard	:	Performance, design & testing shall be in accordance to the latest editions of ASTM B-232.
Shipment	:	On standard non-returnable wooden reels Gross weight shall not exceed 2000 Kg per reel.

Special Features

Shall be of continuous length between supports.

Conductors to be used shall be stressed not more than 33% of their breaking strength.

Overhead line conductors carried by the Substation Gantry structures shall be erected with such a tension that when the conductors are subject to a transverse wind pressure of 640 pascal's on the whole projected area, the factor of safety is not less than 2 (Two).

When dissimilar metals are in contact, approved means shall be provided to prevent elector-chemical action and corrosion.

8.6.24 ELECTRICAL HARDWARE FOR 230kV OVERHEAD LINE TERMINATION POINT

230kV Overhead Line connection to composite type outdoor termination unit and Surge Arrester in the 230kV OHL Gantry Area shall be of ACSR and shall be in accordance with BS 215, 159 and 2898 in respect of current rating and material analysis.

The number and diameters of the individual wires forming the finished conductor shall be subject to approval. All necessary terminals and connectors shall be provided under this Contract and also between equipment provided on this Contract.

All connectors shall be of compression type and made of Aluminum alloy suitable for the conductor. The current carrying capacity of all connectors & clamps shall not be less than that of equivalent length of the respective conductor.

Load support clamps shall be complete with stainless steel 304 bolts, nuts, lock washers etc. and of the appropriate size.

All clamps and fittings and their components shall be electro-chemically compatible with the conductor material and those made of steel or malleable iron shall be galvanized as per BS-729.

Joints and connections shall be such as to permit easy dismantling. All necessary terminals and connections (bi-metallic) shall be provided for connection to the equipment.

Suspension and tension conductor clamps shall be of approved types and shall be as light as possible. Suspension and tension clamps shall be designed to avoid any possibility of deforming the stranded conductor and separating the individual strands.

Tension conductor clamps shall be not permit slipping of or damage to or failure of the complete conductor or any part, thereof at a load less than 70% of the breaking load of the conductor.

Unless otherwise approved, ACSR conductors and connections shall be so arranged and supported that under no circumstances, including short circuit conditions, the clearances between live metal and earth of earthed metal work or between other conductors be less than the specified distances.

Where dissimilar metals are in contact, approved means shall be provided to prevent electro-chemical action and corrosion.

Catalogue with making on the catalogues of the hardware proposed shall be submitted with the offer.

8.6.25 ELECTRICAL EQUIPMENT ENCLOSURES

Equipment enclosures for electrical equipment shall comply with IEC 60079, IEC 60529 and IEC 60947-1 as applicable. Equipment enclosures for use in hazardous areas other than explosive gas atmosphere shall comply with National and Local Regulations relating to this application.

Unless otherwise specified, minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows: -

Indoors only in totally enclosed rooms with provision for limiting ingress of dust	IP31
Indoors except as noted otherwise	IP54
Outdoors and indoors in areas subject to water spray or heavy condensation	IP55W

The enclosure classification of main and auxiliary cable boxes with the cable(s) terminated shall not be less than that of the associated equipment, subject to a minimum classification of IP55.

Current Ratings

Normal Current Ratings Current ratings in accordance with IEC 60059 shall be adopted, unless otherwise agreed with the Engineer.

Every current carrying part of the equipment shall be capable of carrying its site rated current continuously under the site ambient conditions as specified and shall not be rated on the basis of air-conditioned rooms even when these are specified. In no conditions shall the specified maximum temperature be exceeded.

The current ratings specified are the continuous current ratings required at the Site, under the specified maximum temperature conditions.

Temperature Rise

Full provision shall be made for solar heat gain on all outdoor apparatus and any differential temperatures attained as a result of the impringement of solar heat.

The allowable temperature rise shall be in accordance with the relevant Standard, except where the ambient temperature exceeds the maximum permitted in that Standard, when the permitted temperature rise shall be reduced by one degree Celsius for every degree Celsius the maximum ambient temperature exceeds the maximum permitted in the Standard.

To allow for high ambient site temperatures, the allowable temperature rise for transformers shall be reduced by a maximum of 10°C. In such cases where the Contractor is unable to guarantee the permitted maximum temperature reached under site conditions, taking account of solar heating, then sunshades shall be provided to the Engineer's approval.

The maximum temperature attained by components under the most onerous service conditions shall not cause damage or deterioration to the equipment or to any associated or adjacent components.

The Contractor shall submit his calculations to the Engineer to prove that all plant has been sufficiently derated to suit the site conditions and any changes required by the Engineer shall be made at no extra cost.

Short-time Current Ratings

Electrical equipment shall be adequately supported and braced to withstand the forces associated with the maximum short-circuit currents specified or pertaining, whichever is the greater, and assuming that the inception of the short-circuit is at such a time that gives maximum peak currents. No provision for current decrement shall be made unless specifically permitted by the appropriate Standard, or elsewhere in this Specification.

Equipment shall be so constructed as to withstand the specified maximum short-circuit currents for the time specified in the Schedules without the temperature exceeding the specified maximum short-time temperature or value stated in the relevant standard, under these conditions. The equipment shall be considered as being operated at the maximum permitted continuous temperature prior to inception of the short circuit.

The final temperature attained as a result of the passage of short-circuit current shall not cause permanent damage, or deterioration sufficient to reduce the normal operating characteristics below the specified or most onerous operating requirements, whichever is the highest.

Voltage Ratings

Normal Voltage Ratings

Unless otherwise specifically stated, any reference to voltage rating shall be deemed to refer to the nominal rated voltage or voltages of electrical equipment. Standard voltage levels in accordance with IEC 60038 shall be adopted, unless otherwise specified by or agreed with the Engineer.

All electrical equipment shall, except where otherwise specified, be capable of continuous operation at a voltage in the range of ±15% of the nominal voltage and at a frequency in the range of 48 to 51 Hz coincidentally without deterioration.

The temperature rise of electrical equipment continuously operating at the specified extreme voltage and frequency shall not exceed the temperature rise when operating at nominal voltage and frequency by more than 5 °C

Short-time Voltage Ratings

All electrical equipment shall be so designed such as to withstand abnormal system voltages as required by the applicable BS, IEC or acceptable International Standard.

Electrical Insulation

Insulating materials shall be suitably finished so as to prevent deterioration of their qualities under the specified working conditions. Account shall be taken of the IEC 60085 recommendations.

Ebonite, synthetic resin-bonded laminated material and bituminised asbestos cement-bonded panels shall be of suitable quality selected from the grades or types in the appropriate IEC, or approved National Standard.

The insulation of all machine windings, solenoids, etc. other than those immersed in oil or compound, shall be of Class F materials, unless otherwise specified elsewhere.

All cut or machined surfaces and edges of resin-bonded laminated materials shall be cleaned and then sealed with an approved varnish as soon as possible after cutting.

Linseed oil and untreated materials of fibre, leatheroid, presspahn, asbestos or other similar hygroscopic types of materials shall not be used for insulation purposes. Untreated leatheroid and presspahn may be used for mechanical protection of winding insulation.

The use of asbestos is not permitted without the permission of the Engineer.

Wherever practicable, instrument, apparatus and machine coil windings, including wire wound resistors, with the exception of those immersed in oil or compound, shall be thoroughly dried in a vacuum or by other approved means and shall then be immediately impregnated through to the core with an approved insulating varnish. Varnish with a linseed oil base shall not be used.

No material of a hygroscopic nature shall be used for covering coils. Where inter-leaving between windings in coils is necessary, only the best manila paper, thoroughly dried, which permits penetration by the insulating varnish or wax, shall be used.

Polychlorinated Biphenyl (PCB) type materials shall not be used anywhere in the equipment or in any component.

Insulating Oil

Insulating oil shall comply with the requirements of IEC 60296. Insulating oil shall be provided by the Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums. The Contractor shall provide at no additional cost any oil treatment facilities he may require for his own use in order to ensure that insulating oil meets the requirements of the specification.

Control and Selector Switches

Control switches shall be of the three position type with a spring return action to a central neutral position and without a locking feature.

Circuit breakers shall have control switches which shall be labelled Open/N/Close or (O/N/I) and arranged to operate clockwise when closing the circuit breakers and anti-clockwise when opening them.

Control switches of the discrepancy type shall be provided where specified. Such discrepancy control switches shall be arranged in the lines of the mimic diagram. Such switches shall include lamps and be of the manually operated pattern, spring loaded such that it is necessary to push and twist the switch past its indicating position for operation. The lamp shall be incorporated in the switch base and shall flash whenever the position of the controlled device is at variance with the position indicated by the control switch. Hand dressing of the control switch to the correct position shall cause the lamp to extinguish.

Pushbutton test switches shall be provided along the control panel which will illuminate all indicating discrepancy lamps as well as spare lamps on the control panels. The scheme shall be complete with all necessary diodes and other equipment required for satisfactory operation.

Switches for other apparatus shall be operated by pushbuttons, shrouded or well recessed in their housings in such a way as to minimise the risk of inadvertent operation.

Multi-position selector switches shall have a lockable stayput action. Each position of the selector switches shall be suitably labelled to signify the functions in accordance with the approved wiring diagrams. The switch handle shall be of the pistol grip spade type to the approval of the Engineer.

It shall not be possible at any time to close any switching device from more than one location simultaneously, and suitable lockable selector switches shall be provided to meet this requirement. Tripping signals from all locations shall function at all times.

Particular variations of the above requirements may be agreed with the Engineer for special instrument or control equipment, viz. main control room desks and panels, and electrical equipment cubicles.

The contacts of all control and selector switches shall be shrouded to minimise the ingress of dust and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

Panels, Desks and Cubicles

Unless otherwise specified, panels, desks and cubicles, shall be of floor-mounted and free-standing construction and be in accordance with the enclosure classification specified in IEC 60079, IEC 60529 and IEC 60947-1 as applicable . All control and instrumentation panels in any one location shall be identical in appearance, construction, and colour finishes.

Panels shall be rigidly constructed from folded sheet steel of 3mm minimum thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess.

Overall height, excluding cable boxes, shall not exceed 2.5m. Operating handles and locking devices shall be located within the operating limits of 0.95m and 1.8m above floor level. The minimum height for indicating instruments and meters shall be 1.5m unless otherwise approved by the Engineer.

Panels shall be mounted on an approved form of anti-vibration mounting whenever necessary.

All panels, desks and cubicles shall be vermin-proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the Engineer.

All cubicles, desks and panels shall be provided with a natural air circulation ventilation system. All control equipment shall be designed to operate without forced ventilation.

For outdoor equipment, metal to metal joints shall not be permitted and all external bolts or screws shall be provided with blind tapped holes where a through hole would permit the ingress of moisture. For harsh environments, all screws, nuts, bolts and washers shall be stainless steel 304.

Door sealing materials shall be provided suitable for the specified site conditions. Doors shall be fitted with handles and locks. Where walk-in type panels are supplied the door shall be capable of being opened from inside the panel without the aid of a key after they have been locked from the outside. Hinges shall be of the lift-off type, and shall permit the doors when open, to lie back flat so as not to restrict access. Means shall be provided for securing the doors in the open position.

Cubicles and cubicle doors shall be rigidly constructed such that, for example, door mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

The bottom and/or top of all panels shall be sealed by means of removable gasketed steel gland plates. Gland plates for bottom entry shall be at least 250mm above the floor of the cubicle.

Panels shall be suitably designed to permit future extension wherever appropriate or specified.

Each panel shall include rear access doors internal power sockets and door-operated internal lighting, and be clearly labelled with the circuit title at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltages higher than 110V (nominal) shall be partitioned off and the voltage clearly labeled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes. Terminations, wiring and cabling shall be in accordance with the requirements of this section of the specification.

For suites of panels inter panel bus wiring shall be routed through apertures in the sides of panels and not via external multicore cabling looped between the panels.

All panels, whether individually mounted or forming part of a suite, shall incorporate a common internal copper earthing bar onto which all panel earth connections shall be made. Suitable studs or holes to the Engineer's approval shall be left at each end of the bar for connection to the main station earthing system and possible future extension.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel sides and not by interconnecting external cabling.

Where intrinsically safe circuitry is routed from a hazardous area to a safe area instrument panel, it shall be connected through Zener Barriers located in the safe area (instrument panel) of suitable rating and mounted on an insulated earthing busbar having facilities for connection of a separate dedicated outgoing cable to a "clean earth" system.

110V DC and 48V DC Battery Chargers Panels for Control Supplies of 230kV and 110kV GIS Local and Remote Control Panels, Auto Power Transformers Remote Local and Remote Tap Changer Control Panels, 33kV and 11kV Outdoor Type Circuit Breaker and Isolator Control Panels, 11kV Switchgear Control Panels, Metering and Protection Relay Panels, Telecommunication / LAN Racks and Cabinets, Substation Automation Control Panels, and SCADA Panels, etc., shall be connected from a Normal Three Phase Power Supply and Standby Generator.
Contractor shall design the arrangement, size and rating of the Standby Generator with 20 % spare capacity.

Power Supply for Fire Alarm System Panels, FM200 System Panel, Deluge Water System Panel, Substation Nitrogen Injection Fire Protection (NIFPS) System Cubicle Panel, Central Battery System for Emergency Lighting System, and Space Heaters for cubicles and panels shall be connected from a duplicate Standby Generator and UPS system. Contractor shall design the size and rating of the Standby Generator and UPS System with 20 % spare capacity.

The following alarms shall be provided for the Standby Generator and UPS System to monitor the systems:

1. Voltage High
2. Voltage Low
3. No voltage
4. ON, OFF, TRIP
5. Earth Fault

The alarms shall be signaled back to the Control Room.

Instruments having pressure pipe connections containing oil, water, steam or flammable or toxic fluids shall be excluded from the Control Room.

All cubicles, desks and panels shall be painted externally with a high gloss paint of Munsell 5Y-7/1 colour. The interiors of all cubicles, desks and panels shall be painted matt white.

All cubicles, or panels mounted external to control and apparatus rooms shall be fitted with thermostat controlled anti-condensation heaters.

Instruments & Meters

Indicating Instruments

All indicating instruments shall be of the flush mounted pattern with dust and moisture proof cases complying with BS 2011, Classification 00/50/04, and shall comply with IEC 51-1.

Unless otherwise specified, all indicating instruments shall have 96mm or 144mm square cases to DIN standard or equivalent circular cases.

Instrument dials in general should be white with black markings and should preferably be reversible where double scale instruments are specified.

Scales shall be of such material that no peeling or discolouration will take place with age under humid tropical conditions.

The movements of all instruments shall be of the dead beat type. Wherever possible, instruments shall be provided with a readily accessible zero adjustment.

Electrical Meters

All electrical meters shall comply with IEC 521 and, unless otherwise specified, shall be of accuracy Class 0.5. Three-phase power measuring instruments shall be of the three-phase unbalanced load pattern wherever the current and voltage references permit.

Where precision grade metering is specified meters shall be calibrated to precision grade accuracy to IEC 521. Due allowance shall be made for the errors of current and voltage transformers with which they shall work and whose accuracy class shall be Class 0.5.

Where commercial grade metering is specified the meters shall be calibrated to commercial grade accuracy to IEC 521.

Meters shall be single directional and shall be fitted where required with suitable devices for the transmission of impulses to a summator. Var-hour meters shall be complete with phase shifting transformers as necessary.

Front of panel test terminal blocks shall be provided for all meters.

Summators shall be equipped to summate the circuits specified and shall be equipped where required with suitable contacts for the re-transmission of impulses to a printometer. They shall register in kilowatts the value of the impulses received from each kilowatt-hour meter. Printometers shall be of an approved type having the specified demand interval.

Each feeder shall be provided Main 1 and Main 2 energy meters. The energy meter shall be 3-element, 4-wire arrangement of programmable digital type and shall have proven performance and shall consist of different types, either from the same manufacturer or different manufacturers. The accuracy class of the energy meter shall be 0.5.

Indicating Lamps and Fittings

All indicating lamps shall be adequately ventilated and as far as practicable, lamps of a common type and manufacture shall be used throughout the Contract.

Lamps shall be easily removed and replaced where possible from the front of the panel by manual means preferably not requiring the use of extractors.

Where specified every circuit breaker panel shall be equipped with one red and one green indicating lamp, indicating respectively circuit closed and circuit open and an amber lamp for indicating 'auto-trip'. Where specified for in the lines of mimic diagrams, indicating lamps may be of the three-lamp single-aspect type.

The variety of indicating lamps provided shall be rationalised to reduce maintenance and spares requirements. The lamps shall be clear and shall fit into a lamp holder. The rated lamp voltage shall be at least 20% in excess of nominal supply voltage, whether A.C. or D.C. The lamps shall have an operating life of at least 10,000 hours, under site conditions. In the event that other indicating devices, such as light emitting diodes, are used in place of lamps then these shall have the same life expectancy and performance capability as the lamps they replace.

The lamp glasses shall comply with IEC 60073 and be in the standard colours, red, green, blue, white and amber. The colour shall be in the glass and not an applied coating. Transparent synthetic materials may be used instead of glass subject to the approval of the Engineer.

Where illuminated pushbuttons are used for control purposes, the illuminated pushbuttons shall be engraved with a clear instruction such as 'push to open' or 'push to close', and the lamp shall illuminate in accordance with the above colour code after the instruction has been carried out and the device has operated.

Unless otherwise agreed with the Engineer all lamp colours shall conform to the following practice: -

Red	Energized or operative position
Green	De-energized or inoperative position
Amber	Fault or abnormal condition
White	Healthy or normal condition
Blue	Other purposes, to be used with
	descriptive label

Lamp test facilities shall be provided for all switchboards, control panels etc. to enable all lamps to be tested whilst the equipment is in service. Operation of the lamp test facility shall not cause any other device to operate.

Indication circuits shall be fused.

Anti-Condensation Heaters

All switchboards, panels, cubicles and the like shall incorporate thermostat controlled electric heaters capable of providing movement of sufficient heated air to avoid condensation. The apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energised while the apparatus is in operation.

The switchboard anti-condensation heaters shall be fed from a 240V single phase and neutral supply from a UPS System Panel, manually switched by a two-pole switch with red lamp, mounted on the back of the board, panel or cubicle and bus wired through the board. Labels shall be provided on the switch stating "Heater Supply". Heater terminals shall be shrouded and labelled "Heater". Power Supply to the UPS shall be fed from normal power supply and emergency power supply with standby generator.

Motor anti-condensation heaters where fitted shall be fed from an LV single phase and neutral supply bus wired through the board. The supplies shall be individually fused and will be switched by auxiliary contacts on the contactor and isolated by auxiliary contacts on the contactor isolator.

Control and Instrument Panel Wiring, Cable Terminations, and Terminal Boards

General

All electrical equipment mounted in or on switchgear, panels and desks, shall have readily accessible connections and shall be wired to terminal blocks for the reception of external cabling.

The wiring shall comply with BS 6231 and shall be capable of withstanding without deterioration the conditions at Site, due allowance being made for such temperature conditions as may arise within any enclosure. The insulating material shall be flame retardant in accordance with IEC 60332.

All wiring shall be of adequate cross-sectional area to carry prospective short-circuit currents without risk of damage to conductors, insulation or joints.

The following classes of copper conductor, as defined in IEC 60228, shall be used for panel wiring:

(a) Class 1 conductors up to a maximum of 0.9 mm diameter where necessary for wire-wrapped terminations and similar techniques,

(b) Class 2 conductors except where specified otherwise,

(c) Class 5 and Class 6 conductors between points subject to relative movement.

The following minimum conductor sizes shall be used:

(a) 2.5 mm2 for current transformer secondary circuits with a rated secondary current of not exceeding 1A.

(b) 1.5 mm2 except where specified otherwise,

(c) 0.5 mm2 for alarm and indication circuits with a continuous or intermittent load current not exceeding 1A.

Where an overall screen is used, this shall be a metallic screen or low resistance tape, with a drain wire as above.

Wiring shall be supported using an insulated system which allows easy access for fault finding and facilitates the installation of additional wiring.

Small wiring passing between compartments which may be separated for transport shall be taken to terminal blocks mounted separately from those for external cable connections.

Connections to apparatus mounted on doors or between points subject to relative movement shall be arranged so that they are subjected to torsion rather than bending.

Ribbon cables or similar preformed cables with plug and socket connectors may be used for light current wiring. Plug and socket connectors shall be polarised so that they can only be inserted into one another in the correct manner.

If so required, the Contractor shall submit for the Engineer's approval samples of the types of wire, numbered ferrules, and terminal washers or lugs as appropriate which he propose to use.

Identification of Wires

All wiring and cores in control and instrument cables shall be identified in accordance with the associated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colours, except when an automatic or proprietary system of wiring is used, e.g. point-to-point wiring on a mother board.

When a wire numbering system is used, it should be in accordance with a functional marking system. Both ends of every wire and core in control and instrument cables shall be fitted with interlocking ring ferrules of white insulating material indelibly marked with black characters, complying with BS 3858. Heat shrink marking sleeves may be used, but adhesive markers are not acceptable.

When plug and socket connectors are used, they shall be uniquely identified as mating pairs and each connector pin shall be numbered. Wiring which is permanently connected to plugs or sockets need not be identified.

Each core of multipair wiring shall be identified by colour and terminal block identification together with an identification tracer per bundle.

Permanent identification of all terminals, wires and terminal blocks shall be provided.

A consistent system of wiring numbering shall be used throughout the plant, and it shall be agreed with the Engineer at the start of the Contract.

Terminals and Terminal Blocks

Terminal blocks shall have separate terminals for internal and external connections, and not more than one wire shall be connected to each terminal.

Adjacent terminals to which wires of different voltage, polarity or phase are connected shall be separated by a protruding insulating barrier. This requirement also applies to terminals carrying wires of the same voltage but originating from different sources.

Trip circuit wiring and instrument transformer secondary wiring shall be connected using hook type crimped terminations in screw clamp, spring loaded insertion type terminals.

Where clamp type terminals are used, Class 1 and Class 2 conductors may be terminated without lugs. Crimp lugs shall be used for Class 5 and Class 6 conductors. Means shall be provided for retaining the identifying ferrules of the wire end when it is disconnected. Pinch screw type terminals shall not be permitted.

Subject to approval of the Engineer, "wire-wrap", "termi-point" or equivalent methods of terminations of single strand conductors may be used.

Wires shall be grouped on the terminal boards according to their functions. All terminal blocks shall provide a degree of protection of not less than IP2X when correctly installed, either inherently or by provision of insulating covers.

Terminal boards shall be mounted vertically, not less than 150mm above the gland plates, and spaced not less than 100mm apart, on the side of the enclosure and set obliquely towards the rear doors.

Sufficient terminals shall be provided to permit all cores on multicore cables to be terminated. Terminals for spare cores shall be numbered and be located at such position as will provide the maximum length of spare core. At least 10% spare terminals shall in all cases remain after commissioning.

The tails of multicore cables shall be bound and routed so that each tail may be traced without difficulty to its associated cable. All spare cores shall be made off to terminals.

When two lengths of screened cable are to be connected at a terminal block (i.e. junction box) a separate terminal shall be provided to maintain screen continuity.

In the main and local control and equipment rooms means shall be provided on the terminal blocks of panels, desks, cubicles, etc., for testing all the instrument circuits without the need to remove the internal or external wiring from the block.

The Contractor shall submit full details and specification of the proposed means of termination where wire wrapping, soldering and similar methods are used. The adopted methods shall be to the Engineer's approval.

The Contractor shall identify all special tools, such as wire wrapping tools required for termination, and shall make provision for their supply in sufficient numbers.

The use of pre-formed factory tested cable connections to field mounted marshalling boxes shall be to the Engineer's approval.

Cable Boxes and Glands

General

Electrical equipment shall be provided with all necessary cable boxes, which shall be complete with all required fittings. All cable boxes shall be of adequate size to allow for the correct termination of the cable sizes required or specified, taking into account the crossing of cores to achieve the correct phasing, and to accommodate all cable fittings, including stress cones or other means of cable insulation grading, if required. All cable boxes shall be designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

All main cable boxes shall be air insulated for the termination of all types of cable at voltages up to and including 33 kV nominal system voltage, unless otherwise specified elsewhere in this Specification.

The enclosure classification of main and auxiliary cable boxes on motors with the cable(s) terminated shall not be less than that of the associated motor, subject to a minimum classification of IP55.

Clearance and creepage distances shall be adequate to withstand the specified alternating current voltages and impulse voltages for service under the prevailing site conditions. Means shall be provided for preventing accumulation of dirt, dust, moisture, vermin or insects such as to maintain the anticipated life of the equipment.

The terminals for 3 phase cables shall be clearly marked with the specified phase designations to enable the cables to be terminated in the correct sequence.

Flexible connections shall be provided between cable lugs and bushings for all cables of 300 mm2 section and greater.

There shall be no possibility of oil entering the cable box from an associated oil filled compartment.

Inner sheaths shall be arranged to project at least 25mm above the gland plate to avoid moisture collecting in the crutch.

All cable boxes shall be designed to withstand the high voltage d.c. cable tests prescribed in IEC 60055, IEC 60502 or other applicable standard.

Cable lugs and terminations for the receipt of all power, control and instrumentation cable cores shall be provided.

Where air insulated terminations are used, the cable crutch within a cable box or equipment panel shall be protected by the use of a heat-shrink plastic trifurcating sleeve or equivalent placed over the cores and crutch.

The Contractor shall provide full information and instruction for his proposed method of terminating MV cables.

Removable gasketted steel gland plates shall be provided for multicore cables. The cable entry into the cable box shall be arranged so that there is adequate space to manipulate the cable for glanding and termination.

When single core cables are used, particularly for currents in excess of 500A, adequate steps must be taken to minimise the effects of eddy currents in the gland and bushing-mounted plate. An aluminum cable glanding plate shall be used to prevent the effects of eddy currents in the gland and bushing-mounted plate.

Gland plates for externally mounted marshalling boxes shall be in the form of removable gasketted steel plates, forming part of the underside of the box. Indoor marshalling boxes may be fitted with gland plates on all four sides.

Cable Glands

Cable glands for extruded solid dielectric insulated cables (PVC, EPR, XLPE) shall be of the compression type and as specified in BS 6121 Part 1.

All glands shall be provided with an earthing tag or equal facility. For cables having conductors not larger than $4mm^2$ serrated washers may be used in place of earthing tags to provide earth continuity.

Glands for armoured or screened cables greater than or equal to 240 mm2 and all insulated glands for power cables shall be provided with an integral earthing lug. On cable glands up to and including 40 mm nominal size, the earthing connection shall have a short circuit rating of at least 25 kA for 1 second, and of at least 40 kA for 1 second on larger sizes.

Insulated glands shall be provided with removable connections for bonding across the gland insulation. The gland insulation shall withstand a wet insulation voltage withstand test of at least 2 kV a.c. for 1 minute.

Under conditions of severe corrosion, corrosion-resistant cable glands complying with BS 6121 Part 3 may be used, or the Contractor may use an alternative solution with the approval of the Engineer.

Polymeric cable glands complying with BS 6121 Part 2 may be used, but only when terminating unarmoured cables.

Glands for MICS cables shall be to the approval of the Engineer.

Box Filling Compounds

The type of compound shall be to the approval of the Engineer, who shall be supplied with sufficient information by the Contractor. The Contractor shall supply all compound required together with an additional quantity of not less than 10% of normal requirements.

Where hot-pouring compounds are employed the pouring temperature shall be verified by use of thermometers or similar instruments and the metallic case of all joints and terminal boxes shall be adequately pre-warmed to drive off moisture.

The Contractor shall take particular care to adhere to the recommended topping-up procedures and to ensure that no leakage or migration of the filling compound occurs. Should leakages occur during the maintenance period the Engineer will require the joint to be re-made at the Contractor's expense.

Oil or Compound-Filled Chambers

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

Insulating compound shall comply with BS 1858.

The correct oil or compound filling level shall be indicated on the inside and outside of chambers.

Joints and Gaskets

All joint faces are to be flat and parallel to the approval of the Engineer and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil-resisting synthetic rubber gaskets are not permissible, unless the degree of compression is accurately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bonding medium.

Valves on Electrical Equipment Fluid Lines and Vessels

All valves shall be suitable for the service conditions under which they are required to operate. The design, construction and choice of materials shall take into account all operational deviations including pressure surge and Thermal shock.

All drain and filter valves shall be provided with gun metal adaptors suitable for connecting a flexible hose having a screwed coupling of approved size. Captive-screwed caps shall be provided for all such adaptors.

Junction and Marshalling Boxes

Junction and marshalling boxes for use in non-hazardous areas shall be of substantial sheet aluminium anodised coating construction to prevent corrosion, having an enclosure classification in accordance with the requirements of IEC 60079, IEC 60529 and IEC 60947-

1. They shall be fitted with external fixing lugs and finished in accordance with the requirements of the specification for cleaning, painting and finishing. The boxes shall allow ample room for wiring, with particular regard to the routing of wires from the point of entry. Boxes made from aluminium shall be subject to agreement with the Engineer.

Outdoor boxes shall have an anti-condensation finish and all boxes shall be designed such that any condensed water cannot affect the insulation of the terminal boards or cables. No cables shall be terminated into the top of outdoor boxes unless specifically approved by the Engineer.

All outdoor kiosks, cubicles and panels shall be provided with sun/rain shades. All kiosks, cubicles and panels not in air-conditioned rooms shall be provided with thermostat controlled anti-condensation heaters.

All kiosks, and cubicles shall be fitted with door operated internal illumination lamps.

All necessary gland plates shall be provided undrilled.

Boxes shall be complete with suitably inscribed identification labels.

Boxes for use in hazardous areas shall have all entries factory pre-drilled. Every unused screwed entry shall be sealed by means of a tamperproof screwed plug in accordance with IEC 60079.

Hazardous area boxes with bolted or screwed lids shall require the use of special keys or spanners, for lid removal.

Where weatherproof types of hazardous area boxes are not available, the gaps should be protected against the ingress of moisture, by an approved means compliant with local standards.

All box covers are to be arranged for padlocking and padlocks with keys shall be supplied.

All boxes shall be provided with adequate earthing bars and terminals.

8.6.25 MEDIUM VOLTAGE SWITCHGEARS

General

The Contractor shall furnish, install and commission medium voltage switchgear and all its related appurtenances, complete and operable, in accordance with Contract requirements. Works shall include installation of the appropriate concrete pad/foundation and other mounting accessories.
The switchgear and its components shall be designed, manufactured and type-tested in accordance with the latest applicable standards of IEC, NEMA and IEEE.

Product Requirements

MV switchgears shall be free-standing, indoor type, designed for operation on a 11 kV, 3-Phase, 3-wire and 50 hertz system.

The switchgear assembly shall consist of individual vertical sections housing various combinations of vacuum circuit breaker/or fusible load interrupter, switches and other auxiliaries, bolted to form a rigid metal-clad, dead front switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit.

The stationary primary contacts for circuit breaker shall be silver- plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is disconnected or out of the cell. Rails shall be provided to allow withdrawal of each 11 kV circuit breaker for inspection and maintenance without the use of a separate lifting device.

Each vertical section containing a switch shall have a single, full- length flanged front door and equipped with two rotary latch type handles that can be padlocked. Provision shall be made for operating the switch and storing the removable handle without opening the full-length door.

The medium voltage switchgear shall be an integrated assembly of withdrawable type vacuum circuit breaker that is coordinated electrically and mechanically for high voltage circuit protection. Medium voltage switchgear ratings are shown in the table below.

Medium Voltage Switchgear Ratings

Rated Voltage	11 kV nominal
Highest System Voltage	17.5 kV
Phases	3
Rated Frequency	50 Hz
Rated Short Circuit Breaking Current	50 kA
Rated Short Time Withstand Current	50 kA /3 sec.
Rated Short Circuit Making Current	125 kA
Rated Peak Withstand Current	125 kA
Rated Normal Current	4000 A / 1250 A

The manufacturer shall furnish accessories for installation, inspection, testing, operation and maintenance of the medium voltage switchgear. Standard factory tests shall be performed on the switchgear assembly to be supplied under this Contract. All tests shall be in accordance with the applicable requirements of the latest approved edition of IEC, ANSI and NEMA Standards.

Specifications for particular switchgear components and other requirements shall be as follows:

The main bus shall be copper and have fluidized bed epoxy flame retardant and track resistant insulation. The bus supports in between units shall be flame-retardant and track-resistant. The switchgear shall be constructed so as all buses, bus supports and connections shall withstand stresses that would be produced by currents equal to the momentary rating of the circuit breakers.

A set of 4,000-ampere and 1,250 A insulated copper main bus shall be provided and shall have provisions for future extensions. All bus joints shall be plated, bolted and insulated with easily installed boots. The bus shall be braced to withstand fault current equal to the close and latch rating of the breakers.

The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests.

A copper ground bus shall extend the entire length of the switchgear. When required, a bare, fully rated neutral bus shall extend the entire length of the switchgear.

MV Switchgear Enclosure

The enclosure for the switchgear shall be dead front, free standing, pad-mounted.

Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. A master nameplate giving switchgear designation, voltage/ampere rating, short-circuit rating, manufacturers name, general order number and item number shall be likewise furnished.

All components and devices mounted within the assembly, such as fuse blocks, relays, push buttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on the manufacturers wiring diagrams.

Surface finish shall be thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray. Prior to shipment, the complete assemblies, indoor as well as outdoor, shall be given 1.5 to 2.0 mil thick exterior finish spray coat or air drying high gloss gray enamel.

8.6.26 11KV CAPACITOR BANK

GENERAL

The capacitor bank shall comprise five units of 1 MVAR rating 3 phase 11kV and shall be housed in metal clad outdoor cubicles. and a separate cubicle to accommodate the incoming 3 core 11kV cable, three phase I1kV off-load isolator and 11kV voltage transformer. The cubicles arranged in line to form a complete self-standing board.

Capacitors shall be properly selected to attain 98% power factor.

CAPACITORS

The 11kV capacitors shall comply with IEC 70/BS 1650 and shall be suitable in all respects for installation outdoor housed in metal clad cubicles, and for operation in the specified site conditions on the Medium Voltage system.

The capacitor shall be capable of the following permissible over loads as a minimum:

Current / Voltage

- Output 1.3 times rated current continuously
- 1.1 times rated voltage of 11kV continuously
- 1.3 times rated output continuously

The capacitor container shall be of stainless-steel welded construction. Alternative price shall be quoted with mild steel container which shall be protected with the following treatment:

- short blast
- zinc spray
- primary coat
- undercoat
- finishing coat

Bushings shall be of porcelain to withstand an impulse voltage of 75kV and shall have a minimum creepage of 275mm.

The capacitor shall include in-built discharge resistors inside the container permanently connected across the terminals to discharge the capacitor to 50 Volts in less than 5 minutes.

Lifting - fixing brackets shall be provided on low sides of the capacitor container.

OUTDOOR CUBICLES

Each I MVAR capacitor unit with its associated control and protection gear shall be housed in metal-clad outdoor cubicle of mild steel construction with minimum plate thickness of 3mm.

The cubicle shall include hinged front door with lockable chromium finish handle, bottom plate and removable rear and side cover plates secured in position from inside the cubicle. The entire cubicle shall be corrosion proof.

The cubicle as a whole shall be manufactured to degree of protection IP55.

In addition to the cubicles for housing the capacitor units, a separate cubicle shall be provided for accommodating the incoming 11kV cable, control cables, 11kV isolator and 11kV voltage transformer.

All six cubicles shall be arranged in line to form a complete free standing board with base frame and fixing bolts, for installation outdoor on concrete foundation. The board shall include a ridged canopy for protection from rain. Ventilation louvre shall be provided in the cubicle with the gauze for vermin proof.

The board shall be provided with tinned copper earth bar 40 x 4mm running, the entire length of the board with two earth terminals for connecting to the station earthing system.

INCOMING SUPPLY CUBICLE

The cubicle shall include the following :

- Cable entry and termination for 3 core 240 sq.mm Cu/XLPE/SWA/PVC cable, with all necessary dry type termination material including compression type brass gland with PVC shroud and earth tag, and crimping type lugs.

- Control cable entries and terminations, terminal blocks. 3 phase 11kV off-load isolator 400 amps rating.

- Three 11kV lighting arrestors.

- 11kV voltage transformer dry type resin encapsulated connected across two phases ratio 11kV/110V, 500VA min.

- Unbalance protection relays for each capacitor bank to trip the contactor of each bank in the event of unbalance.

- Two 11kV HRC fuses for protection of 11kV VT and one secondary HRC fuse link/MCB.

- 3 phase busbars covered with extruded insulation which shall be suitable for the site conditions.

- Over voltage relay to protect capacitor bank against over voltage, tripping all contactors.

CAPACITOR CUBICLE

The cubicle shall include the following :

- 11.5kV 3 phase 1 MVAR capacitor unit comprising two 500KVA Star connected capacitor banks in parallel and star point of each interconnected.

- Three 11kV single phase reactors for protection against switching inrush currents.

- 11kV 3 phase contactor 400 amp suitable for continuous operation at maximum voltage of 12.5KV.

- Three 11kV HRC fuses 125 amps.

- 1kV busbars 400 amps covered with extruded insulation which shall be suitable for the site conditions.

- One current transformer of suitable ratio and burden on the interconnected star connection to energize sensitive unbalance relay for protection against unbalance current in the bank.

CONTROL CONSOLE

For automatic regulation of the station power factor by switching step by step the five capacitor units, a control console with necessary step by step control relay and associated ancillary equipment shall be supplied.

The console shall be wall mounting of moulded steel construction with minimum plate thickness of 2mm for indoor installation inside the substation building. The console shall include a hinged front door with lockable chromium finish brass handle.

The regulating and control relay shall operate from the 11kV/110V voltage transformer provided in the incoming cubicle of the capacitor board and 1 amp secondary current transformer on the 11kV incoming supply to the substation.

The 11kV contactors provided m the capacitor cubicles controlling individual capacitor units shall close or trip in sequence, step by step, initiated by the regulating and control relay.

The regulating and control relay shall have the following features as a minimum:

No. of steps	:	6 (with one spare)
Measuring principle power	:	Power factor measured of phase shift between supply voltage and CT current.
Target power factor	:	Range: 0.8 capacitive…1.00…0.8 inductive.
Display modes	:	digital

- power factor (Cos phi)
- capacitor steps
- inductive setting value
- target power factor
- operation time delay

No volt release: all steps to be released and output contacts disabled within 10 milli sec. After voltage is restored normal operation to resume in sequence step by step.

Operation time delay : the time delay range between steps to be 0 to 5 minutes.

Accuracy requirement: Power factor shall be maintained with + or - 2.5% of the target value.

Manual over-ride : Manual selector switch with three positions; off/manual/auto.

Alarm : The regulator alarm contact to close with a blink in the display if either the compensating power is insufficient or there is no voltage at the regulator input.

The entire equipment provided in the control console shall be suitable for operation continuously in an ambient of 50 deg C.

The console shall be manufactured to degree of protection IP40.
The console shall be corrosion proof.
The console shall include all necessary secondary wiring, terminal blocks, compressor type brass glands for control cables to capacitor cubicles and 11kV switchboard at the station for CT secondary circuit.

All small wiring inside the capacitor cubicle and the console shall be carried out as per specification.

Network studies should be carried out to ensure the correct rating of capacitors and their operation without causing resonance. Necessary online detuned harmonics filters shall also be provided in the capacitor banks.

11kV CAPACITOR BANK TECHNICAL GUARANTEED PARTICULARS

SI.No.	Description .
	CAPACITOR BANKS
I	Make
	Model No. Rated Voltage Site MVAR rating at rated voltage KV MVAR Permissible over-load capacity
	a. as percentage of rated voltage
	b. as percentage of rated current
	c as percentage of rated MVAR
	Loss of MVAR capacitor unit walls
	Type of di-electric material
	Insulation level
	No. of insulation layers
	Thickness of each layer
	Loss angle value at
	• 500C

- 800C

II VOLTAGE TRANSFORMERS

Make

Type
Class
Ratio
Burden

III CURRENT TRANSFORMERS

Make

Type
Ratio
Class
Burden

IV CONTACTORS

Make

Type
Rating
Current
Rated voltage: KV
Closing coil voltage: V
Coil current: Amp

V 11KV ISOLATIONS

Make

Type

Rating

VI. REGULATING AND CONTROL RELAY

Make

Type/Model
No. of steps
Measuring principle
Frequency
Power supply
Power factor range
Display modes
Operation sequence

Operation delay range
Accuracy
Construction
Degree of protection
Dimensions

8.6.27 LOW VOLTAGE SWITCHGEARS

This specification describe the General Technical Requirements for LVAC switchboards for supplies to GIS Substation Building Services and CP1 Facilities.

REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

IEC60044	Instrument Transformers
IEC 60269	Low Voltage Fuses
IEC 60439-1 60644	Specification for low voltage switchgear and control gear assemblies IEC Specification for high-voltage fuse links for motor circuit applications
IEC 60898	Electrical Accessories - Circuit-breakers for overcurrent protection for household and similar installations
IEC 60947-1	Low-voltage switchgear and Control Gear - General
IEC 60947-2	Low-voltage switchgear and Control Gear - Circuit-breakers
IEC 60947-3	Low-voltage switchgear and Control Gear - Switches, disconnectors and fuse combination units
IEC 60947-4	Low-voltage switchgear and Control Gear- Electromechanical Contactors and motor starters

SWITCHBOARD DESIGN

Main switchboards and MCB sub-distribution boards for substation and building supplies will be constructed to IEC 439, (BS EN 60439) in accordance with the following:

The classification of the main switchboards shall be:

1. The external design of switchboards shall be of the multi-tier, multi- cubicle type.
2. Installation shall be indoors.
3. Switchboards shall be free standing and fixed to the floor.
4. Enclosure degree of protection shall be not less than IP42.

5. Switchboards shall be of metal clad construction.
6. All instrumentation and metering shall be fixed to a hinged lockable compartment.

Switchboards and all associated equipment shall be suitable for use on a 415 / 240 Volt, three phase, four wires, and 50 Hz system having the neutral solidly earthed.

Each circuit shall be clearly labelled to show the destination of the associated cable and the "ON" and "OFF" positions of the switches.

Distribution boards for exterior use shall be galvanized, weatherproof and to category IP55 degree of protection.

The equipment shall be of the single busbar type with circuit equipment housed in separate compartments.

Where two or more incoming circuit breakers are provided at substations, these shall be mechanically and electrically interlocked to prevent more than one circuit closing at the same time.

The enclosures of all switchboards shall be dustproof and vermin proof. Access doors shall be mounted using concealed hinges. All removable covers shall be fitted with captive screws. Anti-condensation heaters with control switches shall be provided on switchboards. They shall be suitable for a tropical climate.

Rating

Incoming supplies to all switchboards shall be protected at the point of supply. All switchboards shall be suitably rated for a prospective short-circuit breaking capacity of 44 kA/3sec. at 415V

Busbars

Busbars shall be capable of carrying the full rated current continuously without exceeding the maximum temperature specified in IEC 60439 under site ambient conditions.

Busbars shall be of copper, individually covered with a heat resistant phase coloured PVC. Busbar links between panels shall not be used. Neutral busbars shall have the same cross-sectional areas as the phase busbars. Busbars shall be of the same current rating throughout their length and shall be capable of extension at both ends with the minimum disturbance to the busbar and cubicle enclosure.

Busbar and Circuit Shutters

For draw out equipment shutters shall be provided over busbar and circuit orifices to close automatically and positively when the equipment is isolated or withdrawn. Means shall be provided for padlocking the sets of shutters. Busbar orifice shutters shall be painted signal red and labelled 'BUSBAR' in white letters. Circuit orifice shutters shall be painted lemon yellow.

One blanking cover of each size shall be provided to prevent access to a circuit compartment when the equipment has been completely withdrawn from the panel.

Circuit Labels

Approved type title labels are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit list shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit list, the list and cover to be easily removable to permit circuit modifications.

CIRCUIT BREAKERS

All MCB and MCCB circuit breakers shall be high speed fault limiting, thermal/magnetic type with quick break, trip free mechanisms which prevent the breaker being held in against overloads or faults, shall comply with IEC 60947 and be fitted with overcurrent releases of both thermal and instantaneous type. Short circuit performance shall be to IEC 60947.

Where circuit breakers incorporate thermal overload protection and short-circuit protection, their settings shall be subject to agreement with the Engineer.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionizing arc chutes.

Circuit breakers on the incoming circuits shall have facilities for locking in the "off" position.

The fault interrupting capacity of the circuit breaker shall not be less than that of the switchboard itself, or if this is not the case, back up fuses shall be included.

SWITCH-FUSES

Each switch-fuse unit shall be housed in a separate metal compartment and provided with a hinged metal door, interlocked with the switch mechanism so that:

The door cannot be opened whilst the switch is closed.

The door, on opening, automatically locks the switch in the "off" position. Facilities shall be incorporated to allow for the deliberate release of this interlock for maintenance purposes, should it be desired to observe the switch in operation.

An insulating barrier shall be fitted to segregate the fuses and neutral link from the switch and the connections of the latter shall be effectively shielded by an inner metal screen when the compartment door has been opened to obtain access to the fuses.

The switch-fuses may be either of the combination fuse-switch type or of the type with the switch and fuse in separate units. In either case, interlocking shall be provided to prevent access to the fuses until the associated switch is opened and provision shall be made for padlocking the switch in the "on" and "off" positions.

The switch shall have a quick make and quick break action, independent of the speed at which the switch handle is operated, and shall be entirely suitable for switching the inductive loads associated with motor circuits.

OIL FILTRATION SOCKET OUTLET AND PLUG

The Contract shall include heavy duty weatherproof three phase and neutral interlocked switched socket outlets and plugs suitable for supplying the transformer oil filtration units.

INSPECTION AND TESTING

Inspection and testing plan during manufacture and after installation on site shall be submitted for approval by the Engineer for approval.

8.6.28 LOW VOLTAGE CAPACITOR BANKS

Capacitors shall be properly selected to attain 98% power factor.

Group of motors fed in motor control center shall be provided with capacitor bank with automatic switching of controller for power factor correction with the following specifications:

Standard	:	IEC 831 or Approved Equal
Type	:	Dry type Design
Frequency	:	50Hz
Degree of protection	:	IP42
Execution	:	Indoor
Discharge Resistor	:	Permanently connected built-in discharge resistors are sized to ensure safe discharge of the capacitor to less than 50V in 1 min. after switch off.
Losses	:	0.5 W/kVAR
Max. ambient temperature	:	+50 deg. C
Min. ambient temperature	:	-25 deg. C

Network studies should be carried out to ensure the correct rating of capacitors and their operation without causing a resonance. Necessary online detuned harmonics filters shall also be provided in the capacitor banks.

8.6.29 MOTOR CONTROL CENTERS

The work covered by this Specification includes the design and manufacture of motor control center (MCC) equipment completely assembled. The Manufacturer shall also provide technical assistance during the installation and placement in service of the equipment.

All equipment shall be designed, built, rated, tested and shall perform in accordance with the latest editions of the applicable standard.

Service conditions

The MCC and all components therein, shall function in a satisfactory manner within the rated capacity under the service conditions specified regardless of whether or not all necessary specific performances are set forth in this Specification or in the applicable standards.

Design Construction Details

General

The MCC within this Specification shall be compartmentalized and shall comply with IEC 439 Form 4 Type 7, and be rated to the levels specified in the Equipment Specification for operation on a 415 Volt 3 phase 4 wire 50 Hz supply.

The MCC shall be constructed with suitably folded and stiffened corners and edges with an integral supporting structure, and shall be manufactured as per section in Low Voltage Switchgears.

The MCC shall be free standing, front connected and front wired. The front of the MCC shall have doors supported with chrome plated pintle hinges. The door shall not extend more than 450 mm perpendicular to the MCC face. The door locking shall be designed to prevent opening when subjected to forces caused by an internal fault. Master locking system on all doors.

All openings shall be fitted with a suitable non distorting compressible seal, which shall engage onto the MCC panel's stiffened return surround on one side and the door's rear face within the stiffened return on the other side.

Each section of the MCC shall be supported on the identical 75 mm RHS hot dip galvanized plinth, fully braced and welded, turned outwards.

Gland plates shall be fitted to the top and the bottom of the MCC and at the incoming supply cable entry, this gland plate shall be 3.5 mm aluminum, and all other gland plates shall be made out of the MCC construction material. All gland plates shall be gasketed and bolted.

A minimum of 150 mm clear space shall be available above and below the gland plate for access to the glands.

Air duct shall be provided for every VFD / Soft Starters compartment to eliminate hot air circulation inside MCC.

Wiring diagram pockets shall be provided.

Provision for 25% spare for future expansion shall be provided.

Component Arrangement

The MCC shall be 600 mm deep, 2200 mm high with plinth, width of a modular panel shall be 1000 mm with door size of twin 450 mm.

All electrical equipment shall wherever possible be mounted on DIN rails on metal mountings. If equipment has to be attached directly onto the mounting plate, they shall be secured by screws in the pretapped holes, self-tapping screws are not permitted.

Terminals shall be of a type providing a positive mechanical clamp on connection, fully shrouded and suitable for mounting on DIN standard rail. Double banked terminals in one composite molding shall not be used.

No apparatus or terminal block shall be mounted within 300 mm vertically from the internal floor level.

All wiring shall wherever possible be wired in ducts. Cable ducting shall be so sized and arranged that the total number of cables and wires to be installed in the duct do not exert pressure on the lid or cause deformation of the duct. Signal wiring where possible be segregated from other wiring.

The minimum clearance between panel mounted equipment, cable looms, ducting, terminals and MCC framework or panels shall be 50 mm.

Shipping

The MCC shall be delivered on site in sections not longer than 4M. Each section shall be suitable braced and have lifting points so that during a crane lift no distortion will take place. Assembly instruction shall accompany the equipment.

Bus Bars

Grounding Bar shall be provided.

Busbars shall be of tinned, hard drawn, high conductivity copper. They shall be insulated throughout their lengths by means of phase color sleeving. The busbar assemblies and joints shall be in accordance with the manufacturer's / supplier's recommendations.

The rating, supports and bracing of all main connections between all main circuit switching mechanisms and busbars shall be designed for operation at the same short-time withstand current rating as that specified for the busbars.

Live connections to and from busbars shall be either fully insulated or suitably screened and all covers screening the busbars and connections shall be provided with adequate warning labels

Current transformers shall be bar type, to BS 3938 accuracy and output mounted on the cabling side of the ACB or MCCB.

MCC's shall be provided with a hard drawn, tinned, copper earth bar located clear of any gland plate or cable access. The earth bar shall have a minimum cross-sectional area of 120 mm2. The earth bar shall be the full length of the panel and split only at sections used for transport and installation purposes. Where splits occur, the bar shall be joined by a minimum of two bolted connections. Provision shall be made at each end of the earth bar for connection to a main earthing system

The sectional area of the neutral bar shall be equal to the sectional area of the phase bar.

Other Requirements

Identification, test and inspections, drawings, wiring and approvals of MCCs shall comply with the relevant sections within this Specification. Instrument cubicles shall be separate; the layout shall be approved by the Engineer.

All fields wiring to remote control panels or instrument shall be terminated into a terminal rail, not wired directly to devices.

Miniature Circuit Breakers, Fuses, and Links

Facilities shall be provided for protection and isolation of circuits associated with protection, control and instruments. They shall be of approved type and grouped, as far as possible, according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Facilities shall be provided to enable the control circuits for any circuit-breaker to be individually isolated for maintenance purposes.

Facilities for protection and isolation of control and tripping circuits are preferably to be mounted on the outside of control panels in approved positions.

All fuses shall incorporate HRC cartridges to BS 88 or IEC 60269.

Fuse holders shall be designed to lock the cartridges firmly into position without the use of screw clamping devices.

Miniature circuit-breakers (MCB's) shall comply with IEC 60898.

Where MCB's are used on control, protection and alarm supplies, tripping shall cause an alarm to be displayed.

Motor Starters and Contactors for Separate Mounting

In special cases for motors below 30 kW, and non-essential non-plant auxiliaries, such as roller shutter doors, and where it is approved by the Engineer, separately mounted starters for motors may be provided. Each such motor starter shall be equipped with two or three pole control gear, as appropriate, for direct-on-line starting and shall be complete with a fully shrouded lockable isolating switch, mechanically interlocked with the means of access.

All starters shall be supplied by one manufacturer, except where otherwise approved by the Engineer.

Contactors shall be of robust design and shall comply with IEC 60947.

All contactors and their associated apparatus for minor motors shall be capable of operating without overheating for all specified motor operating conditions, and including for a period of five minutes at normal frequency if the supply voltage falls to 80% of nominal voltage.

For motors up to 30kW rating motor starters shall be provided with direct connected thermal overload and phase failure industrial pattern protection tripping devices, integral with the motor contactor. Phase failure protection shall operate with out-of-balance currents not exceeding 85% of motor full load current. Separate contacts for a remote trip alarm shall be provided, and connected up if required.

For motors above 30kW starters shall not be wall mounted but included in a switchboard, except with the approval of the Engineer. For such circuits motor protection relays with a more accurate and easily adjustable overload setting shall be used, which are sensitive to out-of-balance currents not exceeding 20% of full load, and shall include instantaneous earth fault elements. Alternatively, instantaneous earth fault protection may be incorporated in the motor circuit breaker. The earth fault protection shall not operate for unbalanced current surges during motor starting.

8.6.30 VARIABLE FREQUENCY DRIVE (VFD)

The Frequency drives shall be of Voltage Source Inverter Pulse Width Modulated (VSIPWM) with GTO/IGBT/IGCT/SGCT/DTC technologies or later version, which performs precise speed and torque control of standard squirrel cage motors with optimum efficiency. All frequency dives shall be suitable for data connectivity with PLC/SCADA system and shall have suitable communication port and protocol. The drives must be easily programmable. The drives shall be provided with surge protection, programmable lockable code. The Frequency drive shall have the following characteristics:

- Accurate open loop torque control
- Torque step rise time typically less than 5 ms
- Speed control inaccuracy typically 0.1% to 0.5% of nominal speed
- 150% overload capacity for 60 second

Total Harmonic Distortion shall comply with the provisions of IEEE 519. Necessary metering, self-diagnostic arrangement (including display and alarm facilities) shall be provided for local/ remote monitoring.

It shall be possible to manually start the motor locally from the local push button station, starter panel or in Auto mode through PLC.

Technical parameters

Main connection		
Voltage	:	3 phase, 415 +/- 10 % permitted tolerance
Frequency	:	45 to 65 Hz, maximum rate of change 17%/s
Imbalance	:	Max. +/- 3% of nominal phase to phase input voltage
Fundamental Power factor	:	0.97 (at nominal load)
Motor connection		
Voltage	:	3 phase, from 0 to applied incoming supply voltage, 3-phase symmetrical
Output Frequency	:	0 to 250 Hz
Frequency Resolution	:	0.01 Hz
Continuous Current	:	1.0 * I2N (normal use)
Short Term Overload Capacity (1min./10min)	:	I2max = 1.1 * I2N
Field Weakening point	:	8 to 300 Hz
Acceleration Time	:	0 to 1800 sec
Deceleration Time	:	0 to 1800 sec
Efficiency	:	Min. 97% at nominal power level
Environment limits		
Ambient temperature	:	0 to 45 deg. Cent.

Standard control connections

- 3 programmable differential analogue inputs (1 voltage signal, 2 current signals)

- 7 programmable digital inputs
- 2 programmables analogues outputs (current signal)
- 3 programmable digital outputs (from C relays)
- Optional analogue and digital extension modules can be added as well as a wide range of field bus adapters.

Protection

- Over current
- Short circuit at start-up
- Input phase loss
- Output phase loss
- Motor overload
- Earth fault
- Overvoltage
- Under voltage
- Over temperature
- Motor stall

Application macros

The features a selection of built-in, pre-programmed application macros for configuration of inputs, outputs, signal processing and other parameters. It shall have interfacing facilities to communicate data to SCADA system. These include:

- FACTORY SETTING for basic industrial applications
- HAND/AUTO CONTROL for local and remote operation
- PID CONTROL for closed loop processes
- TORQUE CONTROL for process where torque control is required.
- SEQUENTIAL CONTROL for processes where torque control is required.
- USER MACRO 1 and 2 for user's own parameter setting
- Comprehensive testing and diagnostic function

Tests

Each unit of Variable frequency drive shall be tested at the manufacturer's work. Test result must satisfy the efficiencies on various loads and at different frequency levels against their quoted values during bidding.

8.6.31 SOFT STARTERS FOR MV AND LV MOTORS

MV Soft Starter particulars

Description	**Unit**	**Particulars**
Type, Application and criteria for sizing		Clear Water Distribution Pumps (Starting current to be limited to 2.5 to 3 times the rated current of the motor)
Connection		On phase/neutral side of stator winding
Quantity	Nos.	Distribution Pump Stations
Rated voltage	kV	11 (12) for MV
Rated lightning impulse withstand voltage		
- Across the isolating distance	kV (peak)	70
- Phase to phase, between phases and across open switching devices	kV (peak)	60
Rated short duration power frequency withstand voltage		
- Across the isolating distance	kV (rms)	26
- Phase to phase, between phases and across open switching devices	kV (rms)	26
Installation		Indoor
Enclosure		
- Sheet steel thickness	mm	2
- Degree of protection		IP4X
- Color finish shade		Light Grey Semi Glossy
External cable details		6.4 / 11 kV, 3C x (*) Aluminum, XLPE, armoured
Type of cooling		Air cooled
Bypass arrangement	Required	By Vacuum contactor/Built-in with soft starter

Description	**Unit**	**Particulars**
Control supply	V	110V DC / 230 V AC as required for the control

LV Soft Starter particulars

Description	**Unit**	**Particulars**
Type, Application and criteria for sizing		Pumps and Blowers (Starting current to be limited to 2.5 to 3 times the rated current of the motor)
Connection		On phase/neutral side of stator winding
Rated voltage	kV	0.415 for LV
Rated lightning impulse withstand voltage		
- Across the isolating distance	kV (peak)	46
- Phase to phase, between phases and across open switching devices	kV (peak)	40
Rated short duration power frequency withstand voltage		
- Across the isolating distance	kV (rms)	12
- Phase to phase, between phases and across open switching devices	kV (rms)	10
Installation		Indoor
Enclosure		
- Sheet steel thickness	mm	2
- Degree of protection		IP4X
- Color finish shade		Light Grey Semi Glossy
External cable details		6.4 / 11 kV, 3C x (*) Aluminium, XLPE, armoured
Type of cooling		Air cooled

Description	**Unit**	**Particulars**
Bypass arrangement	Required	By Vacuum contactor/Built-in with soft starter
Control supply	V	110V DC / 230 V AC as required for the control

(*) Value to be ascertained by the Contractor after submitting design calculations subject to approval.

Constructional and Performance Features

Motor soft starters shall be switched reactance type or flux compensated type or electronic type.

Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for

a) control, metering and current transformers for differential protection, if specified

b) shorting (bypass) arrangement

c) bus bars

d) power cable terminations

e) push buttons with indicating lamps.

Soft starter shall achieve soft starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose.

Separate removable gland plates shall be provided for power and control cables.

Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

It shall be possible to manually start the motor locally from the local push button station, starter panel or in Auto mode through PLC.

Main Bus bars

Bus bars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints. Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit. Bus bars shall be of hard drawn copper conductor and of high conductivity, EC grade copper of 99.7% purity.

Earthing

A copper earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted / welded to the framework. All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

Panel Accessories and Wiring

Panel shall be supplied completely wired internally up to equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.

All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 sq. mm.

Terminal blocks shall be of stud type, 10 A rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

Accuracy class for indicating instruments shall be 1.0 or better. Instruments shall be 110 mm square, 240^0scale for flush mounting with only flanges projecting.

Push buttons shall be provided with inscription plates engraved with their functions. Indicating lamps shall be of clustered LED type. Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230 V, 1 ph, 50 Hz supply. They shall be complete with MCB and thermostat.

Each panel shall be provided with 230 Volts, 1 phase, 50 Hz, 5 A, 3 pin receptacle with MCB located in a convenient position. An interior illuminating lamp together with the operating door switch and protective MCBs shall be provided.

The DC and AC auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

Tests

Each unit of soft starter shall be tested as per relevant standards at the manufacturer's work. Test result must satisfy all the characteristics during starting and acceleration against their quoted values during bidding.

Cable Terminations

Cable termination boxes shall be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection.

Cable boxes for voltages in excess of 1 000 V shall be treated with anti-tracking varnish.

8.6.32 DISTRIBUTION BOARDS

Distribution Boards for use as service disconnecting means shall be circuit breaker equipped. Design shall be such that any individual breaker can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as a means of obtaining clearances as required.

Where "space only" is indicated, provisions shall be included to allow future installations of breaker sized as indicated. All panelboard locks included in the project shall be keyed alike.

Directories shall be typed to indicate load served by each circuit and mounted in a holder behind transparent protective covering.

The enclosure shall be constructed as per section on Low Voltage switchgears.

The door seal shall be of high quality and a pressured catch handle shall be employed.

Exterior cables (power source cables as well as feeding cables) shall be directly connected to the MCCB or isolator. Adequate space for exterior wiring shall be provided.

A permanent connection diagram identifying the feeders shall be provided in holder fitted with a transparent cover inside the door on completion of construction.

Provision for 25% spare for future expansion shall be provided.

Busbars shall be of tinned, hard drawn, high conductivity copper. They shall be insulated throughout their lengths by means of phase color sleeving. The busbar assemblies and joints shall be in accordance with the manufacturers/suppliers recommendations.

Live connections to and from busbars shall be either fully insulated or suitably screened and all covers screening the busbars and connections shall be provided with adequate warning labels

Grounding Bar shall be provided. The sectional area of the neutral bar shall be equal to the sectional area of the phase bar.

UL-listed bus current ratings shall be provided as indicated. Bus bars shall be supported on bases independent of the circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping.

An isolated neutral bus shall be provided in each panel for connection of circuit neutral conductors. A separate ground bus marked with a green stripe along its front and bonded to the steel cabinet for connecting grounding conductors shall be likewise provided.

8.6.33 ELECTRIC MOTORS

Motors shall comply with the requirements of IEC 60034, IEC 60072 and IEEE 3004.8-2016 - Recommended Practice for Motor Protection in Industrial and Commercial Power System as amended and supplemented by this specification.

Type and Rating

Except where specified otherwise or economically justified, all AC motors shall be of the constant speed, cage induction type with windings adequately braced for direct-on-line starting at the rated voltage. They shall be suitable for control by either circuit breaker or fused contactor.

Motors shall be continuously rated, Duty Type S1. Exceptions shall be permitted only when the intermittent or short time duty cycle can be accurately defined by the Contractor.

Three phase AC motors shall be rated for the voltages specified in the Specification and Single Line Diagrams. The minimum rated output of HV motors shall comply with IEC 34-1. The maximum rated output of LV motors shall not exceed 150 kW, except where it is approved by the Engineer.

Induction Motors Starting Method shall be either of the following types:

1. Less than 10 kW	:	415V Direct On Line (DOL)
2. 10 to 100 kW	:	415V Star-Delta / Variable Frequency Drive
3. 101 Kw TO 999 Kw	:	690V Inverter / Soft Starter / VFD
4. More than 1000 kW	:	11kV Primary Resistance Starter / Soft Starter / VFD

Air duct shall be provided for every VFD / Soft Starter/ Primary Resistance Starter compartments to eliminate hot air circulation inside the MCC. Contractor has to design and select the type of starter that shall be used for the efficient operation of the plant.

Contractor shall limit the Total Harmonic Distortion (THD) in the plant to a maximum of 5% for 415V system and maximum of 4% for 11kV system by installing suitable harmonic filters or reactors.

11kV Medium Voltage Motors

All medium voltage motors shall be provided with a primary resistance starter, soft starter or a variable frequency drive with by-pass option for RVAT (Reduced Voltage Auto Transformer) control in case of soft starter or VFD failure.

Each starter is to have isolation, over current and thermal protection, a contactor, control voltage C/B and terminals for output power and control cables. The power wiring shall be red, yellow and blue. The minimum size of all control wiring shall be 2.0mm2. The over current and thermal protection shall be coordinated so that both motor and starter equipment is protected.

Starting or stall current shall not be greater than 7 times the motor full load current.

Process display of every Soft Starter/Variable Frequency Drive shall be located in front of each compartment.

Warranty for Electric Motors

A minimum one-year manufacturer's warranty shall be provided for all motors. Warranty shall commence from the date of acceptance.

Insulation

Motors shall be insulated with materials complying with IEC 85. All motors shall have Class F insulation but the temperature rise shall not exceed the limits applicable to Class B.

Conditions of Operation

A.C. motors shall be capable of continuous operation under the service conditions within the Zone A voltage and frequency variations specified in IEC 34-1 Figure 13.

Unless otherwise specified, the motors shall be capable of continued operation at 75% rated voltage and rated frequency for a period of 5 minutes without injurious heating. In the event of loss of supply, all motors shall be suitable for restarting against the full residual voltage in the motor winding during motor run-down.

Starting Performance

Unless otherwise specified or required, cage induction motors up to and including 40 kW shall have a starting performance better than or equal to Design N in accordance with IEC 34 (External inertias for 50 and 60 Hz motors shall be in accordance with BS 4999 Part 112). Cage induction motors above 40 kW shall have a starting performance better or equal to Design D in accordance with BS 4999 Part 112. The starting current at full voltage shall not exceed 6 times full load current.

The starting torque at 80% voltage shall be adequate for starting the driven load under the most arduous conditions, such as open fan vane or open pump discharge valve. The accelerating torque at any speed and 80% rated voltage shall be not less than 10% of motor rated torque. In any event the motor starting torque at 100% rated voltage, and at all speeds between standstill and the speed at which breakdown torque occurs, shall be not less than 1.7 times the torque obtained from a load curve which varies as the square of the speed and is equal to 100% motor rated torque at rated speed.

The margins between the torques of the motors and driven plant shall include suitable allowances for impeller wear, fouling etc. during the life of the plant.

Electric motors shall be suitable for two successive starts with the motor already at full load working temperature, subject to the motor being permitted to decelerate to rest under operating conditions between successive starts.

After a cooling period of 30 minutes at rest another starting sequence of two successive starts shall be permissible.

Bearings

The type of bearings used in the motor shall be fully compatible with those used in the driven equipment.

The type of bearing, bearing numbers and regressing interval shall be stamped on each motor rating plate.

Bearings shall comply with the applicable ISO standards.

Bearings shall be designed to exclude the ingress of dust and water and sealed to prevent leakage of lubricant along the shaft.

Enclosures and Methods of Cooling

The degree of enclosure protection for motors shall be as follows unless otherwise specifically approved by the Engineer:

1. IP54 for indoor locations not subject to hosing.
2. Not less than IP 55W for outdoor locations, and indoor locations subject to hosing.
3. Where motors are exposed to solar radiation, sunshades shall be fitted, if required by the manufacturer to meet his guarantees.

The cooling classification for motors shall be as follows unless otherwise specifically approved by the Engineer:

- IC4AlA1 or IC5AIA1 for LV motors, or IC4AIAO for small power LV motors.

- IC4AlAl, IC5AlAI, IC6A1A1 or IC7AlW7 for HV motors.

- Ferrous metals should be used for the frames and end shields of all ratings of motors.

Aluminium and its alloys shall only be used when the manufacturer can demonstrate that such materials are entirely suitable for the particular application at its installation location.

Fans of identical motors shall be interchangeable without affecting motor balance.

Anti-condensation Heaters

To minimise condensation in all outdoor 415V, 690V, and 11kV intermittently used motors when out of service, heaters of an approved type and rating, suitable for operation from a 230 V a.c. single phase supply, shall be fitted inside the lower half of the stator frame.

The control of anti-condensation heaters shall be so arranged that they are normally energised when the motor is not running.

Terminals and Terminal Boxes

Winding terminations shall generally comply with BS 4999 Part 145. Separate non-compound filled, terminal boxes shall be provided for each of the following as applicable:

(a) Main (line) connections.

(b) Star point connections.

(c) Anti-condensation heater connections.

(d) Instrumentation and alarm devices.

All terminal boxes with the cables terminated shall have an enclosure classification not less than that of the motor itself. All terminal boxes shall be of an adequate size for the satisfactory termination of the cable(s) required or specified, including all applicable termination components.

All HV terminal boxes shall be provided with a desiccant indicator, externally sealed.

Terminals and terminal leads shall be to approval and shall be substantially designed for connection to a system having the symmetrical short circuit rating of the source switchboard, as limited by fuses, where applicable.

The clearances and creepage distances shall apply also to insulated terminals and connectors.

Porcelain terminal bushings and insulators shall not be used.

Main and star point terminal boxes of HV motors shall be of steel. Cast iron may only be used for LV motor terminal boxes and auxiliary terminal boxes.

Star point terminal boxes shall only be provided where required to accommodate neutral end current transformers and shall be positioned opposite the main terminal box.

Main HV terminal boxes at voltages exceeding 7.2 kV (Um) shall be of a type which restricts internal faults to earth faults only. Where pressure relief terminal boxes are used, they shall be designed to relieve the products of an internal fault safely to the outside, and not into the interior of the motor.

Provision shall be made for earthing the cable armour and the cable insulation screens, where applicable, in accordance with the cable termination method being used.

In auxiliary cable boxes either stud terminals or clamp terminals shall be provided.

The anti-condensation heater terminal box shall have a warning label adjacent to it, stating "Motor heater - terminals live".

Earth Terminal

All motors shall be provided with a means of earthing the frame, which shall be to the approval of the Engineer.

D.C. Motors

D.C. motors which are to operate from batteries shall be capable of operating under the service conditions at any voltage in the range of 80% to 110% of the nominal value.

Motors of the constant speed type shall be designed to operate with a permanent series resistor of suitable rating and with a contactor such that starters with tagged resistors are not required.

All d.c. motors shall be provided with brush gear which does not require to be moved to suit load conditions.

Motors connected to rectifier equipment shall meet the conditions of supply voltage and frequency specified for AC motors. Where necessary, rectifier equipment shall be fitted with a current limiting device.

8.6.34 PUSH BUTTONS AND SEPARATELY MOUNTED LOCAL PUSHBUTTON STATIONS

Pushbuttons, which may be of the illuminated or non-illuminated type, shall be shrouded or well recessed in their housings in such a way as to minimize the risk of inadvertent operation.

In instances where "enable" pushbuttons are required they shall be electrically interlocked with the normal control such that deliberate operation of the "enable" push-button is required before the normal control can take place.

The colour of pushbuttons shall be as follows:

- When mounted on pushbutton stations adjacent to running plant the stop button shall be colored red and the start button colored green.
- When mounted on the front of the contactor panel the stop button shall be colored red and the start button colored green.
- When mounted on panels or desks with adjacent indication lights both buttons shall be colored black, unless required otherwise by the Engineer.

Loose pushbutton stations, unless supplied as weatherproof free-standing enclosures, shall be of the metal clad weatherproof type suitable for wall or bracket mounting with a minimum enclosure classification of IP55. All outdoor mounted pushbutton stations shall incorporate a protective cover or guard (i.e. toughened glass door) to prevent inadvertent operation.

Control stations shall be clearly labelled showing the duty or drive to which they are applicable. Location of ammeters shall be agreed with the Engineer.

Pushbuttons used on covered desks, panels etc. may be of necessity require to be of special types (e.g. miniature, illuminated). The specifications and requirements for these special pushbuttons shall be agreed with the Engineer.

Isolator and Emergency Stop Push Button shall be provided in addition to the local push button station adjacent to all motors and machinery with exposed moving parts, couplings etc. to prevent any danger or harm to the operator. These shall also be provided on main and local control panels. The emergency pushbutton shall have a large "mushroom" head, be coloured red and incorporate a protective cover or guard to avoid accidental operation. These buttons shall automatically lock in the depressed position, requiring twist or key resetting. Contacts shall be provided to cause tripping of the associated circuit, prevent restart of the circuit and bring up an alarm in the Central Control Room.

Stop pushbuttons mounted local to motors shall trip the associated circuit breaker or contactor regardless of the control position selected.

The contacts of all pushbuttons shall be shrouded to minimize the ingress of dust, and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

8.6.35 EARTHING AND BONDING

The Contractor shall design and submit the complete Subgrade Earthing System, Potential Gradient Earthing System, and Above Ground Earthing System for the CP1 230/110/11kV Substation and the whole CP1 Seawater Reverse Osmosis Plant Buildings and Facilities for Engineer's approval.

The maximum permissible earthing system resistance of 1 ohm shall be designed for the Subgrade Earthing System to be able to (a) stabilize the circuit potentials with respect to ground and limit the overall potential rise, (b) to protect life and property from overvoltage, (c) to provide low impedance path to fault currents, (d) to ensure prompt and consistent operation of protective devices during ground faults and (d) to keep the maximum voltage gradient along the surface inside and around the substation within safe limits during ground fault.

The main earthing conductors for connection to all electrical equipment, cables, motors, panels, etc., shall be provided for connection to the main earthing system.

All non-current carrying metal parts of electrical equipment shall be bonded to an earth terminal or terminals mounted on the equipment and readily accessible.

All equipment terminals provided for an external earth connection shall be identified by indelible means unless such terminals are directly and visibly mounted on metallic equipment frames or earth bars, when such marking may be omitted.

Identification marks for earth terminals shall comprise the colours green/yellow in combination or a reproduction of the symbol no. 5019 in IEC 60417.

Assemblies containing electrical equipment, including switchboards, control boards and control desks, shall be provided with a separate copper earth bar running the length of the assembly. All metal parts and the earth terminal or terminals shall be bonded to this earth bar. Earthing connections shall not depend upon the bolting of steel/steel joints between adjacent panels or cubicles.

Earth bars shall be made of tinned Cu busbars of adequate size and suitably supported and braced to carry the rated short circuit current for the associated electrical circuits for the rated short- circuit current duration, without damage or excessive heating likely to damage joints, associated or adjacent components.

Switchgear and control gear assemblies shall be provided with two or more earth terminals unless otherwise specified. The copper earth bar shall be sized to withstand the maximum system earth fault current for three seconds without deterioration.

The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus shall be such as to comply with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall be a minimum of 100 mm2 cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and also providing this size is not less than the size of the largest incoming power supply conductor.

The metal cases of all instruments, relays and the like shall be connected to the panel earth bars by copper conductors of not less than 1.5 mm2 cross-sectional area, or by other means to the approval of the Engineer.

If the plant contains electronic equipment which is vulnerable to possible conductive interference, or if the equipment generates electrical noise, which could interfere with other plant or equipment, then separate earths may be supplied and the actual means of interconnecting with the station earth system shall be agreed with the Engineer.

The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:

1. Conductors above ground shall be tinned copper tape or minimum 150 mm2 Cu/PVC green/yellow conductor.

2. Conductor buried in the ground for subgrade earthing system or embedded in concrete for potential gradient earthing system shall be minimum 150 mm2 bare copper conductor.

The subgrade earthing system shall comprise one or more earth electrodes, bare copper earthing conductors, wire mesh or a combination of these in order to obtain the required earth resistance of 1 ohm.

Earth electrodes shall be of heavy-duty copper alloy of not less than 25 mm in diameter and 3000 mm long. Where multiple rods are use they shall be separated by a distance of not less than twice of the driven length.

Each earth electrode shall be connected to the earthing conductor by exothermic welding and shall be connected to the copper earthing busbar inside the 300mm x 300mm earth pit. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked `Electrical Earth'.

All materials used for the earth electrode installation shall be purposely made for the application, site conditions and shall be submitted for approval by the Engineer.

All excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

After the earth installation has been completed the Contractor shall demonstrate to the Engineer 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 route of buried conductor and electrodes. The markers shall be similar to those provided for cable routes.

The requirement for lightning protection shall be checked as per code of practice for lightning protection – IS: 2309 and if found necessary the same shall be provided by the Contractor.

Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

Circuit Protective Conductors

An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

1. A separate core within a multicore cable.
2. A separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor.The metal sheath of an armoured cable shall be bonded to the metal work of the apparatus and to the apparatus earth bar if any.
3. The copper sheath of a mineral insulated copper sheathed cable
4. An independent earthing conductor that run adjacent to

the circuit it protects.

Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel earth paths.

The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and 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 termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

Instrumentation Earth

An instrumentation earth bus shall be provided in each control panel. This shall comprise of a copper flat bar of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and shall be provided with a single earth connection to the control panel electrical power earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before on the control panel electrical earth bar. In this fashion all instrument earths shall be connected radially from the same earth point.

All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

Surge Protection Devices (SPD) associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

8.6.36 LIGHTNING PROTECTION SYSTEM

General

This Section specifies the lightning protection system for the building(s) or structure(s). This system provides safety for the building and occupants by preventing damage to the structure caused by lightning.

The design of this system is to be in strict accordance with this section of the specification.

The work covered under this section of the specifications consists of design, furnishing labor, materials and services required for the completion of a functional and unobtrusive lightning protection system approved by the Engineer.

The entire lightning protection system shall be designed and installed in accordance with the following codes and standards :

A) National Fire Protection Assoc. (NFPA) Document # 780
B) Underwriters' Laboratories, Inc. (UL) Standard # 96A
C) Lightning Protection Institute (LPI) Standard # 175

Contractor shall design and submit a complete shop drawing of the lightning protection system for Engineer's approval prior to commencement of the installation.

The shop drawing shall show the extent of the system layout designed for the structure along with details of the products to be used in the installation.

The system installation shall be made by a Contractor that specializes in the installation of lightning protection systems and be under the supervision of an LPI Certified Master Installer or Master Installer – Designer.

All materials shall comply in weight, size, and composition with the requirements of a nationally recognized testing laboratory. All equipment shall be properly listed and labelled. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and a member of LPI.

Equipment shall be the manufacturer's latest approved design of construction to suit the application where it is to be used in accordance with accepted industry standards and with NFPA, LPI, & UL requirements.

Acceptable Manufacturers –

- A/C Security Lightning, LLC (www.aclightningprotection.com)
- Advanced Lightning Technology, Ltd. (www.altfab.com)
- East Coast Lightning Equipment, Inc. (www.ecle.biz)
- FURSE, ABB Ltd. (www.furse.com; www.abb.com)
- Harger, Inc. (www.harger.com)
- Independent Protection Company, Inc. (www.ipclp.com)
- PENTAIR/ERICO (www.erico.com)
- Preferred Lightning Protection (www.preferredlp.com)
- Robbins Lightning, Inc. (www.robbinslightning.com)
- Thompson Lightning Protection, Inc. (www.tlpinc.com)

Materials

Class I materials shall be used for systems on structures not exceeding 75 feet in height and Class II materials shall be used for systems on structures exceeding 75 feet above grade.

Copper shall be of the grade ordinarily required for commercial electrical lightning protection work, generally designated as being 95 percent conductive when annealed.

Lightning protection materials shall be coordinated with building construction materials to assure compatibility. Copper lightning protection materials shall not be installed on aluminum surfaces. Copper system components within 2 feet of chimney exhausts shall be tin coated to protect against deterioration.

Strike termination devices shall be provided to place the entire structure under a zone of protection as defined by the Standards. Air terminals shall project a minimum of 10 inches above protected areas or objects. Air terminals shall be located within 2 feet of exposed corners and roof edges.

Metallic bodies having a thickness 3/16" or greater may serve as strike termination devices without the addition of air terminals. These bodies shall be made a part of the lightning protection system by connection(s) according to the Standards using main size conductors and bonding fittings with 3 square inches of surface contact area.

Cable conductors shall provide a two-way path from strike termination devices horizontally and downward to connections with the ground system. Cable conductors shall be free of excessive splices and sharp bends. No bend of a conductor shall form a final included angle of less than 90 degrees nor have a radius of bend less than 8 inches. Structural elements and design features shall be used whenever possible to minimize the visual impact of exposed conductors.

Cable down conductors may be concealed within the building construction or enclosed within PVC conduit from roof to grade level. Down conductors shall be spaced at intervals averaging not more than 100 feet around the protected perimeter of the structure. In no case shall any structure have fewer than two down conductors. Where down conductors are exposed to environmental hazards at grade level, guards shall be used to protect the conductor to a point 6 feet above grade.

In the case of structural steel frame construction, cable down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals averaging not more than 100 feet around the protected perimeter of the structure.

Exposed cable conductors shall be secured to the structure at intervals not exceeding 3 feet – 0 inches. Fasteners, nails, screws, or bolts shall be of suitable configuration for the intended application and of the same material as the conductor or of electrolytically compatible materials. Galvanized or plated steels are not acceptable.

Connectors and splicers shall be of suitable configuration and type for the intended application and of the same material as the conductors or of electrolytically compatible materials.

Ground terminations suitable for the soil conditions shall be provided for each downlead conductor. A separate earth pit with ground electrode shall be provided for each of the downlead conductor and should be minimum 7M away from the plant subgrade earthing system conductors and electrodes.

Where the structural steel framework is utilized as main conductors for the system, perimeter columns shall be connected to the grounding system at intervals averaging 60 feet or less on the protected perimeter. For any structure in excess of 60 ft. in vertical elevation above grade, a ground loop interconnecting all ground terminals and other building grounded systems shall be provided.

Common interconnection of all grounded systems within the building shall be accomplished using main size conductors and fittings. Grounded metal bodies located within the calculated bonding distance as determined by the formulas of the Standards shall be bonded to the system using properly sized bonding conductors.

Surge suppression shall be provided at every system entrance to the structure to prevent massive lightning over voltages from entering the structure. Additional surge protection for internal electronic equipment may be determined through cost-benefit analysis by a trained Engineer.

The installation shall comply with the requirements of NFPA 780, UL 96A, and LPI 175.

The installation of the lightning protection system components shall be done in a neat and workmanlike manner.

Roof penetrations required for down conductors or for connections to structural steel framework shall be made using through-roof assemblies with solid rods and appropriate roof flashings. The roofing Contractor shall furnish the methods and materials required at roofing penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof. (Note: The roofing Contractor will be responsible for sealing and flashing all lightning protection roof penetrations as per the roof manufacturer's recommendations.

The lightning protection roof penetrations and/or method of conductor attachment should be addressed in the roofing section of the specifications.

Upon completion of the lightning protection installation, the installing Contractor shall provide Engineer an as-built drawing of the system, along with copies of the certificates of completion.

8.6.37 CONDUITS AND ACCESSORIES

Conduit installations shall comply with IEC standards 60364, 60621 and 60981. Installations shall also be compliant with local regulations, unless otherwise approved by the Engineer.

All conduit and conduit fittings shall comply with IEC 60423. Unless otherwise approved, all conduit and conduit fittings shall be thread able steel conduit with minimum enclosure classification IP55, heavy mechanical protection and high resistance to corrosion inside and outside. No conduit smaller than 20mm diameter shall be used.

Standard circular boxes or machined face heavy duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanised, weatherproof and fitted with external fixing lugs.

Where conduit is terminated so that the bare end of the conduit is exposed the conduit end shall be fitted with a brass bush.

The use of running threads, solid elbows and solid tees will not be permitted.

Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10m in straight-through runs.

Conduit runs shall be in either the vertical or horizontal direction, unless otherwise approved, and shall be arranged to minimise accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.

Conduits shall be supported on heavy galvanised spacer saddles so as to stand off at least 6mm from the fixing surface.

All conduits run in any circuit are to be completed before any cables are pulled in. Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate earth continuity conductor shall be provided.

Liquid-tight Flexible Conduit

Contractor shall use Liquid tight flexible conduit in connecting the motor power and local push button station control cables which is made of a flexible galvanized metal core with sunlight resistant thermoplastic outer jacket.

Liquid tight flexible conduit shall be manufactured in accordance with UL-360 - Steel Conduits, Liquid-Tight Flexible.

PVC coated gray color flexible conduits shall be used for the final connection to removable field apparatus such as motors, RTD probes and the like.

Conduit installed outside shall be stabilized against ultraviolet light.

Where mounted on moving parts of machinery or where subject to mechanical damage the conduit shall be flexible PVC covered galvanized steel.

All flexible conduits shall be terminated in purpose-built glands.

8.6.38 CABLE SUPPORT SYSTEM

Cable ladder racking, trays and ducting shall have a minimum of 20 percent spare capacity at the end of the contract.

All fixings to concrete or masonry shall be of the expansion type set in holes. Explosive powder-charged fixings shall not be used.

Fixings to structural steelwork shall be by clamping, not welding or drilling, except with the specific prior approval of the Engineer.

Cable support systems shall be installed in accordance with the manufacturer recommendations to give a maximum between support deflections of 10 mm when carrying the final number of cables to be installed.

All steel supports, frames, hangers and the like shall be electroplated and in most areas hot dip galvanized with three coats of powder epoxy.

All exposed threads on support systems, conduit and other places where the galvanizing finish has been removed shall be painted with galvanized paint and three coats of powder epoxy. Spray cans type of paint shall not be used.

All lengths of the cable support system shall be bonded to earth.

The Contractor shall submit to the Engineer a layout of his proposed method of reticulation throughout the Plant showing positions of all cable ladder, tray or ducting system.

Cable Ladder

Cable ladders shall be manufactured from ***non-corrodible material including its supports***. They shall be completed with accessories including hangers, brackets and cable clips.

The Contractor shall supply and erect all cable ladders and all brackets and fabricated steelwork necessary to support the cable ladder and shall ensure that they are adequate in all respects for the loading imposed.

All changes in direction shall be made using purpose made slow radius bends and cranks as manufactured for this purpose.

Cable ladders installed outside the building shall be provided with cover.

Cable Trays

Cable trays shall be manufactured from ***non-corrodible material including its support*****s** and shall be provided in strict accordance with the manufacturer's printed instructions. Allowable cable fill areas shall meet the requirements of the specification. Prior to installation, cable tray fills shall be verified based on cables and trays actually provided.

Continuous grounding of cable trays including bonding jumpers shall be maintained in accordance with the grounding requirements of this specification.

Cable trays shall be installed using hangers and supports on 2.4 metre centres, maximum.

Cable tray systems shall be composed of straight sections, angle couplers, reducers, fittings, and accessories as defined in the latest IEC / British Standards.

The cable tray and fittings shall be hot-dipped galvanized steel with three coats of epoxy coating. It shall be also of the ladder type with 150 mm spacing with a minimum loading depth of 76 mm and nominal width as indicated. When required in corrosive locations, cable trays shall be made of rigid heavy duty industrial grade plastic material.

Where exposed to sewer or other environment that may cause corrosion, suitable non-corrodible materials shall be utilized to prevent corrosion. The Engineer shall approve the alternative non-corrodible material.

All nuts, bolts, and washers shall be stainless steel 304.

Loading capacities shall meet weight classification with a safety factor of 1.5.

Steel cable trunking may be used for running numbers of insulated cables or wires in certain positions to the approval of the Engineer. The trunking thickness shall not be less than 1.2 mm. Connection of conduit to trunking shall be with socket and male bush. All trunking shall be manufactured from hot-dip zinc coated steel sheet with three coats of powder epoxy.

8.6.39 CABLES AND WIRES

Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, number of cores, length, result and date of tests. Cables manufactured more than 12 months before delivery shall not be accepted.

All cables shall be 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.

EHV / MV / LV Cables shall comply with the following International Standards, including those referred to therein.

IEC 60183, 60227, 60502, 60885 and IS 7098, 5831, 8130, 1554, 10810.

Control cables shall be 2C, 3C, 4C, 7C, 12C and 19C type. Minimum size of conductor for control cables shall be 1.5 sq.mm. Copper.

All power cables shall be sized based on continuous current capacity, maximum permissible voltage drop of 3% and rated short circuit current withstand. In addition, de-rating factors for variation in ground/air temperature, grouping of cables, depth of laying, number of racks, etc. shall be considered for cable sizing.

All EHV, MV and LV cables shall be subject to routine tests in accordance with the relevant IEC and Indian Standard Specifications.

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 following tests as applicable but not limited to:

- high voltage dc insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable;
- insulation resistance test;
- core continuity and identification;
- conductor resistance test
- Elongation test
- Smoke density test
- HCl gas generation test
- Anti rodent test (Presence of lead)

Telecommunication Cables

External Use

The cable shall be cellular polyethylene insulated armoured telephone cable manufactured generally in accordance with Indian Department of Telecommunications Specifications. 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 galvanised steel wires shall be applied over this sheath.

A black coloured PVC or polyethylene sheath shall be applied overall.
Installed in ducts, pipe ducts and direct in the ground.

Internal Use

The cable shall have tinned copper conductors of 0.5 mm diameter with PVC insulation and PVC over sheath. It shall comply generally with Indian Department of Telecommunications Specifications.

The colour of the sheath shall be cream.

For use indoors for internal distribution and connection to extension instruments, cables shall be installed in conduit, trunking or clipped direct.

Instrumentation Cables

Contractor shall include in his scope the supply and laying of instrumentation signal and instrument power supply cables and associated civil / mechanical work required for completing the system.

Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.

Cable joints in instrument signals and power supply cables shall not be permitted.

Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground. Cables shall be capable of operating satisfactorily under a power supply system voltage variation of ±10%, a frequency variation of ±5.0% and overall variation limited to ±10%.

a) Cables for Digital Signals

650V/1100 V grade multicore cables, multistranded high conductivity annealed 1.0 sq.mm stranded tinned copper conductor, extruded PVC insulated, overall screened with braided wire or with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium tape, inner sheathed with extruded PVC, armoured with galvanized steel wire overall sheathed with extruded PVC conforming to IS:1554 and IEC:189 Part II.

b) Cables for Analog Signals

650 V/1100 V annealed, tinned, high conductivity 1.0 sqmm stranded copper conductor extruded PVC insulated two/ three cores twisted into pair/ triad, laid up collectively, individual pair/ triad shielded and overall shielded with wire braiding or aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanized steel wire, overall sheathed with extruded PVC conforming to IS:1554 and IEC:189 Part II.

SCADA System

Fiber optic cable shall be applied to the SCADA system to integrate PLCs located at each local control room and operator stations located at the SCADA room. FOC shall be single mode, glass made core and clad and PVC covered with tension member, jelly filled and PVC sheathed. Maximum attenuation of OFC shall be 0.4 dB/k m and 0.3 dB/km at 1310nm and 1550nm wave length light respectively. FOC shall be installed in HDPE conduits including all accessories like couplers, etc for underground installations.

Cable Rating

The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.
In assessing the rating of any cable or wire, the following factors shall be taken into account:

1. Supply voltage and frequency
2. Maximum voltage drop permissible
3. Type and magnitude of load
4. Fault level and duration related to circuit protection relays and fuses
5. Circuit over current protection
6. Route length and disposition of cables
7. Ambient temperature
8. Method of installation

All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 50 deg.C. The design current of any circuit shall exceed the full load current of the supplied device by at least 25%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.

Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. While sizing cables for the remote operation of shunt trip coils the Contractor shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation.

Cable Colors

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:

3 Phase+ N	-	red, yellow, blue & black
Single Phase	-	red &black, yellow & black, blue& black
Earth Wire	-	yellow/green
Control	-	blue (DC) Red (AC)

Cable Conductors

Copper conductors shall be used throughout. Cores of cross-sectional area greater than 1.5 mm2 shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 2.5 mm2. Small power and control cables shall be of a minimum cross-section of 4.0 mm2.

Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm^2 flexible and stranded.

Instrumentation and control cabling shall be of a minimum cross-section 1.0 mm^2 .

EHV/ MV and LV cables shall be sized as a minimum for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

Cable Installation

All 230kV/110kV/11kV EHV/MV cables in the GIS Substation shall be installed in cable trenches in corrosion proof cable ladders / trays , supports & accessories. HDPE pipe sleeves with concrete encasement shall be used for entrance of cables into the cable basement and for road crossings.

A uPVC ducts with concrete encasement and manholes shall be installed for 11kV cables installed outdoor to supply the 11kV Electrical Rooms in the plant. HDPE pipe sleeves with concrete encasement shall be used for entrance of cables into the cable basement and for road crossings. Manhole shall be provided to terminate the HDPE pipe sleeves and uPVC ducts before entering the substation building cable basement.

Low Voltage Power Cables, Control Cables, and Instrumentation Cables installed outdoor shall also be installed in cable ducts encased in concrete and manholes. HDPE pipe sleeves with concrete encasement shall be used for entrance of cables into the cable basement and for road crossings.

Low Voltage Power Cables, Control Cables, and Instrumentation Cables installed indoor shall be installed in corrosion proof cable ladders / trays, supports and its accessories 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 of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference.

In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs. A ***corrosion proof cable support system and its accessories*** shall be provided for power, control, and instrumentation cables.

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 Plant. Where this is not practical a separation of 150 mm shall be maintained between power, control, instrumentation cables when run on the same support system.

Heavy duty **corrosion proof** galvanized iron cable tray and ladder racking shall be used for cable support systems. **Heavy duty plastic cable tray and corrosion proof support systems** shall be used in areas used for the storage and handling of chlorine and other chemicals. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

Instrumentation Cabling

In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilised in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labelled junction boxes shall be constructed of die cast aluminium and provide degree of protection IP 65.

Separate cables shall be used for digital and analogue signals at all times. Instrumentation cables shall be continuous without any joints. Digital and analogue signals shall be segregated within junction boxes.

SCHEDULE OF TECHNICAL REQUIREMENTS OF XLPE POWER CABLES

SL. No	**Description**	**230kV**	**110 kV**	**33kV**	**11kV**
1	Rated system voltage	230kV	110 kV	33kV	11kV
2	Max. permissible system	245kV	145kV	36kV	12kV

	voltage				
3	Rated frequency	50Hz	50Hz	50Hz	50Hz
4	Max. operating current				
5	No. of cable	1/Phase	1/Phase	1/phase	1/phase
6	Cross sectional area				
7	Impulse withstand voltage	1050kV	650 kV	170 kV	75 kV
8	Power frequency withstand voltage	460kV	275 kV	70 kV	50 kV
9	Shape of conductor	Segment	Segment	Compact round	Compact round
10	Insulation thickness				
11	Min. bending radius				
12	DC resistance at 20^0C				
13	Short circuit rating for 1 sec				
14	Three phase symmetrical fault current for 1 sec				

Type Test Requirements for XLPE Power Cable (110kV & 230kV):

1. Bending test on Cable
2. Ten Delta measurement test
3. Heating cycle voltage test
4. Partial discharge tests:
5. At ambient temperature, and at high temperature.

8.6.40 CABLE INSTALLATION

Underground Cable Duct with Concrete Encasement

Underground duct lines shall be constructed with concrete encasement. The concrete encasement shall be rectangular in cross section and shall provide at least 75 mm concrete cover for ducts. Conduits shall be separated at least 50 mm apart. The kind of conduits used in any one-duct bank shall not be mixed. The top of the concrete envelope shall not be less than 460 mm below grade except those under roads and pavement, which shall be not less than 610 mm.

Duct lines shall have a continuous slope towards hand holes with a pitch of 75 mm in 30 meters. Except at conduit risers, changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 7.62 meters. Sweep bends may be made up of one or more curved or straight sections or combinations thereof. Manufactured bends shall have the following minimum radii corresponding to the given conduit diameters, as shown in Table 3.

Minimum Radius Requirements

Conduit Diameter	Minimum Bending Radius
< 75 mm	457 mm
$\geq$ 75 mm	914 mm

Conduits shall be terminated in end-bells where duct lines enter hand holes or cable trenches. Separators shall be of pre-cast concrete, high impact polystyrene, steel or any combination thereof.

The joints of conduits shall be staggered by rows and layers so as to provide maximum strength for the duct line. During construction, partially completed duct lines shall be protected from entry of debris by means of suitable plugs. As each section of a duct line is completed from hand hole to hand hole, a brush thorough having a diameter of the duct, shall be drawn until the conduit is clear of all particles of earth, sand and gravel; then immediately install conduit plugs. Where required, cast-in-place hand holes/manholes shall be provided complete with all accessories, drain facilities and strength indicated. Concrete hand holes/manholes shall have a smooth trowel finish for floors and horizontal surfaces. Walls shall be constructed on a footing of cast-in-place concrete. Walls and bottoms shall be of monolithic concrete construction.

Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Casting shall be free from warps and blowholes that may impair their strength and appearance. Exposed metal shall have a smooth finish and sharp lines. All necessary lugs and brackets shall be provided. Pulling irons and other built-in items shall be set in place before depositing the concrete. A pulling-in iron shall be installed in the wall opposite each duct entrance.

Ground rods for hand holes shall be installed in electrical distribution will be 25 mm diameter by 3000 mm long copper-clad steel, which shall be connected to the cable shielding, metallic sheath at each joint or splice by means of a 22 mm^2 braided tinned copper wire. Ground rods shall be protected with a double wrapping of pressure sensitive plastic tape for a distance of 150 mm above and 150 mm below concrete penetrations. Ground wires shall be neatly and firmly attached to hand hole/manhole walls and the amount of exposed bare wire shall be held to a minimum.

Cables Installed in Conduit

Conduits shall be galvanised heavy gauge solid drawn or welded screwed steel type/ PVC type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanised.

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 boxes 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 25 mm, straight through joint boxes shall be of the trough 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 to 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 Engineer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.
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.

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 Engineer before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanised cable trunking. Conduits installed on structural steelwork shall be secured at spacings 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 Engineer. Any drilling or access which is required through any structural member of the building shall be agreed with the Engineer before carrying out the work.

Exposed threads and places where galvanising 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.

Concealed Installation

Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets 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.

Conduit 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. Conduit installed in floors shall be sealed against ingress of moisture.
The conduit installation shall be inspected and approved by the Engineer before the building operation conceals the work.

Cable Installed in Flexible Conduit

Flexible conduit shall be of the waterproof galvanised 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 conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit 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., shall not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

Cables Installed on Cable Tray

Cable tray 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 and not less than 2 mm for trays from 300 mm to 600 mm width.

Cable Ladders and Perforated Cable Trays, its supports, and accessories for outdoor installation shall be of ***hot dipped galvanized with three coats of powder epoxy coating*** in order to have resistance to corrosion. Cable tray for use in areas where chlorine gas and other corrosive chemicals that may be present shall be constructed from rigid non metallic PVC with UV Resistant. Cable tray supports shall be of a compatible finish (***hot dipped galvanized with three coats of powder epoxy coating)*** with the associated cable tray.

All cable tray tees, intersection units, bends, turns and sets shall be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray.

Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.

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 tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid-span.

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 galvanised trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanised paint. 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 Engineer, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray 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.

Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray.

The sizing of the cable tray shall provide a minimum of 25% spare capacity.
The tray shall be run at least 150 mm clear of plumbing and mechanical services.

Cable Installed on Ladder Rack Systems

Ladder racking either light or heavy weight 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.

The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

Cable 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.
Cable Installed in Internal Floor Trench

In Shallow trenches (maximum depth 600 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 layer 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, cables shall be installed on the walls of the trench in an approved manner.

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' wet 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

Cable Terminations and Joints

Power Cable 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 provision 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 sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable 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.

Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

Multicore or Control Cable Terminations

A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energised when the main equipment is isolated shall be suitably screened and labelled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

Cable Fixings

Suitable Ties and strapping shall be used for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing. Large single cables shall be secured with cable clamps or cable cleats.

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 Engineer. 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.
Cable Glands

Glands shall generally be of the mechanical compression hexagon type. Earth continuity of brass glands shall be assured. This may be achieved by the rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment. Each gland shall be installed complete 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.

Glands for single core cables shall be constructed from non-magnetic materials.

Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.

Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.

For dry indoor situations, standard industrial glands with shrouds are acceptable.

For hazardous areas, glands conforming to EExd standard shall be used with double seal and shroud.

Power cable glanding arrangements in hazardous areas shall incorporate an insulated adapter and earth link. This shall provide the facility to disconnect the armouring from the glanded device in order that a true earth loop value may be measured when carrying out tests on the installation.

Marking Locations of Underground Cables in Ducts

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 m 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 Engineer.

The markers shall be marked `electric cable' in English and the vernacular.

8.6.41 FIRE PROOF SEALING (FPS) SYSTEM

Fire proof sealing system shall be provided and shall consist of Fire- stops / fire-seals for sealing of cable / cable tray and conduit/ pipe penetrations, both horizontal and vertical, through brick or RCC walls / floors, to prevent the spread of fire from one area to Other areas by fire - resistant barriers.

The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop.
The FPS system shall comply in all respects with the requirements of the codes and standards mentioned herein IEC-331 and IEC-332.

Fire Stop / Seal

The FPS system adopted for cables or cable trays penetrating through walls and floor openings, or cables passing through embedded conduits / pipes / pipe-sleeves, constitutes a `fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

Performance Requirements

Requirement of fire stops

i. The material, design and construction of the fire stops shall be such as to provide a fire-rating of 120 minutes for a fire on any side and meet all requirements listed in this specification and the relevant codes and standards.

ii. The materials used in the fire stops shall be non-hygroscopic, compatible with the type of cables.

iii. The fire stops shall be suitable for retrofitting of cables through the penetration seal without disturbing the sealing of the cables already existing.

Application of Fire Proof Sealing System

Fire stops shall be provided for cable penetration openings listed below:

i. The passage of cables / cable trays pipe sleeves / embedded conduits through walls / floors.

ii. Vertical raceways, if any, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

iii. Cable entry through openings in floor slabs.

Contractor shall furnish the test certificates for the fire stops after award of Contract for Employer's Representative review. If the certificates are not satisfactory, all the tests shall be conducted free of cost. The offered system i.e., fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Employer's Representative approval.

Performance Tests:

a) The fire stops shall be subjected to the following type tests:

i. Fire Rating Test
ii. Hose Stream Test

b) Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

c) Preconditioning of fire stop test specimens

Before conducting the Fire Rating and Hose Stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the Fire Rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable penetration fire stop, with a maximum temperature limit on the unexposed surface of 2000C.

8.6.42 NITROGEN GAS INJECTION FIRE PROTECTION SYSTEM AND TRANSFORMER FAST DEPRESSURIZATION SYSTEM

Contractor shall Design, Supply, Deliver, Test and Commission the Nitrogen Gas Injection Fire Protection System and Transformer Fast Depressurization System for the protection of the Auto Power Transformers at the 230/110/11kV GIS Substation as per ***NFPA 850 2020 edition recommendation***. The system shall be linked with the Main Fire Alarm System of the CP1 Plant.

This specification covers the design and performance requirements of Nitrogen Gas Injection Fire Protection System and Transformer Fast Depressurization System for the 230/110/33kV, 150MVA ONAN/ONAF Auto Power Transformer and 110/11/11kV, 50 MVA ONAN/ONAF Auto Power Transformers at the Gas Insulated Switchgear Substation .

It is not intended to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of Engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the ENGINEER.

Ambient temperature for design of all equipment and high salinity level at site shall be considered by the Contractor during the bidding and design stage of the project.

The system shall be reliable without making any mal operation. Even if undesirable nitrogen gas injection is made into the transformer tank under normal transformer condition without the internal faults. Restoration of transformer by vacuum oil purification up to re-energizing shall complete as soon as possible after the undesired gas injection.

In case of an event of the control power failure, the system shall be able to be operated manually.

Various equipment to perform the required fire protection as per NFPA 850 2020 edition recommendation shall be provided under this Contract.

NFPA 850 Recommendation for Transformer Fast Depressurization System

The Fast Depressurization System shall comply with the description for all Power Plants and Substations of the National Fire Protection Association, NFPA 850 Recommendation, 2020 edition, which defines the following criteria as detailed below :

1. ***"a passive mechanical system",*** without the use of sensors, detectors, actuators, or switches sending electrical signals to activate a Depressurization Section.
2. ***"fast depressurization"***, with no obstructions to a direct depressurization flow such as pistons, butterfly valves or other internal parts.
3. ***"triggered by the transient pressure peak generated by the short circuit"*** that propagates at a speed of approximately 4,000 feet per second (ft/s), or 1,200 meters per second (m/s).
4. ***"activates within milliseconds before static pressure increases"*** which means that the Depressurization Sections should be correctly sized to avoid the static pressure to increase as soon as opened.

The Fast Depressurization System shall be made of several sets, each playing a different role:

1. ***The Depressurization Set (DS) with Rupture Disk (RD)*** shall prevent Transformer or Reactor, On Load Tap Changer (OLTC), and Oil Cable Box (OCB) / Oil Bushing Cable Box (OBCB) or Bushing Turrets (BT) explosion following a short circuit.

Each Depressurization Set (DS) shall relieve the dynamic pressure within milliseconds and a Decompression Chamber (DC) favors high-speed depressurization. The Depressurization Time is the critical parameter. Therefore, the Depressurization Set (DS) diameter shall be calculated individually for each Transformer or Reactor power and type.

2. ***The Inert Gas Injection Set (IGIS)*** is required for personal safety to avoid the bazooka effect caused by the explosive gas in contact with air (oxygen) when the tank is opened after the incident. The IGIS creates a safe environment in the Transformer or Reactor and the On-Load Tap Changer (OLTC) after the depressurization process by injecting an inert gas flow, which also cools the tank.

3. ***An Oil-Gas Separation Tank (OGST)*** shall collect the depressurized oil and explosive flammable gas to separate oil from gases.

4. ***The Explosive Gas Evacuation Pipe (EGEP)*** shall then channel the gas to a safe and remote area.

The efficiency and reliability of the Fast Depressurization System shall be ensured by the Depressurization Set (DS), which shall be activated by the First Dynamic Pressure Peak of the pressure wave, avoiding transformer explosions before static pressure build-up.

No sensors and no electrical actuators shall be involved in the depressurization process because they add unacceptable operating delays.

The Transformer or Reactor Depressurization Set (DS) shall preferably be type Vertical

(VDS) and located on the tank cover.

If problems with high voltage clearances render impossible to fit the VDS on the tank cover, then a 45 degrees Depressurization Set (45 DS) or a Horizontal Depressurization Set (HDS) shall be installed. For smaller transformers, typically up to 20 MVA, the Fast Depressurization System can be a 90 degrees Depressurization Set (90 DS).

The transformer manufacturer shall integrate the OGST in the conservator OGST as often done for the On-Load Tap Changer (OLTC) oil conservator; the transformer conservator partition devoted to the OGST should have a volume of 0.5 m^3 - 17.6 ft3.

Several OGST arrangements are the following:

1. SOGST, Sliced OGST, recommended and located in a slice of the conservator.
2. WOGST, Wall mounted OGST, attached to the transformer or reactor firewalls.
3. EOGST, Elevated OGST, elevated above the transformer conservator.

A control panel shall be able to monitor all the signals necessary for the operation logic of the Fast Depressurization System. In option, the integration of a PLC and HMI will allow the records of all events and the monitoring of several Fast Depressurization System.

Two types of injection of inert gas shall be provided :

1. automatic injection
2. manual injection

For the automatic injection, two signals shall be received simultaneously by the control panel to start up the Inert Gas Injection:

1. The integrated Rupture Disk Burst Indicator confirming the activation by the First Dynamic Pressure Peak and the beginning of the depressurization process;
2. One of the electrical protection signals, confirming the electrical fault of the protected Transformer or Reactor, the On-Load Tap Changer (OLTC), the Oil Cable Box (OCB) / Oil Bushing Cable Box (OBCB) or Bushing Turrets (BT).

The manual injection can be triggered from:

1. The control panel in the control room.

a However, alarms should remind operators of the necessity to inject inert gas before maintenance team starts working (bazooka effect).

2. The Inert Gas Injection Set (IGIS), close to the transformer or reactor in a safe

area.

Upon request, the injection set can be completely disconnected to cancel all risk of spurious injection into the transformer or reactor.

The inert gas flow shall prevent air (oxygen) to be in contact with the explosive gases and shall further cool down the Transformer or Reactor, the On-Load Tap Changer (OLTC), and the Oil Cable Box (OCB) / Oil Bushing Cable Box (OBCB) or Bushing Turrets (BT) as inert gas injection should run for 45 minutes. As a result, no more explosive gases remain when the inert gas injection is over. Then, maintenance teams can start working safely.

The oil fire extinguishing system "Inert Gas Drain and Stir" shall back up the Fast Depressurization System for transformers with power range starting at 20 MVA.

The fire extinction backup "Inert Gas Drain and Stir" shall be activated when the control panel received two signals:

1. One of the Linear Heat Detector located on the transformer or reactor;
2. One of the transformer or reactor electrical protections.

Sizing

Pressure Rise Calculations

To avoid Transformer or Reactor, On Load Tap Changer (OLTC), and Oil Cable Box (OCB) / Oil Bushing Cable Box (OBCB) or Bushing Turret (BT) explosion and fire, the supplier shall have specified likely locations of dielectric failure and subsequent arcing events within the oil-filled tank. These locations should be compared to Depressurization Set (DS) position and sizing to maximize the efficiency of depressurization.

Using a physical model capable of describing a multi-phase compressible fluid, quantitative predictions should be made for the following:

1. The creation of high-pressure explosive and flammable gas within the tank during a low-impedance fault;
2. The resultant pressure waves' speed and amplitude;
3. The subsequent increase in static, or average, pressure throughout the tank prior to the activation of the Fast Depressurization System.

Depressurization Calculations

The physical model should accurately represent the following to properly simulate the Fast Depressurization System:

1. The temporal and pressure gradient dependence of the opening of the Rupture

Disks (RD);

2. Transformer tank pressures as a function of time, considering relevant energy sinks such as thermal diffusion, viscosity, tank deformation, etc.;

3. Resultant stresses and deformations on the transformer tank during the pressure drop;

4. Oil-gas mixture volume to be evacuated to avoid transformer explosion and fire as a function of time.

The Fast Depressurization System supplier shall provide Computerized Fluid Dynamic (CFD) and Fluid Structure Interactions (FSI) simulations for the transformer most probable low impedance energy fault (megajoule, MJ).

Tests and Experience

The Manufacturer of the Fast Depressurization System shall have the following qualifications:

1. Proven 10 years of experience with minimum 1,000 units installed in a major substation projects.

2. Certify that the Fast Depressurization System is activated with the first dynamic pressure peak before the static pressure rises and the transformer or reactor tank explodes.

3. Provide a Test Certificate showing a campaign of at least 25 successful live tests of electric arcs events inside the transformer or reactor tank closed and full of oil, from which at least 3 tests have been done with arcs of more than 1 megajoule (MJ).

   This Test Certificate must be granted by a recognized and independent High Voltage Laboratory from a country different than the country of manufacture of the Fast Depressurization System.

4. Provide evidence that the Fast Depressurization System has prevented the explosion of at least 8 transformers or reactors over 60 MVA in 6 different countries with 8 Certificates of Successful Activation signed by the transformer or reactor owner.

Technical Specification Verifications

The Table below shall be used to evaluate each transformer or reactor. Depending on its components, it will be adapted as the Transformer elements. This shall ensures that the system complies with the Technical Specifications of the Fast Depressurization System.

The manufacturer representative shall affix his name and signature on the table below to certify and guarantee that the explosion and fire prevention system for the Transformer complies with the specification of the Fast Depressurization System as stated on the table.

8.6.42.1 Fast Depressurization System Table for Technical Specification Verifications

N°	DESCRIPTION	REQUIRED	GUARANTEED
	FAST DEPRESSURIZATION SYSTEM ON TRANSFORMER AND REACTOR		
A.	**Fast Depressurization System compliance with NFPA 850, 2020 Edition**		
A.1	"Passive - Mechanical" activated without sensors or electrical actuators	Yes	
A.2	"Fast Depressurization", with no obstructions to a direct depressurization flow such as pistons, butterfly valves or other internal parts.	Yes	
A.3	"triggered by the transient pressure peak generated by the short circuit" that propagates at a speed of approximately 1,200 meters per second, 4,000 ft/s.	Yes	
A.4	"activates within milliseconds before static pressure increases" which means that the Depressurization Sections should be correctly sized to avoid the static pressure to increase as soon as opened.	Yes	
B.	**Transformer Elements**		
B.1	Tank	Yes	
B.2	On Load Tap Changer (OLTC)	Yes	
B.3	Oil Cable Box (OCB) / Oil Bushing Cable Box (OBCB) or Bushing Turrets (BT)	Yes	
C.	**Security to avoid the bazooka effect killing operators at tank opening**		
C.1	Inert Gas Injection Set (IGIS)	Yes	
C.2	Oil-Gas Separation Tank (OGST)	Yes	
C.3	Explosive Gas Evacuation Pipe (EGEP)	Yes	
D.	**For physic and mathematic investigations, a multi-physic model must calculate the depressurization based on time and energy**		
D.1	Computerized Fluid Dynamic (CFD) Simulations	Yes	
D.2	Fluid Structure Interaction (FSI) Simulations	Yes	
E.	**Test Certificate for electrical arcs inside a transformer or reactor tank closed full of oil granted by a recognized and independent High Voltage Laboratory from a country different than the country of manufacture**		
E.1	Twenty - Five (25) Succesful Live Tests	Yes	
E.2	Three (3) Tests must be with electrical arcs of more than 1 megajoule (MJ)	Yes	
F.	**Sucessful Activations during the transformer or reactor operation Successful Activation Certificates signed by the owner of the transformer or reactor**		
F.1	Eight (8) Certificates of six (6) different countries	Yes	

AFFIDAVIT

The company and its legal representative guarantees and certifies that the explosion and fire prevention system for the transformers/reactors complies with what it is stated in the table above, assuming the responsibility of the legal and economic consequences for declaring false data.

Company Name: ______________________________

Legal Representative Name: ______________________________

Identification Card Number: ______________________________

Fire Wall

The fire wall having suitable height shall be installed between transformers to prevent the healthy transformer from the spread of fire. The wall shall be constructed by reinforced concrete.

8.6.43 DELUGE WATER SPRAY SYSTEM

Contractor shall Design, Supply, Install, Test and Commission a complete Deluge Water

Spray Fire Protection System or Medium Velocity Water Spray System Operated by Deluge Valve as per NFPA 15 on the following Power Transformers at the GIS Substation Power Transformer Bays:

1. 230/110kV 150 MVA Auto Power Transformers

2. 110/11kV 50 MVA Auto Power Transformers

The system shall be linked with the Main Fire Alarm System of the CP1 Plant.

Medium Velocity Water Spray System (MVWSS) operated by Automatic Deluge Valve shall be designed to protect the Power Transformers at the 230/110 kV GIS Substation from any external fire.

Water spray nozzles shall be provided to protect the surface area of the Power Transformers from fire and provides cooling and prevents structural destruction in the event of fire. The deluge valve actuation shall be controlled by Hydraulic, Electric Relay command and Manual release mode.

Sprinklers with Quartzoid bulb (Temperature rating 68°C) shall be provided around the areas to be protected for deluge valve actuation in hydraulic release mode. In electric release mode, manual command using solenoid ON I OFF switch from remotely located control panel (PXI console) operates the integral solenoid valve which actuates the Deluge valve. In relay command based mode, the command output signal from the flame detectors (UV/IR2) located in the Transformer Bay are to be interfaced with the solenoid valve for automatic actuation of deluge valve in the event of flame detection. In manual release mode, local needle valve which is the integrated part of deluge valve assembly actuates the operation of deluge valve.

All the signal command is communicated to two dedicated command console (PXI console) provided in the control room of the GIS Substation. The signal from pressure switch which is provided at the downstream of Deluge Valve gives status of deluge valve and the alarm annunciation to the command console.

The entire deluge system shall be provided with necessary flow components like filters, isolation valves, pressure gauges/ transmitters, fire pumps (electric / diesel engine), fire water tank, etc. as per the relevant P&I diagram . Based on pressure drop calculation, the outlet pressure of deluge valve shall be suitably set in pressure reducing deluge valve to meet the minimum pressure required at the farthest nozzle in the circuit. The arrangement of the spray nozzles/deluge valves shall be in such a way they do not pose any hindrance to the operating personnel during day-to-day operations in the work area as well as protect the equipment during operation of the Automatic Deluge Sprinkler water system.

All related drawings for the Deluge water Spray System shall be designed and submitted by the Contractor for Engineer's approval.

8.6.44 FM200 SYSTEM

Contractor shall Design, Supply, Deliver, Test and Commission a FM200 Fire Protection System for the GIS Substation, Administration Building and CP1 Facilities:

1. 230kV GIS Switchgear Room
2. 110kV GIS Switchgear Room
3. 11kV Switchgear Rooms
4. Metering, Control and Protection Panel Rooms
5. LV Switchgear / MCC Rooms
6. UPS/Battery Charger Rooms
7. Battery Rooms
8. Substation Automation System and SCADA Control Room
9. Tel/LAN Rooms
10. Generator Rooms
11. Electrical Rooms

The system shall be linked with the Main Fire Alarm System of the CP1 Plant.

This specification outlines the requirements for a "Total Flooding" FM-200 clean agent fire extinguishing system. The work described in this specification includes all Engineering, labor, materials, equipment and services required to install and test the FM-200 fire extinguishing system.

The design, equipment, installation, testing and maintenance of the Clean Agent Suppression System shall be in accordance with the applicable requirements set forth in the latest edition of the following codes and standards.

A. NFPA 2001 - Clean Agent Fire Extinguishing Systems.

B. NFPA 70 - National Electric Code.

C. NFPA 72 – National Fire Alarm and Signaling Code.

D. FM - Factory Mutual Approval Guide.

E. UL - Fire Protection Equipment Directory.

F. NEMA - Enclosures for Industrial Controls and Systems.

H. All Requirements of Authority Having Jurisdiction (AHJ)

The standards listed, as well as all other applicable codes, standards, and good Engineering practices shall be used as "minimum" design standards.

The Suppression System installation shall be made in accordance with the drawings, specifications and applicable standards. Should a conflict occur between the drawings and specifications, the specifications shall prevail.

The work listed below shall be designed and submitted by the Contractor to the Engineer for approval.

A. System control panel and accessories.

B. Interlock wiring and conduit for shutdown of HVAC, dampers and/or electric power supplies, relays or shunt trip breakers.

C. Connection to local/remote fire alarm systems or listed central alarm station(s).

The manufacturer of the suppression system hardware and detection components shall be ISO 9001 and 14001 registered.

The name of the manufacturer shall appear on all major components.

All devices, components and equipment shall be the products of the same manufacturer.

All devices, components and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended.

All devices and equipment shall be UL Listed and/or FM Approved.

The installing Contractor shall be trained by the supplier to design, install, test and maintain fire suppression systems.

When possible, the installing Contractor shall employ a NICET certified special hazard designer, Level II or above, who will be responsible for this project.

The installing Contractor shall be an experienced firm regularly engaged in the installation of automatic Clean Agent, or similar, fire suppression systems in strict accordance with all applicable codes and standards.

The installing Contractor must have a minimum of five (5) years experience in the design, installation and testing of Clean Agent, or similar, fire suppression systems. A list of systems of a similar nature and scope shall be provided on request.

The installing Contractor shall maintain, or have access to, a Clean Agent recharging station. The installing Contractor shall provide proof of this ability to recharge the largest Clean Agent system within 24 hours after a discharge. Include the amount of bulk agent storage available.

The installing Contractor shall be an authorized stocking distributor of the Clean Agent system equipment so that immediate replacement parts are available from inventory.

The installing Contractor shall show proof of emergency service available on a twenty-four-hour-a-day, seven-day-a-week basis.

The installing Contractor shall submit the following design information and drawings for approval prior to starting installation on this project.

Working plans indicating detailed layout of system, locating each component (e.g. agent cylinder, control panel, electric/manual pull station, audible and visual alarms). Include control diagrams, wiring diagrams, written sequence of operation or cause to effect matrix along with battery calculations, and pipe locations including size and length. Refer to NFPA 2001 Section 5.1.2.

Product data for each piece of equipment comprising the system including storage cylinders, control valves and pilot controls, control panels, nozzles, push-button stations, detectors, alarm bells or horns, switches, and annunciators.

Design calculations shall derived from computer programs written specifically for FM-200 and verified by both Underwriters Laboratories and Factory Mutual. Analysis shall include calculations to verify system terminal pressures, nozzle flow rates, orifice code number, piping pressure losses, component flow data, and pipe sizes considering actual and equivalent lengths of pipe and elevation changes. Flow calculation shall also supply pressure venting estimates as required by NFPA 2001. In addition, the flow calculation software shall print specifications of all piping used in the design (mass, ID, etc.). Designers using this software shall be trained and certified by the Manufacturer.

All drawings, calculations and system component data sheets shall be submitted for approval to the local fire prevention agency, owner's insurance underwriter, and all other authorities having jurisdiction before starting installation. Submit approved plans to the Engineer for record.

SYSTEM REQUIREMENTS

A. The fire protection system shall be a Total Flooding System utilizing FM-200 clean agent. System is a fixed installation where equipment is designed and installed to provide fire extinguishing capability for hazards described.

B. The system shall be designed to deliver an FM-200 minimum design concentration in accordance with NFPA 2001, 2012 Edition, in all areas and/or protected spaces, at the minimum anticipated temperature within the protected area. The system should be designed to discharge its liquid contents in 10 seconds or less.

C. The system shall be complete in all ways. It shall include all mechanical and electrical installation, all detection and control equipment, agent storage cylinders, FM-200 agent, discharge nozzles, pipe and fittings, manual release and abort stations, audible and visual alarm devices, auxiliary devices and controls, shutdowns, alarm interface, caution/advisory signs, functional checkout and testing, training and all other operations necessary for a functional, UL Listed and/or FM Approved FM-200 Clean Agent Suppression System.

D. The system(s) shall be actuated by photoelectric detectors installed for maximum area coverage of 250 sq. ft. (23.2 m2) per detector, in both the room and above ceiling protected spaces. Photoelectric detectors shall be installed in underfloor protected spaces. If the airflow is one air change per minute, photoelectric detectors only shall be installed for maximum area coverage of 125 sq. ft. (11.6 m2) per detector. (Ref. NFPA 72).

E. Detectors shall be Cross-Zoned detection requiring two detectors to be in alarm before release.

MATERIALS AND EQUIPMENT

The FM-200 Clean Agent System materials and equipment shall be standard products of the supplier's latest design and suitable to perform the functions intended. When one or more pieces of equipment must perform the same function(s), they shall be duplicates produced by one manufacturer.

All devices and equipment shall be UL Listed and/or FM approved.

The fire suppression agent shall be FM-200 gas; clean dry, non-corrosive, non-damaging, non-deteriorating, and meeting the requirements of NFPA 2001. The agent shall be suitable for use in normally occupied spaces. Agent shall be listed as "Acceptable" on the EPA's SNAP list.

FM-200 AGENT STORAGE AND DISTRIBUTION

Each system shall have its own supply of clean agent.

Each system can protect a single hazard or multiple hazards can be protected by a single system with a common supply of clean agent through the use of selector or zone-type valves

The system design can be modular, central storage, or a combination of both design criteria.

Systems shall be designed in accordance with the manufacturer's guidelines.

Each supply shall be located within the hazard area, or as near as possible, to reduce the amount of pipe and fittings required to install the system.

The clean agent shall be stored in Storage Cylinder Assemblies. Cylinders shall be super-pressurized with dry nitrogen to an operating pressure of 360 psi @ 70°F (24.8 bar @ 20°C). Cylinders shall be of high-strength low alloy steel construction and conform to NFPA 2001 and the regulations of the Department of Transportation and/or CE.

Cylinders shall be fitted with a resilient pressure seat type forged brass valve and shall have a threaded steel anti-recoil protective cap or grooved style anti-recoil protective plate for handling and shipment.

The primary cylinder assembly(s) shall be actuated by a resettable electric actuator with optional mechanical override located at each primary agent cylinder or connected bank of cylinders. Non-resettable or explosive devices shall not be permitted

Each primary cylinder shall be able to actuate up to 15 slave cylinders. The distance between the primary cylinder and the farthest slave cylinder (including any rises or drops) shall not exceed 100 ft (30.48 m) in either direction when using flexible hose or copper tubing for pilot actuation. The distance between the primary cylinder and the farthest slave cylinder (including any rises or drops) shall not exceed 25 ft (7.62 m) in either direction when using 1/4 in (8 mm) schedule 40 pipe for pilot actuation.

The cylinders shall be mounted using wall racks on solid walls. The cylinders and racks shall be arranged to allow a service aisle for cylinder removal and cylinder weighing.

Cylinders of a maximum storage capacity greater than 130 lbs (59 kg) shall come fitted with Liquid Level Indicators.

Each cylinder assembly shall have a pressure gauge and low pressure switch to provide visual and electrical supervision of the cylinder pressure. The low pressure switch shall be wired to the control panel to provide an audible and visual supervisory condition signal in the event the cylinder pressure drops below 280 psi (19.3 bar). The pressure gauge shall be color coded to provide an easy, visual indication of cylinder pressure.

Each cylinder assembly shall have a pressure relief provision that automatically operates before the internal pressure exceeds 850 psi (58.6 bar) to 1000 psi (68.9 bar).

When more than one cylinder is connected to a common manifold, a check valve shall be provided with each cylinder.

Engineered discharge nozzles shall be provided within the manufacturer's guidelines to distribute the FM-200 agent throughout the protected spaces. The nozzles shall be designed to provide proper agent quantity and distribution.

Nozzles shall be available in 3/8 in (10 mm) through 2 in (50 mm) pipe sizes. Each size shall be available in 90° Corner [Listed with a protection coverage area of 32' x 32' (9.753 m x 9.753 m)], 180° Sidewall [Listed with a protection coverage area of 64' x 32' (19.507 m x 9.753 m)], and 360° Center Room [Listed with a protection coverage area of 64' x 64' (19.507 m x 19.507 m)] distribution patterns.

Nozzles shall be of corrosion resistant construction and shall be designed specifically for FM-200 application.

Nozzles shall be permanently marked as to part number and orifice diameter.

Nozzles shall be listed at a maximum 16' (4.876 m) elevation and listed at a maximum 4' (1.219 m) distance below a ceiling while still achieving sufficient mixing.

Nozzles should be listed and/or approved to be used in the upright or pendant position.

Ceiling plates can be used with the nozzles to conceal pipe entry holes through ceiling tiles.

Distribution piping, and fittings, shall be installed in accordance with the manufacturer's requirements, NFPA 2001 and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations. The piping shall be laid out to give maximum flow and to avoid possible mechanical, chemical or other damage. Installation shall follow drawings as closely as possible. System designer must be consulted for anything other than minor deviations in pipe routing.

Black or galvanized steel pipe shall be either ASTM A53 seamless or electric welded, Grade A or B or ASTM A-106, Grade A, B, or C. ASTM A-120, ordinary cast-iron pipe, aluminum pipe, or non-metallic pipe shall not be used. Stainless steel pipe shall be 304, 316, 304L, or 316L for threaded connections or 304L or 316L for welded connections.

Threaded fittings must comply with NFPA 2001 and be at a minimum class 300 malleable iron, class 300 ductile iron, or have a minimum rated working pressure of 416 psi (28.7 bar) at 70°F (21.1°C). Cast iron and Class 150 pound fittings shall not be used.

Grooved fittings and couplings must comply with NFPA 2001 and have a minimum rated working pressure of 416 psi (28.7 bar) at 70°F (21.1°C). Piping shall be rolled or cut grooved in accordance with the fitting or coupling manufacturer's guidelines.

Gaskets must be compatible with FM-200® agent (typically EPDM having a temperature range of -30°F to 230°F [-34°C to 110°C]). Gasket lubricant must be in accordance with manufacturer's specifications.

The minimum allowable working pressure at 70°F (21.1°C) for pipe and fittings in closed sections of pipe must be greater than or equal to the maximum operating pressure of the discharge pipe safety relief valve rated at 450 psi (31.02 bar).

All pipe and fittings shall be new and of recent manufacture.

Reductions in pipe sizes may be accomplished using threaded or grooved concentric reducing fittings, steel or stainless steel concentric swage fittings, or steel or stainless steel reducing bushings. All such fittings must comply with NFPA 2001 and have a minimum rated working pressure of 416 psi (28.7 bar) at 70°F (21.1°C). Pipe reductions can be made using machined or forged steel hex bushings. Malleable and/or cast iron bushings are NOT to be used.

All piping shall be reamed, blown clear and swabbed with suitable solvents to remove burrs, mill varnish and cutting oils before assembly.

All screwed pipe shall be coated with Teflon tape or an appropriate pipe joint compound. When tape or pipe joint compound is used, coating of the threads must start at least two threads back from the pipe end. On small piping, care must be taken so as not to allow sealant to enter valves or controls.

All pipe must be thoroughly cleaned before installation. A wire flue brush should be pulled through the length several times, followed by clean cloth rags treated with a noncombustible metal cleaner designed for the purpose. All foreign matter and oil must be removed by this process.

All pipe and fittings installed out of doors or in corrosive areas must be galvanized or treated with a proper protective coating.

Piping shall be pneumatically tested in a closed circuit for a period of 10 minutes at 40 psi (2.76 bar) per the latest edition of NFPA 2001. At the end of 10 minutes, the pressure drop shall not exceed 20 percent of the test pressure. The pressure test shall be permitted to be omitted if the total piping contains no more than one change in direction fitting between the storage container and the discharge nozzle, and where all piping is physically tested for tightness.

Pressure Switches

The system shall include a normally open contact on a pressure switch actuated by the agent discharge to shut down equipment and sound alarm.

Switches shall be heavy duty, single pole, double throw.

Pressure switch shall require manual reset.

Pressure switch is only required when a manual valve actuator is supplied on the primary cylinder.

Pressure Operated Releases

The system shall include releases capable of holding maximum loads of 35 lbs (15.9 kg) to release self closing doors, dampers, windows, louvers, lids or valves upon FM-200 discharge

(Note : All devices to be closed must be self-closing and capable of being held open by a cable or chain hooked to the release.)

Piping to pressure releases shall be as specified above for discharge piping. All take-offs for pressure release piping shall be from the top of the discharge piping.

DOCUMENTATION AND TESTING

SYSTEM INSPECTION AND CHECKOUT

After the system installation has been completed, the entire system shall be checked out, inspected and functionally tested by qualified, trained personnel, in accordance with the manufacturer's recommended procedures and NFPA standards.

A. All containers and distribution piping shall be checked for proper mounting and installation.

B. All electrical wiring shall be tested for proper connection, continuity and resistance to earth.

C. The complete system shall be functionally tested, in the presence of the Engineer and all functions, including system and equipment interlocks, must be operational at least five (5) days prior to the final acceptance tests.

i) Each detector shall be tested in accordance with the manufacturer's recommended procedures, and test values recorded.
ii) All system and equipment interlocks, such as door release devices, audible and visual devices, equipment shutdowns, local and remote alarms, etc. shall function as required and designed.
iii) Each control panel circuit shall be tested for trouble by inducing a trouble condition into the system.

TRAINING REQUIREMENTS

Prior to final acceptance, the installing Contractor shall provide operational training to each shift of the Engineer's personnel. Each training session shall include control panel operation, manual and (optional) abort functions, trouble procedures, supervisory procedures, auxiliary functions and emergency procedures.

8.6.45 BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

The following clauses describe the General Technical Requirements for Batteries, Chargers and DC distribution switchgear for use in GIS Substation, Electrical Rooms for 110V DC power for switchgear operations, protection, control, alarms, indications and 48V DC power for Telecommunication and SCADA System.

The equipment shall be supplied, installed and commissioned as per instruction and approval of the Engineers.

REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

IEC Standards

IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories.

IEC 60146 Semiconductor converters

IEC 60146-1-1 Basic requirements of electrical power converters IEC 60146-1-3Transformers and reactors

IEC 6060529 Degree of protection provided by enclosures

IEC 60439 Low voltage switchgear and control gear assemblies (BS EN 60439) IEC 60623 Vented nickel cadmium prismatic rechargeable single cells

British Standards

BS 88 Cartridge fuses for voltages up to and including 1000 VAC and 1500 V DC.

BS 381C Specification for colours for identification coding and special purposes.

BS 5634 Method of Test for Potassium Hydroxide.

BS 6231 Specification for PVC insulated cables for switchgear and control gear wiring.

DESIGN REQUIREMENTS

Batteries shall be located in separate mechanically ventilated rooms, which shall be provided with facilities for quick drenching of the eyes and body like sinks, eyewash fountain and water supplies within seven meters of battery handling areas. Storage facilities will be provided for electrolyte, distilled water and maintenance equipment.

The voltage measured at the main distribution switchgear shall not vary by more than plus 10 percent or minus 20 percent of the nominal voltage under all charging conditions when operating in accordance with the requirements of this Section.

The complete equipment shall preferably be a manufacturer's standard but any departure from this Specification shall be subject to the approval of the Engineer.

BATTERIES

Type of Battery

The battery shall be of the high performance Nickel Cadmium pocket plate type complying with IEC 60623 and shall be designed for a life expectancy of 25 years.

Battery cases shall be of high impact translucent plastic or annealed glass and shall be indelibly marked with maximum and minimum electrolyte levels. The design of the battery shall permit the free discharge of the gases produced during the normal operating cycle, whilst excluding dust. Spray arresters shall be included.

The electrolyte shall be free from impurities and the Potassium Hydroxide used shall comply with BS 5634. Dilution of the alkaline electrolyte and topping up of cells shall be carried out using distilled water only.

A complete set of test and maintenance accessories, suitably boxed, shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Cells shall be permanently marked with the following information:

Manufacturer's reference number and code

Year and month of manufacture

Voltage and nominal capacity at the 5 hour discharge rate

The electrolyte capacity and general design of the cells shall be such that inspection and maintenance, including topping up of the electrolyte, shall be at intervals of not less than twelve months.

Initial Charge and Test Discharge

The initial charge, test discharge and subsequent re-charge of the battery must be carried out under continuous supervision. Resistors, instruments, leads, and the other apparatus will be necessary for the initial charge, test discharge and subsequent recharge of the battery.

Battery Duty

The battery shall have sufficient capacity to supply the following continuous and intermittent loads for the periods specified, with the chargers out of service.

Standing DC loading for protection, control, indications and alarms for 10 hours. This loading shall be determined from all equipment to be supplied on this Contract. In addition the future circuit requirements estimated on the same basis as the present requirements.

At the end of 5 hours the battery shall have sufficient capacity to complete the operations listed below, at the end of which duty the system voltage shall not have dropped below 90 percent of the nominal voltage with the standing loads, specified above, connected.

Two closing operations on all circuit breakers (including future) supplied by the battery.

Two tripping operations on all circuit breakers (including future) supplied by the battery. Where busbar protection is provided, it shall be assumed that all circuit breakers in any one busbar protection zone trip simultaneously.

Charging of DC motor wound circuit breaker closing springs (where applicable) to enable the closing operations to be carried out.

At the end of these duties, the battery voltage shall not have dropped such that the voltage at the battery terminals falls below 90% of the nominal system voltage when supplying the standing load.

In addition, the voltages at the terminals of all components in the system (e.g. relays, trip and closing coils) shall not be outside of the individual voltage limits applying to them.

A margin of 10 % shall be allowed for derating of this battery over its life time.

All quantities derived in this manner shall be quoted in the Bid, but shall not be used for ordering materials until specifically approved by the Engineer. Detailed calculations, and loading characteristics on which these are based, shall be submitted to the Engineer at an early stage.

Location of Batteries

The batteries shall be housed in a ventilated battery room. The charging equipment and distribution switchboards shall be housed in a separate room.

The floor of the battery room shall be coated with a suitable electrolyte resistant protective coating. The floor shall be fitted with a drain and shall have sufficient slope to prevent any major electrolyte spillages from entering into other areas.

No ducts or any other items shall penetrate the floor or create a means whereby spillage can drain away apart from the drain provided for this purpose.

The ventilation fans and lamps in battery room shall be an explosion proof type.

Battery mounting connections and accessories

Batteries shall be placed on timber boards mounted in double tiers on steel stands of robust construction and treated with acid resisting enamel or gloss paint to BS 381C No.361. The cells shall be arranged so that each cell is readily accessible for inspection and maintenance and it shall be possible to remove any one cell without disturbing the remaining cells. The stands shall be mounted on insulators and be so dimensioned that the bottom of the lower tier is not less than 300mm above the floor.

Alternatively, batteries may be mounted in a similar manner on treated hard wood stands.

Batteries shall be supplied and erected complete with all necessary connections and cabling. Connections between tiers, between end cells and between porcelain wall bushings shall be by PVC cables arranged on suitable racking or supports. Before jointing, joint faces shall be bright metal, free from dirt, and shall be protected by a coating of petroleum jelly. Terminal and intercell connections shall be of high conductivity corrosion free material.

Cartridge fuses shall be provided in both positive and negative leads, positioned as close to the battery as possible and shall be rated for at least three times the maximum battery discharge current at the highest operating voltage. The two fuses shall be mounted on opposite ends of the battery stand or rack in an approved manner. These fuse links shall comply with BS 88 Clause DC. 40 and shall be bolted in position without carriers.

Warning labels shall be fitted to warn personnel of the danger of removing or replacing a fuse whilst the load is connected and that fuses should not be removed immediately following boost charge due to the possible ignition of hydrogen gas.

Fuses between the battery and charger shall be located adjacent to the battery in a similar manner to that described above. A warning label shall be placed on the charging equipment indicating the location of these fuses and the fact that they should be removed to isolate the charger from the battery.

It shall not be possible to leave the battery disconnected (by means of switches or removal or operation of fuses) without some local and remote indication that such a state exists.

One set of miscellaneous equipment, including two syringe hydrometers, one cell-testing voltmeter, two cell-bridging connectors, two electrolyte-pouring funnels, two electrolyte thermometers, battery instruction card for wall mounting, electrolyte airtight containers, labels, tools and other items necessary for the erection and correct functioning and maintenance of the equipment, shall be provided for each station.

CONTROL AND CHARGING EQUIPMENT

Each battery charging equipment shall comply with the requirements of BS 4417 (IEC 146), shall be of the thyristor controlled automatic constant voltage type with current limit facilities and shall be suitable for supplying the normal constant load, at the same time maintaining the battery to which it is connected in a fully charged condition. All equipment shall be naturally ventilated.

All the equipment for each charger shall be contained in a separate ventilated steel cubicle. The charger cubicles shall normally be mounted immediately adjacent to the DC distribution panel to form a board and shall be of matching design colour and appearance.

Where their ratings permit, chargers shall preferably be designed for operation from a single-phase AC auxiliary supply with a nominal voltage of 230 V. Otherwise a three phase 400V supply may be utilised. Chargers shall maintain the float charge automatically for all DC loads between 0 and 100%, irrespective of variations in the voltage of the ac supply within the following limits:

Frequency variation : 47 to 51 Hz.

Voltage variation : ± 15%

The mains transformer shall be of a suitable rating and design. Clearly marked off-circuit tappings shall be provided on the primary windings and change of tapping shall be by means of easily accessible links. The transformer shall be of the natural air-cooled type capable of operating continuously at full load on any tapping with the maximum specified ambient temperature.

All rectifiers and semi-conducting devices employed in the charger shall be of the silicon type. They shall be adequately rated, with due regard to air temperature within the charger enclosure, for the maximum ambient temperature.

The rating of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate for the battery.

Each charger shall also incorporate a boost charge feature which shall, after having been started, provide an automatically controlled high charge rate sufficient to restore a fully discharged battery to the fully charged state within the shortest possible time without excessive gassing or any form of damage to the battery. The boost charge shall be initiated manually or automatically upon detection of a significant battery discharge. An adjustable timer shall be provided to automatically switch the charger to the float condition after the correct recharge period.

Should the AC supply fail while a battery is on boost charge, the switching arrangements shall automatically revert the charger to float charge status and then reconnect the battery to the distribution board.

The output voltage regulator shall be adjustable for both float and boost charge modes, within limits approved by the Engineer, by means of clearly marked controls located inside the cubicle.

Although it is not intended that the charger be operated with the battery disconnected, the design of the charger shall be such that with the battery disconnected the charger will maintain the system voltage without any damage to itself and with a ripple voltage no greater than 2.0% rms of the nominal output voltage.

The charger shall automatically adjust the charging current from a value not less than the battery capacity divided by 10 hours to a minimum value of not more than the battery capacity divided by 200 hours. The charging circuitry shall be so designed that the failure of any component will not give a situation which will cause permanent damage to the battery by over charging.

Each charger shall have a float charge maximum current rating sufficient to meet the total standing load current on the dc distribution board plus a battery charging current equal numerically to 7% of the battery capacity at the 10 hour rate.

Each charger shall be designed with a performance on float charge such that with the output voltage set at approximately 1.45 V per cell at 50% load and rated input voltage and frequency, the output voltage shall not vary by more than plus 3% to minus 2% with any combination of input supply voltage and frequency variation as stipulated in this Specification and output current variation from 0-100% of rating.

Each charger shall be suitable for operating alone or in parallel with the other charger. When operating with both chargers, one charger shall be arranged to supply the standing load with the second charger in the quiescent standby mode.

Each charger shall also have a taper characteristic boost charging facility which shall be selectable by a float/boost charge selection switch and which will give boost charging of 1.60 - 1.75 volts per cell.

Each charger shall be designed with a performance on boost charge such that with rated input voltage and frequency the charger output shall not be less than its rating in Watts at 1.3 V and 1.65 V per cell, and also the output voltage shall be 1.60 -1.75 V per cell over an output range of 0 - 100% of rating.

The boost charging equipment shall be capable of recharging the battery within six hours following a one hour discharge period.

In the event of the battery becoming discharged during an AC supply failure, the rate at which recharging commences shall be as high as possible consistent with maintaining the automatic charging constant voltage feature and with the connections remaining undisturbed as for normal service.

The charger shall have an automatic boost/quick charge feature, which shall operate upon detection of a significant battery discharge. When, after a mains failure, the AC supply voltage returns and the battery have been significantly discharged, the charger will operate in current limit. If the current limit lasts for more than a specified time and the charging current does not fall back to float level, the automatic high rate charge shall be activated.

An override selector switch shall be provided inside the charger unit to enable a first conditioning charge to be made, in line with the battery manufacturer's recommendations, for batteries which are shipped dry and require forming at site.

A diode voltage regulator(DVR) unit shall be incorporated in the output circuit of each charger to limit the load voltage during charging of the battery. Should the stabilizer fail in the boost charging mode, the charger shall automatically revert to the float mode.

An anti-parallelling diode shall be provided in each positive feed to the DC distribution board to prevent faults on one supply affecting the other. These diodes shall be continuously rated to carry the maximum possible discharge current likely to occur in service and a safety factor of 4 shall be used to determine the repetitive peak reverse voltage rating. The I2t rating of the diodes shall be such that in the event of a DC short circuit, no damage to the diodes shall result.

Each charger shall be capable of sustaining, without damage to itself, a continuous permanent short circuit across its output terminals. The use of fuses, MCBs or other similar devices will not be acceptable in meeting this requirement.

Suitable relays shall be provided for each charger to detect failure of the incoming supply and failure of the DC output when in float charge mode. These relays shall operate appropriate LED on the respective charger front panel and shall have additional voltage free contacts for operating remote and supervisory alarms. These alarms shall be immune from normal supply fluctuations and shall not be initiated when any one charger is taken out of service.

The charger shall also be fitted with a device to de-energise the charger in the event of a DC output float over voltage.

Each charger shall be provided, as a minimum, with the following instrumentation, indication and alarm facilities:-

LED for the AC supply to the rectifier and DC supply from the rectifier.

LED for float and boost charging operations.

Voltmeter - Input voltage.

Voltmeter - Output voltage.

Ammeter - Output current.

Alarm - Charger failure.

Alarm - Mains failure.

The following battery alarms shall also be provided:

Battery fuse failure

Diode assembly failure

Battery circuit faulty

Low DC volts

High AC volts

Earth fault +ve

Earth fault -ve

Lamp test facilities shall be included.

A "charger faulty" alarm for each charger and a "battery faulty" alarm shall be provided in the substation control room and to the SCADA system where applicable.

Each battery charger shall be equipped with charge fail detection equipment to give local indication and remote alarm if the voltage from the charger falls below a preset level which will be lower than the nominal float charge voltage. Suitable blocking diodes shall be provided to prevent the battery voltage being supplied to the equipment and so prevent charge fail detection.

The device shall not operate on switching surges or transient loss of voltage due to faults on the AC system. The voltage at which the alarm operates shall be adjustable for operation over a range to be approved by the Engineer.

Each charger shall be equipped with a switch-fuse for the incoming AC supply and an off load isolator for the DC output.

Bidders shall include particulars with their bid on the method of adjustment included to compensate for ageing rectifier elements. The construction of the charger shall be such that access to all components is readily available for maintenance removal or replacement. Internal panels used for mounting equipment shall be on swing frames to allow for access to the charger interior.

A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the charger panel.

A low voltage detecting device for the system shall be incorporated in the charger panel. No-volt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.

In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

DISTRIBUTION SWITCHBOARDS

The switchboard shall comply with the requirements of BS 5468 (IEC 60439)

The distribution switchboard shall be of the cubicle type or otherwise incorporated in the cubicles for battery chargers. Double pole switches and fuses or switch fuses (miniature circuit breakers to BS 4752 or IEC 60127 may only be used if it can be shown that there will be no discrimination problems with sub-circuits) shall be fitted to the DC switchboard as required by substation services but, as a minimum requirement, that set out in the Schedule A of Requirements.

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of cubicle type control panels. No equipment associated with the chargers shall be installed in the distribution board.

Distribution panels shall incorporate double-pole switches and fuses for each of the outgoing DC circuits and double-pole isolators for the incoming DC supplies. The panel shall be provided with a voltmeter and centre zero ammeter on each incoming circuit.

A double pole switch or contactor shall be provided for the purpose of sectionalizing the busbar.

Connections between the battery and the distribution cubicle shall be made in PVC insulated cable as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring, be sheathed overall and be cleated to walls as required.

Cable boxes or glands shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with an earthing bar of hard drawn high conductivity copper which shall be sized to carry the prospective earth fault current without damage or danger.

The cubicles for the chargers and distribution boards shall be of rigid, formed sheet metal construction, insect and vermin proof, having front facing doors allowing maximum access to the working parts, when open. The design of the cubicles for the chargers shall be such as to prevent the ingress of dust and minimize the spread of flames or ionised zones, shall be to IEC 60529 IP52, but at the same time shall provide all necessary ventilation and cooling. The design of the frames shall allow the clamping and holding of all chokes, transformers and similar sources of vibration, so that vibration will be minimized, satisfy relevant standards, and not limit the life of the equipment. The frame shall allow the fixing of lifting and so that the equipment remains properly mechanically supported whilst being transported, lifted and installed.

LABELLING

All relays, instruments and control devices, and each unit of the equipment, shall be provided with a label. All labels and lettering shall be of sufficient size to provide easy reading from the normal operating or maintenance positions and shall consist of black lettering on a white background. All warning and danger labels shall have white lettering on a red background. Labels shall be of the non- corrodible type and lettering shall be of motorway script or similar. If plastic labels are used, these shall be laminated to avoid warping.

SPECIAL TOOLS

The Contractor shall provide a complete set of all special tools and services necessary for the erection and maintenance of the complete equipment.

INSPECTION AND TESTING

Inspection and testing plan during manufacture and after installation on site shall be submitted by the Contractor for approval by the Engineer.

SCHEDULE OF TECHNICAL REQUIREMENTS OF Ni-CAD BATTERY

(110V DC System)

SL. No.	Description	
1.	Installation	: Indoor
2.	Cell type	: Ni-cd
3.	Voltage (Normal)	: 1.2 volts per cell
4.	Float voltage	: 1.40-1.42 volt/cell
5.	Equalizing voltage	: 1.55 - 1.65 volt/cell
6.	Capacity in AH at 20°C	: 460 AH @ 5 Hr (for 230/110kV Control Room)

150 AH @ 5 Hr

SL. No.	Description	
7.	Ambient temperature	: 45°C
8.	Positive plate	: Tubular
9.	Negative plate	: Pasted
10.	Type of container	: Plastic polymer
11.	Discharge voltage	: 1.0 V/Cell
12.	Sp. gravity of electrolyte	: 1.19 ± 1%
13.	Sp. gravity of electrolyte (Charged)	: 1.23 ± .010 at 20°C
14.	Vent plug	: Anti-corrosive & fire proof
15.	Cell condition	: Pre-charged.
16.	Battery stand	: Steel frame of step type
17.	Standard	: IEC or equivalent

SCHEDULE OF TECHNICAL REQUIREMENTS OF 110 V DC BATERY CHARGER

SL. No.	Description	
	A) GENERAL	
1.	Installation	: Indoor
2.	Rectifier type	: Thyristor controlled.

3.	Rated D.C. voltage	: 110V ±5%
4.	Rated output current	: 120 Amps(for 230/110kV control room)
		: 50 Amps (for 33kV control room)
5.	Charging mode	:Both constant current & constant voltage
6.	High Voltage Insulation	: 1000 V AC for 1 minute between **input to output and input to ground**
7.	Insulation resistance	: 10 M□ with 500 V DC for 1 minute
8.	Cooling system	: Self & natural air cooled.
9.	Relative humidity	: Up to 98%
10.	Ambient temperature	: 45°C (max.)
11.	Noise level	: 65 dB (max)
12.	Altitude	: 150 m
13.	Applicable Standard	: IEC or equivalent.

B) TECHNICAL DATA

A.C. INPUT

1.	Voltage	: 415 Volts
2.	Phase	: 3 Phase
3.	Frequency	: 50 ± 5% Hz
4.	Input AC voltage variation	: ± 5%
5.	Power factor (Full range)	: 0.8
6.	Efficiency (Full load)	: 85%
7.	Charge Characteristics	: Constant current /Constant voltage (During float charge)
8.	Current limitation	: 110%

D.C. OUTPUT

1.	Voltage	: 110 ± 5% volt
2.	Ripple Voltage (Full load)	: ± 3%
3.	Charge modes (3 level)	: Charge, Float charge & Boost charge
4.	Float Voltage (adjustable)	: 1.42 volt/cell
5.	Boost Voltage (adjustable)	: 1.53 volt/cell

8.6.46 CENTRAL BATTERY SYSTEM

The emergency lighting system & all its components shall be designed & installed to meet the Local authority requirements & the respective EN 50172 and the system designed in compliance with EN50171, EN50272-2, EN50172, and EN1838 standards applicable to this project.

Central Battery System shall be connected to an emergency power supply connected to a standby generator set.

Emergency lighting shall fulfill the following functions:

1. Illuminate the escape routes
2. Indicate the escape route direction clearly
3. Provide the Exit signs on all the Exits
4. Permit operations concerned with safety measures & to shut down the hazardous process

Each emergency supply panel shall be used for supply automatic testing and monitoring of up to 32 of Escape route, EXIT and safety luminaires on each circuit.

Panel Shall automatically update new lights after new lamps are installed

The panel shall have following electrical characteristics:

Input Voltage	:	415V AC 3 Ph (Emergency Power Supply)
Output mains	:	220-240 V AC
Output Emergency	:	216 V DC
Emergency Duration	:	Three (3) hours

The number of emergency lighting system panels shall be appropriately decided for maximum reliability to ensure continued emergency supply and failure of one panel shall not result in total emergency lighting supply failure for the entire building.

The system supplier shall be authorized distributor of the equipment, maintaining a local staff of factory-trained personnel for Engineering assistance, installation and maintenance of such equipment in compliance with the requirements of the above mentioned EN standards.

SYSTEM DESCRIPTION

MECHANICAL CONSTRUCTION

The panels enclosure shall be made of sheet steel housing IP20 with separate rack or enclosures for batteries to maintain the safety distance of the battery according to EN50272-2. Colour finish of the panel will be white for housing. Panel shall be suitable for surface wall mounting. Panel shall have a screw fitted front door of lift away type, with front facia for status indication.

Batteries to be mounted on suitable rack/ enclosure for easy maintenance of the batteries.

Contractor shall provide mechanical ventilation to extract the gas emitted from the batteries during automatic boost charge, cyclic charge and trickle charge.

ELECTRICAL CONSTRUCTION

Changeover Module

System shall be built up in a modular format with all units being plug –in –type change over modules. Each changeover module shall have 8 outputs of min 250W each or 2 outputs of max 1400W each. It shall be possible to connect each output circuit as maintained or non-maintained without any programming required. Changeover module shall have integrated transceiver circuit, which allows up to 32 addressable luminaires in each circuit. Each changeover module communicates with the control module through the internal data bus. All out going circuit shall be protected with independent fuses. The unit shall not have a floating DC circuit and shall not require separate changeover relays for both L/DC(+) and N/DC(-).

Battery Charger

Charger module shall be controlled by the micro-processor of the control module. There shall be automatic boost charge, cyclic charge and trickle charge facility for full battery capacity use and maximum battery life. The charger shall have built-in deep discharge protection for long battery life. There shall be a DIP-switch for setting the maximum charging current, according to the battery capacity.

The system shall have temperature sensor at the battery for automatic charging voltage adjustment. Fuse protection shall be provided. The charger shall be designed for a 80% recharge of a fully discharged battery within 12 hours, as required by EN 50171.

Control Module

Control Module shall have the following LED indications:

1. Mains Operation,
2. Battery Operation,
3. Battery Overvoltage,
4. Battery Under voltage,
5. Deep Discharge,
6. Recharge,
7. Current Limit,
8. Battery Fault,
9. Internal Fault,
10. Battery Test Running,
11. Luminaire Test Running,
12. Internal Fault, External Fault,
13. Circuit Number and Luminaire Number.

There shall be an own LED indicator for each luminaire in the same circuit providing simultaneous status information of the luminaires by a single view with corresponding group (circuit) number indicating on the segment display.

Control Module shall have the following Volt free contact:

1. Internal Fault
2. Battery mode operation
3. External Fault

The control module of the panel shall have three main functions:

1. monitor and control all test cycles and functions.
2. Indicate every status of the system and the connected luminaire
3. communicate with the addressable electronic ballast on every slave luminaire.

Each panel shall have push buttons for Battery Test, Luminaire Test and Fault Alarm Reset. The panel shall have the option of an integrated printer to be fitted on it.

The emergency supply panel shall supervise the battery status such as Battery Over voltage / Battery Under voltage. Charging failure shall be indicated as an Internal fault by an indicator LED and potential free relay contact.

The unit shall be fitted with a deep discharge protection circuit, which has two operation phases: When in battery mode the battery voltage decreases to 195V, a preliminary deep discharge alarm shall be given. When the battery voltage decreases to 173V, the load shall be disconnected. The circuit shall allow the battery to increase its voltage without switching the load ON again, thus avoiding detrimental full discharge. The panel shall automatically return to normal operation, once the mains supply recovers.

Exit Light Flashing Operation

The maintained Exit lights shall be able to operate in Flashing Mode (Momentary ON/OFF). As per NFPA 101 7.10.5.2.2: Illumination for signs shall be permitted to flash on and off upon activation of the fire alarm system. Based on the control signal from Fire Alarm System or actuating device, the Exit lights shall flash to draw the attention towards the Escape Route in case of a Zone Fire Alarm or similar situation.

Local Controllers

Local controllers should be connected to every circuit to monitor local normal lighting DBs and switch on the non-maintained luminaries during DB supply failure. There shall be no separate data cabling required between the local controllers, luminaries and panels. All necessary data transfer shall take place through the standard power supply cabling of the luminaires. Continuous monitoring of the lighting sub distribution panels shall be made by Local Controller units, each having 3-phase monitoring input. Each circuit shall have its own Local Controller so that a possible failure of a single controller does not affect the other circuits. The non-maintained luminaires at sub distribution panel area shall be lit during a local supply failure. However, the emergency supply panel shall not switch to battery use as long as its own mains supply is available. The Local Controllers should comply to EN 61347-2-11:2001 in conjunction with EN 61347-1:2001.

Switch Controllers

Switch controller modules shall be provided to allow emergency luminaires to be used for general lighting purpose with ON & OFF switch operations via switches, lighting control system, etc where necessary. Switch controllers shall be fully compatible with the Local Controllers

CENTRAL MONITORING

The System shall have central monitoring software and the entire emergency lighting system shall be controlled and monitored from a single point using standard personal computer and simultaneously, the system shall also have a single BACnet gateway for interface with SCADA System.

Following functions shall be done by using the Central monitoring PC.

1. Luminaire test of all or selected emergency supply panels.
2. Battery test of all or selected emergency supply panels.

Slave Emergency & Exit Luminaire LED Type

Emergency luminaires shall be non-maintained type slave luminaires with long life and high efficiency LED light source and self-testing addressable electronics, which can communicate with central control module. LEDs shall be of surface mounted type with proper heat sink. It is not allowed to use free standing LEDs where the heat is conducted only through the connection leads. Electronics shall supply the LED(s) with constant current, which shall be regulated against supply voltage variations. With the constant current power supply feature, the light output should be maintained more than 90% till the end of three hours battery back up. The indication of the correct operation shall rely on the actual light output of the LED(s), so that an excessive degradation of the light output is also detected. Manufacturer is demanded to show a proof that the specified light output levels are maintained for minimum of 7 years. It shall be possible to connect both maintained and non-maintained luminaires to the same output circuit.

The luminaire shall have sheet steel or plastic polycarbonate housing and plastic polycarbonate or PMMA lens for even light distribution.

The supply connector shall be arranged to provide a possibility for both ingoing and outgoing cable to enable looped cabling between the luminaires without separate junction boxes.

- It shall be maintained type luminaire
- Minimum viewing distance 22 meters
- shall be built according to EN60598
- shall have Constant power output high frequency electronic control gear
- All exit luminaire shall be powered from central battery unit
- The luminaire shall have sheet steel or plastic polycarbonate housing
- Protection class I, ingress protection IP20.
- Supply voltage 220 V/240 V AC/DC
- EMC protection according to EN 55015

Plant Room / Staircase / Car Park areas slave Emergency & Exit luminaire

Same as exit & safety luminaire except protection Class IP-44

Address Modules

All general light fittings converted into emergency lights shall be connected to the manufacturer's address modules up to 200 watts. The address modules should comply to EN 61347-2-11:2001 in conjunction with EN 61347-1:2001. The general luminaries must be fitted with electronic ballast with the following features; It must be able to operate with both AC and DC voltage, It must shut itself off in an event of a lamp failure, input current in shut off mode must be less than 10mA & must have Constant power output high frequency electronic control gear/ transformer. The CBS manufacturer should provide electronic ballast with the above features on request.

Batteries

The batteries shall be maintenance free VRLA sealed lead acid gas recombination type with a minimum design life of 10 years at prevailing ambient temperature.

They shall have extremely low gas generation, low self-discharge and have permanently sealed pressure release vents.

Care shall be taken to store/install these batteries in areas, which are free of prolonged extreme temperatures.

The batteries shall be sized to power complete system for 3 hours following mains failure at 100% light output of all emergency lamps or 75% on slave luminaries.

Wiring

Wiring between the central battery and luminaires shall be carried out in ***fire rated cable*** of suitable size as per the local authority requirement.

8.6.47 LIGHTING AND SMALL POWER

This section of the Specification includes for the interior and exterior lighting and small power systems. Contractor is encouraged to use renewable energy as much as possible for street and area lighting.

Whenever practicable, fixtures shall be sourced as per the approved list of manufacturers. All lamps, fittings, plugs, sockets and general accessories of the same size and types shall be similar and interchangeable throughout the installation.

The lighting and small power equipment and installation shall comply with other sections of this Specification as appropriate.

All civil works associated with this section of the works shall be deemed to be included as part of the works in this section.

The requirements of this section of the works are subject to the Main Conditions and Specifications laid down in the specifications.

REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

British Standards

BS 7671 Code of Practice Regulations for Electrical Equipment in Buildings 15th Edition Institution of Electrical Engineers.

BS 6004 Specification for PVC insulated cables (non armoured) for electric power and lighting

BS 6346:1989 Specification for PVC insulated cables for electricity supply BS 6500 Specification for insulated flexible cords and cables

BS 6121 Mechanical cable glands

BS EN 60947 Specification for control gear for voltages up to and including 1000V AC and 1200V DC

BS 4533 Luminaries

BS 3677 Specification for high pressure mercury vapour lamps

BS 1363 Specification for 13A fuse plugs and switched and unswitched socket outlets

BS 1362 Specification for general purpose fuse links for domestic and similar purposes (suitable for use in plugs)

BS 4568 Specification for steel conduit and fittings with metric threads of 150 form for electrical installation

BS 4066 Test on Electric cable under fire conditions.

DEFECTS LIABILITY PERIOD

The Contractor shall be responsible for the efficient and good working of the installations comprising this section of the Specification for the agreed period.

APPROVALS

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the designs of the specified systems which shall be shown on the working drawings, which is also required to be submitted for approval.

Any approvals shall not, however, relieve the Contractor of his contractual responsibilities which include obtaining local authority approvals for electrical wiring installations.

LIGHTING REQUIREMENTS

The lighting installations shall be designed to give the standard service illuminations and shall incorporate emergency lighting where indicated. Control Rooms, Relay Rooms, Telecommunications Equipment rooms, offices, conference rooms and stores shall have the service illumination measured at 850 mm above finished floor level. All other areas shall have the service illumination measured at floor level.

The installations shall also meet the limiting glare index requirements as set out in the specified codes of practice. This section of work gives proposals for the types of lighting fittings to be used in the area, type of control to be employed, number of socket outlets and the types of mounting expected to be suitable for the respective areas. Where discharge and fluorescent light sources are to be used in areas containing rotating or reciprocating machinery, the fittings shall be allocated between the 3 phase and neutral in such a manner as to avoid stroboscopic effects. When 3 phase lighting installations are to be used, contactor switching controlled by pushbuttons located in the area to be illuminated is preferred.

In all rooms and corridors having two entrances the lighting installation shall have two way switching, the switches being located in appropriate positions adjacent to the entrances.

Exit and Emergency lighting shall be connected to a Central Battery System and shall be arranged to illuminate all stairways, exits and entrances and provide some illumination in offices and operational areas within the Administration Building, GIS Switchgear Building, Control Building, Sea Water Intake Facility, Pre-Treatment Facility, RO Facility, Post Treatment Facility, Electrical Rooms, Transformer Bays, and Gantry Area. Central Battery System shall be connected to a Three Phase Normal Power Supply coupled with a Standby Generator

Security lighting shall be installed around the perimeter walls illuminating the external area and shall be controlled from the gatehouse. The level of illumination for security lighting shall be measured at a distance of 3 metres outside the boundary wall.

SCHEDULE OF DESIGN REQUIREMENTS

The lighting system shall include provision for ease of erection, maintenance, cleaning, lamp replacement and future extension. Lamp replacement and maintenance should, unless otherwise approved, be possible without necessitating outages on main plant items.

Lighting apparatus shall be of top quality, designed to ensure satisfactory operation and service life under all variations of load, frequency and temperature. Sodium discharge lighting shall be used for road and security lighting. GIS Substation, Electrical Substations, & Gantry Area floodlighting shall use 500W Halogen lamps unless otherwise specified.

Streetlighting Illumination Calculation and Area Lighting Calculation shall be submitted to the Engineer for approval.

Key to Abbreviations:

L	Local switches
S1, S2 etc.	Socket outlets or fused spur circuits
P.B	Pushbutton for remote control
T.S	Time switch control
C	Ceiling mounted
W	Wall mounted
P	Pole or earth mast mounted
M	Recessed modular mounting
D	Suspended
F	Flush installation
S	Surface installation
A	Automatic on mains failure
BH	Behind ceiling diffuser.

CODING SYSTEMS

The Contractor shall, when preparing drawings showing the respective designs, use a code to identify each lighting fitting and socket outlet.

The code shall comprise letters and figures so compiled that the following information can be readily identified:

The lighting distribution board to which the fitting or socket outlet is connected.

If connected to the normal supplies or to the emergency DC supplies.

The circuit number and phase of the distribution board to which the fitting is connected.

The sequence of the fitting in a particular circuit.

SWITCHES AND PUSHBUTTONS

Switches shall be rated for 15 amps, shall be single pole types and be provided with an earth terminal.

Switches shall be one way, two-way or intermediate as required and, where mounted together, they shall be fitted in a common box.

Switches for use in areas designated for surface installation shall be quick-make-quick-break fixed grid industrial types mounted in galvanised malleable iron boxes with protected dolly and arranged where necessary for multigang switching.

Switches for use in areas designated for flush installation shall be micro-break types fixed to white plastic cover plates and mounted in galvanised steel flush type boxes.

Switch-boxes shall be galvanised and fitted with screwed stainless steel front plates having a 6 mm overlap minimum for flush installations. They shall be suitably barriered and labelled where two phases are connected in the same box.

Switches mounted externally shall be of weatherproof pattern to IP55 level fitted with machined box and cover joint, brass operating handles, neoprene weather tight seals and external fixing feet.

Where DC emergency lighting circuits are to be switched, double-pole quick make, quick break switches with pillar type terminals and earthing straps shall be provided.

Switches shall be mounted 1.4 m above finished floor level.

Pushbutton switches shall either be flush or surface types contained in galvanised steel boxes and be single pole rated for 5 Amps. Pushbuttons shall be made of non-hygroscopic material, be non-swelling and so fitted as to avoid any possibility of sticking.

The terminals for all switches shall be adequate to accommodate 2 conductors, each a minimum of 1.5 mm2 in area.

LIGHTING FITTINGS

Illustrations and/or samples of all lighting fittings which the Contractor proposes to purchase shall be submitted to the Engineer for approval before issuing any sub-orders.

Lighting fittings for interior and exterior use are to be manufactured and tested in accordance with the appropriate sections of BS 4533, IEC 60162 or equivalent and together with all components are to be suitable for service and operation in the tropical climate stated.

Each fitting is to be complete with all lamp holders, control gear, internal wiring, fused terminal block, earth terminal and reflectors or diffusers as specified. The design of each fitting is to be such as to minimise the effect of glare and such that the ingress of dust, flies and insects is prevented, where open type fittings are used it is to be impossible for insects to become lodged therein.

The control gear for use with fluorescent lamps is to be quick or resonant start type without starters. Chokes are to be impregnated and solidly filled with polyester resin, or other approved high melting compound, are to be manufactured to restrict the third harmonic content to less than 17% of the uncorrected current value, and are to be silent in operation.

The built-in ballast units shall comply with IEC 60082 and shall include radio interference suppressors and capacitors to correct the fitting power factor to a minimum of 0.85 lagging. Control gear noise levels shall be minimal.

Fittings shall be supplied complete with closed end vitreous enameled metal reflectors or totally enclosed opal plastic diffusers, which shall be fully interchangeable.

Dispersive reflector fittings suitable for mercury bulb fluorescent or tungsten filament lamps shall be of heavy gauge sheet steel finished vitreous enamel. They shall be fitted with anti-vibrators and arranged for conduit box mounting, direct or pendant, on galvanised ball and socket dome type lids.

Bulkhead fittings shall have cast bases tapped for conduit entry, hinged bezels, heat resisting prismatic glasses fitted with neoprene gaskets and porcelain lamp holders. Circuit cable shall not be connected direct to bulkhead fittings but shall terminate in a fixed base connector mounted in a conduit box adjacent to the fitting. Final connections to each fitting shall be carried out with silicone rubber covered cable. All bulkhead fittings shall be watertight pattern.

LED flood light fittings shall be explosion-proof, featured with high strength, impact resistance anticorrosion with performances of strong waterproof and dustproof, body material shall be Aluminium alloy.

Internal connections are to comprise stranded conductors not less than 0.75 MM^2 covered with heat resistant insulation to the requirements of BS 6500 or equivalent.

All internal wiring is to be adequately cleated to the fitting casing with an approved form of cleat. The finish of fittings for interior use is to be impervious to deterioration by atmospheric reaction. Fittings for exterior use shall have a vitreous enamel, natural Aluminium or galvanised finish according to the manufacturer's standard product.

Lamp holders for tungsten lamps up to 150 watts shall be brass or porcelain BC type and for higher ratings shall be ES or GES type according to size. Fittings for housing tungsten lamps exceeding 150 watts rating are to be provided with an approved method of dissipating heat from the lamp cap and terminal housing.

Lamp holders as applicable are to be suitable for the lamp specified.

Lighting fittings are to be of the type description as generally set out in the schedule appended to this section of the Specification. The type references used are to be repeated in the Schedules and on the drawings.

LAMPS

The Contract includes the supply and erection of all lamps and tubes necessary to complete the installation.

Fluorescent lamps shall be manufactured and tested in accordance with BS1853, IEC 60081 or equivalent, shall be bi-pin types and shall have colour rendering values of X = 0.335 and Y=0.342 (i.e., Colour 2) on the CIE chromaticity scale.

Tungsten lamps shall be manufactured and tested in accordance with BS 161 or equivalent and shall be bayonet cap for lamps up to and including 100 watts. Lamps rated for 150 watts and higher shall have edison screw caps. Low wattage lamps used in exit signs and emergency lighting units may be small or miniature edison screw.

Discharge lamps shall be manufactured and tested in accordance with BS 3677 or equivalent. Mercury vapour lamps shall be fluorescent types having a 10% red ratio colour correction, whenever used.

LED flood light shall be rain/fog penetrable and tested in accordance with IEC/EN 62471 or equivalent.

SOCKET OUTLETS AND FUSED SPUR OUTLETS

Each socket outlet shall comply with the requirements of the BS 1363 or equivalent and shall be the interlocked shuttered and switched types arranged for surface or flush mounting in single or multi- gang units as appropriate.

Each fused spur outlet shall be equipped with double pole isolator, a fuse to BS 1362 or equivalent and where required front entry for flexible connection.

Each socket outlet and fused spur outlet shall be equipped with a galvanized metal box with earth terminal.

Each group of socket outlets is to be provided with a matching fused plug top.

All socket outlets for exterior use shall be corrosion proof / water proof and be equipped with screwed dust proofed cap attached to the socket by means of a chain.

16A, 32A, 63A, 100A TPN+E Switched Socket outlets shall be provided inside and outside the 230kV/110kV/11 kV GIS Substation, Transformer Bays, Electrical Rooms, Administration Building (outside only) and CP1 Facilities that will be used for testing, commissioning, operation and maintenance.

TIME SWITCHES

Time switches for use with lighting systems shall be the synchronous motor wound types protected by a suitably rated fuse for 230 volts operation with a nine hour reserve spring and are to be fitted with a twenty-four hour hand set dial, two "off" and two "on" levers and manual operation pushbutton. The main contacts shall be rated for 20 Amps on a 230 Volt 50 Hz AC supply.

Time switches shall be suitable for mounting in the distribution boards supplying the circuits to be controlled.

LIGHTING POLES

Lighting poles shall be tapered, hot dip galvanized steel with 3 coats of powder epoxy coating and with bituminous preservative inside and outside at the base and shall be approved by the Engineer.

Each pole shall be equipped with a base section compartment of 470 mm by 150 mm to house an inspection trap, lockable door, fused cutout, cable entry and terminations for both the incoming and outgoing power cables and secondary cables feeding the light sources.

Poles for substation lighting shall support the floodlights at 12 m above ground level and poles for access roadway lights shall support the lanterns at 10 m above ground level.

The Contractor shall ensure each pole is provided with foundations suitable for the ground conditions occurring at each Site.

INTERIOR INSTALLATIONS

Wiring for the lighting and socket outlet installations shall comprise PVC cables drawn into conduits attached to walls or ceilings as appropriate.

Surface and flush type installations are required according to the particular area as indicated in the schedule appended to this section.

In areas where flush type installations are indicated the wiring shall be drawn into conduits buried under wall finishes or concealed above ceilings as appropriate.

All fixings shall be of a type approved by the Engineer and all metalwork used shall be galvanised. Fixings to structural steelwork shall be with purpose made brackets or clamps; the drilling of structural steelwork will not be permitted.

Cleats with two screw fixings shall be used for supporting conduits at not greater than 2m intervals.

All switchboxes, socket outlet boxes and items of a similar type shall be fixed with two screws or bolts.

Switches and pushbuttons for lighting circuits shall be mounted at 1400 mm above finished floor level. Socket outlets shall be mounted 500 m above finished floor level but those for use with workshop benches shall be mounted 150 mm clear of the bench working surface.

Lighting fittings shall be attached to ceilings, walls, trunking or roof steelwork or suspended there from as appropriate.

Where fittings are to be suspended, rod type suspension units shall be employed.

Final connections to all suspended lighting fittings shall be with heat resistant flexible cable terminated in porcelain clad connectors in the ceiling or junction box which shall also terminate the main circuit cable. The cable length shall be such that the suspension unit supports the full weight of the lighting fittings.

Where recessed type lighting fittings are to be installed suspension units shall be used to prevent the weight of the fittings being applied to the suspended ceiling. It shall be possible to carry out maintenance from the underside of the fitting without disturbing the false ceiling. To facilitate this need the final connection to each fitting shall be with heat resistant flexible cable from a plug in type ceiling rose mounted above the false ceiling.

All cables not contained within conduit for their whole route shall be terminated with a cable gland.

Where lighting fittings are mounted direct on walls or ceilings, the main circuit cables may be connected into the fitting terminal block. Where terminal blocks do not exist within the lighting fitting, flexible heat resistant cable shall be used connected to a separate junction box.

Earth continuity shall be maintained throughout the entire wiring installation with separate insulated earth continuity conductors of adequate cross-section ultimately connected to a common earth terminal at the respective distribution board.

Within the interior installation adequate provision shall be made for connection to small ventilating fans, which are not energised from the central air conditioning control and starter panel.

Each and every trunking route shall be bonded across all joints with external copper bonding links supplied for the purpose.

EXTERIOR INSTALLATION

Exterior substation lighting fittings shall be attached to substation walls at high level or pole mounted as appropriate. Security lighting round the perimeter wall/fence is to be provided.

When locating the floodlights for the switchyard lighting, the Contractor shall ensure that all floodlights are outside safety clearance for the high voltage lines at the Gantry Area.

Cables to exterior lighting shall be laid in uPVC ducts, laid in concrete trenches or cleated to buildings structures as appropriate to the route requirement. The cables shall be terminated at a cut-out located at the base of each support. Wiring between the cut-out and the control gear or lantern shall be with multicore cable run within poles or with cable drawn into galvanised steel conduit attached to the supporting structure.

EMERGENCY LIGHTING

Emergency lighting shall comprise lighting fittings of the types indicated in the schedule appended to this section of the Specification.

The system shall be so arranged that on failure of the normal AC supplies to the lighting installation the emergency lighting system will automatically be switched on. Other than those of the "on demand" type, all emergency lighting shall be switched "off" 5 minutes after restoration of normal supplies. Each emergency lighting unit shall have a minimum 3 hours rating.

Sufficient fittings of Type E3 shall be provided in each room to enable the rooms and building to be evacuated safely.

In addition, in designated working areas emergency manually switched lighting, to give not less than 30 lux, shall be provided utilizing Type E4 fittings. Switches shall be labelled to the approval of the Engineer.

The security lighting scheme shall illuminate the area to 6 meters inside the perimeter wall to the lighting level specified.

All emergency light fittings shall be connected to a Central Battery System located in Electrical Rooms of CP1 Plant Facilities, Administration Building, and 230/110/11Kv GIS Substation.

SCHEDULE OF LIGHTING FITTINGS AND SOCKETOUTLETS

All lighting schemes are to utilize fittings and lamp types as per the approved list of manufacturers.

Lighting fittings described in this section shall meet the general requirements of the Lighting Fittings of this specification.

TYPE F1 Shall indicate a basic channel complete with control gear and lamp holders for one fluorescent lamp, equipped with an open ended metal reflector having upward light slots.

TYPE F2 Shall indicate a fitting which shall comply generally with the description for Type Fl but be equipped for use with two lamps.

TYPE F3 Shall indicate a recessed modular fitting suitable for mounting in a suspended ceiling and equipped with a clear prismatic controller.

The metalwork and trim are to comprise a rigid welded unit so arranged as to be invisible when erected complete with controller. The fitting is to be equipped with a pre-wired removable gear tray and adjusting facilities to enable levelling relative to the ceiling to be carried out after erection.

The assembly is to be complete with control gear and lamp holders for one 1500 mm long 65 watt fluorescent lamp.

TYPE F4 Shall indicate a fitting which shall generally comply with the description F3 but with an open type grid diffuser.

TYPE F5 Shall indicate a dust-tight, weatherproof and vapour resistant fitting, having a grey polyester fibre glass reinforced chassis containing the control gear and having lamp holders for one 1500 fluorescent lamp. The fitting shall be complete with a vacuum formed acrylic diffuser which is secured to the body with injection moulded toggles and sealed with a neoprene gasket.

TYPE F6 Shall indicate a weatherproof bulkhead fitting with a cast aluminium base and vandal resistant diffuser equipped with control gear and lamp holders for two fluorescent lamps.

TYPE E1 Shall indicate a self-contained, self-sustained (normally off) emergency lighting unit, complete with integral batteries and control gear, with the words "EXIT" in white letters on red background in English and Arabic. It shall be energized from the batteries under mains failure conditions.

The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

Light Fitting shall be compatible with the Central Battery System.

TYPE E2 Shall indicate a self-contained, self-sustained (normally off) wall mounted emergency lighting unit comprising a pilot light and two 100 watts spotlights complete with integral batteries and control gear. The pilot light shall be energized under mains failure conditions with manual "on demand" switches for the spotlights. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

Light Fitting shall be compatible with the Central Battery System.

TYPE E3 Shall indicate a self-contained, self-sustained (normally off) wall or ceiling mounted emergency lighting unit complete with integral batteries and control gear. The lamps shall be energized under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

Light Fitting shall be compatible with the Central Battery System.

TYPE E4 Shall indicate a 110V DC wall or ceiling mounted emergency lighting unit which shall be manually switched and be similar to type E3.

Light Fitting shall be compatible with the Central Battery System.

TYPE H1 Shall indicate forward throw floodlight fitting comprising a sheet steel vitreous enameled or spun aluminum reflector housing a 500 watts Halogen lamp. The fittings to be complete with wall mounting bracket.

TYPE H2 Shall indicate a semi cut-off roadway and perimeter security lantern with housing manufactured from a piece of LM6 aluminum alloy casting enameled white internally and equipped with reflector bowl of heat resisting glass, all suitable for housing the lamp holder and control gear for one 250 watts sodium vapor lamp. The fitting to be equipped with pole arm suitable to give an outreach of 1 meter.

TYPE S1 Shall indicate a 13 Amp single or double gang flush mounted switched socket outlet.

TYPE S2 Shall indicate a 13 Amp single or double gang surface mounted switched socket outlet.

TYPES3 Shall indicate an ironclad one gang heavy duty 4 pole interlocked switched socket outlet with scraping earth connection suitable for use on a 415V 3 phase 4 wire 50 Hz for 16A. Each socket is to be supplied complete with cable box with 2 glands, suitable for terminating a Cu/XLPE/SWA/PVC cable and shall be fitted with a screwed dustproof cap attached to the top of the socket by means of a chain. Matching plugs to be provided in each socket.

TYPE S4 Shall indicate an ironclad one gang heavy duty 4 pole interlocked switched socket outlet with scraping earth connection suitable for use on a 415V 3 phase 4 wire 50 Hz for 32A. Each socket is to be supplied complete with cable box with 2 glands, suitable for terminating a Cu/XLPE/SWA/PVC cable and shall be fitted with a screwed dustproof cap attached to the top of the socket by means of a chain. Matching plugs to be provided in each socket.

TYPE S5 Shall indicate an ironclad one gang heavy duty 4 pole interlocked switched socket outlet with scraping earth connection suitable for use on a 415V 3 phase 4 wire 50 Hz for 125A. Each socket is to be supplied complete with cable box with 2 glands, suitable for terminating a Cu/XLPE/SWA/PVC cable and shall be fitted with a screwed dustproof cap attached to the top of the socket by means of a chain. Matching plugs to be provided in each socket

SCHEDULE OF LIGHTING REQUIREMENTS

Location	Service Glare Illuminance (Lux)	Index
Control Relay Room	500	25
Behind panels	150	-
Offices, Conference Rooms	500	20
Battery Room	300	-
Kitchen/Canteen	400	20
Toilet	100	-
Corridors, Stairs	150	-
GIS Substation Flood lighting	30	-
230/110kV GIS Room	400	20
11kV Switchgear Room	400	20
Low Voltage Switchgear Room	400	20
Transformer Compounds	150	-
Roadway Lighting	30	-
Perimeter Wall Security	20	-
Control Building Exterior	30	-
Electrical Rooms	400	20
Plant Facilities/ outdoor	300	-
Workshop	400	-

8.6.48 AIR CONDITIONING AND VENTILATION

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the heating and ventilating systems for the 230/110kV GIS Substation Building and CP1 Facilities.

Codes and Standards:

BS 4434 Specification for safety aspects in the design construction and installation of refrigerating appliances and systems.

Institution of Heating and Ventilation Engineers Guide to current practice.

American Society of Heating, Refrigeration, and Air conditioning Engineers

Recommendations

Heating and Ventilation Contractors Association of U.K. specification DW/ 121

BS 5970 Code of Practice for thermal insulation of pipe work and equipment

BS 848 Fans for general purposes

BS 6540 Method of test for atmospheric dust spot efficiency and synthetic dust weight arrestance

BS 2871 Specification for copper and copper alloys: tubes

BS 1470 Specification for wrought Aluminium and Aluminium alloys for general Engineering purposes, plate, sheet and strip

All heating and ventilating systems shall be fully automatic in operation and shall be capable of maintaining internal conditions within the bands of temperature and humidity specified hereafter. the substations are normally manned and allowance shall be made for at least four persons on site in the design.

Heating

Electrical heating shall be provided for each room of the building. Except for the battery room, the heating shall comprise of 1500mm long tubular heaters with a load of 60 watts/foot (300mm) which shall be mounted in double tier banks. Electric heaters shall be fitted with bright plate safety guards affording full protection to the heating tubes. The Contractor shall assess the thermal performance of the building and ensure that the sizes of units are adequate to maintain internal temperatures of 5° C when the external temperature is -3°C, measured 1200mm above finished floor level out of an air stream.

The heaters in each room shall be controlled by contactors which have thermostats connected into the coil circuit. Thermostats shall be located in each room and have a maximum cut-off temperature of 17° C.

Each heater bank shall be equipped with a local isolator. The lower tubular heater shall be mounted at 500mm above finished floor level.

Air Conditioning

The following areas shall be air conditioned :

Administration Building

Gas Insulated Switchgear Room

11kV Switchgear Room

Low Voltage Switchgear Room

Motor Control Center Room

Electrical Rooms

Control / Relay room

Tel/LAN / SCADA / PLC room

Offices / Record Room

Laboratory Room

Canteen / Kitchen

Air conditioning shall be provided in the form of Air-Cooled Split System Air Handling Units. The systems shall handle predominantly recirculated air with a controlled quantity of fresh air introduced either at each unit or independently via a separate supply and extract system. Supply air distribution ducts for the Control/Relay room shall be located in the false ceiling serving supply diffusers. Return (recirculated) air shall be drawn in through the front of each unit.

The cooling medium for the split System Air Handling Units shall be direct expansion provided by air cooled refrigeration condensing units located on the roof of the building or wall mounted on building exterior, and interconnected by refrigerant pipe work to multi circuit direct expansion cooling coils.

Air conditioning system shall be thermostatically controlled to maintain internal conditions under continuous operation within the limits stated. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

Mechanical Ventilation

Supply and extract ventilation shall be provided to serve the following areas:

1. Switchgear room
2. Battery Rooms
3. Toilets (Extract only)
4. Cable basement

Supply air handling plants shall consist of a sand trap fresh air intake louvre, insect screen, pre-filter, bag filter, electric air heater battery, fan and distribution ductwork.

The air intake shall not face the prevailing wind.

Extract ventilation shall be provided by means of wall mounting fans, roof extract units or ducted systems with louvered discharges to atmosphere. Individual extract fans shall be provided for Battery room and toilets.

Extract fans for battery room shall be corrosion resistant throughout, with a 4 mm PVC lining.

Basis for Design

External Design Conditions

The external conditions for the calculation of duties for the mechanical services shall be with mean monthly, maximum and minimum values as below:

Maximum ambient shade temperature		45 deg C
Minimum ambient shade temperature		4 deg C
Maximum daily average temperature		35 deg. C
Relative humidity	- maximum	100%
	- minimum	80%
Solar radiation		100mW/sq.m

All plant and equipment installed externally, or which can be affected by external condition shall be capable of withstanding without damage or deterioration the effects of solar radiation, rain, wind, dust, sand storms or other weather phenomena prevalent in the area in which particular building is located.

Internal Design Conditions

Air conditioning systems shall be capable of maintaining internal conditions in all air conditioned areas within the following bands or, if necessary for the satisfactory operation of the equipment housed, more stringent requirements:

For substations 22+4 ^{o}C DB

40 to 70% R.H.

The following air change rates/hour shall be provided in mechanically ventilated area:

Switch gear Rooms	10
Battery Rooms	10
Toilets 12 (Extract only) Cable basement	6
Other general areas	4

All air conditioning and ventilating systems shall be designed for continuous operation. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

The Contractor shall calculate heat gains and losses under the specified conditions for each part of each building, taking into account solar radiation, thermal transmittance through roofs, walls, floors and windows, fresh air requirements, heat emission from installed e1ectrical equipment and lighting, personnel, infiltration and any other sources. The Contractor shall be responsible for determining the heat transfer coefficients for all materials used in building construction. In the event of any change in materials. design or method of building construction, the Contractor shall at all times be responsible for rechecking the design of all systems to ensure that they are capable of meeting the specified design requirements.

Air Cooled Condensing Units

The cooling medium for the air conditioning shall be direct expansion refrigeration provided by air cooled condensing units located externally.

The condensing units shall be of the fully packaged type requiring only site connection of refrigeration pipe work, isolated electrical supply and input from the control system.

The individual item of refrigerant equipment shall be matched such that the required performance of the evaporator is achieved concurrently with the satisfactory operation of the compressor and adequate heat rejection at the condenser. Each system as a whole shall maintain the correct duty at the design ambient and operate at the maximum ambient conditions stated without exceeding the safe operational limits of any individual item of equipment and without causing any safety device to operate.

All electrical equipment, control, magnetic coils and solenoids shall be manufactured specifically for operation at the electrical characteristics specified herein and such items designed for any other characteristics shall not be used.

Air cooled condensing units and air handling units that are inter-connected on site with refrigerant piping shall all be supplied by the same manufacturer.

The casings of the condensing unit shall be weatherproof and shall incorporate adequate access and inspection panels secured in place by rustproof fasteners.

The whole of the casing shall be treated for corrosion and weather resistance and ungalvanized mild steel shall not be used (even if painted). The unit shall be finished in not less than two coats of weather resistant finish, such as baked enamel of a light reflective colour.

The access panels shall be adequately sized for the service and removal of all working parts of l the unit. All panels shall be stiffened and supported to prevent flexing and drumming.

Electrical equipment shall he contained in a fully weatherproofed enclosure with internal division between the power connections and equipment and the control connections and equipment.

Refrigeration Systems

(a) Liquid lines shall be insulated where they are in direct sunlight or where they pass though non-airconditioned areas.

Suction lines shall be insulated over their entire length.

All insulation to refrigeration pipe work shall be flexible closed cell l foam phenolic rubber type with a temperature range of -40°C to +105°C and having a thermal conductivity of 0.0375 w/m °C at 2l °C and a water vapour transmission of less than 6.0 ng/Ns.

The thickness of insulation shall be in accordance with the following tables:

Suction Lines

Location	**Insulation thickness for O.D.**	**Pipe Sizes Range**
	6-10mm	12-22mm
Exposed to weather	13mm	19mm
In airconditioned spaces	9mm	19mm

In non-airconditioned spaces	9mm	9mm
Liquid Lines		
Exposed to weather and in non-airconditioned spaces	9mm	9mm

(b) The refrigerant used shall conform to BS 4334 Group 1 or equivalent and shall be non-explosive, non-combustive, non-toxic and non-irritating.

Packaged air conditioning plant items requiring interconnection with refrigeration piping on site shall be leak tested by the manufacturers and delivered to site with a holding charge of refrigerant.

Console Air Conditioning Units

Console model room air conditioners shall be of the slim-line pattern and complete with 4-way adjustable grilles, heavy gauge zinc coated stove enamelled sheet steel casing with single or two colour decorative finish. Electrical-heaters shall not be fitted.

The casing and position shall be such as to protrude not more than 250 mm into the air-conditioned space and no external projection beyond the building line will be permitted other than the fixing of the condenser cooling air grille.

The units shall be extremely quiet ill operation, the noise level not being higher than 30 dB. All sections of the casing shall be acoustically and thermally insulated.

Compressors shall be of the fully hermetic type, fitted with resilient mountings and complete with thermal overload protection and starting relays.

Evaporators shall be manufactured of' copper tube with copper or aluminum fins mechanically bonded. The evaporator fan shall be of double inlet, double width type and complete with continuously rated totally enclosed electric motor.

Filters shall be of the washable type, suitably positioned for easy access for cleaning.

Automatic control by means of an integral thermostat shall be provided, together with the safety control to prevent excessive cooling.

Motors shall be air cooled and units shall be complete with internally mounted condenser cooling fans with totally enclosed motors.

Fresh air shall be introduced separately by means of a central fresh air plant, where these units are proposed to serve individual offices in a building.

Units shall be supplied as a whole and be suitable for easy removal and re- positioning should this be desired at a later date.

Ductwork

All sheet metal ducting shall be manufactured and installed in accordance with the Institution of Heating arid Ventilation Engineers Guide to Current Practice Section B 16, the American Society of Heating, Refrigeration and Air Conditioning Engineers, or the Heating and Ventilating Contractors Association of United Kingdom Specification DW/142 or equivalent international standards for sheet metal ductwork for low velocity low pressure air system with air velocity of up to 10 m/s.

Ail ductwork and fittings serving hazardous areas, such as battery rooms where corrosive fumes are expected, shall be of rigid PVC materials.

Condensate Drains

Provision shall be made for condensate to be passed into the rainwater drainage system. Condensate drains must be routed directly into the drainage system or individual soakaways. Pipes discharging onto substation or building brick paving will not be permitted.

Extract Ventilation Units

This clause covers fan powered extract ventilation units for mounting in walls and windows, on roofs and in plant rooms.

Extract units shall incorporate propeller. aerofoil, axial, centrifugal or hybrid type fans which shall be constructed in accordance with the relevant sections of this Specification.

Roof units shall comprise a galvanised sheet steel base suitable for use as a weathering skirt, a mild steel fan/motor mounting frame and a spun Aluminium cowl. The sheet steel base shall be constructed to support the fan/motor without distortion and where the fan is belt driven shall incorporate a rigid subframe for motor mounting. Fans shall be diaphragm mounted or fitted with a cylindrical casing designed for removal from the unit from inside or outside the building without disturbing the weathering skirt or cowl fixings. The cowl shall be weatherproofed and shall be hinge mounted to provide complete access to the fad/motor.

Lubricating points shall be extended to a convenient access point.

Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

Air Filters

All filter media hall be properly bonded and protected against filter fibre or particle migration. The direction of air flow shall be clearly marked on all filter panels and on installation frames.

Access to filters shall be through removal panels fitted with quick release fasteners and rubber sealing gaskets.

Each disposable panel filter system shall be provided with 4 complete spare sets for use during the commissioning period. These sets shall be in addition to any filter cells supplied as spares in accordance wit11 the general clauses of this specifications.

Filter performance shall, unless otherwise noted, be taken to mean the Overall Gravometric Efficiency against BS 6540:Part I Duct Test or equivalent.

Filter media of all types and sizes shall be supported in rigid peripheral frames with internal or external wire support of the media to ensure that the media shall not collapse under air flow. The holding frames shall incorporate accurately sized channel sections to provide a good fitting for the filters.

The type of washable and/or disposal panel filters shall be subject to the Engineer's approval.

Grilles and Louvres

Grilles shall be of aluminum construction and shall be fixed by means of subframe with spring clips or screw fixings.

The corners of front flanges of grilles and subframes shall be mitred and jointed to produce a clean unbroken appearance and visible aluminum sections shall be free from extrusion marks.

Front flanges shall be at least 30mm wide and shall incorporate a lip of at least 4.5 mm and a felt gasket. Blades shall be fixed at even centers with intermediate mullions giving support for blades of more than 550 mm long. Grille finish shall be anodised natural Aluminium colour except where otherwise indicated.

All grilles shall be fitted with an opened blade damper for regulation purposes and shall be fitted with acoustically lined inlet plenums where necessary in order to comply with the acoustic limits of this Specification.

Outdoor air louvers shall be of all extruded Aluminium construction fitted with opposed blade dampers in the connected ducting where necessary for air flow regulation, Movable blade louvres shall not be used.

Louvers shall be weatherproof and shall incorporate an Aluminium wire mesh screen on the inside surface.

The dimensions of louvers for mounting in the building structure shall suit the concrete block or brick modules and shall be fixed to a hardwood frame.

Control Equipment

Each item of shall be provided with local isolation and/or emergency stop buttons to facilitate maintenance, inspection and emergency operation.

The control system shall be of the electronic type, capable of providing the degree of thermostatic control specified. The Contractor shall provide full wiring diagram of all control circuits giving terminal connection reference.

The control system shall incorporate all necessary safety interlocks for the successful operation of the mechanical plant and system. All of the individual control elements shall be provided by the same manufacturer.

Temperature sensors shall be of the resistance type using nickel based elements and shall be accurate to + 1^{o} C over the range of 0 ^{o} C to 30 ^{o} C. The sensor resistance shall be compatible with the measuring bridge of the matching control box.

Electrical Connections

All electrical power control cables and wiring associated with the air conditioning and ventilation systems, including all connections between control panels, valves, thermostats, sensing probes and other like items shall be supplied, installed and connected up as part of this Contract.

The cabling and wiring system shall comply with the requirements of the relevant clauses of this Specification and be either surface or flush installation as appropriate.

Cables and wiring shall comprise either PVC/WPVC laid in cleats or trenches, or PVC drawn into galvanized conduits and trunking.

Final connections to electric motors and all other items of plant subject to movement and vibration shall comprise flexible cable in flexible conduit.

Manufacturers

Wherever possible all air conditioning and ventilating plant shall be selected from a single manufacturer's product range and origin. Where this is not possible, because of practical or technical constraints. then the number of different sources of origin shall. be kept to a minimum. Local service facilities shall be available for the equipment proposed.

The Contractor shall provide, with his submission, illustrated technical literature covering all plant and equipment offered.

Standards

All air conditioning and ventilation equipment shall conform to British Standards, Chartered Institution of Building Services or ASHRAE recommendations or other recognized International Standards.

Approval

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the selection of all air conditioning and ventilating plant, plant selection details and full working drawings. Such approval shall not relieve the Contractor of his contractual responsibilities.

Maintenance

The Contractor shall be responsible for the maintenance of all installations covered by this section of the Specifications for the period stated elsewhere in the Specification.

EARTHING AND BONDING

All equipment being supplied under this Section shall be effectively bonded to ensure earth continuity throughout the system. Continuity may be provided by means of cable armouring but a separate earth continuity conductor shall be included with all wiring in conduits. No reliance shall be placed on metal to metal joints in conduits for earth continuity. The earth continuity conductors shall as far as possible be in one continuous length to the furthest part of the installation from the controlling switchboard. The earth conductor shall connect all metal cases housing electrical equipment. The branches shall be connected to the main conductor by permanently soldered on mechanically clamped joints.

8.6.49 TELEPHONE / LAN SYSTEM

Contractor shall Design, Supply, Deliver, Test and Commission a complete TEL/LAN System as per ANSI/TIA/EIA 568-B in 230/110/11kV Gas Insulated Substation, CP1 Facilities and Administration Building. Complete conduit/ductbank system shall be provided throughout the GIS buildings, Administration Building and CP1 Plant facilities to enable the telephone / LAN cables to be run to the proposed extension points. This includes telephone wiring to operators' desks, office in the GIS Control Building and Administration Building.

Telephone instruments, the PABX and connections to PTT exchange lines shall be carried out by the approved Telecommunication / LAN Contractor.

8.6.50 CCTV SYSTEM

At least 12 (twelve) IP based CCTV Camera with complete necessary hardware & software for video recording, monitoring and storage, switch etc. shall be supplied, installed and commissioned inside and outside of 230/110/11kV GIS building for security purpose. The suitable location of the camera shall be finalized during contract execution and shall be submitted to the Engineer for approval. Data connection for individual camera shall be through well protected fiber optic cable.

CCTV Camera specifications shall be as follows:

PTZ type camera

Signal Format : NTSC

Input Voltage : 12/24V

Panning range : 0-360 degrees

Tilt Range : 0-90 degrees Horizontal resolution : 480TV lines

Fixed Type camera

Signal Format : NTSC

Input Voltage : 12/24V Horizontal resolution : 550TV lines

Digital Video Recorder

Recording mode : Continuous Camera display : 16 channel

Signal cable Type : Fiber Optic Type

CCTV camera system shall have to be integrated with substations Fiber Optic Multiplexer equipment for remote monitoring.

CCTV camera system for the Administration Building and the whole CP1 Plant shall be designed by the Contractor and shall submit the drawings to the Engineer for approval.

TESTING AND COMMISSIONING

The Contractor shall be required to prove that the installed system meets the design requirements and Specification to the satisfaction of the Engineer.

8.6.51 BUILDING AND CIVIL ENGINEERING WORKS

GENERAL

Under this Section the Contractor will be responsible for the design and construction of all Civil Engineering and building works and services for new 230/110/33 kV indoor GIS substation at CP1.

Scope of Work

The Bid must cover all requirements of the bid documents and any other items not specifically mentioned but which are necessary for the satisfactory design, construction, operation and maintenance of all equipment to the satisfaction of the Employer. No additional costs will be considered for any items which have been overlooked but which are essential for the proper completion of the project in every respect.

The work shall include but not be limited to:

1. Site survey and subsoil investigation.
2. Site preparation, cutting or filling up to the level specified in civil requirements and leveling.
3. Roadways, car ports, paths and surfacing.
4. Foundations for all equipment to be installed in power receiving facility gantry area, control building, indoor switchgear and any other building required for the project.
5. 230/110KV GIS Rooms, Transformer Bays, 11kV Switchgear Room, Control Room, Battery Room, Fire Pump Room, Cable Basements, Cable Trenches, Toilet, etc. (complete building consisting of concrete piles, foundations, structural reinforced concrete frames, brick walls, concrete roof and floor slabs).
6. Motorized roller shutter door for GIS entrance.
7. Floor finishing: screed for cable basement and GIS room, Nitocote epoxy resin coating in battery room, raised floor for control room and homogeneous tile for other floors.
8. Cable trenches, cable tunnels, cable ducts and pipe ducts.
9. Water supply and plumbing installations
10. Surface water and foul drainage.
11. Guard house
12. Security fence (claustra block wall with stainless steel gate).
13. Air conditioning and ventilation.
14. Electric Overhead Travelling Crane for the 230kV and 110kV GIS Rooms
15. Lighting, small power, external floodlighting, emergency lighting and fire protection.

For all substations and for individual rooms in substations suitable nameplates, signs and labels shall be provided to ensure identification, safe operation of plant and warning of danger. The text, which shall be both in Tamil and English, shall be approved by the Engineer. The substation sign board(s) shall be 3 mm, Aluminium sheet powder coated and the text (Tamil & English) shall be UV resistant, CMWSSB logo on a separate circular plate to be fixed at the centre of sign board. The inscriptions shall be engraved with colored lettering. All nameplates, signs and labels shall be non-deteriorating and non-warping under aggressive weather conditions and shall be guaranteed for a minimum period of 10 years.

Plates, etc., will be securely attached using stainless steel 304 bolts and nuts or screws; adhesive will not be permitted.

Included in the scope of work is the detailing, construction and maintenance of the following items which shall generally be constructed to the Employer's standards, but full working drawings shall be prepared by the Contractor:

1. Septic tank and soak away
2. Underground water storage tank

Drawing and design of septic tank and soakaway shall be prepared by the Contractor and shall be finalized during detailed Engineering.

The Bidder shall state which approved local building Contractor(s) he proposes to employ to carry out the work.

Contractor to satisfy himself as to all conditions

The Contractor shall assess:

1. access conditions at all sites, plus ground conditions and ground bearing capacity
2. transport costs, materials costs and restrictions of availability of supply of materials locally
3. importation restrictions and delay due to customs controls
4. restrictions imposed by existing equipment on sequence of construction, access, etc.
5. restrictions caused by cable laying, equipment and line Contractors
6. ground conditions and temporary works required to provide support during excavation.

8.6.52 STANDBY DIESEL GENERATOR SET

Contractor shall design, supply, deliver, test and commission the frame sizes, KVA ratings, and sizes of fuel tanks of the Diesel Engine Generator Sets in order to supply all the Critical Loads (i.e.: UPS System, 110V DC Battery Charger, 48V DC Battery Charger, Central Battery System, Fire Pump Control Panel, Fire Pump, Jockey Pump, Deluge Water Spray System, Smoke Extract Fans, Battery Room Ventilation Fans, Potable Water Pumps, etc. on the following CP1 Facilities:

1. 230/110/11kV GIS Substation / Control Room
2. Administration Building
3. Sea Water Intake Building
4. Pre-Treatment Building
5. RO Building 1

6. RO Building 2

7. Post Treatment Building

8. Water Storage Building

The Diesel Generator set shall be locally supported and shall preferably be as per IEC, British Standards and NEMA Standards.

The generator supplier shall have the capability to conduct on-site load bank tests.

Generator set frame sizes and ratings shall not be less than that of the available electrical critical loads of the CP1 plant facilities. These ratings as a minimum should be acceptable for site conditions of altitude up to 305 M (1000 FT) and temperatures up to 50° C (122° F).

Technical Specifications

The Diesel Generator set shall be equipped with a 4 stroke-cycle diesel engine generator set, not to exceed 1800 revolution per minute, manufactured in accordance with B.S. 5514 or ISO 3046 and generally to such International standards as D.I.N., E.I.C., N.E.M.A. The engine shall be capable of providing a 10% overload for a maximum of one hour in any twelve-hour period over its prime output. The governor shall be electromechanical type and complies with BS85514 Class A1.

The diesel engine shall be housed in a Generator Room and should have a maximum sound level of 85dBA measured one meter away from the equipment. It shall also comply with the emission standards of the Clean Air Act of the local environmental authority.

If the installed equipment proposed does not meet the 85dBA maximum sound level, the Contractor has to provide sound-absorbing materials in the generator room's walls and ceilings to achieve the maximum sound level requirement. The proposed sound-absorbing material and method of installation shall be submitted to the Employers Engineer for approval.

The engine shall be diesel, radiator and fan cooled. A governor shall provide automatic frequency regulations adjustable to 5% drop. The governor shall have provision for paralleling with the addition of load sharing controls. The engine shall be cooled by a mounted closed loop radiator system rated for full load operation in 50 degrees C (122 degrees F) ambient as measured at the generator air inlet. Radiators shall be provided with a duct adaptor flange. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental contact and meet all OSHA requirements.

The engine-generator set shall include the engine accessories as follows: A DC electric starter capable of three complete cranking cycles without overheating, before over crank shutdown (75 seconds). Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator. An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element. Replaceable dry element air cleaner with restriction indicator. Flexible supply and return fuel lines. Engine mounted battery charging alternator, 45 ampere minimum, and solid-state voltage regulators.

The AC generator shall be brushless design screen protected, fan ventilated, drip-proof, self-exciting in accordance with IP23 (NEMA 1) Protection and directly connected to the engine with flexible drive discs. It shall be fitted with heavy-duty long life bearings, lubricant packed for 40000 hours operation. The genset shall be constructed in accordance with BSEN 60034 and relevant section of other international standards such as BSS 5000, UDE 0530, NEMA MG1-22 and IEC4.

Temperature rise measured by resistance method at full load shall not exceed 110 degrees Centigrade.

The genset output voltage shall be 240/415volts AC, 50 Hz 3phase and Neutral. The voltage regulator shall be immune from disoperation due to load-induced voltage waveform distortion.

The voltage regulator shall be equipped with three-phase voltage sensing (3 phase RMS sensing automatic voltage regulator and set mounted control panel). The regulators shall control buildup of the AC generator voltage to provide a linear rise and to limit overshoot. The regulator shall include torque-matching characteristics, which shall reduce output voltage in proportion to frequency below a threshold of (48-50) HZ. The voltage regulator shall include adjustments for gain, damping, and Frequency roll- off.

The set control shall have automatic remote start capability from a panel- mounted 3-position (Stop, Run, Remote) switch. The unit shall provide cycle cranking of 15 SEC (ON)/15 SEC (OFF) for three attempts (75 EC). If engine fails to start a lockout of the engine shall be in place and indicate over crank on alarm status panel. The control shall shut down and lock out upon: failing to start (over crank), overspeed, low lubricating oil pressure, high engine temperature, or operation of a remote manual stop station. A panel mounted switch shall reset the engine monitor and test all the lamps. Local and remote panel shall have emergency stop button.

Local panel shall have a common digital instrument with LCD display. The following parameters shall be displayed as a minimum:

1. Phase Voltage
2. Line Current
3. Load in kW
4. Engine Speed in rpm
5. Frequency

6. Engine Temperature, in deg C
7. Oil pressure in psi
8. Running hours meter

Lamp indications on the control panel shall be provided as follows:

1. Over crank shutdown – red
2. Over speed shutdown – red
3. Low oil pressure shutdown – red
4. High engine temperature shutdown – red
5. High engine temperature pre-alarm – yellow
6. Low engine oil pressure pre-alarm – yellow
7. Low coolant level – yellow
8. Low fuel level – yellow
9. Overload alarm – red
10. Run – green
11. Not in automatic start - flashing red
12. Auxiliary (2 each) - red (Customer identified)

The NEMA 1 enclosed control panels shall be mounted on the generator set within the weather protective housing with vibration isolators. Control panel mounted indicating meters and devices shall include: Engine Oil Pressure Gauge, Coolant Temperature Gauge, DC Voltmeter, Running Time Meter (hours), Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/- 5% from rated value; Analog AC Voltmeter, dual range, 90 degree scale, 2% accuracy; Analog AC Ammeter, dual range, 90 degree scale, frequency meter, +/- 0.6 Hz accuracy; Seven position phase selector switch with OFF position to allow meter display of current and voltage in each phase. When supplied with re connectable generators, the meter panel shall be re connectable for the voltage specified.

Voltage regulation is maintained within the limits of + or – 1 to 2% from no load to full load including cold to hot variations at any power factor between 0.8 lagging and unity and inclusive of a speed variation of 4.5% nominal voltage is set.

Stator and rotor insulation shall be Class "H" standard.

Radio and television suppression shall be provided and shall comply with B.S.S. 800/1983.

The complete generating set shall be mounted as a whole on a heavy-duty steel base frame to maintain alignment between components. The base shall incorporate a battery tray with hold down clamps within the rails.

Back-up starting batteries shall be provided connected through a double- throw switch (100 ampere rating minimum) for easy transfer in case of battery failure. This shall be in addition to the standard starting battery normally provided by generator suppliers.

Alternator

The alternator shall be synchronous, four pole and brushless excitation type and shall comply with the relevant requirements of IEC 60034 or an equivalent international standard. The alternator shall be designed for operation of 10% engine overload at any power factor between unity and rated power factor for a maximum period of one hour in any 12-hour period as permitted by ISO 3046/II. The alternator shall be rated for IP-23 protection. The insulation of the winding shall be class H. All winding shall be tropicalized and suitably impregnated to withstand the site ambient conditions.

The alternator shall be complete with all necessary cooling fans, excitation and voltage regulating equipment. The alternator shall be capable of maintaining its continuous maximum rated output when operating within + 5% of rated voltage and at rated power factor. The alternator shall be brushless rotating field, self-exciting and self-regulating type complete with permanent magnets and fully connected damper windings. The stator winding shall be star connected and shall be brought out together with the neutral point to terminals located in a sheet steel box mounted on top of the generator to facilitate connection of a power cable of suitable capacity.

The following protection shall be provided for the alternator:

1. Over Current Protection
2. Earth Fault Protection.

Automatic Transfer Switch (ATS)

The ATS shall comply with IEC 60947 or equivalent international standard. The separately mounted generator control cubicle and ATS panel shall be of sheet steel vermin proof with lockable hinged front doors. A Four pole circuit breaker and auto transfer switch should be provided rated for full load of the current (+ 10% overload). The ATS equipment shall be of 3 attempt type and capable of sensing single phase and three phase failure of main supply or any variation in main supply voltage. The main supply and generator supply contactors or Solenoid/Motor operated change over switch shall be of fool proof design with mechanical and electrical interlock.

Fuel Tanks

Built-in Fuel Tank:

A minimum capacity of not less than 8-10 hours full running time built in fuel tank shall be provided. Design shall be capable of preventing accidental spilling of fuel and hand pump feeding on emergencies is possible.

External Fuel Day Tank

An external fuel day tank shall be calculated and shall be provided by the Contractor based on the approximate diesel fuel consumption of the selected size and model of the diesel generator set in each facility.

Contractor shall provide pre-engineered above ground atmospheric tank system complete with tank, piping, secondary containment, gauges, and other accessories specified herein as a complete assembled system.

The external tank shall have enough fuel to provide the diesel generator with fuel for 24 hours.

Tank Construction

The tank shall be manufactured from carbon steel with thickness as U.L. Standard 142. The tank shall be externally coated with 4 layers of coatings. The prime layer using Red Oxide paint and the top layer using 3 coats of powder epoxy paint (the tank shall be sand blasted first before painting). Tank shall comply with the normal and emergency venting requirements of NFPA 30.

Tank shall carry a ten (10) years warranty including materials and workmanship. Fuel tank to have, lowest point drain facility for water and sludge, fuel level gauge direct mounted or remote electric, filler pipe and locking cap.

Accessories

The tank shall be manufactured to support the following accessory equipment and shall be provided with suitably located lifting lugs:

1. Direct Level Indicator shall be made of plastic pipe connected through suitable valves and shall be approved by the Employers Engineer.

2. Lockable cap for inspection and manual gauging of fuel level

3. Gauge port accessible from steps or ladder to minimize the oil spilling during tank filling operation.

4. Pipe to prevent the increase of gas pressure inside the tank. The vent opening should be covered with a wire mesh to prevent anything from entering and blocking the vent.

5. Schedule 40 Black steel supply pipe connection with a stainless steel two–piece body, stainless steel ball, Teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends with union Ball Valve shall be provided with a suitable sized ASME B36.10, Schedule 40 Black Steel Drain pipe connection with a Carbon Steel, Stainless ball, with Viton seals Spill Sump Drain Valve. Steps and ladder shall be of welded steel construction with prime and finish paint similar to the day fuel tank, and shall be designed to conform to OSHA requirements.

Fuel Distribution Pipe and Pipe Fittings

The design criteria shall conform to the following minimum requirements:

1. Steel Pipe: ASME B36.10,
2. Schedule 40 Black Steel Fittings: ASTM B16.3, 300 lb.
3. Threaded malleable iron, or ASTM A234, forged steel welding type.
4. Finish: Prime and finish paint similar to day fuel tank.

Drawings

The Contractor should submit design (shop) drawings for the tank and fuel pipe distribution, location of fittings and accessories with specific dimensions, for approval by Employer's Engineer prior to product fabrication.

Test

The tank shall withstand an internal air pressure test of 3-5 psi.

Welding

Welding shall be carried out in accordance with an approved standard or code of practice. The welding plants and processes used shall be suitable to the materials, configurations and purposes of the welded parts. Only qualified welders, certified for the type of welding required, shall be employed. The Contractor shall exercise strict control over the welding conditions and parameters and shall continuously monitor the standard of welding achieved in accordance with the requirements of the Clause on Quality Control and Quality Assurance.

Exhaust System

The engine shall be efficiently silenced and be complete with primary and terminal silencer arrangements.

Mounting

Complete unit shall be mounted on robust skid frame. Vibration mountings shall be used where required. Skid frame to be dimensioned to accommodate generator/alternator assembly and all its accessories. Skid frame shall be of rigid construction suitable for concrete foundation.

Concrete Foundation / Pad Drawings

Detailed drawings of the concrete/pad foundations required for mounting/installation of all equipment (i.e.: generator set and external fuel day tank) shall be provided with all necessary details within three months of award of contract.

Detailed drawings of the concrete/pad foundations required for mounting/installation of generators and external fuel day tank shall be provided with all necessary details within three months of award of contract.

Inspection and Testing

Factory Acceptance Tests shall be conducted for all generator sets prior to shipment. For new generator brands never been used, the Contractor shall submit the technical specification comparison sheet to the Employer's Engineer for approval before any witnessing of Factory Acceptance Test.

Tests shall include but not limited to running at full load, maximum power, voltage regulation tests, transient and steady-state governing, single step load pick- up, emission tests and safety shutdowns. Tests not witnessed by the Engineer shall be documented and submitted to Engineer for approval.

On-site acceptance tests shall be conducted for all generator set brands regardless if they are already in use. All gensets that have been tested at the factory shall also undergo on-site acceptance tests. The Engineer standard testing procedure shall be followed which shall include a 5-minute cold start test, load tests for 15 minutes at 25% load, 50% load and 75% load. At 100% load, the genset shall be tested for 30 minutes. At 105% load, it shall be conducted for 5 minutes. Contractor shall provide the required load bank for the above tests.

The Contractor/supplier shall provide a resistive load bank, cables, connectors, tools, instruments and shall make the necessary connections for such an on-site load test. On-site acceptance tests shall not utilize the existing and actual load of any facility.

On-site tests shall conform to NFPA 110 par 5-13.2.3, including strip chart documentation to verify voltage and frequency.

The following parameters at the minimum, shall be logged/recorded during the test: kW load, phase voltages, line currents, frequency, speed in rpm, water jacket temperature and pressure and oil pressure. These shall be monitored before and during changes of generator set load.

8.6.53 UPS SYSTEM AND ITS BATTERIES

Contractor shall Design, Supply, Deliver, Test and Commission a fully functional Dual Redundant UPS System for the following CP1 facilities critical loads (i.e.: space heater power supply, instrumentation power supply, Fire Alarm System panel, Public Address System Panel, CCTV System, FM200 panel, Deluge Water Spray System panel, Nitrogen Gas Injection Fire Protection panel, SCADA System, PLC power supply and telecommunication/LAN system power supply):

1. 230/110/11kV GIS Substation / Control Room
2. Administration Building
3. Sea Water Intake Building
4. Pre-Treatment Building
5. RO Building 1

6. RO Building 2
7. Post Treatment Building
8. Water Storage Building

ELECTRICAL SYSTEM DETAILS

Design Temp. – 50 deg. C.

Power Supply Input for UPS: 3 Phases – 415V AC, +/- 10%, 1 Phase – 240VAC, +/- 10%, 50Hz+/- 3% (Emergency Power Supply connected to a Standby Diesel Generator Set)

STANDARDS

In general, the Equipment shall be in line with latest edition of relevant IS / BS / IEE / IEC / IS.

Some of relevant Indian Standards are listed below:

IS: 3700 - Essential ratings and characteristics of semi-conductor devices.

IS: 3715 - Letter symbols for semi-conductor devices.

IS: 4411 - Code of designation of semi-conductor devices.

IS: 5001 - Guide for preparation of drawings for semi-conductor devices.

IS: 5469 - Code of practice for the use of semi-conductor junction devices.

IEC 62040-3 - Uninterruptible Power Systems (UPS) – Part 3: Method of specifying the performance and test requirements.

IEEE 587 (ANSI C62.41) Category A & B – Recommended practices on surge voltages in low voltage power circuits.

CISPR 22: FCC Rules and Regulations 47, Part 15, Class A (Federal Communications Commission) – Radio Frequency Devices (prior to Feb 16, 2006).

MIL-HDBK-217E (Military Handbook) – Reliability prediction of electronics equipment

ISO 9001, "Quality Management Systems - Requirements." or

ISO 14001, "Environmental Management Systems - Requirements with Guidance for Use."

UPS should be certified for LEED credits and/or for sustainable/GREEN product certification

DESCRIPTION & SYSTEM OPERATION

The UPS shall consist of a ***Dual Redundant System*** to continue to support the critical load should one or more UPS modules fail which consist of Rectifier / Charger, Battery, Inverter, Static Transfer Switch, Maintenance Bypass Switch, Synchronizing Equipment, Protective Device and other Accessories.

The UPS shall provide continuous electric power within specified tolerance, without interruption, to the critical loads.

Normal power supply of 415V, 50 Hz TP, shall be supplied to UPS System.

The solid-state rectifier / charger shall convert incoming AC power to DC power. The rectifier / charger output shall be fed to solid-state inverter. The inverter shall convert the DC power into AC power, which shall supply the load. Upon failure of AC power, input power for inverter shall automatically be supplied from the battery with no interruption / disturbance in inverter output in excess of limits specified herein (in these specifications). At the same time, UPS shall energize an alarm circuit.

The duration for which Battery shall supply A/C power to critical loads shall be minimum 15 minutes.

When A/C power is restored, the input power for the inverter and for recharging the battery shall automatically be supplied from rectifier / charger output without interruption/ disturbance in inverter output in excess of limits specified herein (in these specifications).

The solid-state circuitry used for both Rectifier & Inverter shall be IGBT technology.

Intelligent RS-232 Communication shall be possible which will Provide UPS status indications, electrical parameters such as Input & Output Voltage, Load levels etc and unattended shutdown.

User-friendly LCD Display to indicate all important UPS parameters such as Input Voltage, Output Voltage, Battery Level and Load Level shall be provided.

The UPS system shall consist of the following modular architecture

ARCHITECTURE

Scalable array Infrastructure:

The system power train shall be comprised of power modules and shall be capable of being configured for N+X redundant operation at the rated system load. The systems shall be capable of paralleling with similar rating system to form a load bus. The system should be a load bus synchronous to a similar rating bus. The 2 nos. bus shall form 2 sources (A&B). The architecture should have the flexibility of adding the power modules without the need of any external cabling of addition of panels.

B. Module Management:

The modular UPS shall offer the ability to scale its capacity and/or redundancy by automatically shifting load to fewer power modules. The UPS shall provide a Module Management System, which will control the UPS to selectively place unnecessary modules in the "mode" based on the sensed output load level. This is in order to drive the load higher on the remaining modules. Therefore, with multiple modules, a UPS shall achieve 2-3% higher efficiencies than conventional operation when loaded less than 50% of system rating.

In case of instantaneous addition of full load on the bus these modules should assume load without any interruption to the total load.

C. Eco Mode:

In bypass operation, an even higher operating efficiency may be achieved without sacrificing protection when there are good power conditions. Depending on configuration, efficiency can exceed 99%. This load remains in bypass mode until the input voltage exceeds tolerance levels, and then enters full protection mode. This setting is disabled by default and can be configured using the display. UPS should be capable of operating in ECOMODE even when they are paralleled to form 1MW bus.

E. Concurrent Maintenance:

Any redundant internal module can be concurrently isolated and serviced (by factory-trained service Engineers) while the other internal module/s continues to provide protected power to the load.

F. Load Test at Site:

UPS should have the ability to perform a full load test in double conversion mode without the connection of a load bank.

5. MODES OF OPERATION:

Each UPS shall have a KVA rating suitable for Contractor all the facilities mentioned above and shall be ***dual redundant*** and shall be made up of the following components, described in detail in this specification:

1. rectifier
2. battery charger
3. inverter
4. battery
5. automatic bypass (via a static switch)
6. user and communications interface
7. Individual battery management system.
8. any and all other devices required for safe operation and maintenance, including circuit breakers, switches, etc.

Battery:

Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the batteries without any operator intervention.

There shall be no interruption to the critical load upon failure or restoration of the commercial AC source. Each module or system shall have its own Batteries to meet the autonomy time requirement.

Batteries shall be located in separate mechanically ventilated rooms, which shall be provided with facilities for quick drenching of the eyes and body like sinks, eyewash fountain and water supplies within seven meters of battery handling areas.

Recharge:

Upon restoration of the AC source, the Charger shall recharge the batteries and simultaneously the Rectifier shall provide power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.

Bypass:

If the module must be taken out of the standard double conversion mode for overload, load fault, or internal failures, the static bypass switch shall automatically transfer the critical load to the commercial AC power. Return from Bypass mode to Normal mode of operation shall be automatic. No-break transfer to and from Bypass mode shall be capable of being initiated manually from the front panel.

Input Current Total Harmonic Distortion:

The input current THDI shall be held to less than 5 percent at system load greater than 50 percent while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting both a linear or non-linear load. This shall be accomplished without the requirement for additional or optional filters, magnetic devices, or other components.

Soft-Start Operation:

As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0 percent to 100 percent of the nominal input over a default 10 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation.

Magnetization Inrush Current:

The UPS shall exhibit zero inrush current.

SYSTEM CHARACTIRISTICS:

A. UPS output in standard double conversion mode

1. 415V, 3-phase, 4 wire plus ground. Output wiring configuration is based upon input wiring configuration for systems without internal transformers.

2. Steady-state voltage regulation (in inverter) shall be within +/- 1% average from nominal output voltage.

3. Transient voltage response shall be < +/- 5% from nominal voltage for load step from 10% to 100%.

4. Linear load harmonic distortion capability: Output voltage THD of less than 2% for 100% linear load.

6. Non-linear load harmonic distortion capability: Output voltage THD of less than 5% for 100% non-linear load when tested using the non-linear load described in IEC 62040-3.

6. Manual output voltage adjustment shall be +/- 3% from nominal.

7. Line synchronization range shall be +/- 3Hz, adjustable to +/- 0,5Hz.

8. Frequency regulation shall be +/- 0.1Hz free running.

9. Frequency slew rate shall be adjustable up to 0.7 Hz/second maximum.

10. Phase angle control:

a) Balanced linear load shall be +/- 1 degree from nominal 120 degrees

b) Unbalanced linear loads shall less than +/- 3 degrees from average phase voltage for 100% load unbalance.

11. Phase voltage control:

a) Balanced linear loads shall be +/- 1% from average phase voltage

b) Unbalanced linear loads shall be less than +/- 5% for 100% load unbalanced

12. Overload current capability (with nominal line and fully charged battery): The unit shall operate with up to 110% of resistive/inductive load for 10 minutes, up to 125% for 30 seconds, and up to 150% for 10 seconds.

13. Fault clearing current capability: 1000% RMS for 20ms., 600% for 50 ms. With bypass intervention. Inverter 200% phase-to-phase for 10 cycles;

14. Static transfer time: No break, completed in less than 4ms.

15. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 85dbA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load, per ISO7779 standard..

16. EMC Suppression: The UPS shall meet IEC 62040-2, Category C3.

17. Electrostatic discharge (ESD): The UPS shall meet EN61000-4-2 level 3.

18. Efficiency: The UPS efficiency shall be up to 94,5%. If UPS requires input filters for controlling input THD, manufacturer shall state efficiency of UPS with input filters connected.

Battery management system:

The UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.

2. The battery management system shall automatically test the battery string(s) to ensure that the battery is capable of providing greater that 80% of it's rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the

battery needs attention/replacement. The battery test shall be able to detect the following:

a. Open battery string

b. Shorted battery string

c. Battery capacity (runtime) less than 80% of "new" battery capacity

3. The UPS shall communicate battery test and monitoring data to the UPS

manufacturer's remote monitoring site. Battery life remaining, capacity, and number of on-battery events shall be provided in a monthly report.

4. An optional temperature sensor shall be available to monitor the ambient temperature internal to the battery cabinet. If the ambient temperature increases, the UPS system charger shall automatically reduce the charging voltage to a level recommended by the battery manufacturer. If the ambient temperature is decreased the UPS shall automatically increase the battery charge voltage to that recommended by the battery manufacturer.

UPS MODULE CABINET

The UPS Module Cabinet shall consist of a rectifier / charger, a three-phase inverter, static transfer switch, maintenance bypass switch, logic, synchronizing equipment, protective devices, and accessories as required for proper operation.

RECTIFIER / CHARGER UNIT

a) The rectifier / charger unit shall be solid state and shall provide direct current to the inverter unit and for battery charging.

b) An input AC filter shall be incorporated into the rectifier / charger unit. The filter is not to be add-on in front of the rectifier / charger. This filter is to reduce the current harmonics feedback into the input AC line to no more than 10%. The filter is to also improve the input power factor so that it is no more lagging than 0.95.

c) The rectifier / charger unit shall provide for input current limiting whereby the maximum input current shall be limited to 125% of the full input current rating. This current limit shall be in effect, no matter whether the load is connected to the UPS module or the static transfer switch. That is, if the static transfer switch is supplying full rated load, then the rectifier / charger must limit the battery recharging to 25%. Further more, if the load is connected to the maintenance bypass line, the rectifier / charger input current must automatically reduce to 25%.

d) The rectifier / charger unit shall provide features whereby when the AC power is returned after the UPS has been operating on battery power or has been de- energized, the total initial power requirement at the input terminals will not exceed 20% of rated load, and the power will gradually increase to 100% of full rating over the 15 second time interval. The unit shall be provided with an internal switch so that walk-in time can be changed from 2 seconds to 15 seconds.

e) IGBTs in the rectifier / charger shall be fused with fast acting fuses, so that loss of any one power semiconductor will not cause cascading failures. All fuses shall be provided with a blown fuse indicator with an alarm indicator on the control panel.

f) The rectifier / charger unit shall have an output filter to minimize ripple voltage into the battery. Under no conditions shall ripple voltage into the battery exceed 2% RMS. The filter shall be adequate to insure that the DC output of the rectifier/ charger will meet the input requirements of the inverter.

g) The rectifier unit shall be designed to boost charge the completely discharged batteries in 10 to 14 hours. The changeover between boost charger mode and float charge mode shall be affected manually/automatically.. Necessary alarms to

indicate battery discharged and D.C. over voltage conditions shall be provided. Selector switch shall be provided for selecting the float charge or boost charge mode.

h) There shall be DC overvoltage protection so that if the DC voltage rises to the pre- set limit, the UPS module is to shut down automatically and the load is to be transferred to the static bypass line uninterrupted.

i) To prevent battery damage from over-discharging at light load, the rectifier / charger is to automatically raise the shutdown voltage set point as the load is reduced. The shutdown set point is to increase linearly from minimum to 1.75 volts per cell as the discharge time increases from 15 minutes to one hour.

j) The output voltage of the rectifier / charger unit shall be as follows:

Float mode: Variable 115 - 130V DC or 230 - 260V DC

Boost mode: Variable 125 - 145V DC or 250 - 290V DC

INVERTER UNIT

a) Advanced PWM Inverter with Precision Control Circuitry using High Performance IGBT Power Stage. The output shall be Pure Sine-wave output with less than 3% THD. Exceptional reliability, superior performance, quiet operation with very high reliability and efficiency shall be the key characteristics.

b) The inverter unit shall be a solid-state device capable of accepting the output of the rectifier / charger or the unregulated voltage of the battery and provide regulated rated AC output within specified limits.

c) The output frequency of the inverter shall be controlled by an oscillator. The oscillator shall be temperature compensated and be adjustable +5% of rated frequency. The oscillator shall hold the inverter output frequency to +0.1% for both steady state and transient conditions. Drift shall not exceed +0.1% during a 24 hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed +0.1% from the rated frequency.

d) The inverter output shall stay synchronized with the static bypass line provided the static bypass line remains within +3 Hz of the nominal frequency. If the line frequency goes outside these limits, the inverter is to break sync with the line and run on its internal frequency. When the line frequency returns, within limits, the inverter output is to automatically re-synchronize with the line. The rate of change of frequency is not to exceed 0.1 Hz per second. The unit shall be provided with an internal switch so that the synchronizing frequency range can be changed from +3 Hz to +1 Hz or to +0.5 Hz.

e) The inverter shall be able to sustain an overload across its output terminals up to 150% load, while supplying any load within its rating, without reducing the output voltage. Loads greater than 150% shall be transferred to the static bypass line.

f) The inverter, with the static bypass line disabled, shall current limit at 150% rated current at reduced voltage for any loading over 150% rate load. The inverter shall be capable of at least 300% current for short circuit conditions. If the short circuit is sustained, the inverter shall shut down and disconnect automatically from the critical load bus.

g) The inverter unit shall be designed to operate from the rectifier output without use of battery smoothing effect. With the battery connected to the UPS system, a filter shall be provided at the input of inverter unit to reduce the A.C. Feedback from the inverter to the battery to a maximum of 2% of the battery AH capacity.

h) The inverter unit shall be designed to operate with 93V to 145V DC or 186V to 290V DC at the terminals of inverter input filter. The output inverter voltage shall be stabilised to within +2% of the nominal output voltage with a load variation of 0 - 100% at 0.6 power factor (lagging).

During step loading of 100%. The system voltage dip shall not exceed 15% and output voltage shall recover to within + 3% of the nominal output voltage within 10 cycles (200 m sec.)

i) The inverter voltage regulator is to regulate each phase so that an unbalance loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement.

j) An output AC filter shall be incorporated in the inverter unit. The filter shall reduce the inverter output voltage harmonics to 5% RMS total and single harmonics to 3% RMS for linear loads.

k) Power semi-conductors in the inverter unit shall be fused with fast acting fuses, so that loss of any one power semiconductor will not cause cascading failures. All fuses shall be provided with a blown fuse indicator with an alarm indicator on the control panel.

STATIC TRANSFER SWITCH

a) The Static Transfer Switch, using solid state devices, shall be provided to transfer the load between the UPS module and the static bypass line uninterrupted. Automatic static load transfers are to be initiated when a system overload is greater than specified here, a branch load circuit faults or a fault within the UPS module occurs.

b) For Auto or Manual operation of Static transfer Switch Load should not suffer.

c) If the static transfer was caused by an overload or branch fault and this condition was rectified, then the static transfer switch is to automatically re-transfer the load to the UPS module.

d) The static transfer switch shall be sized to provide 125% rated load continuously. The switch shall also have an overload rating of 2000% rated load for two cycles.

e) Any time the load is on the static bypass line, the control panel shall indicate so. The audible alarm is to sound only after a ten-second delay. If the transfer was due to a momentary overload and automatically re-transferred back to the UPS module after the overload was removed, the alarm and indicator are to automatically reset.

f) This Static Bypass Operation in any Case should not cause any interruption to the load.

MAINTENANCE BYPASS SWITCH

a) A manually operated maintenance bypass switch is to be incorporated into the UPS module cabinet that will connect the load to the input AC power source bypassing the rectifier / charger, inverter, and static transfer switch.

b) All energized terminals shall be shielded to ensure that maintenance personnel do not inadvertently come in contact with energized parts or terminals. A means to de- energize the static switch shall be provided when the UPS is in the maintenance bypass mode of operation.

c) While the load is on the maintenance bypass line, it shall be possible to check out the operation of the rectifier / charger, inverter, and static transfer switch. It shall also be possible to check the battery operation.

BATTERY

A Battery system shall be furnished for the UPS with sufficient capacity to maintain UPS output at the specified load for a duration of minimum 15 minutes. The type of battery shall Maintenance-free, Valve-regulated type. A minimum of 10 years warranty for performance of declared parameters within permissible limits shall be provided.

CONTROLS AND INDICATORS

A. Microprocessor controlled circuitry: The UPS controls shall have the following design and operating characteristics:

1. Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled Digital Signal Processing. DSP shall eliminate variances from component tolerance or drift, and provide consistent operational responses.

2. All operating and protection parameters shall be firmware controlled, thus eliminating a need for manual adjustments. The logic shall include system test capability to facilitate maintenance and troubleshooting. Printed circuit board replacement shall be possible without requiring calibration.

3. Start-up and transfers shall be automatic functions.

B. Digital Front Panel Display: The UPS control panel shall be a digital front panel display that features an 8x40 (8 lines, each with 40 characters) backlit LCD display. The LCD shall display UPS status, metering, battery status, alarm/event queue, active alarms and UPS configurations. The front panel display shall show a system mimic diagram with an outlined power path, current operating mode and event logs.

C. Control Panel Indicators: The UPS control panel shall provide the following monitoring functions with indicator LED's:

NORMAL: This shall indicate that the commercial AC utility or generator source is supplying power to the rectifier and the inverter is supporting the critical load. A text message shall indicate if the bypass line is not within tolerance.

BYPASS: This shall indicate that the UPS has transferred the load to the bypass circuit.

BATTERY: This shall indicate that the commercial AC utility or generator source has failed and the battery is supplying power to the inverter, which is supporting the load. A text message shall indicate if the battery charge is low or if the battery is installed but disconnected.

ALARM: This shall indicate that the UPS detects an alarm condition, outlined in detail in the operator's manual.

D. Control Panel Controls: The UPS control panel shall provide the following functions from front panel push buttons:

EVENTS: Displays the list of Active System Events and a historical log of system events. Historical logs shall include a detailed time stamped list of the latest 128 events.

METERS: Displays performance meters for the system or critical load. When selected, the front display shall show individual screens of input parameters, output parameters or bypass parameters including; voltage, current and frequency. In addition, the battery display shall show runtime remaining.

CONTROLS: Displays a System Controls screen. Allows selection of operating mode, normal, bypass, charger on/off and Power Module on/off.

SETUP: Allows display contrast, date and time information serial communication port configuration and display of firmware revision numbers.

RETURN: Confirms selection or returns to previous screen.

E. Interface panel: The UPS shall be equipped with an interface panel, located behind a protective cover, which provides the following signals and communication features in a Class 2 environment:

F. Alarm contact: A dry contact for annunciating a summary alarm shall be provided for customer use. This contact shall be Form "C" capable of supplying both N/O and N/C contacts. Contact ratings shall be 5A max at a voltage not to exceed 28VDC or 30VAC.

G. RS232 (EIA / TIA-232) communications interface: Circuitry shall be provided for one RS232 (EIA / TIA-232) communication port for connection to automated service department diagnostic tools. This port may be used with simple ("dumb") terminals to gain remote access to all unit operation information.

H. Building alarms: Two inputs shall be provided for monitoring the status of external dry contacts. Building alarms shall be set up through the UPS configuration mode function on the RS232 (EIA / TIA-232) port.

I. External EPO contacts: Shall be provided to connect an external remote emergency power off switch to shutdown the UPS and de-energize the critical load.

J. Battery control contacts: Contacts shall be provided to connect the battery shunt trip and auxiliary signals from a battery breaker or battery disconnect switch.

K. External bypass indicator connection: A connection point shall be provided to acknowledge that an external maintenance bypass has been closed around the UPS, placing the critical load on utility power.

The system shall have options to add four (4) additional building alarms, 384 logged events, 4 additional languages, English as a primary language.

CABINET

All the cells making up the Battery shall be installed in a free-standing cabinet, that is, of the same constructions as the UPS module cabinet. The cabinets shall be of the same height and depth.

Each cell is to be held in place to prevent movement during seismic motion.

Connectors are to be used so that the battery can be disconnected in no more than 42volt sections.

BATTERY DISCONNECT CIRCUIT BREAKER

The UPS Module shall have a Battery Circuit Breaker. This circuit breaker is to be mounted in the battery cabinet. When open, there shall be no battery voltage present in the UPS module cabinet. The UPS module shall be automatically disconnected when the battery reaches the minimum discharge voltage level or when signaled by other control functions.

MIMIC PANEL

The Mimic Panel is to depict a single line diagram of the UPS. Indicating Lights shall be integrated with the single line diagram to illustrate the status of the UPS power paths. The functions whose status are to be displayed shall include, but not be limited to, the following:

a) Input power available

b) Output power available

c) Normal operation

d) Bypass operation

COMMUNICATIONS

A. Communications Bay: The UPS shall be equipped with field configurable communications bays that will accommodate four (4) communication devices.

B. Remote Monitoring:

1. Optional WEB/SNMP communication capabilities will be available for all systems.

2. The UPS shall be able to be monitored remotely via communications devices. UPS manufacturer shall provide optional communications devices capable of communicating via various industry standard protocols such as RS232 and ModBus. Monitoring of UPS status may also be performed through isolated dry contact Form C relays.

3. Remote monitoring of the UPS shall also be possible through status indicators elsewhere in the same facility through a device that replicates these indicators.

The UPS communication capability should be able to integrate into any industry standard Building Management System (BMS) and/or SCADA System. The UPS must also be able to be monitored via any standard Internet browser (i.e. Internet Explorer and Netscape).

All optional hardware interfaces shall be "Hot-swappable" (UPS maintains power to critical applications while changing interfaces).

Shutdown:

1. There shall be a mechanism that provides graceful, orderly, unattended, sequential shutdown of one or multiple computers powered by one UPS. This shutdown shall be performed via in-network or out-of-network means. The order of shutdown shall be user-defined, allowing the maximization of runtime on battery for more critical systems.

2. Shutdown of AS/400 computers shall be possible through open-collector relay contacts or isolated, dry contact, Form-C relays.

3. The UPS shall also be capable of interfacing with an operating system's built-in shutdown routine, e.g.: Windows NT. This shall be done through a cable connection to the optional serial port on the UPS.

Notification:

1. There shall be a mechanism to send alerts to key personnel via email or SNMP traps. An alarm notification may also be sent by a network message.

2. Dial-out to a computer for alarm notification may be performed. The user may respond by dialing-in to retrieve alarm history and a summary of current meter status.

3. Management: A remote battery test may be performed via an Ethernet network. The UPS shall be tested through invoking a single command.

INSTRUMENT, INDICATIONS AND ANNUNCIATIONS

Following along with described above shall be provided on the system:

- Charger Panel
- AC Line Voltage (with a selector switch)
- AC Line Current (with a selector switch)
- Charger Output Voltage (each)
- Charger Output Current
- Battery Current (charging / discharging current)
- Inverter Panel
- DC Input Current
- Standby Transformer Secondary Voltage
- UPS Output Voltage
- UPS Current
- Power Factor Meter
- Frequency Meter

Following indications lamps shall be provided:

- Charger Panel AC mains ON (3 Lamps)
- Battery on Float
- Battery on Boost
- Inverter Panel Battery Output ON
- Inverter - I Feeding
- Inverter - II Feeding (redundant system)
- Standby Supply ON
- Load on Bypass
- Mains Synchronized

Audio-Visual Alarm shall be provided for the following complete with 'ACCEPT', 'RESET' and 'TEST' facilities:

Charger Panel

a) Mains Undervoltage / Single Phasing

b) Charger Failure / SCR Fuse Failure

c) Reverse Polarity on DC Bus

d) Cooling Fan Tripped (common for all fans)

e) Battery Discharged

f) DC Over-Voltage

g) Battery Earth Fault

Inverter Panel

a) DC Input Failure

b) Inverter - I Output Trouble

CONSTRUCTION

a) Rectifier / Charger and Inverter sections shall be housed in separate panels and shall be complete with all interconnections. The panels shall be fabricated with 1.6/2 mm thick cold rolled sheet steel and structural steel. The panels shall be free-standing. Vermin-proof fitted with suitable louvers for ventilation and cooling fan. Hinged doors shall be provided at the front and back where required, with dust tight gaskets. Inter-panel sheet steel barriers shall be used. The enclosure shall be IP-51 (NEMA- IA).

b) Power cables shall be with copper conductors. Control cables shall be with copper conductors. All Cable connections shall be from bottom and from the front of the panel. At the bottom of the panels, a removable bolted gland plate shall be provided with double compression type cable glands fitted to it for external cable connections. Clamp type terminals shall be used for connection of all wires up to 10 mm2 and terminals for larger size shall be bolted type suitable for cable lugs.

c) Busbars shall be color coded and live parts shall be properly shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All equipment inside the panel and on door shall have suitable nameplates and device number as per the schematic diagram.

d) All fuses shall be link type with HRC links and mounted inside the panel. All power and control switches shall be mounted on the door operable externally and shall be rotary type. Space heaters and 100W incandescent lamps shall be provided in each panel. All instruments shall be switchboard type, back connected, 96 x 96 mm square of own manufacturers make. Scale shall have a red mark indicating maximum permissible operating rating. Test terminals shall be provided on a separate rail for measuring and testing of equipment to check the performance.

e) A suitably sized earth bus shall be provided at the bottom of the panels with provision for earth connection at both ends to main earth grid. Suitable earthing of potential-free metallic parts of various equipment shall be done to ensure safety.

f) All metal parts shall be treated so as to ensure efficient anti-corrosive protection. Hardware shall be zinc passivated or electro galvanized. Panel enclosure and structure supports shall be thoroughly cleaned and degreased to remove mill scale and rust, etc. External surface shall be prepared for final painting with Manufacturer's standard color code.

MECHANICAL DESIGN

A. Ventilation: The UPS shall be designed for forced-air cooling. Air inlets shall be on the front of the unit. Air outlets shall be on the top. Eighteen inches of clearance over the UPS outlets shall be required for proper air circulation.

B. No back or side clearance or access shall be required for the system. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.

C. Cable entry: Standard cable entry for the UPS cabinet shall be through either the enclosure bottom or top. A dedicated wireway shall be provided within the UPS cabinet for routing user input and output wiring.

D. Front access: All serviceable sub-assemblies shall be modular and capable of being replaced from the front of the UPS (front access only required). Side or rear access for installation, service, repair or maintenance of the UPS system shall not be required.

E. Service area requirements: The system shall require no more than 1 meter of front service access room and shall not require side or rear access for service or installation.

EQUIPMENT DETAILS

All materials and parts comprising the UPS shall be new, of current manufacture, of a high grade and free from all defects and imperfections and shall not have been in prior service, except as required during factory testing.

All active electronic devices shall be solid state. All semiconductor devices shall be hermetically sealed. All relays shall be dust tight.

The maximum working voltage, current and di/dt of all solid-state power components and electronic devices, shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid-state component cases shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 90% of their voltage rating.

WIRING

a) Access holes with cover plates are to be provided on top and bottom of the UPS and battery cabinets for inter-cabinet wiring and customer installation wiring.

b) Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards.

c) All bolted connections of bus bars, lugs and cables shall be in accordance with requirements of the National Electric Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked.

VENTILATION

Adequate ventilation shall be provided to ensure that all components are operated within their environmental ratings. All fans are to be equipped with wind vane sensors connected to an alarm on the module control panel.

Temperature sensors shall be provided to monitor temperature of critical components. Upon detection of temperatures in excess of component manufacturer's recommended ambient working temperature, the sensors shall cause audible and visual alarms to be sounded on the module control panel.

Forced ventilation if provided by means of fans shall have 100% redundancy.

If redundancy is not provided then it shall be possible to run the system at rated load for half hour and at reduced load (about 75%) continuously without any damage to the system.

ENVIRONMENTAL REQUIREMENTS

A. The UPS shall withstand any combination of the following external environmental conditions without operational degradation.

1. Operating Temperature: 0 degrees C to + 40 degrees C (32 degrees F to 104 degrees F) no derating is required within this range (excluding batteries).

2. Storage Temperature: - 25 degrees C to + 60 degrees C (-13 degrees F to 140 degrees F). Prolonged storage above + 40 degrees C (104 degrees F) will cause rapid battery self-discharge.

3. Relative Humidity (operating and storage): 95% maximum non-condensing.

4. Elevation:

1. Operational: 1000 meters above sea level at 40 C maximum. Above this level altitude de-rating as per EN62040-3.

2. Transportation: Capable of air transport, excluding batteries.

UPS PROTECTION

A. Rectifier/Charger and Bypass protection shall be provided through fusing.

B. Battery protection shall be provided by thermal-magnetic molded-case circuit breakers in each battery cabinet (if standard battery pack is provided) or external protective device for an external battery.

C. Electronic current limiting circuitry and fuses in the Inverter circuit shall provide output protection. To comply with agency safety requirements, the UPS shall not rely upon any disconnect devices outside of the UPS to isolate the battery cabinet from the UPS.

D. To comply with agency safety requirements, the UPS shall not rely upon any disconnect devices outside of the UPS to isolate the battery cabinet from the UPS.

SPARES

Vendor shall recommend and provide spare parts needed for start-up and two years operation. Recommended spares should take into account related factors like equipment reliability, effect of equipment downtime upon production and safety, cost of and availability of equipment service facilities.

All spare parts furnished by vendor shall be wrapped and packed so that they will be presented in original as new condition under the normal conditions of storage to be anticipated and shall be properly taped and coded so that later identification as to intended equipment usage will be facilitated. They shall be packaged separately, clearly marked as spare parts and shipped at the same time as the equipment. Packing list shall be furnished so that the parts can be handled without uncrating, if desired.

INSPECTION & TESTING

The Battery shall be subject to inspection by Client's representative. Manufacturer shall furnish to inspectors all requested information concerning the supply.

Battery shall be tested as per relevant IEC standards and test certificates shall be furnished before dispatch.

The UPS System will be tested in the presence of Employer's Engineer.

The following tests shall apply:

1. Full load heat run for eight hours (unit rate to be furnished separately).
2. Current forcing test.
3. Recording of time for mains to inverter changeover and vice-versa.
4. Recording of 1/2 load change transient.
5. Recording of full load change transient.
6. Functional Tests.

Detailed inspection will be performed to ascertain that the data sheet and other contractual aspect are complied with and the earthing system must be inspected for robustness and continuity.

Quality Assurance Plan shall be submitted for approval before any inspection.

SAFETY

The UPS shall be compliant with IEC 62040-1.

DRAWINGS

The manufacturer shall supply drawings & documents to the satisfaction of the Engineer in 6 sets. All drawing to be submitted in Auto CAD format only.

SUBMITTALS

A. The UPS shall be supplied with sufficient documentation, including the following manuals:

1**. Installation and Operation Manual:** One copy of the installation and operation manual shall be furnished. It shall possess sufficient detail and clarity to enable the Engineer's technicians to operate the UPS equipment and accessories. The manual shall include the following major items:

a) UPS description

b) UPS site planning and unpacking

c) UPS installation

d) Optional accessory installation

e) UPS theory of operation

f) Operating procedures

g) System events

h) UPS maintenance

i) Performance and technical specifications

j) Power and Control Schematic Diagrams

k) Wiring requirements and recommendations

l) Physical features and requirements Cabinet dimensions

DATASHEET- The Manufacturer shall Supply Drawings & Technical User Guide Documents to the satisfaction of the Engineer in 6 sets.

INSTALLATION

A. Install in accordance with manufacturer's instructions.

COMMISSIONING

A. UPS manufacturer shall offer the following optional services:

1. Pre-energize visit to inspect installation and provide guidance to installers as required.

2. Post-start-up visit for alarm notification configuration, operator training, etc.

B. The following procedures and tests shall be performed by Field Service personnel during the UPS startup:

1.Visual Inspection:

a) Visually inspect all equipment for signs of damage or foreign materials.

b) Observe the type of ventilation, the cleanliness of the room, the use of proper signs, and any other safety related factors.

2.Mechanical Inspection:

a) Check all the power connections for tightness.

b) Check all the control wiring terminations and plugs for tightness or proper seating.

3.Electrical Pre-check:

a) Check the DC bus for a possible short circuit.

b) Check input and Bypass power for proper voltages and phase rotation.

c) Check all lamp test functions.

4. Initial UPS Startup:

a) Verify that all the alarms are in a "go" condition.

b) Energize the UPS module and verify the proper DC, walkup, and AC phase on.

c) Check the DC link holding voltage, AC output voltages, and output waveforms.

d) Check the final DC link voltage and Inverter AC output. Adjust if required.

e) Check for the proper synchronization.

f) Check for the voltage difference between the Inverter output and the Bypass source.

5. Operational Training: Before leaving the site, the field service Engineer shall familiarize responsible personnel with the operation of the UPS. The UPS equipment shall be available for demonstration of the modes of operation.

QUALIFICATIONS

A. The UPS manufacturer shall have a minimum of fifteen years experiences in the design, manufacture and testing of solid-state UPS systems.

B. The UPS manufacturer shall have ISO 9001 certification for Engineering/R&D, manufacturing facilities and service organization.

C. The UPS manufacturer shall maintain a staffed 7x24x365 call center for technical and emergency support.

D. Field Engineering Support: The UPS manufacturer shall directly employ a nationwide field service department staffed by factory-trained field service Engineers dedicated to startup, maintenance, and repair of UPS equipment. The organization shall consist of local offices managed from a central location. Field Engineers shall be deployed in key population areas to provide on-site emergency response within 24 hours. A map showing the location of all field service offices must be submitted with the proposal. Third-party maintenance will not be accepted.

E. Spare Parts Support: Parts supplies shall be located in the field to provide 80% of all emergency needs. The factory shall serve as the central stocking facility where a dedicated supply of all parts shall be available within 24 hours.

F. Product Enhancement Program: The UPS manufacturer shall make available feature upgrade service offerings to all users as they are developed. These upgrades shall be available as optional field-installable kits.

G. Maintenance Contracts: A complete range of preventative and corrective maintenance contracts shall be provided and offered with the proposal. Under these contracts, the manufacturer shall maintain the user's equipment to the latest factory revisions.

TO BE FILLED BY UPS VENDOR.

Sr. No	Description	Requirement

Vendor to Specify the UPS KVA ratings for the following facilities :

1. *230/110/11kV GIS Substation / Control Room*

2. *Administration Building*
3. *Sea Water Intake Building*
4. *Pre-Treatment Building*
5. *RO Building 1*
6. *RO Building 2*
7. *Post-Treatment Building*
8. *Water Storage Building*

1.0 **MODEL** please specify

1.1 **TECHNOLOGY** IGBT Rectifier & IGBT Inverter, Microprocessor based, true online double conversion, Online Transformer free Technology

1.2 Inverter IGBT

1.3 Rectifier IGBT

1.4 Max. Permissible Non-linear loads 100%

1.5 Max. unbalanced load 100%

2.0 **PHYSICAL Dimension & Weight**

2.1 Construction Compact. Modular design

2.2 UPS Floor Space Each UPS Floor space should not exced 1.26 Sq meter

2.2 Ventilation Specify

2.3 UPS Dimension & weight

Length in MM Specify

Width in MM Specify

Height in MM Specify

Weight in kgs Specify

2.4 Batterty Bank (Dimention and weight)

Length in MM	Specify
Width in MM	Specify
Height in MM	Specify
Weight in kgs Specify	
Accessibility (front & back with clear Dimension to be specified) Specify	
Cable connection Bottom for Input & Output.	Specify
Parallel Configuration upto no of Module .	no required
DG Set Sizing No of time of UPS Module	Specify.
& Minimum Size of DG set Required	Specify
Minmum Input circuit breaker required to be specified	Specify

3 **INPUT**

3.1	Voltage	415V
3.2	Voltage range	340 to 460V
3.3	Frequency	50 Hz
3.4	Frequency range	+/- 5 Hz
3.5	Ripple content	<1% with battery connected
3.7	Input Power Factor	
	100% 0.99	
	75% 0.99	
	50% 0.99	
	25% 0.98	
3.8	Current Harmonic on source	
	100% <3%	

	75%	<5%
	50%	<5%
	25%	<10%

3.9 Maximum current with out Battery ChargingAmps

4 **OUTPUT**

4.1	Voltage	415 V
4.2	KW	
4.3	Voltage regulation	
	Balanced	+/- 1%, 3 Ph. + N
	Un Balanced	+/- 3%, 3 Ph. + N

4.4 Power Factor 0.8lag - unity- 0.9 lead (Derating of UPS not acceptable in this range)

4.5	Frequency	50Hz
4.6	Frequency range	+/- 0.5 Hz
4.7	Frequency synch. range	0.25 to 3 Hz
4.8	Transient output voltage variation for 100% block loading	+/-2%
4.9	Recovery time for 100% block load	< 5 mill second (ms)
4.10	Wave form	Sinusoidal
4.111	Total Voltage Distortion out put side	
	Linear load	< 2 %
	Non-Linear load	< 3 %
4.12	Crest Factor	3:1
4.13	Phase Displacement	
	a) Balanced load	120 +/- 0.65°
	b) 100 % Unbalanced load	120 +/- 2°
4.14	Inverter Efficiency	

	c) 100 %	Specify
4.15	Overall Efficiency for UPS	
	b) 50 %	91%
	c) 75 %	91%
	d) 100 %	92%
4.16	Efficiency of UPS in Battery Operations	
	b) 50 %	
	c) 75 %	
	d) 100 %	
4.17	Overload	
	a) 125 %	10 minutes
	b) 150 %	30 Sec
4.18	Short circuit Capability	Vendor to Specify
5	**BUILT IN STATIC BYPASS**	Required
5.1	Inverter and Static Bypass change over time	Specify
5.2	Fuse @ static bypass	No. as per IEEE standards.
5.3	Short circuit Capability	Vendor to Specify
5.4	Overload	Specify
5.5	Transfer time	Less than 5 milli secs.
5.6	Manual Bypass inside ups only(input/output)	Required
6	**DC CHARACTERISTIC**	
	Battery backup to be calculated at .9 pf.	
6.1	VAH	>43200
6.1	DC bus voltage	Specify

6.2	DC Current	Specify
6.3	No. of cells with AH	Specify
6.4	battery voltage	Specify
6.5	End Cell voltage	1.75
6.6	Float voltage	specify
6.7	DC current at 100% load	specify
6.8	Charging current	specify
6.9	Charging time 10 Hrs. max.	
6.10	True autonomy / measurement	Software on SNMP & UPS monitor panel
6.11	Temp. compensated charger	Required/ Mandatory
6.12	Automatic battery load test	Required/ Mandatory
6.13	Batt. Breaker with protection	Required/ Mandatory
	Required Battery Back Up	15 Minutes
7	**PROTECTION**	
7.1	Overload (O/L)	Required
7.2	Short circuit (SC)	Required
7.3	Input low voltage	Required
7.4	Output over voltage	Required
7.5	Battery over charging	Required
7.6	Battery over discharging	Required
7.7	IP Protection	
7.8	DC over current Protection	
8	**ENVIRONMENTAL**	
8.1	Ambient temperature range	0 to 40° C
8.1	Relative humidity	95 % RH
8.2	Max. operating altitude without derating	1000 M above MSL

8.3	Acoustic Noise	65db (Specify)
9	**AUDIO / VISUAL DISPLAY**	
9.1	Over load	Required
9.2	Short circuit	Required
9.3	Input low voltage	Required
9.4	Input over voltage	Required
9.5	Battery over discharging	Required
9.6	Battery on load	Required
9.7	Battery low	Required
9.8	Fuse failure	Required
9.9	Fan failure	Required
9.10	Inverter failure	Required
9.11	DC over voltage	Required
10	**VISUAL DISPLAY**	
10.1	Input/Output voltage	Required
10.2	Output current .	Required
10.3	Input/ Output frequency	Required
10.4	Output power in KVA and KW	Required
10.5	Output load power factor	Required
10.6	Output load crest factor	Required
10.7	battery DC voltage	Required
10.8	Charging current	Required
10.9	Dis-Charging Current	Required
10.10	Autonomy Time	Required
10.11	Event logs	2500 events mandatory
11	**OTHERS**	
11.1	Software with LAN connect	Required

11.2	Auto paging	Required
11.3	SNMP compatibility	Required
11.4	Diagnostic system	Required
11.5	Single line mimic diagram	Required
11.6	Telemonitoring with software	Required- Mandatory
11.7	Capability to parallel similar UPS systems	Not required
11.8	ventilation	forced air cooling with integral fans
11.9	Operating temperature	0-45deg.C
11.10	Battery management	required
11.11	Power Transfer Mode auto systems	(during fault condition)
12	**Color**	
13	Online Thermal Dissipation in Btu/Hr	
	at 100 %	
	at 75 %	
	at 50 %	
	at 25 %	

8.6.54 APPROVED LIST OF MANUFACTURERS

230KV & 110KV GAS INSULATED SWITCHGEARS

1. SIEMENS	-	FRANCE / GERMANY
2. ABB	-	GERMANY / SWITZERLAND
3. AREVA	-	FRANCE
4. TOSHIBA TMT & D	-	JAPAN

110KV GAS INSULATED SWITCHGEARS

1. SIEMENS	-	FRANCE / GERMANY
2. ABB	-	GERMANY / SWITZERLAND
3. MERLIN GERIN	-	FRANCE

4. ALSTOM	-	FRANCE
5. TOSHIBA	-	JAPAN

230/110 KV 150MVA AUTO POWER TRANSFORMERS

1. SIEMENS	-	CROATIA
2. HYUNDAI	-	SOUTH KOREA
3. AREVA	-	TURKEY
4. EFFACEC	-	PORTUGAL
5. HICO HYOSUNG	-	SOUTH KOREA

110/11 KV 50MVA AUTO POWER TRANSFORMERS

1. SIEMENS	-	CROATIA
2. ABB	-	FINLAND
3. AREVA	-	TURKEY
4. STROMBERG	-	FINLAND
5. FUJI	-	JAPAN
6. PAUWELS TRANSFORMER	-	BELGIUM
7. BONARLONG	-	SCOTLAND
8. EFFACEC	-	PORTUGAL
9. ILJIN	-	SOUTH KOREA

EARTHING TRANSFORMERS

1. ABB	-	SWITZERLAND
2. AREVA	-	FRANCE
3. STROMBERG	-	FINLAND
4. PAUWELS TRANSFORMER	-	BELGIUM
5. BONARLONG	-	SCOTLAND

11/0.433KV DISTRIBUTION TRANSFORMERS

1. ABB	-	SWITZERLAND
2. SIEMENS	-	GERMANY

3. PAUWELS TRANSFORMER - BELGIUM
4. VOLTAMP TRANSFORMER - OMAN
5. EMIRATES TRANSFORMER - UAE
6. FEDERAL TRANSFORMER - UAE

11/0.69KV CONVERTER TRANSFORMERS

1. ABB - SWITZERLAND
2. SIEMENS - GERMANY
3. VOLTAMP TRANSFORMER - OMAN
4. EMIRATES TRANSFORMER - UAE
5. FEDERAL TRANSFORMER - UAE

NEUTRAL EARTHING RESISTOR

1. GEC INDUSTRIAL CONTROL - UNITED KINGDOM

33/11KV OUTDOOR TYPE VACUUM CIRCUIT BREAKER AND ISOLATOR

1. SIEMENS - GERMANY
2. ABB - SWITZERLAND
3. ALSTOM - FRANCE

230KV HIGH VOLTAGE XLPE CABLES

1. ABB HIGH VOLTAGE - GERMANY
2. TAIHAN - SOUTH KOREA
3. BRUGG CABLE - SWITZERLAND
4. ILJIN - SOUTH KOREA
5. LS - SOUTH KOREA

110KV HIGH VOLTAGE XLPE CABLES

1. BRUGG - SWITZERLAND
2. MITSUBISHI - JAPAN
3. FURUKAWA - JAPAN
4. ABB KABEL DRAHT - GERMANY

5. TAIHAN	-	SOUTH KOREA
6. ILJIN	-	SOUTH KOREA
7. LS	-	SOUTH KOREA

33KV & 11KV CABLES

1. DUBAI CABLE	-	UAE
2. SAUDI CABLE	-	SAUDI ARABIA
3. OMAN CABLE	-	OMAN
4. EL SEWEDY CABLE	-	EGYPT

LOW VOLTAGE CABLES

1. DUBAI CABLE	-	UAE
2. SAUDI CABLE	-	SAUDI ARABIA
3. OMAN CABLE	-	OMAN
4. EL SEWEDY CABLE	-	EGYPT

230/110KV EXTRA & HIGH VOLTAGE CABLE ACCESSORIES

1. PFISTERER	-	SWITZERLAND

33KV & 11KV CABLE ACCESSORIES

1. TYCO ELECTRONICS/ RAYCHEM GMBH	-	GERMANY/INDIA
2. 3M	-	USA/INDIA
3. PFISTERER	-	SWITZERLAND

230KV OVERHEADLINE CONDUCTOR

1. OMAN CABLE	-	OMAN
2. MIDAL CABLE	-	BAHRAIN
3. J POWER SYSTEM	-	JAPAN
4. OMAN ALUMINIUM	-	OMAN

OPTICAL GROUND WIRE (OPGW) CABLE AND ACCESSORIES

1. ABB	-	UK
2. PIRELLI CABLES	-	SOUTH KOREA
3. TAIHAN ELECTRICAL WIRE	-	SOUTH KOREA

230KV OVERHEAD LINE GANTRY TOWERS

1. LTO	-	INDIA
2. ZAMIL	-	KSA

230KV OUTDOOR SURGE ARRESTER

1. ABB	-	SWEDEN
2. TYCO ELECTRONICS / ENERGY DIVISION	-	IRELAND
3. BOW THORPE EMP	-	ENGLAND

SCADA & TELECOMMUNICATION

1. ABB	-	SWITZERLAND
2. SIEMENS	-	AUSTRIA

COMPOSITE OUTDOOR TERMINATION UNIT

1. PFISTERER SEFAG	-	SWITZERLAND
2. ABB	-	SWITZERLAND

PROTECTION RELAYS

1. SIEMENS	-	GERMANY
2. ABB	-	FINLAND
3. SCHNEIDER ELECTRIC	-	FRANCE / UK
4. ALSTOM	-	FINLAND

CONTROL, METERING & RELAY PANELS

1. SIEMENS	-	GERMANY
2. ABB	-	FINLAND
3. SCHNEIDER ELECTRIC	-	FRANCE / UK
4. ALSTOM	-	FINLAND

11KV SWITCHGEARS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA

11KV MOTORS

1. ANSALDO MOTORS	-	ITALY
2. ABB	-	SWITZERLAND
3. SIEMENS	-	GERMANY
4. WEG MOTORS	-	UK

LOW VOLTAGE SWITCHGEAR

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA

LOW VOLTAGE MOTORS

1. ANSALDO MOTORS	-	ITALY
2. ABB	-	SWITZERLAND
3. SIEMENS	-	GERMANY
4. GRUNDFOS MOTORS	-	USA

PRE-TREATMENT MIXERS & CLARIFIERS

1. HASSLER GROUP	-	FRANCE
2. ABB	-	SWITZERLAND
3. SIEMENS	-	GERMANY
4. GRUNDFOS MOTORS	-	USA

MOTOR CONTROL CENTERS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA

VARIABLE FREQUENCY DRIVES / SOFT STARTERS / PRIMARY RESISTANCE STARTERS / WYE-DELTA STARTERS / DIRECT ON LINE STARTERS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA
4. SOLCON	-	USA

LOW VOLTAGE DISTRIBUTION BOARDS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / IN

BATTERY CHARGERS, DISTRIBUTION BOARDS AND BATTERY CELLS

1. CHLORIDE INDUSTRIAL SYSTEMS	-	FRANCE
2. SAB NIFE POWER SYSTEMS LIMITED	-	INDIA
3. HBL	-	INDIA
4. CEG	-	ITALY

CENTRAL BATTERY SYSTEM

1. SCHNEIDER ELECTRIC	-	FRANCE
2. EATON	-	UNITED KINGDOM
3. ABB	-	SWITZERLAND

UPS SYSTEM

4. CHLORIDE INDUSTRIAL SYSTEMS	-	FRANCE
5. SAB NIFE POWER SYSTEMS LIMITED	-	INDIA
6. HBL	-	INDIA
7. CEG	-	ITALY

FM200 SYSTEM

1. NAFFCO - UAE
2. ANSUL - USA

DELUGE WATER SPRAY SYSTEM

1. NAFFCO - UAE
2. ANSUL - USA

POWER TRANSFORMER NITROGEN INJECTION FIRE PROTECTION SYSTEM AND TRANSFORMER FAST DEPRESSURIZATION SYSTEM

1. SERGI TRANSFORMER PROTECTOR - FRANCE

LIGHTING AND SMALL POWER

1. PHILIPS - NETHERLANDS
2. DESANO - ITALY
3. THORN - UK
4. THORLUX - UK

CENTRAL BATTERY SYSTEM

1. ABB - SWITZERLAND
2. CEAG EATON - UK
3. SCHNEIDER - UK

LIGHTNING PROTECTION

1. A/C Security Lightning, LLC (www.aclightningprotection.com)
2. Advanced Lightning Technology, Ltd. (www.altfab.com)
3. East Coast Lightning Equipment, Inc. (www.ecle.biz)
4. FURSE, ABB Ltd. (www.furse.com; www.abb.com)
5. Harger, Inc. (www.harger.com)
6. Independent Protection Company, Inc. (www.ipclp.com)
7. PENTAIR/ERICO (www.erico.com)
8. Preferred Lightning Protection (www.preferredlp.com)
9. Robbins Lightning, Inc. (www.robbinslightning.com)

10. Thompson Lightning Protection, Inc. (www.tlpinc.com)

SUBGRADE EARTHING SYSTEM, POTENTIAL GRADIENT EARTHING SYSTEM AND ABOVE GROUND EARTHING SYSTEM

1. FURSE EARTHING - UK
2. WALLIS EARTHING - UK

CHAPTER - 9

9. INSTRUMENTATION, CONTROL & AUTOMATION (ICA) REQUIREMENTS

9.1 General

The Instrumentation, Control and Automation specifications shall cater for 400 MLD (200MLD x 2 Lines) capacity Perur desalination plant. This specification defines the general requirements and philosophy for instrumentation, control and automation.

The ICA shall comprise, but not be limited to the following:

a) Plant Control System incorporating Distributed Control System (DCS) and integrated system through the internet and other protocols.
b) Plant instruments, control elements, and remote equipment;
c) Shielded data highway (including dual-redundant fiber loop) connecting all plant items;
d) Engineer and Operator workstations and a Control Desk with a Mimic and HMI Panel for Operator information;
e) All required hardware, servers, software, redundancy;
f) Local control panels, emergency stop devices, hard-wired controls, and interface terminals;
g) Alarm management system and reporting system;
h) Computer Maintenance Management System(CMMS), Conditioning Monitoring System (CMS), and Optimization system;
i) Instrumentation cabling and segregation with power supply system;
j) Secure power supplies and UPS system;
k) Remote communications facilities and integration;
l) Interface with external stakeholders system;
m) Redundancy and other features to ensure two streams of 2 x 200 MLD SWRO Desalination Plants availability, guaranteed performance, operational control, and operational flexibility.

9.1.1 Reference, Codes & Standards

All the equipment's and their accessories covered in this specification shall be designed, manufactured, and tested in compliance with the latest relevant standards and codes of practices referred in the table below.

Table 9-1: Latest Standards and Codes of Practices for ICA

STANDARDS	TITLE
INTERNATIONAL STANDARDS	
ISO	International Standardization Organization
IEC	International Electro-technical Commission
ANSI	American National Standards Institute

STANDARDS	TITLE
BSI	British Standards Institution
DIN	Deutsches Institutfür Normung
EN	European Standards
JAPS	Japanese Standard Organization
BIS	Bureau of Indian Standards
REGULATIONS, RECOMMENDATIONS, DIRECTIVES	
ACI	American Concrete Institute
AGMA	American Gear Manufacturers Association
AIJ	Architectural Institute of Japan
AISC	American Institute of Steel Construction
AISE	Association of Iron and Steel Engineers
AISI	American Iron and Steel Institute
AMCA	Air Moving and Conditioning Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
HIS	Hydraulic Institute Standards
IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
JEC	Japanese Electro-technical Institute
JEMA	The Japan Electrical Manufacturers Association
JIS	Japanese Industrial Standards
NFPA	National Fire Protection Association
OCIMF	Oil Companies International Marine Forum
TEMA	Tubular Exchanger Manufacturers Association
IBC	International Building Code
USEPA	United States Environmental Protection Agency
VDE	Verband Deutscher Elektrotechniker (German Society of Electrical Engineers)

All equipment shall comply with the statutory requirements of the Government of India and the State Government. Wherever required by regulations, the Supplier shall have to obtain approval of the Electrical Inspector / Director of Explosives / competent authority. Any changes required by the said Inspector shall be to the account of the Supplier. The same condition applies to obtain the approval of other statutory authorities. Wherever the Indian Standards do not exist, the equipment/components shall be designed, assembled, and tested under the other relevant applicable standards' latest editions mentioned in the above table. KKS codification should be followed.

9.1.2 Scope of Supplies and Services

a) The scope of supply shall include design, manufacture, assembly, factory testing, supply, erection, testing at site & commissioning, and handing over.
b) Various Types of Field Instruments like measurement (flow, pressure, level, temperature, etc.), Transmitters, Analyzers, Sensor, etc. as required to monitor and control the process equipment's performance proposed in each process zone.
c) Receiving, Handling, Storing, Issuing, and Transportation to the site for installation, Erection, Testing, Commissioning, and integration with DCS.
d) The Bidder shall include everything necessary for the execution of the above scope of works, whether mentioned explicitly in this document or not.
e) The Bidder shall finalize the required number of instruments and their ranges including I/O list during the detailed design stage.

9.2 Instrumentation

This section defines the minimum mandatory technical requirement of the instrumentation for the SWRO desalination application.

It is the responsibility of the /Contractor to design the ICA that meets all criteria defined in this document as well as to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.2.1 Instrumentation Design Considerations

a) In addition to the technical requirements of this section, the selection of technology, design, and arrangement of instrumentations shall be based on the relevant Site conditions
b) The instrumentation and control equipment shall have high electromagnetic and radio frequency interference immunity and shall not be affected by portable radio transmitters operated in the equipment's vicinity.
c) Instrumentation shall be suitable in every respect for continuous operation at the maximum output as well as part loads and shall be designed to permit unconstrained operation over the full range of ambient conditions and under the anticipated transient operation conditions as well as the climatic conditions peculiar to the Site and environmental pollution restrictions.
d) The successful bidder Contractor shall apply acceptable engineering practices in preparing the Instrumentation Control & Automation design. The proposed equipment

shall be new and from reputable manufacturers with sufficient experience in the application's respective field.

e) The Contractor must utilize components and systems which are of new manufacture and proven design. The selection of instrumentations shall be as per internationally recognized standards and shall comply with all the applicable national and statutory codes.

f) The plant shall be designed so that the impact of a failure of any single piece auxiliary equipment will cause no reduction in the plant's output.

g) Provision for future expansion in design & selection, e.g. space inside the control room, space on the panels / cabinets / desks etc.

h) Wetted parts of the instrumentation equipment shall be selected to withstand the service fluid's physical and chemical properties coming in direct contact with the instrument.

i) Where binary signals cannot be derived from an analogue value, binary transmitters, e.g., temperature switches, pressure switches, etc. may be used. All switches shall be of robust design and reliable performance and shall be of the snap-action and change over type. The switches shall have an adjustable switching hysteresis.

j) Whenever a corrosive atmosphere is present, all instruments and associated equipment exposed to such a medium shall be designed & protected to withstand the adverse effects.

k) All instruments components shall be tropicalized to protect against humidity, moisture, and fungal growth through hermetically sealed units, protective coating on circuit boards, etc.

l) All equipment shall remain unaffected by radio transmissions (Levels of permissible RFI shall be as per IEC 801).

m) The field equipment requirements are based on conventional signal interfacing using central/remote I/O equipment.

n) Generally, two (2) wire transmitters shall be used. If for some particular purposes (e.g., analyzers) 230 V AC power supply is required, the output circuit shall be isolated. All transmitters shall be individually fused.

o) Necessary protections shall be taken care of for the Instruments coming in contact with a high-pressure line.

p) Colour codes for pipelines, cables, lamps, and panels shall be followed for the plant as per industry/plant standard and as approved by the Engineer.

9.2.2 Instrumentation Strategy

9.2.2.1 *General*

a) All field instruments shall be of high standard industrial type and suitable for the coastal / corrossive environmental condition.

b) All instruments, gauges, and control equipment that perform similar duties shall be of uniform type and manufacture throughout the Works to facilitate maintenance and the stocking of spare parts.

c) All instruments shall have high reliability, low power consumption, and low maintenance.
d) All materials in contact with seawater and concentrate shall be of suitable design / material and shall have proven suitability in the comparable installations.
e) All part of the instruments in contact with the process fluids shall be fully compatible with the fluid to be measured, process temperature, and the ambient conditions and shall not deteriorate under normal operating conditions.
f) All instruments shall be of the Latest state-of-art and proven technology.
g) All instruments shall be from the reputed make with field-proven supply and service.
h) All transmitters shall be SMART type. The Contractor shall consider all necessary software libraries to communicate with the supplied instrumentation via an appropriate protocol.
i) All transmitters shall have an accuracy of 0.5 or better, and the repeatability shall be within a range of ± 0.1% of full span.
j) All transmitters shall have local indication installed at a visible location. The transmitter and local indicator shall be integrated with the sensor were as possible. All instruments shall be mounted in visible locations with easy access for adjustments.
k) The range of local instruments shall be that the normal measurement of the process variable is between 50% and 75% of the instrument's full scale.
l) All switches shall be of robust design and reliable performance and shall be of the snap-action and change over type. The switches shall have an adjustable switching hysteresis. Limit switches shall be of the proximity type or metallic type (SPDT/DPDT).
m) All instruments installed on the Product water line shall not affect the quality of the product water.
n) All instrumentation system components, such as transmitters, analyzers, and controllers, shall be calibrated before equipment shipment. Calibration has to be documented, and testing certificates shall be included in the scope. Calibration shall be performed in five points of operating range.
o) Sunshade with UV-resistant coating shall be provided for all outdoor instruments, Control Panels, and Analyzer panels.
p) Field mounted transmitter display, indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requires observation.
q) Sampling points shall be provided for all the analytical parameters
r) All I&C equipment shall have enclosure classification not less than IP 54, according to EN 60529, when mounted in an enclosed building and IP 65 for mounting outdoors.
s) Control cubicles installed in air-conditioned rooms shall be at least IP 32.
t) Sunshades shall be provided for all cubicle located outdoor, and all cubicles shall be adequately ventilated or air-conditioned, if necessary, for operability.
u) The Dry Run Protection is mandatory for each drive.

9.2.2.2 *Instrument Installation Philosophy*

All work shall be of the highest quality craftsmanship and shall conform to the best applicable engineering practices and relevant codes referred to in this document.

All instruments shall be installed in a neat, professional manner, ensuring ease of operation and maintenance. The Contractor shall prepare hook-up and installation detail drawings regarding each instrument's type and shall carry out the installation per these approved drawings.

The Contractor shall install instruments and equipment with due consideration of the following:

a) Instrument installations shall conform to all applicable standard and manufacturer specifications and warranty requirements.
b) No instrument except for pressure gauges and temperature indicators shall be installed to depend on its impulse piping or electrical connections for its support.
c) The positioning of equipment shall not constitute a safety hazard. Where possible, instruments shall be mounted so that they are protected from the effects of rain and sun while maintaining access and visibility requirements. If this is not possible; the Contractor shall provide a fixed cover or hood to protect instruments, without impairing access or visibility.
d) Visibility and accessibility to be provided for both maintenance and operations purposes.
e) Ease of access for lifting heavy items of equipment such as valves and flow meters.
f) All instruments and valves shall be free from vibration.
g) Instruments shall be mounted/connected so as not to stress vessel nozzles or pipe tapping.
h) All local process-connected instruments shall be located as close as possible to the measurement point while still accessible from the deck, ladder, or platform.
i) Instruments shall be mounted at a functional level between 1.0 and 1.5 meters above the operating floor.
j) Instruments shall be appropriately supported on brackets or mounted on subplates, or placed on a suitable pedestal, pipe stand, or structural support. Pipe or structural stands may be welded directly onto the platform plate, with a proper penetration in the grating, where applicable.
k) Instruments, tubing, cables, and cable ladder shall not be fixed to gratings or handrails.
l) Instruments (other than pressure instruments) shall not be mounted directly on process piping without approval.
m) Fittings such as instrument isolating valves and instrument air or gas regulators shall be supported either on the instrument stand or close-coupled to the instrument in a manner that no undue stress is imposed on the tubing or instrument.
n) Instrument installation materials, tube, tube fittings and manifolds shall be standardized throughout the plant to reduce spare supply inventories and minimize rework time for a replacement.
o) Analyzers for primary process lines shall be installed in bypass assemblies external to

the main process headers to allow routine maintenance. The assemblies shall include an isolation valve at each process connection tap, pressure regulator, manual sample valve, flow meter with integral flow metering valve, check valve, miscellaneous piping, and fittings. Assemblies for analyzer sensors, which must remain wetted at all times (e.g., pH or conductivity sensors), shall incorporate a vacuum breaker in the drain piping. The sample drain shall be routed to a hub drain.

p) Instrumentation taps to process lines shall be isolated by root valve at the point of connection. Isolation valves for taps to process lines shall be 1/4-turn ball valves of materials compatible with the process fluid. Isolation valves for chemical service shall match isolation valves used in other portions of that chemical piping.
q) Critical instrumentation associated with seawater inlet, brine discharge, Product Water quality, or other essential parameters of process shall be duplicated and shall not use the same impulse line but have separate process tapping.
r) All field mounted transmitters vulnerable to damage shall be housed inside transmitter cabinets.
s) Wherever instrumentation equipment is installed underground, a suitable approach, sufficient space for maintenance, drainage, ventilation, and illumination shall be provided.
t) All cables laid below surface level or in trenches are to be installed in uPVC conduits, and these conduits are to be sealed to prevent the ingress of moisture or water even if submerged.
u) Cables carrying electricity and cables carrying digital communications must be laid in separate conduits to prevent electromagnetic interference.
v) Plugging of extra holes in JB's, panels, cabinets, etc., plugging of additional holes for conduits, filling up the conduits & conduit opening with waterproof sealing compound after completion of erection.

9.2.2.3 *Instrumentation Redundancy Strategy*

a) Instrumentation shall be designed such that the impact of a failure of any single piece of instrument and auxiliaries will cause no reduction in the output of the plant.
b) Redundancy shall be applied such that "No" single I&C failure shall:
   - Cause any danger to personnel and the plant;
   - Invalidate protection by inhibiting a trip;
   - Shut down more than one Major Equipment item;
   - Simultaneously trip a Plant item and invalidate its auto-change-over; and
   - Affect more than one control area.
c) Instrument Voting:
   - If a parameter envisaged to trip a part of the plant process and eventually reduce the production, the instrument voting of that parameter shall be 2 out of 2.
   - If a parameter envisaged tripping the entire plant and complete loss of production, the instrument voting of that parameter shall be derived from 2 out of3.

The Contractor may propose feasible solutions as per their control strategy, considering point b above.

d) Measuring points and measuring equipment for interlocking and protection purposes for the critical control points shall be separate and not combined with measuring equipment for monitoring or automatic control equipment, except they are designed in a redundant configuration (2oo2 or 2oo3 voting).

9.2.3 Field Instrumentation

A general guideline on the Selection and approach of the instrumentation is given below. However, the selection of a particular type of sensor shall be decided based on the application requirement.

9.2.3.1 *Pressure Measurement*

a) All pressure instruments shall be provided with the isolation valve and vent/drain valve or manifold.
b) The differential pressure transmitter/indicator shall be mounted with a manifold.
c) Transmitter housing shall be made of Die-cast aluminum, with a minimum IP rating of IP65.
d) All wetted parts shall be made of Hastelloy C or AISI 316 depending upon the process fluid to be measured.
e) Pressure transmitters and gauges shall have over-range protection up to 1.5 times the maximum line pressure they may be exposed to.
f) Where necessary, a special diaphragm shall be used to segregate the gauge tube from corrosive fluid media. Minimum it shall be used in sludge and chemical dosages.
g) Pressure transmitters shall have accuracy typically better than 0.25% of the span.
h) For pressure measurement in slurries, viscous and corrosive fluids, diaphragm seals of suitable material shall be provided along with pressure sensing devices.
i) Pressure gauges shall have minimum dial size of 150 mm.
j) Pressure gauges shall have a threaded process connection of ½" NPT male.
k) Pressure gauges shall be in general diaphragm type , white with black markings dials for 270 degrees of the dial. The pointer shall be externally adjustable, and the gauge movements shall be stainless steel, geared type. The case shall have a blowout disc in the back. Ranges are typically selected such that the operating point falls between 1/3 and 2/3 of the full-scale range. Indicators are located such that they are visible from the floor or adjacent platforms, where practical. Wetted parts shall be suitable for the fluid handled.
l) The window material of the pressure gauge shall be shatterproof glass.
m) Pressure gauges/switches used in pulsating pressure applications (e.g., the delivery side of pumps, compressors, etc.) shall be provided with externally adjustable pulsation dampener or snubber.
n) Wherever the process pressure exceeds 30 bar, solid front type pressure gauges shall be

used (i.e., a metal partition shall be provided between dial and element).

o) The sealing liquid for the diaphragm seal shall be an inert liquid compatible with process fluid and its temperature.

p) Pressure gauges shall have an external zero adjustment facility.

9.2.3.2 *Flow Measurement – Electro Magnetic Flowmeter*

a) Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground applications.

b) To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream and downstream from the flow sensor's location, shall be provided in accordance with the requirements of the flow meter manufacturer.

c) Flow Meter shall be of the electromagnetic flow-through type with a minimum accuracy of 0.2 % at flows between 15 - 110 % concerning the nominal flow.

d) Product water metering flowmeter shall have an accuracy of 0.1% at flows between 15 - 110 % to the nominal flow.

e) Flow sensing element and liner shall be fully compatible with the fluid to be measured, process temperature, and the ambient conditions and shall not deteriorate under normal operating conditions.

f) Flow meters shall be designed to operate on 230 VAC power supply, and a 10% variation in power line voltage shall not affect the meter output accuracy over 0.1 % of the full scale.

g) The remote mounted transmitter is preferred, and it shall be located for easy access.

h) The transmitter shall be a smart type with outputs including communication interface, 4-20mA (HART), Pulse, and programmable relay discrete output. The transmitter shall include flow rate, alarm monitoring, self-diagnostics, and forward/reverse/net flow totalizer.

i) The measuring electrode, the reference electrode, and the empty pipe detection electrode shall be inbuilt, and the type of electrodes shall be manufacturer specifics based on the process fluid.

j) Flowmeter shall be provided with inbuilt grounding electrodes, and the material shall be the same as the sensing material. Insulation flanges, gasket, and copper shall be provided as required. The instruments shall be provided with dismantling joint.

k) Flowmeter flanges shall be in accordance with ANSI / ASME.

l) If the pipework has cathodic protection, the manufacturer's recommendations for bonding and protecting the instrument and its signals shall be adhered to.

m) Rotameters

- Rotameters shall be provided for areas where the flow parameters are only for monitoring and the least priority. Simple manufacturer standard scaled tube and float shall be used for line sizes less than 100mm, and for higher size pipes with the exception that the process pressure is not disturbed, a bypass type flow rotameter arrangement with flow restriction orifice plate shall be used. The rotameters shall be provided with discrete SPDT switches.

- Rotameter shall be a metal tube/glass type as applicable for process fluids; material shall be selected according to process requirements and fluids.

9.2.3.3 *Level measurement*

a) The level measurement system shall consist of a level transducer, level transmitter, digital level indicator, and any other items required to complete the level measuring system.
b) Level instruments shall have all weatherproof, dust, and corrosion-resistant enclosures of IP-67 grade.
c) Level instrument materials of construction shall be compatible with the fluids to be measure and the service conditions.
d) Level probes, waveguides, and stilling wells shall be situated to allow sufficient overhead clearance for their installation and removal.
e) Flushing ring, drain valves, tubing shall be provided where required.
f) Accuracy of the level measurements shall be better than ± 0.5% of full scale or 10mm.
g) The design and application of level meters shall consider the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size, etc.
h) The transmitters shall be 4-20mA (24V DC loop powered) / Field bus compatible and possible to calibrate through handheld universal and field bus configurators.
i) Ultrasonic Level Measurement
    - Ultrasonic type level transmitters shall be microprocessor-based and shall use digital signal processing techniques for signal conditioning.
    - The transmitter shall have facilities for storing the echo profile, manipulating the echo profile to remove noise, multiple profile-averaging, etc.
    - The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signals due to heavy dust or fill-stream interference.
    - In applications where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e., repetitive, pulsating displacement at its face shall be used to remove the material build-up).

9.2.3.4 *Analyzer*

a) All analyzers shall be industrial type, proven design, robust construction, low maintenance, and suitable for the intended application.
b) Each process area shall be provided with the required type of analyzer to monitor the process condition.
c) The different types of analyzers required in plants are pH, ORP, Turbidity, Temperature, Conductivity, Free Chlorine, Oil, Hydrocarbons, SDI, Alkalinity, .etc.
d) The type of sensors and measuring principle shall be selected based on the liquid's electrochemical and physical properties.

e) The analyzers shall be selected based on reagentless or reagent free operation
f) Multi-parameter type analyzers shall be used, but transmitter output shall be individual and dedicated per each parameter.
g) Analyzers shall be installed in analyzer panels if a cluster of analytical equipment exists in an area. Analyzer panels shall be installed, preferably in a sheltered area; when a circumstance requires the outdoor installation, the suitable shelter shall be provided to protect from direct sunlight and rain.
h) The analyzer panel shall be made of Plastic UV resistant panel or vendor standard material to withstand the climatic condition.
i) Suitable drain arrangement shall be provided where required.
j) Analyzer cabinet with air-conditioner shall be provided for analyzer were required based on manufacturer recommendation.
k) The analyzer cabinet shall be made of GRP or FRP with a minimum degree of protection of IP67.
l) pH:
    - The measuring electrode shall be glass with a suitable reference electrode (preferably silver).
    - Measurement shall be flow-through type, and the Sensor element shall have a built-in temperature sensor for temperature compensation. The electrode response shall be linear with temperature changes.
    - The systems shall have an auto cleaning facility and facility of auto-calibration.
m) ORP
    - The measuring electrode shall be platinum/gold with a suitable reference electrode (preferably silver)
    - pH and ORP sensors can be connected to a single transmitter, in which case the transmitter shall be capable of processing the two input signals as per the requirement
n) Conductivity
    - In the case of flow-through, the electrode shall be preferably titanium/ SS316L with a suitable reference electrode
o) Turbidity
    - Turbidity measurement shall be based on the Nephelometric measuring principle 90° NIR scattered light according to ISO 7027/ EN 27027
    - It shall be complete with the light source, light receivers, sensor assembly with an integrated viper, flow assembly with integrated gas bubble trap, Remote transmitter, etc.
    - An internal bubble removal system shall be included to vent entrained air from the sample stream.
p) TOC
    - TOC measurement shall be based on Non-Dispersive Infrared TN1/2012/04 Sensing Technology

- The analyzer shall measure organics reliably in high-salt or brine samples with a precision of +/-2% with a range of 0-250ppm and calibration stability of min. 6 months.

q) SDI

- Online SDI measurement shall be automatic for continuous monitoring &unattended operation in the desalination plant.
- Facility for data logging, status display, fault detection, auto flushing/cleaning, control of water pressure, flow rate measurement, automatic transfer of filters after each measurement, number of measurement (as required), etc.

r) Oil

- The probe shall be a continuous-reading sensor that utilizes a UV-fluorescence technology.
- The sensor shall be equipped with a stain-resistant measuring window. The sensor shall compensate for the interference effects of ambient light and UV lamp output fluctuations.

9.2.3.5 *Instrumentation Plan:*

The following table represents the minimum required instrumentation but not limited to, for each process units of the Proposed Perur DSP. The CONTRACTOR shall accordingly provide all required instrumentation that are necessary for process control in each 2x 200MLD process streams as applicable.

S. No.	Location	Instrumentation Plan
1.	Seawater pumping station	i. Travelling band screens - Ultrasonic differential level Sensors ii. Intake forebay – Total Hydrocarbon, Turbidity, Oil, Conductivity, Temperature, pH and Residual Chlorine Analysers. – iii. Pumps station: Level, Pressure, Protection/ Condition Monitoring
2.	Chemical building - Pre-treatment	i. The dosing tanks shall be provided with an Online Non-Contact Radar Type level sensor, and the dosing pumps shall be provided with Electromagnetic flowmeter at dosing pump discharge headers for the following chemicals - NaOCl (Chlorination), Sulphuric acid, Ferric Chloride, Polyelectrolyte etc.
4.	Pre-treatment – Dissolved air floatation	i. Dissolved Air Floatation Common effluent outlet - Turbidity meter, and other specific

S. No.	Location	Instrumentation Plan
		quality analyser to ensure the pre-treatment efficiency. ii. Electromagnetic meter on the sludge discharge line.
5.	Pre-treatment – Gravity dual media filtration	i. Differential Pressure sensors at each Gravity dual media filtration unit, Ultrasonic level sensors at each filter. ii. Backwash pump discharge header-Electromagnetic meter iii. Pumps: Pressure, Protection/ Condition Monitoring
6.	Pre-treatment – RO feed/ Backwash tank	i. Ultrasonic level sensors
7.	RO Feed Water	i. Chlorine, pH, conductivity, temperature, SDI and Boron Analyser before cartridge filter ii. Feed Water Pumping – Pressure, flow, Protection and Condition Monitoring
8.	Chemical building for Seawater Reverse Osmosis (SWRO)	i. The dosing tanks shall be provided with Online Non-Contact Radar Type level sensor, and the dosing pumps shall be provided with Electromagnetic flowmeters at pump discharge headers for the following chemicals - Sodium hydroxide, Antiscalant and Sodium meta-bi-sulphite, Biocide (as needed)
9.	RO building	i. RO feed pump discharge header – Online Pressure sensor ii. Micron Cartridge filter – Differential Pressure sensor iii. Micron cartridge filter outlet – Conductivity, ORP, pH, Temperature, Alkalinity, SDI Sensor iv. SWRO High-pressure pump suction – Electromagnetic flow meter, Online Pressure sensor v. SWRO High-pressure pump discharge – Online pressure sensor

S. No.	Location	Instrumentation Plan
		vi. ERD booster pump discharge – Online Pressure sensor vii. CIP dosing tanks- Online non-contact radar type level sensor viii. CIP dosing pumps discharge header – pH, Online Pressure sensor ix. RO flushing pump discharge header – Online Pressure sensor, Electromagnetic flowmeter x. RO permeate line outlet – pH, Conductivity, Electromagnetic flowmeter xi. Pumps: Pressure, Protection/ Condition Monitoring
10.	RO permeate tank	i. Ultrasonic level sensor
11.	SWRO Reject discharge line	i. Electromagnetic flowmeter, Online Pressure sensor, Temperature, pH, Turbidity, Conductivity, Residual Chlorine
12.	Post-treatment area	i. Lime filter inlet/outlet – pH, Electromagnetic flowmeter ii. Lime filter backwash – Electromagnetic flowmeter, residual chlorine iii. Lime filter Backwash air blower- Online Pressure sensor iv. Lime Silo level v. All required sensors and flow meters for CO2 injection. vi. The dosing tanks will be provided with Online Non-Contact Radar Type level sensor, and the dosing pumps will be provided Electromagnetic flowmeter at pump discharge headers for the following chemicals – Sodium hydroxide and Sodium hypochlorite
13.	Product water storage tank	i. Ultrasonic level sensor in the tank ii. Float type level sensor in the tank iii. Product water storage tank outlet line – Electromagnetic flow meter, Conductivity, pH, Turbidity, Residual chlorine, Temperature.
14.	Autosamplers	i. Seawater intake area ii. Lamella/DAF effluent and sludge line

S. No.	Location	Instrumentation Plan
		iii. Gravity dual media filter outlet iv. Remineralized water lines v. Product water lines to CWR vi. Seawater/ Brine outfall discharge area
15.	Package sewage treatment Plant	i. Inlet Electromagnetic flowmeter and treated water flowmeter and all other process sensor
16.	Wastewater treatment units	i. Lamella clarifier sludge discharge common line – Electromagnetic meter ii. DAF sludge discharge common line – Electromagnetic meter iii. Sludge balance tank and Thickeners - Ultrasonic level sensor iv. Sludge holding tank -Ultrasonic level sensor v. Sludge transfer pumps discharge header to thickener- Electromagnetic flowmeter, Online Pressure sensor vi. The dosing tanks will be provided with Online Ultrasonic level sensor and the dosing pumps will be provided Electromagnetic flowmeter at pump discharge headers for the Polyelectrolyte dosing in Thickener inlet and Belt filter press inlet vii. All pumps pump discharge line – Electromagnetic flowmeter, Online Pressure sensor viii. Neutralisation pit – Electromagnetic flowmeter, Online Pressure sensor. ix. Outfall tank -Ultrasonic level sensor

9.2.4 Condition Monitoring System (CMS)

a) The Integrated Machine Condition Monitoring system is required for all the critical Pumps; the criticality of the pumps shall be based on
   - The impact of the failure of a pump and auxiliaries will cause no reduction in the plant's output.
   - The failure of the pump doesn't affect more than one process area.
   - Size of the pump

b) The critical pumps are listed below, but not limited to the following.
   - Sea Water Intake Pumps
   - RO Feedwater Pumps
   - High-Pressure Pumps
   - Booster Pumps

   The Contractor, with their experience, shall include additional pumps, which may be sought as critical. The final list shall be approved by the Engineer.

c) It is recommended that the sensors for the condition monitoring system shall be supplied by the respective pump vendor dully installed and wired to their respective cabinet.
d) Various parameters such as Vibration, axial displacement, thrust, temperature, speed, key phasor, etc. shall be measured and made available for analysis and interlocking.
e) The data gathered from various machines shall be used for monitoring, machine diagnostic analysis, and decision support. The vendor shall provide software capable of data monitoring functionality in client-server configuration so that monitoring, diagnostics analysis, and configuration changes are possible from CMS Workstation.
f) The CMS shall be modular and expandable.
g) The CMS server shall have provision for interfacing Process data from the DCS in the respective control room for correlation of Fault diagnostics. The same shall be available from the OPC server's Ethernet port in the control room being provided by the DCS vendor. The CMS vendor's scope shall include coordination with the DCS vendor, including identifying process data required, developing the OPC client module at their end (CMS server), and successful integration with DCS.
h) Condition Monitoring system server shall have OPC connectivity with DCS network and shall comply with OPC foundation standards. A firewall shall be provided for the MCMS servers by the DCS vendor for the interface.
i) Fault diagnostic analysis software shall be able to detect various malfunctions like shift bow, high synchronous vibration, fluid-induced instabilities, radial preloads forces, shaft crack, rotor rub, loose rotating parts, electric motor non-uniform, air gap, etc
j) Software shall have the capability to evaluate the following data for analysis, as a minimum:
   - Magnitude and amplitude of the vibration
   - Form of vibration
   - Amplitude/Phase lag angle
   - Shaft centerline position
   - Frequency of the vibration
   - Process variable data
   - Machine geometry data
   - Trend file data
   - Report history files
k) The following list of parameters are to be included as a minimum but not limited to:

- Vibration monitoring
- Temperature monitoring

The final quantity of monitoring parameters to be installed in each type of equipment is confirmed by each equipment manufacturer's specific vendor and according to the mechanical construction.

l) Vibration monitoring shall measure bearing vibrations by accepting any voltage output or standard electric piezoelectric accelerometer. A minimum of two vibration transducers shall be provided for each bearing when permitted by the equipment's mechanical design.

m) Temperature monitoring shall be intended for the measurement of winding and bearing temperatures. Each equipment shall be provided for motor winding temperature monitoring points, motor bearing temperature monitoring points, and Pump bearing temperature monitoring points.

n) The Bidder/CONTRACTOR shall be responsible for coordinating with various Machine vendors (Original Equipment Manufacturers) concerning:
   - Obtaining/validation of required information for the engineering of offered CMS.
   - Verification of configuration data during Installation and commissioning.
   - Calibration verification of sensors and monitors during commissioning.

9.3 Distributed Control System (DCS)

Due to the requirement of availability, reliability, and function, the Plant processes' control and monitoring task be performed by a state of art digital Distributed Control System unified for all SWRO units and other main plant equipment. The DCS shall be of proven design successfully in operation at other similar desalination plants.

The Contractor shall be responsible for designing the integrated DCS, based on the information given in this specification, its referenced requirements and standards, and accompanying drawings/documents.

The listed requirements presented here in this section are intended as minimum recommendations and provide general guidelines and establish minimum system requirements.

9.3.1 DCS Strategy

a) A tentative DCS architecture for the SWRO Desalination Plant is attached within the drawing section ref: 7061563/PMC400MLD/CP1/DCS/001. The DCS shall incorporate Distributed controllers, Plant Control Station, Various Operator Workstations, engineering workstations, Control Servers, Controllers, Historian, Optimisation/CMMS server, and touch screen displays for field control & annunciation.
   Remote input/output (I/O) racks shall be distributed throughout the site to minimize the amount of wiring back to the central control room. The SWRO Desalination Plant shall be visible from the Control room.

b) The Design strategy for the DCS shall take into consideration the following criteria:
- Fail-Safe Design
- System Availability
- Equipment Reliability
- Expandability
- User friendly to operate and maintain
- Fault Monitoring and Diagnostic Capability
- Compatibility for Integration with the third party

c) The DCS shall synchronize the date and time via the GPS clock provided. All DCS facilities shall be synchronized to this system time and date, which shall be used to tag all alarm and events and in all displays and reports.

d) The SWRO Desalination Plant shall use a tree-type communications system to integrate equipment, instruments, and computers. The equipment level systems shall communicate with motor control centers, variable frequency drives, and other PLC's using standard Plant control network protocols.
The instrument-level system (field bus) shall communicate to most of the process instruments, air-operated valves, and/or motor operated valves using field bus, hardwired or equivalent.
The computers shall communicate peer to peer via standard TCP/IP or equivalent Ethernet.

9.3.2 Redundant Configuration

a) Process and Mechanical redundancy should be reflected in the DCS redundancy as well. The plant is envisaged into two independent production lines configuration of 2 x 200MLD, and the DCS redundancy should be harmonized as per the envisaged Process and Mechanical redundancy.

b) The following equipment shall be supplied in a redundant configuration
- All Controllers.
- All Power supply modules.
- All Control network equipment.
- All communications equipment required for communications between controllers, Servers, and Workstations
- All applicable station level equipment's

c) The following requirements apply to those parts of the system supplied in a redundant or fault-tolerant configuration:
- The system shall continuously monitor and test all backup equipment to determine whether the backup equipment can assume control.
- Failure of backup Equipment shall be alarmed as a system alarm.
- Automatic switchover to backup equipment shall occur on the detection of failure of the primary equipment.
- Switchover shall not degrade the module's performance or functionality or result in

the operator's loss of view to the process.
- Switchover of controllers shall not cause the initialization of any control strategies implemented in the controllers.
- Replacement of any redundant module shall not disturb or interfere with the redundant pair's functional module's performance.
- Switch back to repaired equipment shall be permitted only after the system diagnostics function has determined that the module is fully functional.
- Automatic and manual switchover shall be displayed, logged, and alarmed by the system.

d) The following requirements apply to the Control Network and Internal Communications
- DCS networks shall be based upon industry standards from IEEE/IEC.
- Communication at the control network level shall have redundant or fault-tolerant paths.
- Communications from the controller to the I/O subsystem shall have redundant paths.
- DCS internal communication shall be designed such that no single failure will degrade the performance of the system. This requirement applies to all communication between controllers to their I/O modules.
- Data highways shall continuously use both paths and shall check the backup path at least once per minute to determine if the backup path is operating normally.

9.3.3 Availability

a) A single failure anywhere in the system shall not result in the loss of production and regulatory control.

b) A single failure anywhere in the system shall not result in the loss of an operator's ability to view or manipulate the process from his workstation.

9.3.4 Reliability

Equipment supplied as part of the DCS system shall meet or exceed the MTBF data specified below at the equipment's design temperature.

- Process controllers and input/output modules – 300,000 hrs
- Power Supply modules – 200,000 hrs
- Commercial off-the-shelf networking or communications equipment – 100,000 hrs
- All other electronic modules and power supply modules – 100,000 hrs

MTBF figures shall be "Predicted" using data and calculation provided by MIL-HDBK-217.

9.3.5 System Support

Contractor shall guarantee support of all hardware, firmware, and software associated with the controller and I/O subsystems and any proprietary communications equipment through the operations period from the hardware freeze date. Support shall include spare parts and technical support.

9.3.6 Scope of Supply and services

The scope of supply and services includes (but not limited to) for Distributed Control System (DCS) / Controller shall include designing, engineering, manufacturing, software development, testing, erection, commissioning, documentation, and handing over complete plant control system to ensure satisfactory operation of the plant. Including Complete Integrated Plant Control System for Data Acquisition, Data Processing, Process Monitoring, Process Control, Process optimization, Events and alarm handling, Data storage, retrieval and analysis, Diagnostics, and Information exchange with Management / Office network. The design shall be in accordance with Contractor standards but with amendments to meet the CMWSSB/Engineer specifications.

9.3.7 DCS Hardware Requirement

9.3.7.1 *Scope of Supply and Services DCS Hardware*

The scope of supply and service for DCS hardware includes, but not limited to:

a) Distributed Control System (DCS) /Controller, PC based HMI units; Control desks; servers and redundant servers; computers for operator stations, plant overview, process optimization, information management system, peripherals; programmable controllers (PCs); power supplies; ethernet switches; distributed / remote I/O panels along with Large Screens, Monitors for plant overview shall be Min. 80" LED type for each stream shall be provided.
b) Modems / protocol converters / data transmission RF transmitters / receivers / link devices / Ethernet switches / coupler / terminators / routers / bridges / power supplies for communication wherever required, as per system configuration.
c) Ergonomic furniture for operators & Engineers at Main Plant Central Control Room (CCR)
d) The laptop computer of the latest configuration with necessary licensed software loaded as Portable Programming Unit for the programmable controller and other field instruments/devices/drives.

9.3.7.2 *Distributed Process Controllers*

a) The controllers shall be of a minimum 32 bit, high performance, RISC, multi-task processing. Including adequate clock frequency capability to process in 16 bits
b) The CPU load shall not be more than 60%. The memory utilisation shall be within 60%, the loading of communication channels like high-speed Ethernet, I/O channels, and programming terminal channel, if any, shall be less than 60%.
c) The controllers shall be programmed to achieve sequential interlocks for a start/stop of plant and machinery, process and safety interlocks, alarm generation & distribution, monitoring and supervision of process parameters and PI / PID, fuzzy loop controls for process optimization.

d) Controllers shall be controlling the sections independently & the stoppage of one controller shall not affect the operation of others unless otherwise they are deliberately interlocked. However, these processors shall also communicate between themselves to take care of the safety interlocks/process requirements shared between the process related sections. Any programmable controller in the network can access the data and I/O of any other controller in the same network.

e) The processors shall have self-diagnostic features to ensure healthy working at all times, including memory, processor loading, the status of communication channels, and to give warning through audio-visual means for any fault. Suitable programming devices to facilitate online program changes; storage of program for safekeeping and handheld terminal shall be included.

f) Process controllers shall be redundant, with automatic failover to the backup processor on the primary processor's failure. Engineering of a redundant unit should be transparent, i.e., no extra manual synchronization shall be needed. The backup processor shall be in hot standby mode, continuously updating its memory from the primary controller. The redundancy should have a switch over time less than 10 msec.

g) Controllers shall be supplied in a configuration to ensure continuous and bumpless processing of data while permitting online changes to control logic. There shall be an online and offline programming feature. The programmable controller shall have Remote, run, program, online program & test modes (Simulation mode).

h) The system shall have scalability both horizontally and vertically. The details of scalability in terms of number & type of controllers, number & type of I/O, number & type of communication modules, number of MMI, number of external systems, number & type of network nodes, different communication protocols, software, size of memory, additional functionality, distance, the mix of multiple processors, networks & I/O without restrictions, etc. are to be furnished by the Bidder.

9.3.7.3 *Inputs And Outputs*

a) I/Os in Panels or integrated to MCC shall be connected to DCS Controller through a redundant serial link. I/O list shall be provided by the contractor during detailed engineering.

b) The I/O and their interfaces shall have provisions configured either as remote I/O or as distributed I/O. The protocol envisaged for this purpose shall be of industry standard and open protocol. The same shall be mentioned in the Bid. I/O cards shall be with 32 channels for digital and 8 for Analogue with 20% spare.

c) As far as possible, field bus devices/transmitters shall be used. If such devices/transmitters are not available for any application, they shall be with a 4–20 mA DC analog signal with HART communication.

d) I/O panels required to be mounted at the field away from MCC rooms etc. shall have IP65 protection.

e) Input / Output (I/O) modules shall be capable of being inserted into or removed from their chassis or mounting assemblies without disturbing field wiring and while the chassis is powered (hot replacement).

f) All Input / Output modules shall provide a status LED that indicates the module's health or operational condition. The status of the module shall also be communicated to the system diagnostics software.

g) The modules selected shall be of rugged construction, low power consumption/heat dissipation, and to an extent, do not require forced cooling.

9.3.7.4 *Analog Input*

a) The system shall automatically check the calibration of the A/D converters periodically.

b) The system shall indicate calibration error.

c) The noise level generated by the input circuitry shall be less than the minimum resolution of the measurement.

d) Analog input modules shall power 4-20 mA field instrumentation loops with a loop resistance of 600 ohms.

e) Analog input modules shall be able to connect to 4 wire field instruments.

9.3.7.5 *Discrete Input*

a) The system shall be capable of detecting discrete input transitions with a duration of 50 milliseconds.

b) 24Vdc inputs shall be able to use either internal or external power supplies. External power supplies may provide other voltages.

c) Relay or solid-state input from field powered contacts shall be available.

d) The system shall support configurable digital input filtering to prevent digital input "chatter" or "bounce."

e) Discrete input modules shall have visible LED indicators on a per-channel basis to indicate the input's current state.

9.3.7.6 *Analog Output*

a) The system shall support 4-20 mA outputs.

b) Output modules shall be provided with individually fused outputs or current limiters.

c) Analog output modules shall have the following configurable failsafe options:

d) Drive to zero output or full-scale output

e) Maintain last good output value

9.3.7.7 *Discrete Output*

a) The system shall be capable of supporting the following:
   - On/off
   - Single pulse, (configurable width).
   - Latching and non-latching (momentary) contact outputs

b) The following solid state or relay board output ratings shall be available:
   - 24 VDC, 80 mA, non-inductive load

c) Relay or solid-state output contacts that are free of voltage and ground shall be available.
d) The duration of the single pulse outputs shall be individually configurable.
e) Output modules shall be provided with individually fused outputs or current limiters.
f) Discrete output circuits shall be provided with protection for the switching of inductive loads.
g) Discrete output modules shall have visible LED indicators on a per-channel basis to indicate the output's current state.
h) Discrete output modules shall have the following configurable fail-safe options:
    - Drive to either energize or de-energize output
    - Hold last output

9.3.8 DCS Software Requirement

a) The online real-time operating system supplied shall be proven for similar applications and shall support all the equipment/peripherals.
b) For Level -1, a Licensed software bundle for online & offline programming, configuring, diagnosis, troubleshooting, firmware update of flash PROMs of the controllers along with necessary drivers and interfaces shall be included and specified by the Bidder
c) For Level- 2, Licensed Operator Station software / Human Machine Interface (HMI) software for graphics development, tag configuration & management, data acquisition, plant viewing, plant operation, plant control, real-time & historian trending, alarm generation, and log reporting, event log, historian, PID, and other process loop manual & auto-tuning, interfacing & access for Field Bus devices/drives, interfacing & access for Management Information System (MIS) & Process Optimization Systems, OPC interface shall be included and specified by the Bidder.
d) Any other software required for the reliable & successful operation of the desalination plant and the system offered
e) The DCS system shall carry out the following functions on data received from the plant facilities:
    - Perform control algorithms as per configuration
    - Store historical information
    - Produce logs, reports, and trends
    - Handle alarms and events
    - Calculate derived values
    - Run application programs like measurement validation and comparison, valve stroke testing
    - Perform logic control and sequencing
    - Trending and Reports generation
    - Auto window generation of trending and Grouping from the tags in each Graphic display using soft key

- Safe view (Multi-window opening with the facility to open the window in the specified position with the first opened – first closing principle)
- HMI availability embedded in the FCS for viewing Advanced diagnostic and predictive maintenance feature (Latest version) for valves and transmitters
- Grouping of alarms UNIT / Equipment-wise
- Forcing I/O signals to individual states via the engineering workstation for commissioning and maintenance purposes.
- Loading I/O cards and Grouping of logics.
- Perform configuration of all HART devices from a single engineering station
- Automatically perform diagnostic checks on all conventional HART devices and continuously report their status and health to the operator interface.
- Provide the necessary software interface to the third-party devices

f) The Contractor shall supply:

- Fully configured database(s)
- Fully configured overview, operating, alarm and trend displays sufficient to provide full control and monitoring as specified by the CMWSSB/Engineer
- Fully integrated single database for process control and asset management data
- Fully configured tabular display pages
- Fully configured mimic displays
- Fully configured reports as specified by the CMWSSB/Engineer
- All other software required to meet the Specifications
- All User-Defined Programs supplied under this Contract
- Offline Diagnostic Software for comprehensive testing of the DCS

g) The Contractor shall ensure that all hardware and software supplied are mutually compatible and function through interfaces with any other equipment or software.

h) Control Functions:

The following standard control algorithms shall, as a minimum, be available for configuration:

- Normal PID
- Cascaded Loops
- High/Low Over-Ride Selection
- Ratio Algorithms
- Feed Forward Control
- PID with Gap Action
- Summer / Subtractor
- Multiplier / Divider
- Boolean Operations
- Differential Gap Control
- SetPoint Tracking (remote / local)

- External Reset Feedback (EFB)

9.3.8.1 *Optimization Package*

a) An optimization/expert system, along with necessary hardware & software, shall be provided. This optimization package shall be an integral part of the automation system or a standalone system.
b) The system shall be designed so that even if the expert optimization system fails, the plant operation shall not get affected, and all the controls shall automatically get transferred to appropriate control levels.
c) The optimization system shall provide a solution for the advanced process of membranes in desalination plant with the following minimum functions:
    - Monitors the membrane fouling through Key Performance Indices (KPIs)
    - Estimates the due date for next membrane chemical cleaning
    - Provides the optimal set points to improve the productivity / minimize energy consumption
    - Maximize membrane life and reduces unplanned outages
    - Maximizes water production and decreases operating cost

9.3.8.2 *Historian Package*

a) Online History Collection and Storage
   There shall be a configurable, real-time, and historical data collection package to support trending, logging, and reporting.
b) Offline History Storage
   It shall be possible to archive raw historical data for long term data storage. The facility to recall and display any data that has been archived shall be provided. The system shall keep a record of data that is transferred to removable media. The record shall contain the timeframe of the data transferred and the name of the file or storage area to which it has been transferred.

9.3.8.3 *Computerized Maintenance Management System (CMMS)*

A completely integrated computerized Maintenance Management System(CMMS) with relevant databases entirely populated and customized for desalination plant application shall be provided. The system to be provided shall include all necessary hardware, software, firmware, and interfaces required for implementing a fully functional CMMS suitable for integrated maintenance management function for a modern SWRO Desalination.

CMMS systems shall be envisaged to automate most of the logistical functions performed by maintenance staff and management.

The typical CMMS functions shall include the following, but not limited to:

- Work order generation, prioritization, and tracking by equipment/component.
- Historical tracking of all work orders generated which shall be sortable by equipment, date, person responding, etc.

- Tracking of scheduled and unscheduled maintenance activities.
- Storing of maintenance procedures as well as all warranty information by component.
- Storing of all technical documentation or procedures by component.
- Real-time reports of ongoing work activity
- Calendar- or run-time-based preventive maintenance work order generation.
- Capital and labor cost tracking by component as well as shortest, median, and longest times to close a work order by component.
- Complete parts and materials inventory control with automated reorder capability.
- PDA interface to streamline input and work order generation.
- Outside service call/dispatch capabilities.

9.3.8.4 *Database*

It is required that the DCS maintains, on mass storage media, the complete current database. Any changes made to the database shall also be copied to this backup. If a memory loss occurs, then the DCS shall reload with either an archived or the current backup version of the database from the storage.

9.3.9 DCS Controller Grouping

a) DCS controller and RIO shall be grouped. The Bidder/CONTRACTOR/Vendor shall specify an indicative number of IOs. The requirement and scheme of remote IOs shall be established.
b) The vendor shall ensure DCS IO loading is within limits.
c) Grouping of the controller shall be such that inter controller communication for acquisition and interlock are minimized to its extent.

9.3.10 Control Room

a) The complete desalination plant operations shall be operated and monitored from four operator stations located in Central Control Room, individual HMI operator workstations shall be envisaged for each 200MLD streams.
b) The control desk and the associated furniture shall be ergonomically designed as per standard industrial practices for comfortable working to the operators. The furniture shall comply with the relevant IEC standard for ergonomic design.
c) Colour Monitors, Keyboards, mouse, printers, Public Address System Master Unit, Walkie Talkie Station, P&T telephone, intercom telephone, CCTV switching unit, Process Log Books, etc. Shall be mounted/placed on Control Desk inappropriate cut outs / suitable arrangements.

9.3.11 Local HMI

Local HMI shall be provided for the field controllers. Local HMI shall be provided at each field process area controllers, which can be used sparingly in case of urgency only. This HMI shall be hooked directly to the controller liable to control functions of the concerned area.

9.3.12 Communication

a) DCS networks shall be based upon industry standards from IEEE/IEC.
b) High-Speed Ethernet communication shall be used for monitoring and control of the plant. There shall be two networks, such as Plant Bus and Station Bus.
c) Plant Bus shall have all Controllers, Application Server, Historian Server, OPC server, and Engineering Station connected to it. Station Bus shall have Operator stations, printer, and GPS clock connected to it.
d) Ring-type Network Topology shall be followed.
e) A firewall shall be provided for interfacing the Station bus with other LAN and interfacing outside network.
f) Level 0 shall contain all field instruments, Profibus DP slave devices such as VSD, Package Vendor PLC's, MOV, Control valve, and electrical switchgear feeders.
g) Level 1 shall contain all controllers and communication with field devices.
h) Level 2 shall be having both plant and station bus. This level shall contain all controllers, application server, operator stations, engineering station, Historian server, and GPS clock
i) Level 3 & Leve 4 shall be an interface to external systems using TCP/IP or Internet
j) Communication network-level shall be redundant or fault-tolerant paths.
k) Communications from the controller to the I/O subsystem shall have redundant paths.
l) Communication shall be designed such that no single failure will degrade the performance of the system. This requirement applies to all communication between controllers to their I/O modules.
m) Open system Interconnection type data highway shall be provided
n) Communication speed shall be Min. 100 MB/ sec.
o) Topology: Bus topology with (two) redundant network having Manageable Ethernet switches. The contractor shall also ensure that 25% of spare parts are available in ethernet switches.

9.3.13 Alarms and Message Handling

Alarm Management and Optimisation shall be envisaged as per standards during the abnormal and crisis condition.

9.3.14 Displays and Graphics

a) All displays and graphics that show real-time data shall update automatically when the collection is resident on the screen. Updates shall not require operator initiation.
b) Special indication shall be used to indicate that a value is invalid.
c) The update frequency for real-time data displayed alphanumerically and symbolically (shape change, color change, etc.) shall be at least once every two (2) seconds for all displays and graphics.

9.3.15 Diagnostics

9.3.15.1 *General*

a) The status of all modules shall be periodically checked to verify the online status and operation.
b) Errors shall be alarmed with an error message identifying the effected module.
c) The status of each online module shall be checked at least once per minute.
d) Diagnostic tools shall provide the following information:
e) Module status (e.g., online, offline, failed, standby)
f) Overall Processor loading (CPU) for controllers and other vendor proprietary DCS modules exclusive of I/O Modules.
g) Network utilization of control network.
h) Software and firmware (if applicable) version of all modules installed in the system.
i) System and Diagnostic Displays

9.3.15.2 *Communication System Status Displays*

Standard displays shall show as minimum as the operational status of the communication system. Each module's state connected to the communication system (online, offline, failed, primarily failed, backup failed) shall be shown.

9.3.15.3 *Module Status Displays*

Displays shall be provided to show the operational status and error conditions for all system modules down to the card level.

9.3.15.4 *Diagnostics*

a) Online and offline diagnostics shall be provided to assist in system maintenance and troubleshooting. Diagnostics shall be provided for every major system component and peripheral. If diagnostics do not exist for a particular peripheral device (for example, printers and terminals), the system must detect and provide an error indication for these devices' failure.
b) Online displays shall indicate the results of self-diagnostic tests. Failure diagnosis shall be sufficiently specific to indicate which printed circuit boards, modules, or devices are at fault. The displays shall be designed to help maintenance and engineering personnel diagnose faults in the system and communications paths. Each category of diagnostic display shall be organised hierarchically.
c) Communications diagnostic displays shall show errors for each of the redundant paths.

9.3.16 DCS Electrical Requirements

9.3.16.1 *Power Supply and Distribution*

a) Equipment shall be powered from separate Uninterruptible Power Supply (UPS).

9.3.16.2 *Redundancy*

a) All controllers, I/O modules, communication networks, and I/O bus communications equipment shall be fed from redundant UPS power sources.
b) A single failure of any power supply shall not fail more than one module in a pair of redundant DCS modules. This failure shall not cause a disturbance to the process or result in loss of operator functionality.
c) Power supplies shall be capable of being removed and replaced without disturbing the other power supplies' operation.
d) Power supplies for the same voltage rating shall be of the same make and model for interchangeability and spare parts management.
e) The power supply to a controller, I/O, or communications module is supplied from the chassis or baseplate, which houses the module. The chassis or baseplate shall be fed from two separate power supply circuits. Each circuit shall be provided from different and independent power sources.
f) Power supply redundancy shall be provided using an N+N configuration.

9.3.16.3 *Power Distribution within DCS Cabinets*

a) Power supplies that feed multiple chassis or base plates shall have their outputs wired to a power distribution panel within the cabinet. The term "power distribution panel" in the above requirement and subsequent requirements of this section refers to a collection of din-rail mounted circuit breakers and/or fused terminal blocks, terminal blocks, and wiring used to distribute power to multiple loads from a single source.
b) Branch circuits from power supplies shall be individually fused or protected by a circuit breaker.
c) Terminal blocks in the power distribution panel shall be segregated by voltage level.
d) Power distribution terminal block wiring shall not be daisy-chained using wires or crimp connectors. Jumper bars or preformed jumper combs designed for the specific terminal blocks being used are acceptable methods of distributing power supply wiring.

9.3.16.4 *Revision Level*

a) All controller and I/O subsystem hardware and other vendors proprietary hardware shall be the latest "field-proven" revision level
b) All vendor proprietary software, exclusive of application software, shall be the most recent, commercially released, software revision level
c) All personal computers, monitors, printers, peripherals, Ethernet switches, and other commercial off-the-shelf (COTS) equipment provided by the vendor as part of the system shall be the latest model available
d) The system shall allow for upgrading of system operating Software on all redundant modules of the system without requiring a shutdown of any process equipment, without losing the operator's view to the process, and without the loss of access to any control function.
e) Software and hardware upgrades are to be considered and included within the proposal

covering the O&M period.

9.3.17 Documents to be submitted during Bid Submission

a) A filled-in table of Conformance to every part of the specifications. Use a chart format with the specification part identified, indicate whether each element complies, a deviation, or an exception to the specific part. If any exception or deviation, include a narrative description of how the deviation or exception can benefit the end-user.
b) Provide a written overview of the proposed DCS system, instrumentation system describing the principal functions and capabilities of the system's PC, controllers, system communications, and general system capabilities (maximum number of network nodes, Controllers and I/O points, communication protocols available, etc.).
c) Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all major hardware items. The list shall consist of a minimum, the manufacturer, and model numbers. Technical schedules for Instruments, Controllers & DCS shall be duly filled with relevant details.
d) Provide an operating system and software applications list with descriptive literature for the proposed system. Include all significant software items, supplier name, quantity, and model numbers. Confirmation that all softwares along with licenses shall be handed over to the Employer.

9.4 Interfaces – External Systems

9.4.1 CP1 – Data towards CMWSSB Control Centre

a) The data from the desalination plant and the pumping station will be accessed by CMWSSB through web interface as presented in the system architecture.
b) To interface pumping station data towards DCS, an interface panel shall be used to transfer data between the pumping station and Desalination plant DCS.
c) The parameters and interlocks for operations of pumping station and DCS shall be accordingly shared through communication interface.
d) The main Control room of the Desalination Plant shall be located in such a way that the plant operation is visible physically and the Contractor shall obtain the approval of the Employer's Representative before commencing the detailed design work.

9.4.2 TANGEDCO / TNEB

a) The interface point to the TANGEDCO/TNEB shall be the interface cubicle for analogue/ digital signal exchange located at the central power supply receiving station. This interface panel shall be supplied, and installation is as part of the project scope.
b) All required equipment (e.g., fibre optic cables, patch panel, patch cords, fibre optic converter, cabinet, etc.) shall be provided.
c) All signal sharing between the TANGEDCO SCADA and DCS shall be interfaced

through this cubicle. The list of signals is to be finalized during the detailed design stage.

d) The communication protocol between DCS and TANGEDCO/TNEB shall be decided during the detailed design stage.

9.4.3 TN Pollution Control Board / TNCRZ / CMWSSB

a) The User-specific information shall be made available to the stakeholders TNPCB, TNCRZ, and CMWSSB.
b) The Webserver shall populate the required information based on user rights.
c) The list of data for sharing shall be decided during the detailed design stage.

9.5 Cyber Security

9.5.1 Codes & Standards

Material or equipment supplied to this specification shall comply with the latest edition of the references listed below unless otherwise noted

STANDARDS	TITLE
IEC 62443-3-3	Industrial communication networks – Network and system security
ISO 9001	Quality Management Systems – requirements.
IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
ISA 99	Industrial Automation and Controls Systems Security
ISA-62443-3-3	Security for industrial automation and control systems Part 3-3: System security requirements and security levels

9.5.2 Network Architecture

Ref the tentative DCS System Architecture drawing: 7061563/PMC400MLD/CP1/DCS/001

a) Level 1 and Level 2 networks shall use physically separate network switches and routers from Level 3 & 4 networks.
b) IT Components on Level 1 and 2 shall be separated from Level 3 and above by a managed firewall. The firewall policies or rules should be configured such that only required communications are possible.
c) Level 3 and above systems shall be configured using firewall policies or rules that permit only required traffic. All policies or rules applied to the firewalls not required

during the operate phase shall be removed before the handover is run and maintained.

d) Internet access from IT Components directly connected to Level 1, or Level 0 shall not be allowed, and Internet access from other IT Components shall be:
   - Via the process control access domain proxy and
   - From and to explicitly authorized systems and
   - Specify a fully qualified domain name for the internet host, and
   - Route traffic through the process control access domain firewall.

e) All unused interface ports (e.g., Ethernet and USB) on IT Components shall be protected against unauthorized access. This includes, but is not limited to, configuration and diagnostic ports or interfaces. This requirement intentionally leaves it to the project to decide on the means of protection, e.g., logical or physical.

f) Remote user access and remote management access to L4, L3, and L2 network devices shall only be permitted via the firewall.

g) Access to L1 network devices and below shall be limited to Internal Remote Access.

h) All IT Components requiring antivirus or patch updates shall be network-connected where technically possible, thus allowing centrally located services to provide these updates. This allows for centralized management and monitoring of IT Components.

9.5.3 Firewall

All firewalls implemented shall be state-full inspection hardware firewalls. The firewall rules shall be configured to deny all traffic except for the traffic, which is required explicitly for the system.

Firewalls shall be subject to a rule set review at least annually, to ensure that only the necessary traffic is permitted.

9.5.4 Access Control

a) All network traffic between Level-2 and any other domain SHALL be through a secure firewall solution unless an IP connection is impossible. If and where non-IP modems are used to access a Level-2 IT Component, the following shall apply:
   - The modem shall be physically disconnected or disabled when not in use, and
   - A documented procedure for monitoring remote user activities when the modem is in use shall be applied. This procedure shall be reviewed and approved by the IT Security Accountable Manager.

b) If in case external remote user access to Level-2 applications and IT Components is required, this shall be authenticated with the following minimum criteria:
   - Two-factor authentication, or
   - One-time password.

c) External remote user access accounts shall be locked after six consecutive failed authentication login attempts.

d) The Level-2 shall provide the capability of restricting and terminating any external remote user access session:
   - Manually by the administrator, or
   - Automatically by specifying an allowed session time, and upon exceeding the specified session time
e) IT Components at Level 2 requiring system-to-system access to the Internet via the proxy service shall be isolated in one or more dedicated VLAN(s). The firewall policy of the firewall protecting the Level 2 network shall be configured to allow outgoing only connections from the Level 2 IT Component IP address to the proxy IP address.
f) Each IT Component in the network shall have a documented procedure for applying system hardening techniques from the Supplier, the original manufacturer (e.g., Microsoft™), or the Center for Internet Security (CIS) or NIST. The procedure shall include Supplier endorsement.
g) Before commissioning, all IT Component elements that are not required during the operate phase shall be removed; at a minimum, the following shall be reviewed and removed if not needed:
   - User accounts and groups
   - Applications, utilities, services

9.5.5 User Groups and User Roles

a) The system shall be capable of defining user groups or user roles. System access privileges shall be configurable for each user group or user role. Individual user privileges shall be determined based on the user group/role to which they are assigned.
b) The system shall be capable of defining the following user roles as a minimum:
   - View Only
   - Plant Operator (1 – 10 plant operator roles shall be specifiable)
   - Process Supervisor
   - Engineer
   - System administrator

9.5.6 Operating System Security Patches

a) Patches shall be approved (qualified) by the system Supplier before installation.
b) There shall be a procedure for the installation of qualified emergency patches
c) An exposure level shall be determined for each IT Component in scope to apply operating system security patches. Per the applicable component, one of the following exposure levels shall be determined and stored in the asset inventory:

Low	Qualified patches will be applied at least once every 12 months during the operating phase.
Medium	Qualified patches will be applied at least once every 6 months during the operating phase.

	At a minimum, this includes systems designed to use portable media and/or network file transfer during their normal course of operation.
High	Qualified patches will be applied at least once every 3 months during the operating phase.

9.5.7 Event Log Management

The log files shall, at a minimum, include the following information:

a) For Microsoft™ Windows®-based IT Components:
- Account login failures.
- Discovery of an infected file.
- Shutdown and restart.
- Change to the event logging configuration.
- Account password change and reset.
- Account, group, and OU addition, deletion, or group membership change.
- Microsoft™ Windows® group policy modifications.
- Successful system administrator and operator logons shall be logged.

b) For other IT Components (i.e., Unix systems, switches, routers, and firewalls):
- Account login failures.
- Discovery of an infected file.
- Shutdown and restart.
- Unauthorized devices.
- Change to the event logging configuration
- Account password change and reset.
- Account addition, deletion, or group membership change.
- Configuration changes.
- Successful system administrator and operator logons shall be logged

9.5.8 Antivirus

a) IT Components supporting antivirus software shall be checked for computer viruses before being installed into or connected to the network.
b) Antivirus software shall be configured to automatically scan files accessed by the IT component and configured to log and notify malware-infected files.
c) The impact of a full antivirus scan on the operational performance of the component shall be evaluated when determining the frequency for performing the full scan and use of automated or manual full scans on the IT Component

9.5.9 System Hardening

a) Removal or non-installation of software and functionality that is not required for the system's intended functional purpose; e.g., E-mail, office applications, games, USB ports, Bluetooth, and Wi-Fi communication, etc.

b) Physical and logical access to diagnostic and configuration ports shall be protected.

c) All unused ports on switches and routers shall be disabled to prevent unauthorized access to the network infrastructure.

d) The Supplier shall demonstrate the use of hardening guidelines, tools, and instructions from either the original manufacturer (e.g., Microsoft®) and/or reputable organizations (e.g., NSA security configuration guides, NIST).

9.5.10 Backup, Restore, and Disaster Recovery

a) The system shall be backed-up at [user defined] intervals that fulfill the data restore and disaster recovery objectives for the system.

b) A backup shall be completed before an engineering change being made to the hardware or software, e.g.:
   - Installing an operating system patch or upgrade
   - Hardware modifications
   - Before a change is made for which automatic roll-back is impossible
   - After modifications to the system (scheduling changes, authorization and authentication changes, process trip, or application changes).

c) The following types of data shall be backed-up:
   - Operating system files
   - Applications (including middleware, such as an OPC tunneller)
   - Configuration data
   - Database files
   - Log files
   - Electronic logbook
   - Unconventional file types; e.g., network equipment settings, DCS controller settings (tuning parameters, set points, alarm levels, etc.), field instrumentation parameters, and Microsoft® Active Directory
   - Other files, identified by the Supplier, are required to create a complete backup of the Supplier's system.

d) The vendor shall provide detailed instructions on making a full backup of its system using at least one of the four methods below.
   - Proprietary backup architecture on removable media
   - Single system backup architecture on removable media
   - Distributed backup architecture
   - Centralized backup architecture

9.5.11 Remote Access

Where there is a requirement for remote support of DCS systems, secure connectivity solutions shall be implemented to ensure that:

- Communications outside of the electronic security perimeter are encrypted;
- User accounts authenticate users with passwords which conform at least with the baseline password standard;
- User privileges are restricted to only those required to fulfill remote support roles.
- Connectivity for remote access shall only be available when required and authorized, i.e., remote access connectivity shall not permanently be in place.

9.6 Spares

9.6.1 Equipment Spares

a) After Commissioning of the system, at least 20% installed spare capacity shall be provided for each type of I/O module, and 20% spare software tags shall be provided in DCS
b) At least 20% of spare terminals, PDB circuit breakers, and cable trunking shall be provided.
c) Within each system cabinet, at least 20% spare card/module positions shall be available for future modifications within the racks.
d) The software (application) spare capacity for the communication connections to third party devices shall be at least 20%
e) Loading on the control processors shall not exceed 60 % of its capacity
f) Future spare space shall be 10%

9.6.2 Spare Parts

a) The Contractor shall provide any special tools, spare parts required for permanent installation at the site as part of the supply.
b) These shall include all non-standard equipment needed to perform installation and maintenance. All special tools are to be supplied in the sectionalised purpose-built cases with hinged lids.
c) The vendor shall indicate the list of recommended tools, spare parts, etc. to be maintained by the O&M Contractor during the operational period.
d) The vendor shall supply all spare parts & consumables required for installation and commissioning operation based on vendor recommendation.
e) Spare parts and consumables for two years of commercial operation after commissioning operation.

9.7 Reporting System

This section describes the basic design and requirements for the Reporting system. The offered system shall collect all relevant data mentioned below to produce a consolidated monthly report:

- Water Production metering

- Water Quality verification
- Plant availability
- O&M performance verification
- O&M report backing and analysis.

Accordingly, this functional specification forms the basis of the design, engineering of the hardware and software components, selecting the right make and model, including software licenses required to be engineered by the Contractor in close co-ordination with CMWSSB.

9.7.1 International Standards

STANDARDS	TITLE
ISO 4064	Measurement of Water Flows in Closed Conduits - Meters for Cold Potable Water (Parts 1, 2 and 3)
OIML R 49	Water Meters Intended for the Metering of Cold Potable Water
ISO 7066-1	Measurement of Liquid Flow – Assessment Of Uncertainty In The Calibration And Use Of Flow Measurement Devices.
BS EN 14154-1	Water meters. General requirements

9.7.2 Design Requirements

e) A highly reliable, secured and tamper-proof automatic reporting system shall be proposed to measure, collect, register and report all relevant data to produce an accurate monthly report.

f) The proposed system shall perform data collection of :
   - Product Water dispatched to the transmission system, interfaced from Water flowmeters
   - Electricity consumption of the Plant, interfaced from the Plant main incomer Electricity Energy Meters
   - Product Water Quality, interfaced from DCS
   - Maintenance Report including the preceding /current /succeeding month maintenance work order/reports from CMMS (Maintenance Management System)
   - Plant/rack Availability Data from DCS
   - Seawater Quality data from DCS
   - Any other relevant data as required by CMWSSB
   - Any Manual input data which aids in reporting

g) The data collected shall then be validated and shall be stored or marked for report generation.

h) The system and the data should be secure and tamper-proofed
i) Security of the system shall be as per the Cybersecurity hardening referred to in section:9.5
j) Appropriate secured two-factor sign-in authentication to be implemented for the system, such that CMWSSB should authenticate any configuration login
k) The data collection and the validation process shall perform the following function:
   i. Establish robust data, flagging any discrepancies or integrity issues
   ii. Identify potential metering equipment and communication links failures
   iii. Identify unauthorised interference or manipulation of data
l) For accurate Product water dispatch measurement and data validation, Data loggers shall be used.
m) The data logger data acquisition should cover both the main and check water flowmeter. The flow meter's pulse train output shall be programmed to provide a pulse when a certain amount of (m^3) water is dispatched or passed through the flow meter.
n) The data logger shall accept or count the pulse train and calculate the totalised quantity flow. The collected water data is then pushed or acquired by the reporting system for reporting purpose.
o) The electricity tariff meters' data collection should be from the plant main power incomer line energy meters.
p) The data acquisition shall be done both for the main and check energy tariff meters. The tariff meters shall communicate in the IEC-62056-21 metering protocol or any standard metering protocol. The reporting system and related components shall support the envisaged protocol.
q) CMMS data should cater to the consolidated reports as required by the reporting system
r) All interfaces to DCS and CMMS shall be interfaced through communication interface with a proven industrial standard protocol
s) All measuring equipment shall be designed, procured, and commissioned as per the Indian Grid Code.
t) The Water Metering device Main and Check flow meter shall be of the electromagnetic flow-through type with a minimum accuracy of 0.2% at flows between 15-110% nominal flow. The flowm meters shall meet the general requirements of ISO 4064/OIML R49 and the accuracy classes set.

9.7.3 System Configuration

a) A high reliable reporting system shall be proposed to provide accurate reporting data during each reporting period, i.e. calendar month.
b) The reporting system shall have the option to produce Manually triggered reports.
c) The Reporting system shall comprise field mounted outstation or meters pulse interface, DCS interface, CMMS interface, Interface Unit (IU), Reporting system, and failsafe communication system to interconnect all components.

d) The outstation unit shall consist of data logger's which receives the pulse from the water meters and perform logging and processing of data before transmitting it to the reporting system

e) The reporting system shall be an industrial computer-based system with two redundant dedicated servers and one operator station. The data shall be acquired from all the interfaces, i.e. from the Interface Unit(IU), Distributed Control System (DCS) and Computerized Maintenance Management System (CMMS) on a routine basis; the acquisition time shall be user-definable.

f) Archiving shall be done at the Reporting System computers.

g) FO based communication shall form the backbone of communication connecting the flow meter MIU and Ennergymeter to the Reporting system.

9.7.4 Data Storage

The data shall be archived as per the table below as minimum parameters on equipment identification, equipment measurement, time, and any other data requested by CMWSSB to be included as mandatory within the archived data.

Period	Back-up Frequency	Retained for Minimum	Remark
Day data	End of day	One week	Each hour back-up stored separately
Week data	End of week	One month	Each week back-up stored separately
Month data	End of month	One year	Each month back-up stored separately
Monthly finalised settlement data	First of the subsequent month	Ten Financial years	Each month back-up stored separately
Financial years	End of year	Twenty Financial years	Each year back-up stored separately

9.7.5 Redundancy

Redundancy shall be taken into consideration at all levels, from the hardware level to the data level. Storage of data shall be proposed with RAID function. No single point failure of hardware or data shall directly or indirectly affect the Reporting system's normal required function or any other auxiliaries.

9.7.6 Time Synchronisation

Time synchronisation shall be envisaged, and the time shall be synched with Control system time or from the GPS clock. The vendor shall provide time synch resolution.

9.7.7 Security

External or remote access to the system shall be monitored and governed; the latest technology firewall and router shall be envisaged.

The system shall maintain separate user accounts for each user for accessing the system

All the instrumentations and data acquisition devices shall be assembled inside a panel; any panel or instrumentation access should be authorized and logged into the reporting system.

Instrumentation configuration should be accessible through user credential rights, and all credentials are to be authorized in the two-factor authentication.

The reporting systems shall be interfaced to the CMWSSB web portal through a secured data interface, and the data shall be published on to the public web-portal.

9.7.8 Datalogger Water Meter

The water meter data logger shall be capable of recognising 10 msec digital impulse from the flow meters. Each pulse represents a value represented by meter constant. The pulse shall be counted, multiplied as per the meter constant in the data logger. The values then shall be available as load profile data. The data shall be stored in the data logger periodically. The data collected shall then be transmitted to the reporting system database after validation.

Time synch pulse from the GPS or the DCS shall be considered to synchronise the time accurately accordingly when a report is published, the time integrity is maintained.

The flow meters shall be programmed to provide pulsed outputs with the impulse shall be free programmable, which shall be acceptable by the data loggers.

Two data loggers shall be provided. The Main and Check flow meters shall be interconnected to both the dataloggers, which will aid in data validation and duplication.

Data loggers shall store all meter data collected by the meters, including alarms, for a minimum of forty days.

9.7.9 Product Water Meter - Flow data

9.7.9.1 *Meter Registration*

The Contractor is required to register in writing with CMWSSB, the Metering System.

Registration information shall include the Contractor respective identities, loss adjustment details whether by meter biasing or software and full technical description of the Metering Equipment, single-line drawings of the installation, and all applicable calibration/approval documentation applying to the specified equipment following the procedures. Such registration shall be subject to CMWSSB confirmation that the Metering System is compliant for billing.

9.7.9.2 *Water Meter - Electro Magnetic Flowmeter*

n) Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground applications.

o) To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream and downstream from the flow sensor's location, shall be provided in accordance with the requirements of the flow meter manufacturer.

p) A product water metering flowmeter shall have an accuracy of 0.1% at flows between 15 - 110 % concerning the nominal flow.

q) Flow sensing element shall be fully compatible with the fluid to be measured, process temperature, and the ambient conditions and shall not deteriorate under normal operating conditions.

r) Flow meters shall be designed to operate on 230 VAC power supply, and a 10% variation in power line voltage shall not affect the meter output accuracy over 0.1 % of the full scale.

s) The remote mounted transmitter is preferred, and it shall be located for easy access.

t) The transmitter shall be a smart type with outputs including Fieldbus, 4-20mA (HART), programmable Pulses, and programmable relay discrete output. The transmitter shall include flow rate, alarm monitoring, self-diagnostics, and forward/reverse/net flow totaliser.

u) The measuring electrode, the reference electrode, and the empty pipe detection electrode shall be inbuilt, and the type of electrodes shall be manufacturer specifics based on the process fluid.

v) Flowmeter shall be provided with inbuilt grounding electrodes, and the material shall be the same as the sensing material. Insulation flanges, gasket, and copper shall be provided as required.

w) Flowmeter flanges shall be in accordance with ANSI / ASME.

x) If the pipework has cathodic protection, the manufacturer's recommendations for bonding and protecting the instrument and its signals shall be adhered to.

9.7.9.3 *Inspection, Testing and Calibration*

a) Contractor shall ensure that all Metering Equipment registered with CMWSSB shall be calibrated to meet the accuracy requirements according to the Code.

b) CMWSSB shall be granted access to all such Metering Equipment and any other plant or apparatus on any site in order to inspect the basis of any adjustments made to Metering Equipment.

~~c)~~ Calibration shall be undertaken using working standards that have traceability to suitable reference standards verified at an Accredited Laboratory.

d) No calibration adjustment shall be carried out to any Metering Equipment outside of an internationally Accredited Laboratory with traceability of calibration techniques i.e. ISO 17025.

9.7.9.4 *Site Verification testing*

Contractor shall carry out a routine test of the accuracy and/or verification of all Metering Equipment performance.

9.7.10 Product Water Quality Data

a) The product water quality data are to be interfaced through DCS.
b) In principle, the monitoring equipment must comply with the requirements set out in Seawater Quality Monitoring, Product Water Quality Monitoring and outfall discharge water quality monitoring requirements.
c) According to ISO standards, the Plant shall be equipped with a laboratory that allows testing of all relevant parameters.
d) Scope of analysers to be finalized in discussion with CMWSSB, during the detailed design stage.
e) All analysers shall be industrial type, proven design, robust construction, low maintenance, and suitable for the intended application.
f) The analysers shall be selected based on reagent less or reagent free operation.
g) 2oo2 voting to be proposed for the continuous online analysers.
h) Multi-parameter type analysers shall be used, but transmitter output shall be individual and dedicated per each parameter.
i) Analysers shall be installed in analyser panels if a cluster of analytical equipment exists in an area. Analyser panels shall be installed within a sheltered spot; when a circumstance requires the outdoor installation, a suitable shelter shall be provided to protect from direct sunlight and rain.
j) The analyser panel shall be made of a Plastic UV resistant panel or vendor standard material to withstand the climatic condition.
k) A suitable drain arrangement shall be provided where required.
l) Analyser cabinet with air-conditioner shall be provided for analyser were required based on manufacturer recommendation.
m) The analyser cabinet shall be made of GRP or FRP with a minimum degree of protection of IP67.
n) Refer to ICA section 9.2.3.4 for more specific details.

9.7.11 Plant / Rack Capacity Data

The reporting system shall gather the "RO Rack IN-Service" data from the DCS, and this data shall be interpreted as plant capacity data. The Reporting system's interface shall be through OPC or any feasible communication finalized during the detailed stage.

The frequency of data fetching shall be user-configurable, the data shall be available on 24 hours basis.

9.7.12 Plant Maintenance Data CMMS

The Maintenance Management System (CMMS) shall be interfaced to the Reporting system using OPC interface or any feasible communication to be decided during the detailed design stage.

The CMMS shall interface data related to the summarised work orders data during the current month and the preceding month. An additional report shall be included within the data interface to cover works-related to the commencing months, including the planned work orders.

This CMMS report interface will ensure that the plant maintenance has been carried out as per the requirements and shall monitor the O&M performance.

Minimum following data's are to be made available for the reporting system:

- Calendar report on Work order status Current and Preceding Month
- Planned Work order for succeeding month
- Breakdown Maintenance report

9.7.13 Reports

The reports shall be available by default monthly. The Reporting system shall be configured such that user-triggered reports shall be available on demand.

The report formats shall be finalized during the detailed design stage in close co-ordination with CMWSSB.

9.8 Operation Control & Monitoring Strategy

The following Operation, Monitoring, and Control strategy section set forth the essential specific requirement for safe operation and control of the SWRO desalination Plant. The listed requirements presented here in this section are intended as minimum recommendations and provide general guidelines and establish minimum system requirements.

It is the responsibility of the Contractor to design each system that meets all criteria defined in this document as well as to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset in close consultation with CMWSSB.

9.8.1 Seawater Intake System

9.8.1.1 *System Description*

Seawater enters the plant through the intake pumping station. The intake system consists of:

a) Intake pump station: with pumps equipped with VFDs, regulating the flow of raw water according to water demand delivers the raw seawater to the pre-treatment system.

b) Screens: Mechanical screening equipment consisting of rotating band screens (mesh ≤ 5mm) provided upstream of the intake pumps for screening debris and marine organisms. Spray jets arrangement shall be provided to clean the band screen.
c) Sodium hypochlorite Dosing: To prevent the growth of marine organisms in the intake structure
d) Airbust system: Jellyfish prevention system

9.8.1.2 *Instrumentation*

a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
b) As a minimum following instrumentation is to be provided, but not limited to:
   i) Total Hydrocarbons, at intake forebay
   ii) Turbidity at intake forebay
   iii) Conductivity at intake forebay
   iv) Temperature at intake forebay
   v) Oil in water analyzer
   vi) pH, at intake forebay
   vii) Chlorine, at intake forebay
   viii) Parameters listed in the Seawater Intake Quality specifications
   ix) Level for intake chamber, intake forebay, and Pump bay
   x) Flow and Pressure for Pump discharge
   xi) Protection and Condition monitoring for the pumps
   xii) Any other device required to meet the operations, guarantee, and environment.
c) Instrumentations to ensure the raw seawater is within the design envelope and to provide sufficient information to adjust the Pre-treatment process.
d) Instrumentation shall be sufficient to operate and follow over the project life of the pumps and associated equipment.
e) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.8.1.3 *Automation Control Strategy*

a) Intake Pump Flow: The intake pump station shall be demand driven by the RO requirement and maintain the RO feed water tank level. During the plant's initial startup, the intake pump station level control loop shall control the RO feed water tank level maintaining at 95%. Once the RO trains are functioning, the seawater pumping station control loop shall switch to a cascaded control loop maintaining the RO flow demand and the RO feed water tank level.
b) Combined control system control loop programming and the VFDs tuning shall consider operating the pumps at its best efficiency point. If the intake flow is suspended for any reason, including non-routine, this shall trigger an automatic intake pump shutdown sequence.

c) Intake Pump Flushing: Flushing with service water shall be incorporated during the pump stopping sequence to avoid long time contact of seawater with the idle pump.
d) Intake pumps Screens Cleaning: There will be a consistent spray of water to clean the traveling screen. In case manual cleaning is needed, the screens cleaning sequence will be controlled based on level difference or based on the timer for scrapping and cleaning.
e) Chlorine Shock dosing: Timer or intermittent dosing shall be envisaged for the intake pipeline as per the Operator decision. Simultaneously a flow controlled dosing to be envisaged for the intake forebay.
f) The flowrate on the seawater supply pumps' discharge shall regulate the coagulant, flocculants, and acid dosing rates towards the Pre-treatment system.

9.8.1.4 *Key Operational Monitoring Points*

a) Following seawater parameter shall be continuously monitored, appropriate alarms should be raised with high priority:
    - Low Intake Well Water Level at intake forebay
    - High TOC, at intake forebay
    - High TDS (Conductivity), at intake forebay
    - High Turbidity, at intake forebay
    - High Temperature, at intake forebay
    - High pH, at intake forebay
    - High Chlorine, at intake forebay
    - High Oil level, at intake forebay
    - High/Low Flow, Pressure & Level, for pumps & intake forebay
    - Loss of REMOTE status and Measurements from connected devices
b) Pump Condition Monitoring: The condition monitoring system alarms are set as per the Original Equipment Manufacturer (OEM) limits. All warnings are to be configured as high priority alarms.
c) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks. The level measurement readings are to be considered the early warning and proper actions to be taken by the operator.
d) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.1.5 *Critical Control Point, CCP-1:*

a) Seawater Intake, Oil, Turbidity and Hydrocarbon CCP-1
   The intake pump control system shall incorporate provisions to alarm at the high seawater quality parameters' level above the acceptable limits. Provision shall be there to automatically shut the pumps and the intake structure(Gates) connected to the seawater supply line; if seawater Oil, Turbidity and Hydrocarbons are excessively high beyond the limit. Appropriate instrument voting should be provided for the instrumentation reading the parameter.
b) Instrument voting on (2oo2) shall be provided, thus avoiding damage to the downstream

plant.

c) The automatic closure or shutting must not result in transients that cause damage to any of the infrastructure.

9.8.2 Pre-Treatment System

9.8.2.1 *System Description*

The Pre-treatment system aims at transforming the raw seawater into feedwater for the RO membranes. Pre-treatment facilities shall be provided ahead of the RO system to protect the integrity and consistent performance of the downstream cartridge filters and reverse osmosis membrane system. The pre-treatment system will:

- Remove suspended and settleable colloids and particles.
- Achieve a pre-treatment product water quality

9.8.2.2 *Instrumentation & Monitoring:*

a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.

b) As a minimum following instrumentation is to be provided but not limited to:
   i) Chlorine Residual, before Cartridge filters
   ii) pH, before Cartridge filters
   iii) Conductivity, before Cartridge filters
   iv) Temperature, before Cartridge filters
   v) Boron, before Cartridge filters
   vi) SDI before Cartridge Filter
   vii) Any other Quality Analysers to monitor the performance of the Pre-treatment
   viii) Pressure and Flow measurements for all associated pumps and discharge lines
   ix) Protection and Condition monitoring for the pumps
   x) Any other device required to meet the operations, guarantee, and environment

c) Instrumentations to ensure RO feed Water meets the quality and quantity for the RO process.

d) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

e) All pumps of Backwash Pumps, Scour Blowers, Filtrate Pumps, Maturation pumps, and other equipment shall be monitored. All ancillary equipment should be arranged on duty/standby and provided with a VSD to ensure efficient operation.

f) Instrumentation shall be sufficient to operate and follow over the project life of the associated equipment

9.8.2.3 *Process Strategy*

The Pre-Treatment system installed on the plant shall be equipped with Coagulation, Flocculation chambers, Lamella Filters, DAF, and DMF.

a) Flash Mixing

The coagulant dosing provides a positive charge in the form of metallic cations that destabilize the particles' natural negative charge. The metallic cations combine with hydroxide in the water to form a metallic hydroxide that is an insoluble compound. The destabilized particles and metal hydroxide precipitate after agglomerating into small visible particles called flocs.

b) Flocculation Chamber

The flocculation reagent added to the seawater eases the formation of floccules. A complete line for its preparation and dosage has been included. This reagent is added to the seawater before the flocculation chambers (with low-speed mixing).

c) Lamella Filters

Lamella filters are to be designed and supplied by OEM; Lamella filters shall be designed to remove 90-95% of the suspended solids from the raw seawater. The collected turbid materials shall be drained from the filter to the wastewater tank periodically. The effluent from the lamella filters flows into the DAF.

d) DAF

Dissolved Air Floatation (DAF) system shall be operated to reduce the light TSS particle in seawater. The DAF system shall be instrumental if the algal blooms' occurrence prevents the desalination plant operating at the design availability of 98% and/or complying with the water quality requirements of the pre-treatment system.

The DAF uses microbubbles that cause the coagulated and flocculated particles to float onto the clarification basin's surface. If the raw seawater condition concerning Turbidity and algal measurement is within range and not very bad, recycling and micro bubbling processes will be held in standby mode. In this operational mode, the seawater will pass the DAF without treatment.

The operator will determine the micro bubbling floatation operation according to the conditions of the raw seawater and requirements in the downstream DMF.

e) GDMF

Effluent from DAF flows into DMF, which contains anthracite and Silica in each Bed. Adequate size and Layer thickness to be specified by the Contractor. When gravity filters are chosen following objectives are to be considered as a minimum:

- Low energy consumption
- Capacity to deal with essential loads of suspended solids and other contaminants
- To deal with fast variations
- The quality of the obtained filtered water is steady
- Very low or none, chemical product needs

The backwashing system shall be provided with all pumping setup and scenario to maintain the GDMF performance. Maturation pumps shall be provided to recycle the bed rinse water back to the filter inlet channel.

f) RO FEED Water and Backwash Tank

After the gravity filtration stage, the filtered water is collected into an inline tank with two compartments first one compartment for backwash overflowing to the second compartment to ensure the backwash reserve is always maintained full.

Filtered water is forwarded to the RO system's inlet, through the cartridge filters, utilizing RO Feed pumps. Two types of RO feed pump (HPBP to HPP) with discharge pressure to satisfy HP NPSHr conditions and (ERDBP to ERD) with minimum pressure to feed ERD to pressure the brine to the outfall tank.

9.8.2.4 *Automation Control Strategy*

a) GDMF Backwash

Gravity Media Filters are to be back washed automatically. Filtered water stored in the filtrate storage tank shall be used for filter backwash.

The following shall be the minimum procedural steps in Backwashing; the Contractor shall optimize the Backwash step and timing as per performance requirement:

- Drain step
- Air scouring step
- Venting step
- Backwashing step
- Rinsing step

Backwashing programming shall be triggered by controlling the water level inside the gravity filters, the difference of flow between the filter inlet and output, and the Turbidity of the filtered water. It shall be possible to determine the necessity of cleaning the filter beds. Alternatively, a Timer based on 24hr countdown shall be used as an option once a filter is sequenced into filtration mode.

b) RO Feed Water Pumps

The flow rate from the RO feed transfer pumps' discharge shall be controlled automatically by the pressure and flow control of the RO demand.

c) Sea Water Intake Dosing

The flow controller on the seawater supply pumps' discharge shall automatically regulate the coagulant, flocculants, and acid dosing rates towards the Pre-treatment system proportion to the feed flow rate.

d) Pre-Treatment Chemical Dosing

Several dosages of chemical reagents are present in the Pre-treatment System. These dosages' objective is to prepare water characteristics to those required by physical pre-treatments and RO stages. The following sections include a description of this part of dosing:

- Coagulant Dosing

  Flash mixing is done in the Coagulation chamber after injection, coagulant and polymer are mixed with a mixer impeller running at 40-100 RPM, and contact time about 20 seconds.
- Flocculant Dosing

  Slow mixing is done in the Flocculation Chamber with slow mixing impeller running at 3-6RPM and contact time about 20min.

e) All chemical feed dosing rates shall be tuned, optimized, and sent via the plant control system.
f) A presentation of the dosing points are included in the CCP drawing 7061563/PMC/400MLD/CP1/PFD/001, and final dosing points are to be optimized by the Contractor.

9.8.2.5 *Key Operational Monitoring Points*

a) Level transmitter installed in the RO Feedwater tank shall be used to prevent the RO feed transfer pumps and GDMF backwash pumps from starting if the tank level is low, high priority alarms are to be configured.
b) Following filtered water parameter shall be continuously monitored before pumping towards Cartridge filter, appropriate alarms should be raised with high priority:
    - High Turbidity, before Cartridge filters
    - High pH, before Cartridge filters
    - High Boron, before Cartridge filters
    - High Residual Chlorine, before Cartridge filters
    - High SDI, before Cartridge Filters
    - High / Low; Flow, Pressure, and Level, for associated pumps and tanks
    - Loss of REMOTE status and Measurements from connected devices
c) Pump Condition Monitoring: The condition monitoring system alarms are to be set as per the OEM limits. All warnings are to be configured as high priority alarms.
d) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks, the readings from the level measurement to be considered as the early warning and appropriate actions to be taken by the operator
e) Other monitoring and safeguarding strategies are in line with the instrumentation design criteria philosophy referred to in Section 9.2.2.

9.8.3 Reverse Osmosis System

9.8.3.1 *System Description*

The RO system envelopes the following:

- RO Feedwater Conditioning.
- RO Membrane Trains.
- Membrane Cleaning System.
- Membrane Flushing System.

9.8.3.2 *Instrumentation & Monitoring:*

a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
b) As a minimum following instrumentation is to be provided but not limited to:
    i) Instrumentation and Controls to Protect the Integrity and Life of the RO

Membranes
- ii) ORP(Redox), after cartridge filters
- iii) Turbidity, after cartridge filters
- iv) pH, after cartridge filters
- v) Conductivity, after cartridge filters
- vi) Temperature, after cartridge filters
- vii) Differential Pressure Measurement
- viii) Pressure and Flow measurements
- ix) Protection and Condition monitoring for the pumps
- x) Any other device required to meet the operations, guarantee, and environment.

c) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

d) RO instrumentation shall be sufficient to implement the membrane follow up (as per membrane supplier recommendation), in particular, NSP (Normalised Salt Passage), NDP (Normalised Differential pressure), NPF (Normalised Permeate flow).

e) An instrument station equipped with Residual Chlorine, Redox, Conductivity, Turbidity, and pH instruments shall be installed to monitor quality before the reverse osmosis membranes.

f) The cartridge filters shall be equipped with a differential pressure meter with high differential pressure alarm.

g) HP Pumps, Booster Pumps, RO Feed pumps, CIP pumps, and Flushing pumps shall be monitored. All ancillary equipment should be arranged on duty/standby and provided with a VSD to ensure efficient operation.

h) Necessary instrumentations to follow over the project life on the performance of membranes, to trigger CIP operation (and follow CIP efficiency), and to trigger membrane replacement.

9.8.3.3 *Process Strategy*

a) RO Feedwater Conditioning

Pumped filtered RO feed water to the RO system shall be conditioned to remove residual oxidants, prevent scale formation of the membrane elements, and provide a final barrier against incidental particulate breakthrough from the pre-treatment system.

Anti scalant shall be injected into the low-pressure feed stream to prevent sparingly soluble salts' precipitation in the RO concentrate stream. Scale inhibitors (antiscalants) shall be used to control mainly carbonate, sulfate, and calcium fluoride scaling. Preparation and dosing systems have to be considered.

The feedwater must be de-chlorinated to prevent oxidation of the RO membranes. The feed water to the SWRO system shall be treated with sodium bisulfite when the oxidation-reduction potential in RO feed water exceeds 250 mV. Similarly, an online Boron Analyzer shall be provided in the RO feed pump discharge to measure the Boron content and appropriately dose NaOH. Chemical preparation and dosing systems for

Sodium bisulfite and NaOH to be considered.

The retention of the final particulate barrier in the pre-treated water shall be achieved through cartridge filtration sized ≤ 5 µm. These filters' function is to protect the RO HPP and RO membranes from contamination introduced after the pre-treatment system and/or failure or breakthrough through the membrane filters/granular media filters.

b) RO Membrane Train

RO Membrane Train is a stand-alone modular unit incorporating a high-pressure feed pump, pressure vessels with membrane elements installed on racks, vessel manifold piping, permeate header, and concentrate header flow control, booster pump, ERD, associated instrumentation, and valves. The train shall be operated manually from the local control panel and control system.

c) Membrane Cleaning System

Membrane Cleaning System is a permanently piped clean-in-place (CIP) system to clean membranes in each RO train in-situ. Cleaning solutions shall be prepared in a cleaning solution storage tank(s) and pumped through the train vessels being cleaned via dedicated solution feed and return pipe headers.

Membrane Cleaning system the capacity of the installed cleaning solution storage tank(s) shall be sufficient to clean all vessels from a single batch of prepared solution. In addition to the cleaning solution feed and return connections on the feed/concentrate manifolds of each train, individually isolated return connections shall be provided on each train's permeate header to recycle permeate created during cleaning back to the cleaning solution storage tank(s). The system shall be designed to mix and recirculate a range of other cleaning chemicals made up of RO permeate

d) Membrane Flushing System

Membrane Flushing system is a permanently piped membrane flushing system that automatically flushes vessels of the RO trains along with the high-pressure pump within 30 minutes of a shutdown to remove residual concentrate or as stipulated in the RO membrane warranty. The Flushing shall be accomplished using the RO system permeate, which does not contain post-treatment chemicals. The flushing shall be done simultaneously for the RO pumps and membranes.

9.8.3.4 *Automation Control Strategy*

a) RO Membrane Train

Each train shall be fed, discharge, and controlled independently from the other trains, and each train shall be capable of being started and stopped from the control system interface terminal(s). Configurable operating parameters shall include the train permeate flow setpoint and recovery set point.

Automated control sequences shall be developed to start up individual trains, monitor train performance during operation, shut down trains (under both emergency and non-emergency conditions), and flush trains. The control system shall be configured to allow operators to select individual trains for operation; or input an overall system setpoint, designate trains available for operation, and enable the control system to determine trains for operation.

The system shall receive status feedback from all controlled devices (e.g., ON, REMOTE, OPEN, CLOSED, etc.) to confirm that all devices are in the correct operating mode and that requested control actions are successfully implemented. System operation shall require all associated devices in the REMOTE or AUTO operating modes before system start or continued operation.

Train permeate flow shall be controlled by varying the high-pressure feed pump's speed to achieve the selected permeate flow set point. Train recovery shall be regulated by controlling concentrate flow to a set point derived from permeate and recovery set points through modulation of the energy recovery system or train concentrate control valve (as applicable). Additional automated flow valves shall be provided for each train as follows but not limited to:

- Feedwater inlet valve on the suction side of the high-pressure feed pump.
- Flush inlet valve on the suction side of the high-pressure feed pump.
- Permeate isolation valve, on the train permeate header.
- Permeate dump valve, on the train permeate header (configured to fail open on loss of power).

b) Membrane Cleaning System

The membrane cleaning system shall be initiated manually by the operator, located near the cleaning tank(s) and recirculation pump. The panel shall house system indicators and alarm lamps and controls for the pump and tank immersion heaters. All instrumentation indicators (including gauges) shall be mounted on the panel or the panel support frame assembly.

c) Membrane Flushing System

Train flushing shall be controlled automatically through the control system to flush individual trains on shutdown. The system shall be configured to allow manual initiation of train flushes and stop a flush in progress. If multiple trains require a flush simultaneously, the control system shall be configured to flush them one at a time in sequence.

d) RO Feed Water Conditioning Chemical Dosing

All chemical feed dosing rates shall be tuned, optimized, and sent via the plant control system. The dosing points presentation is in the CCP drawing 7061563/PMC/400MLD/CP1/PFD/001 final dosing points are to be optimized by the Contractor.

The proposed dosages, type, and locations of water conditioning chemicals shall not contradict the RO system membrane manufacturer's standards, as documented on the RO membrane supplier guarantee. System design shall incorporate the listed facilities and any additional facilities required to guarantee compliance with the acceptance criteria.

9.8.3.5 *Key Operational Monitoring Points*

a) Based on the measured parameters, the following configurable alarms shall be provided as a minimum for the continued operation of the train, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:
   - High Differential Pressure across Cartridge Filters
   - High feed water pressure.
   - The high differential pressure across the individual bank of pressure vessels.
   - High permeate flow.
   - Low permeate flow.
   - Low concentrate flow.
   - High permeate pressure.
   - High permeate conductivity.
   - Loss of REMOTE status and Measurements from connected devices
   - High Boron, before Cartridge filters
   - High SDI, before Cartridge Filters

b) Pump Condition Monitoring: The condition monitoring system alarms are to be set as per the OEM limits. All warnings are to be configured as high priority alarms.

c) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks. The level measurement readings are considered the early warning and proper actions to be taken by the operator.

d) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.3.6 *Critical Control Point – CCP 2:*

a) RO Feed Water Oxidizing Agents CCP-2a
   The control system shall incorporate the provisions to automatically shut the running RO trains when high oxidizing agents are detected in the RO feed filtered water after the dose of SMBS.
   The maximum allowable value and duration of exposure should be chosen based on warrantees by the membrane supplier/vendor.

b) Instrument voting on ORP (2oo3) shall be provided, thus avoiding damage to the RO membranes.

c) RO Feed Water Boron measurement, CCP-2b
   Boron analyzer shall be installed in the main RO feedwater pump discharge. When the online Boron measurement is high, the control system shall incorporate the provisions to alarm in the beginning and allow NaOH's controlled dose before the RO system to reduce the Boron in permeate within the permissible limit. The shutting of the trains shall be strategically planned based on the combination of parameter readings.

d) The trip or shutting down of the RO system in an adverse situation must not result in transients that damage any other systems or infrastructure.

9.8.3.7 *Critical Control Point – CCP 3*

a) Permeate Water TDS/Conductivity and Flow, CCP-3
The control system shall incorporate the provisions to alarm in the beginning and later automatically shut the running RO train where the high TDS detected in the permeate water. The maximum allowable value should be chosen based on warrantees by the membrane supplier/vendor. After early warnings are included in the Key Operational Monitoring points, the shutting down the RO train should be programmed based on a timer or by operator decision. The same philosophy shall be implemented for the permeate flow parameter.

9.8.4 Post-Treatment

9.8.4.1 *System Description*

Post-treatment system to include two key components

- Remineralization
- Disinfection

The objective of remineralization is to achieve sufficient Hardness and Alkalinity in the product water while maintaining acceptable Turbidity according to the Indian standard, IS 10500 (2012), that shall be <1 NTU.

The objective of disinfection is to ensure protection during transportation in the product distribution line. Chlorine, in the form of sodium hypochlorite (NaOCl), shall be used as a disinfection chemical for biological growth control.

Permeate from the SWRO system shall be conditioned with a combination of lime and carbon dioxide and disinfected with NaOCl to ensure safe and non-corrosive water supply. The final pH adjustment, if needed, shall be done by NaOH doing after disinfection to keep the LSI (Langelier Saturation Index) within the acceptable limit to avoid corrosion in the transmission pipeline.

The post-treatment system shall be designed such that the water exiting the Product water tank meets the drinking water quality requirements.

9.8.4.2 *Instrumentation & Monitoring:*

a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
b) As a minimum following instrumentation is to be provided but not limited to:
   i) Hardness, after limestone filter
   ii) Chlorine Residual, after limestone filter
   iii) Turbidity, after limestone filter
   iv) pH, after limestone filter
   v) Conductivity, after limestone filter
   vi) Level, at limestone silo

vii) Pressure and Flow measurements
viii) Calcite Bed Blanket level Measurement
ix) Any other device required to meet the operations, guarantee, and environment

c) Instrumentations shall ensure for the online parameters that product water meets contractual requirements in quality and quantity.
d) Any other instruments to achieve the Water Quality, SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.
e) Necessary instrumentation shall be sufficient to operate and follow over the project life of the pumps and associated equipment

9.8.4.3 *Process Strategy*

a) Remineralization
Up-flow type Limestone filters shall be envisaged. The Limestone bed with Continuous Feeding Remineralization where only a portion of the main permeate flow is treated (45-55%) in limestone filter and the remaining flow bypasses it. Both the streams are mixed outside the limestone building. With the up-flow type, the stream passing through the filter receives the hardness necessary for the full flow before mixing with the bypassed flow.
The limestone filters shall have in-built reserve silo in their upper part and series of small feeding funnels placed at the bottom of the silo guide the Calcite from the silo to the surface of the Bed. In this way, the Calcite feeds the Bed by gravity, replenishing it continuously as it becomes dissolved. With such a design, the bed thickness always remains the same.
A backwash system shall be installed for Backwashing the limestone filter, which shall comprise air and water circulation.
b) Disinfection
Chlorine, in the form of sodium hypochlorite (NaOCl), shall be used for disinfection to kill micro-organisms and to prevent biological growth in the transmission line. The point of application will be in the pipeline at the outlet of the limestone beds.
c) LSI
The Langelier Saturation Index (LSI) shall be kept positive within the range of $0 < LSI < 0.5$. For this purpose, sodium hydroxide dosing shall be envisaged.

9.8.4.4 *Automation Control Strategy*

a) Remineralization, Lime Filters
With an up-flow type lime filter system, the permeate stream passing through the filter receives hardness depending on the flow split ratio, pH, and contact time in the limestone bed. The automation control loop shall be programmed to achieve the targeted hardness $CaCO_3$ >80ppm as $CaCO_3$ in the mixed product water outside the limestone filter.
The permeate flow control loop shall adjust the control valve to attain the desired

permeate flow rate split ratio based on the number of RO racks running. At the same time, the media level is maintained by gravity filling from the limestone silo. Lime level monitoring to be envisaged in the silo.

The CO2 dosing shall be a dosing control loop based on the permeate flow to the lime filter to allow the controlled dissolution of the Calcite to obtain the required hardness in the overall product flow.

b) Disinfection

Desalination water product does not require a high level of disinfection chemical dosing, and most of the injected Chlorine will remain as free active Chlorine. Hence dosing of at 1mg/l shall be envisaged for the treated water flow to maintain the residual Chlorine> 0.5 mg/l. The chlorine analyzer shall be provided strategically considering the contact time the signals shall be included in the cascaded control loop.

c) LSI

The final optimal pH is obtained when the Langelier Saturation Index (LSI) is slightly positive (saturation of calcium carbonates) and maintained between $0 < LSI < 0.5$. For this purpose, sodium hydroxide dosing shall be envisaged.

9.8.4.5 *Key Operational Monitoring Points*

a) Limestone filter backwash shall be initiated manually by the operator or automatically when the outlet treated water turbidity hits >0.5NTU. RO permeate water shall be used for Backwashing.

The following shall be the minimum procedural steps in Backwashing;

i. Drain step
ii. Air scouring step
iii. Venting step
iv. Backwashing step
v. Rinsing step

The Contractor shall optimize the Backwash step and timing as per performance requirement.

b) Based on the measured parameters, the following configurable alarms shall be provided as a minimum for the effective operation of the post-treatment system, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:

- High Turbidity
- High / Low Hardness
- High / Low pH
- High / Low LSI (calculated)
- High Conductivity
- Loss of REMOTE status and Measurements from connected devices

c) Pump Condition Monitoring: The condition monitoring system alarms are to be set as per the OEM limits. All warnings are to be configured as high priority alarms.

d) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks. The level measurement readings are considered the early warning and appropriate actions to be taken by the operator.

e) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.5 Product Water System

9.8.5.1 *System Description*

The Product water Metering system includes two key components

- Product water Flow Tariff Metering
- Product water Quality monitoring

9.8.5.2 *Instrumentation & Monitoring:*

a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.

b) As a minimum following instrumentation is to be provided:
   i) Main and Check Flow Measurement in the product water line
   ii) Hardness in the product water line
   iii) Chlorine Residual, in the product water line
   iv) Turbidity in the product water line
   v) pH, in the product water line
   vi) Conductivity/TDS, in the product water line
   vii) Temperature, in the product water line
   viii) Level, in the product water tank
   ix) Devices required to monitor the desalination plant-oriented parameters referred to in Indian Water Standard specification "IS:10500-2012 Drinking Water Specification."
   x) Any other device required to meet the operations, guarantee, and environment

c) Instrumentations to ensure the online parameters that product water meets contractual requirements in quality and quantity shall ensure the online parameters.

d) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.8.5.3 *Process Strategy*

a) Product water Flow Tariff Metering
   The product water delivery pipeline shall be equipped with one main flow meter and one check flow meter connected to the site Metering or Reporting system for production reading. The flow meters are connected to the Plant DCS to measure and control plant production flow.

b) Product water Quality monitoring
   The Quality monitoring arrangement shall be equipped with the required water quality

analyzer connected to the Site Metering system for Contractual quality conformance. The quality monitoring instruments are connected to the plant DCS for measurement, control, and out spec water management.

9.8.5.4 *Automation Control Strategy*

a) Dispatch & Product water Storage Tank Level
The control system shall be programmed to ensure that the dispatch requirements are always met, the level in the Product Water Storage tank is always maintained at the required level.

b) Water Quality Management
The control system shall ensure that the water qualities are always within limits. Any abnormal conditions shall be alarmed, and individual action plans are triggered.

9.8.5.5 *Key Operational Monitoring Points*

c) Flow Deviation
The control system shall be programmed to alarm if the main and check flow meter deviation is more than 0.3% at flow rates 15%-49% and 0.25% at flow rates 50% -100%.

d) Following configurable alarms shall be provided, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:
   - Turbidity - High
   - Hardness – Out of Limit
   - pH – Out of Limit
   - LSI (calculated) – Out of Limit
   - TDS – Out of Limit
   - Chlorine out of limit
   - Flow – Low
   - Product Tank Level – Low
   - Loss of REMOTE status and Measurements from connected devices

e) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.5.6 *Critical Control Point – CCP 4*

a) Product Water Storage Tank Level Low – 4A
The control system shall incorporate the provisions to alarm when the Product Water Storage tank level becomes Low. If the level further creeps below Low, the control system shall initiate the sequence to start the required number of RO rack automatically. This RO rack starting shall be coordinated with other process areas through the Plant Level Global Automation sequence programmed in the control system.

b) Product water Quality Limit violation – 4B
When following product water quality parameter measurements are set limits referring to the Indian Water quality, the Control system shall incorporate alarm with High priority annunciation.

- LSI
- Residual Chlorine
- Conductivity / TDS
- pH
- Turbidity
- Boron

Further, if the measured limits continued to stay after an elapsed time, operator actions specified in the water quality manual must be followed. Appropriate action should be envisaged such that the out-spec water should not reach the transmission mains network.

Instrument voting on 2oo3 shall be considered for continuous online measurement, and 2oo2 measurement shall be considered for semi-continuous sample aspirated type online measurement.

The Bidder must provide details on out-spec water management procedure in the bid with a summary of the intended operations when the water goes out of specification.

c) Product water Quantity

The product water quantity shall be continuously monitored and compared with the dispatch instructions, any deviation from the dispatch instruction shall be alarmed at high priority.

9.8.6 Outfall

9.8.6.1 *System Description*

The brine from the RO system and treated wastewater shall be disposed to the outfall facilities, where the treated water is disposed to sea.

9.8.6.2 *Instrumentation & Monitoring:*

a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2

b) As a minimum following instrumentation is to be provided:
   - TSS, at outfall tank
   - Residual Chlorine, at outfall tank
   - Iron, at outfall tank
   - Temperature, at outfall tank
   - pH, at outfall tank

c) Devices required to monitor the outfall wastewater parameters referred to in State Pollution Control Board under Water Act 1974.

d) Any other measurement required by the Environmental Approval to ensure there will be no harm to the marine environment;

e) Any other instruments to achieve the Water Quality, SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.8.6.3 *Key Operational Monitoring Points*

a) Following configurable alarms shall be provided, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:
   - TSS - High
   - Residual Chlorine - High
   - Iron- Out of Limit
   - Temperature – High
   - pH – Out of Limit
   - Loss of REMOTE status and Measurements from connected devices

b) Other monitoring and safeguarding strategies are to be in line with the instrumentation design criteria philosophy referred in section 9.2.2

9.8.6.4 *Critical Control Point – CCP 5*

a) Outfall Wastewater Quality Parameters Limit violation
When outfall wastewater quality parameters are out of limits, the Control system shall incorporate alarming with High priority annunciation. The operator has to take necessary actions by appropriate tuning parameters to bring the parameters within range.

9.9 Integrated Security System

This specification describes the technical requirements for the Security System at 400 MLD SWRO desalination plant and covers the minimum requirements for design, engineering, manufacture, erection, inspection and testing.

The Integrated Security System (ISS) and related equipment shall be complete in every respect and suitable for safe and reliable operation.

Preferably, the whole integrated security system of the entire plant would be one unified system of the same make and type, which would ideally be sub-contracted as a whole to a single reputable company subject to Employer's approval.

This specification does not enumerate or describe all the materials and equipment to be supplied and all the services to be performed. All materials and equipment shall be provided as are required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship.

The Integrated Security system shall cover the whole area of the Plant site and shall cater for all potential risks and provide correct response to any if detected. The Integrated Security System (ISS) shall comprise following discrete systems:

- CCTV Surveillance System
- Access Control System

- Identity Management system
- Central Security Control
- Public Addressing System
- Communication System

The above systems are required to safeguard the assets by various collusion threats from insider or outsider and to improve the overall security & surveillance.

The scope of work includes as a package: designing, obtaining authorities approval, manufacturing, construction, factory testing, packing for transport, transport and delivery to site, unloading at site, storing, complete erection, testing at site, painting, commissioning, acceptance tests, preparation of test reports and handing over a fully Integrated Security System.

9.9.1 Scope

The scope of supply includes but is not limited to : a computer-based central security system, CCTV cameras, TV monitors, video recorders, intrusion detectors, work stations, card readers, door switches, uninterruptible power supply, any special tools or test equipment and software for the purpose of installation, maintenance, administration and operation of the system.

A functional design specification (FDS) shall be prepared for approval of the Engineer.

The factory acceptance test procedure (FAT) for the ISS shall be approved prior to the execution of the tests.

The proposed system should provide a fully functional and integrated command and control security system. This system shall assist the security managers and security staff in maintaining the maximum level of security at the site. The main control of the system will be from a dedicated security control room.

The ISS shall include:

- CCTV Surveillance system with recording and playback facility with LCD screen technology display showing a sitemap and lower-level maps of buildings of various zones. The details are given in Chapter 9.

- Intrusion Detection & Assessment System (IDAS) based on CCTV system, other trending technologies if any shall be proposed by the Contractor.

- Access Control System (ACS) with door monitoring system, access control, metal detectors, raising arm barrier, turnstiles, barriers, under- vehicles surveillance system. The details are given in Chapter 9.

- Identity Management System (IDMS) inline with the Access Control system(ACS) with computer-based security system for ID badge, security administration, event/alarm management, recording of all the information, etc.

- Integration with public address, telephone and site radio system.

- Security Control Centre (SCC) including all security equipment as also furniture.

- All programmable equipments must be supplied with software, hardware communication protocol and documentation and necessary licenses.
- Cable, cable trays, conduits, channels and related accessories as required.
- Power supplied for all the system components, including cameras, sensors and recording system, should be powered by a centralized uninterruptible power source/ solar power fully compliant with project specifications.
- Complete design and installation
- The Contractor shall submit welding procedure specifications (WPS) and procedure qualification records (PQR) and Quality Assurance Plan (QAP) for approval before starting any welding work.
- Training for the operation and maintenance of the system
- Commissioning of the system

9.10 CCTV Surveillance System

9.10.1 Design Considerations and Overview

A Common CCTV System shall be designed for surveillance of both security and operations purposes, providing continuous monitoring and recording of security as well as operation cameras.

The system design and system component specification shall meet all the operational, security and emergency response requirements of desalination plant. CCTV cameras to be utilized for operational use shall be installed strategically within the plant to optimally capture all the intended operational activities and store them in the video storage server of the system.

Based on the need of surveillance, the camera shall be chosen to be a PTZ camera or fixed camera. All the CCTV equipment shall be of a modern, proven and reliable design and shall follow ROP standards.

The CCTV cabinet shall be installed in RO Building – Engineering or Control room. The CCTV central system shall be common for both the plant & security CCTV systems. Both the CCTV systems will be configured on separate VLAN's and will be independent of each other. The CCTV camera footage storage duration shall be 30 days at CIF 25 frames per second.

The intelligent CCTV system shall be capable of running different video analytics which shall ensure proactive information to guards as well as operators thereby reducing their investigation time.

The CCTV Management System shall be a fully distributed solution, designed for 24/7 surveillance with support for devices from different vendors. The Management System shall offer centralized management of all devices, servers and users.

All the servers of CCTV system shall be installed in engineering room located in RO Building. No remote monitoring of CCTV cameras (operational as well as security) is envisaged. However, the system shall be capable of providing this functionality (if required in the future).

The cameras shall be strategically positioned around the main areas, perimeter, entrances of the Plant as well as inside the buildings, whilst the monitor/controller shall be located in the Control room in RO Building as well as in Guard house.

The Vendor shall design the number of cameras to cover intended areas of the plant. The number of cameras shall increase if the required area of coverage demands additional cameras. The following components shall be provided, as part of the IP Surveillance system:

a. Fixed & PTZ Outdoor Cameras
b. Indoor Dome Cameras
c. Indoor Ex proof PTZ Cameras
d. Indoor Fixed Cameras
e. Network Switches
f. Hardware (Server & Storage) and software
g. Management System with Monitor and Control keyboard
h. Video Recorder
i. Poles, Structures and Supports for CCTV cameras
j. Marshalling box for power & other control signals

The cameras of CCTV system will be spread around the desalination Facility and the video streams and control signals of these cameras shall be transported to the CCTV system servers by means of dedicated individual fibre optic cables. All the cameras shall operate on 240VAC UPS to operate in all situations which shall comply with the autonomy of 2 Hours.

The CCTV system shall be completely designed by the vendor and approved by the PMC. The system shall be commissioned using vendor engineers and staff and then certified by the vendor validating that it meets the design requirements.

Following sections provide minimum specifications of the camera systems.

a. Several simultaneous video streams using different video compression formats including H.264.

b. Megapixel resolutions and vandal resistance.

c. Input/output ports for connection to external devices such as sensors and alarms

d. Built-in intelligence including video motion detection and tampering detection.

e. Sophisticated alarm and event management functions that shall communicate with different devices and applications simultaneously, and can send separate video streams in different resolutions, at different frame rates and to different places.

f. Audio support.

g. Power over Ethernet, which enables power to be delivered over the same cable as for data transmission.

h. The network camera shall capture and send live images, enabling authorized users to locally or remotely view, store and manage video over a standard IP-based network infrastructure.

i. All network cameras shall have an auto iris lens to regulate how much light is received.

j. Outdoor cameras shall have a protective housing or designed with a protective enclosure to withstand the harsh environment conditions mentioned in section 4.

k. All cameras shall have protection from harsh environments such as dust and humidity, and from vandalism or tampering.

l. PTZ cameras and PTZ domes shall be used having full 360-degree.

m. Dome cameras shall have optical zoom of 35X.

n. Image sensor: CCD (charge-coupled device) shall be used.

o. Progressive scan technology shall be used.

p. Lens shall be zooming allowing the camera to stay in focus when zooming in on objects.

q. A lens iris, which controls the amount of light coming into the camera automatically. An auto iris lens shall be controlled by the camera's processor (DC-controlled), or by video signal.

r. Lenses shall be CS-mount types.

s. The cameras shall have automatic day/night functionality: This feature shall be incorporated into outdoor cameras to enables the automatic removal of the infrared (IR) cut filter that is incorporated into all colour cameras to prevent colour distortion from near-infrared light. When there is light, the IR-cut filter is on and the camera delivers colour video. In dark conditions, the camera removes the filter to make use of near-infrared light to deliver infrared-sensitive black and white video.

t. Input and output (I/O) ports shall be provided in the camera: Input/output connectors enable external devices to be connected to a network camera. Inputs to a camera shall include a door contact, infrared motion detector, glass break sensor or shock sensor, as applicable. The camera shall react to an external event by initiating the sending and recording of video. Outputs shall enable the camera to control external devices such as activating alarms, triggering door locks, generating smoke or turning on lights, as applicable. This shall be finalized during the detailed design and according to the PMC/CMWSSB requirement.

u. Video motion detection shall be provided for security cameras that monitors changes in the camera's field of view and if a change occurs (e.g. an intruder enters the scene); an alarm condition shall be generated. This function shall be a built-in feature of a network camera and video management software.

v. Active tampering alarm shall be provided in the cameras: When a camera is manipulated in any way (e.g. accidental redirection, blocking, defocusing spray-painted, covered or damaged), it shall automatically trigger recordings and alert notifications.

w. Alarm and event management shall be supported. With this capability, event triggers shall be programmed based on schedule, I/Os, video motion detection, active tampering alarm or temperature, among others, as specified by the PMC. Pre- and post-alarm image buffers within a network camera shall save and send images collected before and after an alarm occurs. Once an alarm or event is detected, a network camera shall raise alarms and send notifications via e-mail, TCP, HTTP and upload images via e-mail, FTP and HTTP.

x. Network management features shall be provided. This shall include support for Quality of Service (QoS), which can prioritize and reserve network capacity for mission-critical surveillance in a QoS aware network, and support for Internet Protocol version 6 (IPv6) in addition to IPv4 addresses.

y. The outdoor cameras shall be provided with a built in wiper as cleaning mechanism that can be controlled.

z. All equipment and software shall be designed with 20% growth capacity allowance to allow for possible expansion at a later date without the need to add any additional hardware, software for the network operating system, or any additional changes to the network management system.

All the detail specification given in this document for CCTV system equipment/cables should be verified by vendor to be before procurement.

9.10.2 Security CCTV System

The CCTV system required for desalination facility shall be IP based intelligent surveillance and analytic system. The CCTV system shall cater to the security requirements for which the cameras shall be installed along the fence of the facility and on the main entrance gates as well as entrance doors of the buildings. The monitoring and control of these cameras shall be extended to the guard house as well as RO building Control room, so that the perimeter of the facility is continuously monitored by the guards and operators for safe operation of the facility. The CCTV system shall be equipped with analytic features which shall enable the guards to be proactive and would reduce the analysis time during any emergency.

The security cameras shall have Intelligent Video Motion Detector (iVMD) feature to analyses video in real-time and detects valid motion in a scene. The resolution of the cameras shall be sufficient enough to identify the object intruding the facility.

One no of 55” and one no of 21” LED screens shall be installed respectively in Control Room and Guard House. The monitoring and control of the cameras from these locations should be provided with the help of the control accessories that shall be provided along with the CCTV package.

The security cameras shall be mounted on 6m fixed poles. The CCTV poles are to be located within the facility close to the fence. For cameras, lighting arrestors shall be provided to protect the camera from any damage due to lightning.

The security CCTV cameras around the fence/perimeter and main gate shall allow the guards to monitor movement of any intruder, animal, trespasser or any unidentified object around the fence. Upon detection of such incident, the guards can take necessary actions required as per the response plan.

The cameras shall not compromise the quality of video feeds in harsh and adverse environmental and zero illumination levels. Infrared illuminators shall be provided on the relevant perimeter cameras for operation under zero illumination levels.

All cameras shall have a junction box for termination of fibre optic cable, to house FO converters, power supplies and other associated items. There shall be a separate lockable type isolator to ensure proper power isolation procedures are followed during maintenance.

9.10.2.1 *Security Camera Specification*

The following cameras shall be used for security CCTV system. The vendor shall provide their specifications for approval:

- IP 66 Outdoor Weather Proof Fixed Cameras

  The Fixed CCTV cameras to be located around the perimeter at 50m interval and must have a maximum view of 75m. Each fixed perimeter camera is to have an overlap view of the next camera in line; the overlap is to be not less than 30m to cover any surveillance blind spots.

  Each fixed camera is to be fitted with an LED infra-Red illuminator to support an illumination range of not less than 75m and the IR unit is to operate in the 850nm wavelength spectrum.

- IP 66 Outdoor Weather Proof PTZ Cameras

  The PTZ cameras are to be located at each corner of the facility and guard house to monitor along the perimeter fence and entrance/exit gate to a maximum distance of 300m enabling the option for intruder detection.

  The PTZ cameras are to be fitted with an LED infra-Red illuminator to support an illumination range of not less than 300m and the IR unit is to operate in the 850nm wavelength spectrum.

The cameras installed at the main gate shall ensure recognition of all the personnel entering in the plant and shall also capture the registration number of vehicles entering/exiting the plant. The guards shall control the security cameras with the help of the control accessories which shall be provided along with the CCTV package.

9.10.2.2 *Fixed IP CCTV Camera*

General

External fixed CCTV cameras are to be mounted on 6m fixed poles and located at 50m intervals around the perimeter with a maximum surveillance distance of 75m. The camera is to be designed for harsh environments and is to be able to withstand high temperatures and dust storms.

- The internal camera and housing is to be specifically designed for day/night surveillance in hot, and dusty conditions. The unit is to have an optimised heat - sinking design that protects the camera from internal overheating caused by solar heat gain.
- The unit is to provide reliable performance to 65 ºC.
- The unit is to incorporate MFP (Mechanical Filter with Photocell) technology using dual window mechanical filter technology to deliver accurate colour during the day and high-resolution infrared sensitivity at night.
- Using minimal mechanical moving parts, the unit is to be weather sealed and tested to perform in hot conditions.

Fixed IP CCTV Camera Specification

Resolution	:	2 MP/HDTV 1080p, maximum
Image Sensor	:	Progressive scan RGB CMOS 1/3”
Lens	:	DC-iris IR corrected, CS-mount 5-50mm F1.2 (Lens selection to be confirmed during site survey)
Illumination	:	Colour: 0.1 lux, F1.2, B/W: 0.02 Lux, F1.2 with dynamic capture and power line frequency 50 Hz, 1/231 s to 1/44 s.
Resolution	:	1920 X 1080 (2 MP) to 160 X 90
Frame Rate	:	H.264 25 fps in 50Hz capture mode.
Security	:	Password protection, IP address Filtering, encryption, IEEE 802.1x network access control, user access log
Memory	:	256 MB RAM, 128 MB Flash
Power	:	PoE IEEE 802.3af POE, IEEE 802.3af
Operating Conditions	:	0º to 60ºC
Humidity	:	10 – 100% RH (Non – Condensing)
Housing Construction	:	Robust aluminium/Zinc/Stainless steel casting/extrusion
Mount	:	Top Mount 6m CCTV column
Sun Hood	:	Integral Sun Hood compulsory

Connection	:	Cat6a cable for video and PoE
Operating Temperature	:	-50º C to 65ºC
Storage Temperature	:	-50º C to 85ºC
Environment Rating	:	IP 66/NEMA 4 x compliant

Fixed CCTV unit Housing Infra-Red Illumination Specification

Each fixed camera is to be fitted with an LED Infra-Red Illuminator to support an illumination range of not less than 75m and the IR unit is to operate in the 850nm wavelength spectrum. The IR illumination is to provide coverage of the outside and sterile area of the perimeter fence.

9.10.3 PTZ CCTV Camera

9.10.3.1 *General*

External 1/3" 2MP camera fitted long range Megapixel zoom lens for PTZ CCTV cameras, to be mounted on 6m columns (Dual Mounted where a PTZ camera position coincides with a fixed camera position). The camera is to be designed for harsh environments and is to be able to withstand high temperatures and dust storms.

The PTZ unit is to be a high-performance integral unit containing camera, zoom lens telemetry, PTZ unit and infra-red illuminator. The unit is to have a continuous high speed rotation and positioning precision on alarm pre-sets. The Infra-Red Unit is to provide illumination up to 300m.

9.10.3.2 *PTZ Camera Specification*

Lens	:	4.7 – 141mm Megapixel 1/3" lens – High Sensitivity
Optical Zoom	:	28
Digital Zoom	:	Optional
Day/Night	:	Auto ICR
Image Sensor	:	1/3" Low Light 2 Megapixel Progressive scan CMOS
Resolution	:	1920 X 1080P
Shutter Time	:	Automatic increase adjustment to improve night time performance
Focussing system	:	Auto
Video line	:	Cat6e as appropriate
I/O alarm card	:	alarm inputs and relay outputs
Variable pan speed	:	0.1° to 40°/sec manual operation
Variable tilt speed	:	0.1° to 30°/sec manual operation
Pre-set accuracy	:	0.1 degrees

Fixing	:	Pole mount/Wall mount adaptor to be included, as required
Operating Temperature	:	-40º C to 65ºC
Storage Temperature	:	-50º C to 85ºC
Environment Rating	:	IP 66/NEMA 4 x compliant

9.10.3.3 *PTZ CCTV Unit Infra-Red Illumination Specification*

IR LED	:	Integral, built onto the camera housing or P/T unit
Beam Pattern	:	10 degrees
No of LED's	:	As required for distance up to 300m
Wavelength	:	850nm
Camera/Light Beam	:	Must be factory aligned
Lighting sensor	:	Built in photocell or keyboard command

9.10.4 Operations CCTV System

CCTV cameras to be utilized for operation shall be installed strategically within the plant to optimally capture all the intended operational activities and store them in the video storage server of the system. The cameras catering to operational requirements within the plant shall be PTZ cameras. The stream transmission of individual cameras to servers shall be based on Fibre optic backbone communication.

The CCTV system will be interfaced with the Fire Alarm System (FAS) through redundant Modbus TCP/IP interfaces. The vendor shall integrate CCTV Management software with FAS software. The Fire alarm from the FAS should trigger the camera to be directed to the alarm location in the facility. The PTZ CCTV camera installed in the area of detection shall automatically focus on the intended area of coverage (i.e. the programmed PTZ pre-set shall be activated) and the live coverage of the affected area shall automatically get displayed on the CCTV screen installed in control room.

The cameras shall be installed on steel structures/walls within the plant or on a fixed pole and does not obstruct any normal operation activities or approach ways.

The PTZ/Fixed cameras to be installed at all the building entrances shall be monitored by both security guards and operators.

9.10.4.1 *Operations CCTV Camera Specification*

A wide variety of network cameras shall be provided ranging from indoor fixed and dome cameras to Explosion Proof and weather proof PTZ cameras, and designed for use indoors or outdoors.

For any application requiring constant monitoring, fixed cameras shall be provided. For other applications that require covering the field, PTZ cameras shall be used.

The following cameras shall be used, depending on the application at the facility and provide their specifications for PMC approval:

- Indoor Dome Cameras
- Indoor Fixed Cameras- for RO building entrance
- Indoor Explosion Proof PTZ Cameras- for Battery rooms
- PTZ Outdoor Cameras

As appropriate, each camera station shall be either structure/wall or pole mounted, fixed or pan/tilt/zoom, with auto iris. A facility shall be provided to access the camera easily for maintenance. The exact quantity of camera stations, types, mounting arrangements and locations shall be determined by the Vendor in conjunction with the PMC.

For cameras, lighting arrestors shall be provided to protect the camera from any damage due to lightning.

All cables installed indoor shall be flame retardant type.

All material supply and installation in Battery rooms shall be Explosion proof.

9.10.4.2 *Indoor Fixed Camera*

The indoor fixed camera shall be Day/Night infrared Bullet camera with the following minimum requirements:

Resolution	:	2 MP/HDTV 1080p
Image Sensor	:	Progressive scan RGB CMOS 1/3.2"
Lens	:	3-9mm, 1000 – 300 view, F1.3
Illumination	:	Colour: 0.2 lux, F1.3, B/W: 0.04 Lux, F1.3
Resolution	:	1920 X 1080 (2 MP) to 160 X 90
Frame Rate	:	H.264 25 fps in 50Hz capture mode.
Memory	:	256 MB RAM, 128 MB Flash
Power	:	PoE IEEE 802.3af/802.3at Type 1 Class 3
Operating Conditions	:	0º to 55ºC
Humidity	:	10 – 100% RH (Non – Condensing)
IR Distance	:	15m

Automatic Day/Night switching, photocell control and Video motion detection.

9.10.4.3 *Explosion proof PTZ Camera*

The Explosion proof PTZ cameras shall:

- The camera shall be designed to provide simultaneous Motion JPEG, MPEG-4 video and H.264. However, H.264 shall be used.
- Resolutions HDTV 1080i, 1920 X 1080
- Be designed to provide video at 30 frames per second (NTSC) or 25 frames per second (PAL) for all resolutions.
- Provide high speed pan and tilt functions and be equipped with 35x optical and 12x digital zoom.
- Operate on an open source, Linux-based platform, and include a built-in web server.
- Be manufactured with an all-metal body.
- Use a high-quality IR-sensitive 1/4" progressive scan CCD sensor.
- Be equipped with a removable IR-cut filter, providing so-called day/night functionality.
- Be equipped with a high quality F1.4 – F4.2 DC-iris lens with horizontal angle of view between 55.8□ and 1.73□.
- Provide pictures down to 0.16 lux at F1.4 while in day mode (with IR-filter in use) and down to 0.0015 lux while in night mode (with IR-filter removed).
- Use a dedicated video compression chip, and be equipped with a minimum of 128 MB Flash memory and 512MB Random Access Memory (RAM).
- Provide 256 MB memory for pre & post alarm recordings.
- Be able to provide a total data throughput of up to 20Mbit/s on the network port.
- PoE IEEE 802.3af/802.3at Type 1 Class 3
- Wall mount
- Explosion proof housing suitable for hazardous area Zone1, Gas Group II C, Temperature Class T4, IP 65 and ATEX certified with glands.

9.10.4.4 *Indoor Doom Camera*

The indoor dome cameras shall be Day/Night camera with the following minimum requirements:

Image Sensor	:	1/4" CCD Day/Night camera
Lens	:	3.6 - 44.3mm, F1.6 Wide / F2.0 Tele
Zoom	:	10 x Optical, 12 x Digital
Min Sensitivity	:	0.7 lux colour at 50 IRE F1.65, 0.07lux monochrome at 50IRE F1.65
Focus	:	Automatic with manual Override
Iris	:	DC Auto-Iris
Max Frame Rate	:	30 fps
Memory	:	256 MB RAM, 128 MB Flash
Power	:	PoE IEEE 802.3af/802.3at Type 1 Class 3

Mount	:	Ceiling mount or wall mount

Automatic Day/Night switching, Automatic white balance and gain control and Video motion detection.

9.10.4.5 PTZ Outdoor Camera Specification

Lens	:	4.7 – 141mm Megapixel 1/3" lens – High Sensitivity
Optical Zoom	:	28
Digital Zoom	:	Optional
Day/Night	:	Auto ICR
Image Sensor	:	1/3" Low Light 2 Megapixel Progressive scan CMOS
Resolution	:	1920 X 1080P
Shutter Time	:	Automatic increase adjustment to improve night time performance
Focussing system	:	Auto
Video line	:	Cat6e as appropriate
I/O alarm card	:	alarm inputs and relay outputs
Variable pan speed	:	0.1° to 40°/sec manual operation
Variable tilt speed	:	0.1° to 30°/sec manual operation
Pre-set accuracy	:	0.1 degrees
Fixing	:	Pole mount/Wall mount adaptor to be included, as required
Operating Temperature	:	-40º C to 65ºC
Storage Temperature	:	-50º C to 85ºC
Environment Rating	:	IP 66/NEMA 4 x compliant

9.10.5 CCTV Management System

The CCTV Management system is to monitor and control using software based Management System with a graphical user interface and operator man machine interface.

9.10.5.1 Required Interfaces

The Management System is to control all aspects of the CCTV Security and Operation systems.

The video management system shall allow multiple users to share common resources. The system shall be viewable on a single monitor that displays a facility map and video overlay, or it shall be viewable on a two-monitor system in which the facility map displays on one monitor and video on the second.

The following sections describe the Management system and the components (products) of the system. The Vendor shall provide all the supporting functionalities and specifications, as mentioned below. The Vendor shall include in the Management system all the below supported components and specifications in the solution to be provided to the PMC. The milestone corporate latest edition is the preferred Management software.

9.10.5.2 *System Description*

The proposed solution shall provide a secure, scalable and easily accessible software based solution for the management of the CCTV Systems. The Management System shall be capable of managing the following:

- System Explorer
- Maps
- Reports
- Forms
- Workflow & Alarm Stack
- Video Wall Management
- Video Recording & Storage

The system will be capable of displaying video images on a minimum of 2 Large Screen Monitors which will act as Video wall & General display screen where required. The system will also provide a "Slave Position" within the proposed new security gatehouse on the facility; this will allow the guards inside the gate house full access to the system.

9.10.5.3 *Management System General Specifications*

The Management System is to form the centralised management of the CCTV systems and also control the recording and storage of the CCTV images.

The system will be built around network technology so all CCTV and alarm data will be carried over the security LAN and stored in dedicated servers within the RO Building Engineering Room.

The system should confirm to the following specifications as a minimum standard:

- The CCTV system is to be monitored and controlled using software based Security Management System (SMS) with a Graphical User Interface and operator man machine interface.
- The SMS will also interface to the Milestone Corporate 5.0 system and will interface with the Video Recording system.

The other features of Management System are:

a. The IP video management system shall be an IP network-based, fully distributed digital video system. The security video system will utilize local area networks (LAN) as a transmission medium for video, configuration, as well as storage of all data.

b. The system shall provide full video control at the control room as well as guard house, with additional full selection capability at any point within the network from a workstation or a video console display. The system shall provide unlimited expansion capability for the addition or modification of video inputs.

c. The system shall recognize the intruder detection and raise alarm working closely with the motion detection alarms from the cameras.

d. The Vendor shall furnish and install all security video cameras, pan/tilt/zoom (PTZ) cameras, mounts, housings, power supply systems, network cables, connectors, equipment racks, monitors and consoles, computer controlled network switchers, work stations, network storage managers , video console displays and keyboards, and all other hardware and software to provide a fully operational system.

e. The IP video management system shall permit normal and event monitoring of all secured areas on digital monitors as required. Video monitoring consoles shall be installed at the control room and guard house.

f. The IP video management system shall permit the normal and event monitoring of all secured areas on monitors as required. Video monitoring of all security cameras shall be possible at the control room and at the guard room. Review capabilities for the digitally recorded video via the secure network specified without interruption to recording capabilities.

g. Network Storage Manager shall be configured using fault-tolerant RAID-6 drive arrays. Network Storage Manager Devices shall be sized to record the camera videos at 4CIF resolution, 25 images per second for 31 days.

h. The IP video management system based digital recording and monitoring system shall incorporate a fault tolerant architecture and shall include redundancy in critical areas of concern. Network Storage Managers shall provide RAID 6 redundancy for the storage drives.

i. The IP video management system shall provide multi-level diagnostics of each component in all critical areas. These diagnostics shall be reported to a diagnostic console for processing. In addition, the diagnostic data shall be capable of being scripted into actionable events within the system.

j. The intent of this specification is to provide to the owner a networked digital security system supplied by the Vendor and shall be a complete and operational system as per the performance requirements and objectives of this specification. Vendor shall be responsible for the coordination of related work with other trades affecting his work or the work of others.

k. The management system shall be provided such a way that Guard room shall monitor and control all the security cameras and Control Room all the security/operation cameras.

l. One number HD LED 55 inch and one number HD LED 21 inch display shall be provided respectively at the central control room and the guard house. The LED displays shall be connected to the video surveillance system private network. In addition, keyboard, joystick and PC shall be provided at each location connected to the video surveillance system. PC shall be located inside the Cabinet. Only Monitor shall be kept in Control room. Monitors shall be positioned in such a manner that reflections from other materials and cabinets are minimized.

m. The system including all the components shall be powered by Uninterruptible Power Supply (UPS). As a guideline the UPS shall be sized with sufficient capacity to supply power to all systems for a minimum of 2 hours autonomy. The decision on autonomy requirement purely depends on the custodian/customer of the CCTV system.

9.10.5.4 *Management /Recording /Failover Server System Requirements*

The following are the minimum requirements for the servers running the System Manager/Recording/Failover applications.

- Rack Mount HP Server
- Processor Intel Xeon E3 – 1220 (for Management/Failover servers)
- Processor Intel Xeon E5-2420 v2 (for Recording server)
- RAM : 12GB RAM
- HP Slim SATA DVDRW
- 2 no's 500GB+ HDD, 10K RPM (SATA/SAS) - OS / Application / SQL DB and Transaction Logs RAID 1
- HP NC364T PCI express Quad port gigabit Server Adapter
- HP 750 W CS HE power supply kit
- Graphics Adapter – 2 X DVI-I
- Gigabit Network Connection
- Windows Server 2012 x64 Standard/Data Centre
- SQL Express (Included)

9.10.5.5 *Client Viewer*

a. The Client Viewer shall provide remote users with a comprehensive suite of features including as minimum:

    1. Viewing live video from cameras on the surveillance system.
    2. Browsing recordings from cameras on the surveillance system, with a selection of advanced navigation tools, including an intuitive timeline browser.

3. Creating and switching between an unlimited number of views, each able to display video from up to 64 cameras from multiple servers at a time. The system shall allow views to be created which are only accessible to the user or to groups of users.
4. Accessing views of cameras on any camera with a Client Viewer application installed.
5. Creating special views for widescreen monitors.
6. Using multiple screens as well as floating windows for displaying different view simultaneously.
7. Quickly substituting one or more of a view's cameras with other cameras.
8. Viewing image from several cameras in sequence in a single camera position in a view or a so called carousel.
9. Viewing video from selected cameras in greater magnification and/or higher quality in a designated hotspot.
10. Receiving and sending video through the Matrix application
11. Include HTML pages and static images (e.g. maps or photos) in views.
12. Controlling PTZ cameras.
13. Using digital zoom on live as well as recorded video.
14. Activating manually triggered events.
15. Activating external outputs (e.g. lights and sirens)
16. Using sound notifications for attracting attention to detected motion or events.
17. Getting quick overview of sequences with detected motion.
18. Getting quick overviews of detected alerts or events.
19. Quickly searching selected areas of video recording for motion (also known as Smart Search).
20. Skipping gaps during playback of recordings.
21. Configuring and using several different joysticks.
22. Printing images, with optional comments.
23. Copying images for subsequent pasting into word processors, email, etc.
24. Exporting recording (e.g. for use as evidence) in AVI or JPEG database formats.
25. Using pre-configured as well as customizable keyboard shortcuts to speed up common actions.
26. Selecting between a numbers of language versions, independent of language used on main surveillance system.

b. The Client Viewer shall allow remote users to connect to the Management Server for initial authorization then to the Recording Servers for access to video recordings.

c. The Client Viewer shall have the ability to adjust the display parameters for the video images from the recording server to optimize bandwidth utilization.

d. The Client Viewer shall typically be installed on remote user's computers.

e. The Client Viewer shall provide a Graphical User Interface (GUI) and feature Live, Browse and Setup tabs for the convenient access of live and recorded video as well as camera properties and display quality.

f. The Client Viewer shall support the use of standard PTZ controller or 3-axis USB joysticks for control of pan, tilt, zoom and auxiliary camera functions.

g. The operator shall have the ability to use digital zoom where the zooming is performed in the image only on any number of cameras simultaneously. This functionality shall be the default for fixed cameras. The use of digital zoom shall not affect recording or other users.

9.10.5.6 *Client Viewer System Requirements*

The workstation shall be a server-class computer with two dual links DVI-I monitor outputs, USB keyboard, and mouse. The following are the minimum requirements for the computers running the Client Viewer application.

Processor	:	Intel i7 3770 Ivy Bridge Quad-Core 3.4GHz (3.9GHz Turbo)
Memory	:	8GB2 DDR3 SDRAM at 1600MHz
Hard Drive	:	500GB 3.5 6.0Gb/s SATA with 16MB Data Burst Cache
Video Card	:	Intel Integrated Graphics
Operating System	:	Windows server 2012 R2
Key Board	:	USB 104 Quiet Key Keyboard, English
Mouse	:	USB 6-Button Laser Mouse
Monitor	:	24" LED Monitor
Network Connection	:	100Mbits/sec or greater, GB recommended.

An Adapter for Ethernet Networking compatible with TCP/IP network

9.10.6 Joystick Controller / Keyboard

a. The keyboard shall be used in conjunction with a complete network-based video system product, and it shall be the point from which all user functions can be accessed. The keyboard shall be compatible with all Network Series distributed, network-based video products. One keyboard can control all system cameras through either a PC or video console display.

b. The keyboard controls are located on three interchangeable modules in the keyboard.

c. Modules can be positioned and rotated to suit user preferences. The keyboard modules shall include a variable speed, vector-solving joystick for precise PTZ control, jog/shuttle for playback control and pattern control, a keypad for camera and monitor control, and a built-in speaker.

d. The keyboard shall be part of an integrated system and shall be configured so any number of keyboards can be added to the system.

e. The keyboard shall meet or exceed the following design and performance specifications.

Keyboard Base Specifications

i. Keyboard Interface : USB 2.0
ii. Cable : USB, captive, 16.4 ft (5.0 m)
iii. 3. Input Voltage : 12 VDC
iv. 4. Input Current : 1.3 A (maximum)
v. 5. Upstream Port : USB 2.0 (USB type B connector)
vi. 6. Downstream Port : 2x USB 2.0 hi/full/low speed (USB type A connector)
vii. 7. Audio Output : Embedded speaker
viii. 8. Audio Input : Plug-in microphone

Keyboard Module Specifications

i. Keyboard Keypad : 0-9 keys, camera, monitor, and multiple view keys
ii. Joystick : Fully proportional PTZ, variable speed
iii. Jog/Shuttle : Proportional, fast forward, reverse, and vide transport.
iv. Module Connectors : Three (one for each module), USB 1.1 mini-USB.

Power Supply Specifications

i. Input Voltage : 100-240 VAC, 50/60 Hz
ii. Output Voltage : 12 VDC
iii. Power Output : 20 W
iv. Input Connector Type: Universal, interchangeable
v. Output Connector Type : 2.5 mm screw-on barrel

9.10.7 Network Storage Manager

a. The network storage manager shall record video and audio streams from IP cameras on the network.

b. The network storage manager shall incorporate the server functions and storage elements into a purpose-built chassis.

c. The network storage manager shall use RAID 6 parity across the storage drives to protect recorded data against a hard disk drive failure.

d. The network storage manager shall only use enterprise-level hard disk drives specifically rated for operation in RAID systems.

e. The network storage manager chassis shall be designed for video surveillance recording applications and encompass redundancy at all vital points:

01. Redundant, hot swappable power supply modules
02. Redundant, hot swappable system fans

03. Hot swappable O/S drive

04. Hot swappable CPU fans

f. The network storage manager chassis shall be designed for online service and maintenance and cannot be removed from the rack when hard disk drives, fans, power supplies, or operating system drives must be replaced.

g. The network storage manager shall support the recording of MPEG-4 and H.264 baseline, and high-profile streams from standard resolution and megapixel cameras.

h. The network storage manager shall support continuous, scheduled, alarm/event (including analytics alarms), motion, and manual recording. Pre- and post-alarm periods shall be configurable up to the total capacity of the system.

i. The network storage manager shall support bookmarking and locking/unlocking of video content on the drives.

j. The network storage manager shall support privacy tools that allow administrators to establish maximum retention times for normal, alarm, and locked video.

k. The network storage manager shall support an intelligent video grooming protocol that can reduce the frame rate of recorded video as the video ages. Administrators shall have the flexibility to determine whether to groom alarm video or leave it at its real-time level.

l. The network storage manager shall be fully managed from a remote workstation, including the ability to configure settings and update firmware and software.

9.11 ACCESS CONTROL SYSTEM

9.11.1 Design Considerations and Overview

Access Control System shall be provided to monitor access of authorised personnel into the facility, including main entry/exit gate (excluding escape gates) and main entry doors of the buildings.

All the Access Control equipment shall be of a modern, proven and reliable design.

The scope of supply shall include but not be limited to the provision of access control for the Buildings and locations mentioned above and the access card issuing equipment to enable the access cards to be programmed with the requisite user and access information. Access shall be obtained by the use of contact less ‘proximity cards.

Badge readers shall be installed along with Reader interface module and locks at the doors/entry points of the specified rooms in the buildings. Exit push button shall be installed on the other side of the door.

Entry to these points shall be made through swiping/placing the Badges issued to personnel's/visitors on the Badge reader. On recognition of the badges, the door shall open, and under normal circumstances the door shall remain closed.

The movement of people shall be recorded on a Management Terminal located in the RO Building. This Management Terminal shall be connected to the Ethernet LAN and allow access to the system database from other defined PCs or terminals elsewhere within the total Plant Complex.

All the readers shall be connected to their respective Reader Interface Module, which shall be connected in an independent network extended till the Segment controller. The initial configuration of ACS system and cards shall be done by using the ACS server which shall be installed in Engineering room in RO building.

In case of emergency, all the doors with access control within the facility shall be released for easy evacuation of personnel working in facility. Hence an emergency push button shall be installed at operator's desk in CCR so that they can initiate immediate release of the access-controlled gates and doors.

For assured safety, the Fire Alarm System shall be interfaced with the access control panel so that upon the detection of fire, the associated access-controlled doors shall be released for prompt evacuation of personnel.

The break glass unit shall be provided at every exit of the access-controlled doors so that the personnel can break the glass unit and activate the door release in case of emergency.

The system shall operate on 240V AC and shall have 240V AC UPS input to operate in all situations. The autonomy required for ACS shall be minimum 4 hours.

The ACS shall constitute the following main components at the locations mentioned below:

- ACS server and Management system with associated hardware, installed in the Telecom cabinet located in RO control room Building.
- Central Control and Monitoring station with all related hardware and software in the CCR and Guard house
- Badge maker set with camera and badge printer at Guard House.
- Access control panels/Segment controllers, as required per building.
- ACS door Hardware: Reader Interface Module (RIM), Card readers, door contacts, magnetic locks, Emergency Break glass and Exit push button per Access controlled door. For emergency doors, only door contact will be provided.
- Vehicle Entry/Exit Lane: The vehicle entrance/exit to the facility is to have an Access Control System installed; this will take the form of a Reader Pedestal mount at the entrance/exit which will have an Access Control Reader at car height and lorry/tanker height, with a traffic light system. An Intercom connection to Guard house shall also be provided at Entry side to facility.
- Main Pedestrian Entry/Exit to facility: In order to register pedestrian entry/exit to the facility, 2 card readers are to be provided in Guard house.

- Access gate: In order to secure access gate, Card readers at both sides as well as door contact, magnetic lock, Junction box, etc. as require to be provided.
- Passive badges (minimum 100 numbers).

The access-controlled doors and gates shall be monitored via access control operator workstations located in Control Room and Guard House.

The ACS to be supplied shall have a badge printing station which shall also configure new cards and reconfigure existing cards for allowing access to specific locations of the facility.

The badge printing station (containing access configuration software) shall be installed in Guard House and shall be connected to the main ACS server located in engineering room of Facility. Hence any new entrant to the facility will first visit Guard House, where after all the required inductions and depending on nature of work, the access cards will be configured and provided. On receipt of valid card, the visitor shall be allowed to access the Facility.

All equipment and software shall be designed with 20% growth capacity allowance to allow for possible expansion at a later date without the need to add any additional hardware, software for the network operating system, or any additional changes to the network management system.

9.11.2 System Requirements

The Vendor shall ensure that the Access Control System meets or exceeds the following requirements:

- Reliable and proven equipment.
- Modular in design.
- Badge reader interrogation should be by inductive coupling or radio and not rely on physical contact with the badge.
- Central Equipment to hold database of authorized personnel.
- ACS system shall function as a standalone system and shall be interfaced with Fire Alarm System.
- The Control room shall have the ability to release all the locks in the event of an emergency.

9.11.3 Technical Requirements

9.11.3.1 *Access Control Panel / Segment Controller*

The ACS Control Panels shall have the following minimum facilities:

- Have multiple zone capability to allow or restrict personnel from entering building or a number of buildings.
- Have the facility to program specified access times to different buildings enabling personnel to enter the buildings only within these specific periods.

- Have the facility to permit access to personnel only on specific dates or days of the week. weekend or public holiday restrictions

Access Control Panel shall be microprocessor-based hardware, equipped with RAM and Flash memory (or other equivalent non-volatile memory) in order to maintain application program, configuration data, resident data base, events log and transactions.

All Access Control Panels shall be able to interface a local printer for logging, reporting and maintenance purposes. Local database shall be stored in removable static memory in order to easily restart system operation (simply moving the memory cartridge to the new unit) should the need arise for a new Controller to be installed in lieu of a failed unit.

If the entry from card reader is valid then the Control Panel shall release the locking mechanism to allow entry to take place. If an invalid access card is presented more than three times to proximity card reader the Control Panel shall activate an alarm signal warning of an illegal entry attempt.

Access Control Panel shall be capable of connecting and managing access control terminals providing personal card reading as well as input of additional data (PIN codes, biometric parameters, etc.) and output of messages and other information to the user.

Access Control Panels shall have inputs for connection of local hardware such as exit push buttons, lock monitoring and position monitoring (via contact sensors installed on emergency exit doors), BGU monitoring, device tampering etc. They shall also provide outputs for electromagnetic locking devices and onward connection to other ACS devices and transmission units.

Access Control Panels shall ensure communication on LAN and WAN networks. Access Control Panel will store alarms, events and transit transactions and send them to server either establishing a connection when the buffer memory has reached a given level or at scheduled times.

9.11.4 Card Readers

The proximity card readers shall use inductive coil, radio technology, or any state-of-the-art technology to identify the access card and feed the data to the System Controller Unit. The proximity card readers shall be Multi-technology contactless smart card reader and be able to accurately read the data from the access identification cards from a distance of >6 cm, preferred 9 cm.

The multi-technology contactless smart card reader(s) shall be designed to securely read, interpret, and authenticate access control data from 13.56 MHz contactless smart card credentials and 125 kHz proximity cards.

Long range card readers shall be installed for Main entry/exit gate enabling the drivers not to get out of their vehicle for badging. Card readers for small vehicles as well as trucks shall be installed in same pedestal with dual head.

The card reader units shall be protected against the ingress of dust and moisture.

The contents of the memory of the badge reader shall not be lost in case of power failure. The system shall start automatically at power return.

There shall be communications between the reader and the controller such that if wiring is cut, or the reader is disabled or tampered, an alarm message shall be sent to the system to inform the operator about the condition.

The card readers shall provide the ability to transmit an alarm signal to the Controller via an integrated tamper switch if an attempt is made to remove the reader from the wall.

All card readers should be affixed with tamper proof screws.

The outdoor card reader units shall be IP65 or higher, making them suitable for external installation. The Electronic equipment installed outdoor are working under hard environmental conditions so must be tropicalized.

9.11.5 Door Locks

All doors located throughout the plant that are required to be access controlled shall make use of magnetic door locks to hold doors closed under normal conditions and release the door for access once suitable access is granted via the card reader. All magnetic locks shall also have a break glass unit on the inside (secure area) to release the door for egress during an emergency.

In emergency situations the door locks should be released to allow speedy evacuation of the secured area. Fire Alarm system interface shall be provided to release the door lock instantaneously during a confirmed emergency.

Door locks shall suit door hardware proposed for the facility and should have a holding force of 1200 lbs.

9.11.6 ACS Management System

The ACS management system will use a Client Server architecture based around a modular PC network, utilizing industry standard operating systems, networks and protocols.

Main application areas covered by the management system shall include:

- Access Control (including Visitors management, Reception management, Guard Tour management, Risky Area Access Control management).
- Time & Attendance.
- Security Management for intruder detection.

Access Control will be based upon personal identification of employees and visitors using personal identification cards supplemented by additional personal data (PIN, biometric, etc.) should the need arise.

The ACS management system shall receive the data from the system Controllers, where the access control data from proximity card readers is gathered, to determine the validity of the presented access card.

The ACS management system shall record the identification of the location of the door, the person entering or leaving along with the day, date, and time of the entry or exit from the facility.

The records maintained by ACS management system shall be used for statistical purposes to identify who is in anyone building at any one time for use in the event of any emergency or evacuation. Access to the database shall be made available to the security at the Guard House as well as operators in CCR. The storage at this place shall be sufficiently large enough to maintain the data for a period of one month.

The management system as a minimum shall have the following facilities:

- Restricted access with password security to access the data.
- Anti-Pass-Back facility configuration.
- Trouble shooting facility.
- Statistical information on the Access Control System.
- Specific graphics showing as a minimum the access points.
- Access recording and personnel ID file database.
- Display of list and the total no. of personnel in each building.
- Display of date / time of entry / exit.

This management system shall be capable of displaying all the network settings, system interface modules and their individual settings. It shall allow the system manager to configure, control, fault find, activate or de-activate interface modules, monitor status and alarms etc.

There shall be several levels of password-controlled access to the management terminal from low level, (monitor only), to the highest level, (able to reconfigure etc).

All the local controllers, badge readers, locks and sensors associated with each door, on the Access Control system shall be monitored and managed from the management station.

System failures shall be automatically reported on the PC and shall include, as a minimum, date, time, location and type of all the alarms in the system.

9.11.7 Alarm Communication

The ACS shall provide monitoring and alarm communication functions for Doors / Gates including all entrance and emergency exit doors.

The ACS shall provide real-time alarm communication to security system operators in the event of:

- Door forced open
- BGU activation
- Door held open (for greater than x seconds)

- Door opened under duress (via duress PIN code input)
- Unauthorised access attempt
- Access attempts by pre-defined cardholders/cards
- Communications failure
- Mains & battery power failure
- Reader Tampering
- Panel Tampering
- PSU Cabinet Tampering

Alarms shall be communicated to the central workstation in the CCR where they shall be displayed on a GUI showing the location of the alarmed door and gate. The system shall use dynamic icons that change in colour and appearance in accordance with the alarm status of each door.

A unique icon shall be displayed for each type of device, including reader, locking device and emergency exit monitoring device. In addition, an audio alarm shall be sounded.

Alarms shall be automatically assigned a priority level according to the type of alarm.

In the event of two alarms having the same priority level they shall be displayed in chronological order by time of occurrence.

The system shall present the operator with a list of predefined actions to instruct them what to do in the event of that alarm occurring. Operators shall only be able to cancel alarms when the alarm condition has returned to normal.

Supervisor rights shall be required to acknowledge and cancel alarms that have not returned to their normal state, or to cancel multiple alarms.

All alarm details shall be recorded on the central database server, along with the identity of the operator who acknowledged and cancelled the alarm, in order to allow future reporting.

9.11.8 Access Cards

Read/write contactless smart card technology in a single card - providing high-speed, reliable communications with high data integrity shall be provided for this project. iCLASS technology ensures high security with mutual authentication between card and reader, encrypted data transfer, 64-bit diversified keys for read/write capability.

Access cards shall meet ISO standards for thickness for use with direct image and thermal transfer printers. The cards shall have the ability to add a magnetic stripe, barcode, custom artwork, or photo ID and shall be available in 2k bit (256 byte), 16k bit (2K Byte) or 32k bit (4K Byte) memory configurations.

9.11.9 Door Contact Switch

Door Contact switch shall be mounted on top of door (not close to hinge side) to show the position of the door (This will give indication of unauthorized opening).

In the case of authorized access, door status changing to open will be taken as an indication to the Access Control Panel that the authorized presenter has pass through the door and to cancel any remaining unlock time.

All Emergency doors shall have door contacts.

9.11.10 Exit Push Buttons

- All exit push buttons are to be a made of stainless steel and with an IP rating of IP54 due to the requirement for heavy and prolonged usage
- All devices should have a pictorial illustration of operation
- All devices should have a maximum operation temperature of up to 55.C
- All devices should have a minimum mechanical life of 1,000,000 cycles
- All devices should have a potential free contact rating of 5A@240V AC N.O/N.C Output

9.11.11 Card Issuing Facility

Vendor shall supply an access identification card issuing facility that shall enable Company to issue valid Access Cards.

Cards shall be credit size cards that shall indicate the following information as a minimum:

- Registered owners name
- Works number
- Department of employment
- Photograph
- Plant name, returning address and logo.
- Expiry Date

The identification cards shall not contain any visible information or indication of the buildings to which the holder is permitted access, this information shall be retained within a microchip embedded within the card.

Guest or visitor passes shall be made available programmed to restricted areas in the buildings.

The card issuing facility shall comprise a PC based recording and information system with a digital camera unit linked to the PC for taking the users photographs and the facility to enter access data to the passive system on the card.

The data, which is required to be programmed onto the card, shall include as a minimum:

- Card Holder's details
- Name
- ID Number
- Department/Organisation
- Building or Buildings for which the card is valid.
- Times of days for which the card is valid.
- Days for which access is permitted. Start and finish dates for the card's validity.

9.12 Public Addressing System

9.12.1 Design Consideration and Overview

A Public Address (PA) system shall be installed in 400MLD Perur Desalination facility where people may be present and aural communication is practicable.

An IP based Public Address system shall be provided within the Facility including RO building and Guard house.

The PA system shall provide basic functions for:

- Announcements: The capability to support prioritized one-way voice audio broadcasts to one or more zones from PA access panel and external audio interfaces.
- Emergency Notification: The capability to support prioritized alarm responses that include audio notification when initiated from PA access panels or external interfaces.
- Supervision: The capability to continually monitor all critical audio paths and circuits so that any failure can be brought to the attention of the system operators or maintenance personnel for corrective action.

An IP based Public Address System (PA system) shall be designed and installed in the Central Control Room or at the Security Control Room so that the operator can page any instructions to the personnel.

PA speakers shall be installed within the plant facility at the strategic locations where it is necessary to page important and emergency messages. PA speakers shall also be installed in RO building and guard house.

All the loudspeakers shall be connected to the same control cabinet in RO building.

Suitable speakers with acoustic specifications shall be installed in plant areas and buildings. PA access panel with goose neck microphone and zone selection facility shall be installed in the Control room of RO building through which the operator will be able to make speech announcement.

The PA system and its workstations shall be powered up by 240V AC station UPS which shall comply the autonomy of 8 Hours.

9.12.2 PA System Features

The system shall provide facilities for the control and management of a high integrity, IP based Public Address and Alarm System specially designed for industrial environments where advanced technology coupled with very high system availability is demanded. The materials used shall have characteristics suitable for the installation site and for the service required.

The equipment shall be fully solid state type, multi-microprocessor based and programmable. The system shall be software program controlled to enable easy system configuration and self-diagnostics, as well as future software upgrade. Configuration of the system shall be achieved by software for maximum flexibility. A user friendly set-up and checking routine shall provide system management and programming through LCD displays and Personal Computers, which enables an operator using a system controller to implement quick commissioning and fault finding functions. The use of these methods shall allow adjustments to be easily made after the system is installed, without resulting in modifications to the system wiring.

Facilities to indicate the status of the main system units shall be provided. Such indications shall show any faulty unit for easy replacement. The system shall be provided with standard serial/Ethernet interface for local or remote access for supervision and maintenance activities (such as diagnostics with a mimic panel, status and logging of events).

9.12.3 Main System Features of the Public Announcement System

a) Sound Pressure Level (SPL) Requirements

The design of the PA system shall be such that the ratio of PA speech level to background noise is a minimum of 6 dB and optimally 12 dB above ambient noise in all parts of the plant where persons may be present during normal operations and ambient noise levels permit.

Alarm tones shall be a minimum of 15 dB(A) and a maximum of 20 dB(A) above noise level in all parts of the plant where persons may be present during normal operations and ambient noise levels permit.

In areas where the ambient noise exceeds 85 dB (A) flashing beacons shall be provided.

The SPL at the listener shall not exceed 110 dB (A) or be less than 65 dB (A) in any circumstance.

The SPL in high ambient noise areas shall be checked during commissioning and any necessary adjustments made to the PA SPL to ensure requirements are met.

b) Loudspeakers

The Sound Pressure Level at the listener shall not exceed 110 dB (A) or be less than 65 dB (A) in any circumstance.

All outdoor loudspeakers shall be protected against water ingress to IP 65 as defined in IEC

60529 and indoor loudspeakers shall be IP54.

c) Configuration of Alarm Tones and Priorities

Alarm tones and priorities shall be just a feature inbuilt in the PA system. No alarms will be initiated by PA and PA shall be used for routine speech, emergency speech & operator announcements etc.

d) Configuration of Announcement Priorities

Announcements from different sources shall be configured to override others.

e) Pre-Announcement Tones

Single chime or double chime as pre-announcement tones shall be generated under software control, with the possibility to associate these different chimes to different sources and activation types. For example, typically a single chime precedes a routine announcement and a double chime precedes a telephone access.

f) Zone Selection of Announcement and Alarms

Real time voice messages and Emergency Alarm signals may be diverted to predetermined groups of amplifiers/loudspeakers. The access priority regime will determine which announcement has priority of access and is broadcasted.

The configurations of groups of zones shall be changed via software without the need to alter wiring of audio inputs or the speaker loops and this shall be inherent feature of the PA system.

g) Gain Control of Alarms and Announcements

Alarms and announcements shall be individually configurable to different volume levels to allow for clearly audible emergency broadcasts. An alarm in progress can be attenuated (up to 12 dB) or fully muted while an emergency broadcast is made and then increased back to its original level afterwards.

h) Digital Tones and Important Messages

The microprocessor shall control the generation of alarm tones, as well as digital speech messages. The system shall be provided with alarm and test tones.

Emergency notification alarms can be broadcast manually. Each alarm is fully configurable and initiated by a direct command from an access panel for security reasons it shall only be possible to reprogram either the important message or the alarm tones.

i) Audio Alarm

Suitable and sufficient speakers shall be provided in the facility to ensure all areas are covered.

Alarm tones shall be a minimum of 15 dB(A) and a maximum of 20 dB(A) above noise level in all parts of the plant where persons may be present during normal operations and ambient noise levels permit.

j) Power Amplifiers

Industry standard 300 Watt power amplifiers shall be provided with the following minimum features: low idle current, LCD indicators for output level, built-in thermal protection, overload and short circuit protection. The short circuit protection shall shut off the power amplifier for a 5-second period, repeating until the fault is rectified. Power amplifiers shall be provided with built-in supply capability from AC mains.

k) **Multiple Sources of Speech**

Announcements shall be able to be made from a variety of sources, such as engineer test panel, operator access panel, microphone panel, Secretary desk panel and from telephones.

l) Built-in Self Diagnostics

Each piece of system equipment shall have a comprehensive built in diagnostic test feature so that at all times the status of the system can be monitored. Circuit failures shall be reported on the LCD display of the Controller Unit and on the operator's control sets, and reported remotely through dry contacts and/or serial lines.

The system monitoring functions shall include; Management System alarms, power amplifier alarms, power supply alarms, speaker loop alarms and communication alarms between the various system equipment.

m) Speaker Loop Monitoring

The system shall provide the facility for monitoring speaker loop status. Automatic setting procedures shall be able to be programmed in order to check all output line conditions at real time (or scheduled) trouble-shooting of the individual speaker loops.

The system shall provide facility for detection of speaker line earth leakage and for detection of speaker line impedance deviation.

n) Audio Recording

The calls originated from telephone or microphone consoles shall be automatically recorded through a suitable digital audio recorder, with a removable storage media.

During an incident or emergency, it shall be possible to record voice traffic on the system for future replay.

o) Alarm Attenuation

Attenuation of alarms while a broadcast is being made shall be provided. The alarm audio level shall be reduced up to 12 dB from the broadcast level.

p) Audio Path Monitoring

The system shall provide full audio path test from microphone panels for loud speaker checks.

q) Background Broadcast

The system shall be able to provide broadcasts of background sound/music from various sound/music sources such as CD players, cassette recorders or tuners.

r) PABX Access

A priority telephone interface unit shall be installed at equipment cabinet.

Upon receipt of a valid access code (e.g., 333) a confirmation tone is returned to the call originator and the message to be broadcast shall be recorded.

s) Public Address Announcement

The PA system shall provide one-way voice audio broadcast primarily utilizing access panels located in the Control room. Additional broadcast services shall be provided through interfaces to the telephone system.

Alarm audio notification shall employ circuitry integral to voice audio broadcast so as to facilitate prioritization. Access panel, external audio interface and alarm audio sources shall be prioritized by content to allocate access to the most critical broadcast information.

A facility to combine both zone selection and announcement initiation shall be supported. This facility shall allow an operator to select one momentary switch to launch a routine announcement to one pre-configured zone. Zone selection is automatically terminated after an announcement.

Status facilities shall be provided to display system information regarding active or non- active announcement information on access panel indicators. This status serves to sequence equal access announcements.

t) Emergency Notification

The PA system shall support alarms that consist of distinctive tones to predetermined destinations. The system shall have the provision to provide Visual notification for alarms and emergency announcements to supplement audio notification in areas where noise levels typically exceed 85dBA or in accordance with customer requirements. Visual notification shall be through colour coded beacons that indicate the severity of the alarm or emergency announcement.

Each alarm may be initiated through an access panel, serial link and external voltage free contact interface. The standard manual format for alarm operations from an access panel shall be through switches for activation. The external interface shall support configurable serial interface, normally open or normally closed, maintained or momentary voltage-free contacts for each automatic alarm activation.

Audio notification shall be prioritized to assure the broadcast of the most critical alarms. Customization of the system design shall be provided for additional alarms.

Status facilities shall be provided to display system information regarding active or non- active alarm information on access panel indicators. This status serves to provide a visual interpretation to access panel operators.

u) Supervision

The central equipment shall incorporate configurable automatic monitoring facilities. These facilities shall be selected during system design in accordance with the customer requirements.

The standard set of monitoring facilities shall interrogate:

- Controller unit with built-in message/tone generator.
- Power amplifiers.
- Loudspeaker loops.
- Digital communication paths between different system equipment.

The interrogation of supplemental circuits shall be supported as required.

The standard system design shall ensure that all critical audio paths and operation of the PA system are continuously monitored, so faults are immediately identified. The Controller Unit located in the central equipment cabinet shall assist in fault location and diagnosis during a failure condition. Voltage free relay contacts shall be provided to enunciate equipment failure conditions to external systems.

Facilities shall be provided to display system information regarding health or fault information on access panel indicators.

Another access panel shall be provided to the operator in control room to monitor the PA alarms.

v) Plant Telephone Access

The following steps are completed to make an all zone page announcement from a plant telephone:

Dial the "PA Access" number – the system will auto-answer if the line is not already engaged; otherwise, a busy notification will be returned. As an alternative it is possible to provide zone selection from PABX access by keying the appropriate zone once a seize condition has been registered. Make announcement – then through the use of the page delay feature to eliminate feedback, the system broadcasts the user's voice to all zones if no other higher or equal priority broadcast is active.

w) Loudspeaker Loops

The loudspeaker distribution shall be based on a PA coverage study/noise report developed by the Vendor during detailed design.

The number of PA speakers and their tapings for required SPLs shall be finalized/specified by Vendor. The HSE noise study shall be used in the background during the PA coverage study, to determine the Signal to Noise ratio for speaker allocation.

Loudspeaker loops shall be designed in such a way that there will be always an overlap between two independent loops, so that in case of a loudspeaker failure, service would be maintained.

Loudspeaker loops shall be fed from both ends so that in case of cable damage service would be maintained on both half loops.

9.13 Fire Detection and Alarm System

9.13.1 General

A centralised electronic fire detection and fire alarm system shall be designed, installed and commissioned with all necessary equipment, accessories and cabling.

A complete system shall be provided with all components required for automatic operation.The main functions of the system shall be as follows:

- The actuation of any fire detection device shall be audible and visible displayed on a central fire alarm control panel and audible alarms shall be initiated throughout the building.
- The system shall differ whether the alarm was initiated by an automatic detection device or by a manual fire alarm station.
- Audible alarms may be silenced by pushing a silence button on the central fire alarm control panel. Any subsequent actuation of a detection device shall again sound the audible alarms.
- Fire doors, fire dampers, if any, air handling units or any other equipment or devices shall be released or shut down as required.
- Short circuit, wire break or any other system troubles shall be indicated on the central fire alarm control panel.
- After restoration of the alarm detection device to its normal condition, the system shall be returned to normal stand-by condition.

The fire alarm system shall comply with requirements as per the latest applicable Indian Standards, Indian Electricity Rules 1956, Fire Regulations and relevantCode of Practices. NFPA Standard 72 for Protected Premises Signalling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.

Any item which may not have been specifically mentioned herein but are needed to complete the equipment / system shall also be treated as included and the same shall be furnished and erected, unless otherwise specifically excluded as indicated.

Wherever the Indian Standards do not exist the equipment / components shall be designed, assembled and tested in accordance with the latest editions of the other relevant applicable Standards. In such a case the Bidder shall clearly indicate the standards adopted, furnish a copy of the latest revision of standard along with copies of all official amendments and revisions in force as on date of opening of bid and clearly bring out the salient features for comparison.

For fire protection, firefighting system refer to section Fire Protection System specification.

The fire detection and fire alarm system shall mainly consist of the following equipment.

9.13.2 Main Fire Alarm Control Panel:

Main Fire Alarm Control Panel (FACP) shall contain a microprocessor based Central Processing Unit (CPU) and power supply. The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent addressable smoke and thermal (heat) detectors, addressable modules, printer, annunciators, and other system-controlled devices.

In conjunction with intelligent Loop Control Modules and Loop Expander Modules, the main FACP shall perform the following functions:

1. Supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
2. Supervise all initiating signaling and notification circuits throughout the facility by way of connection to addressable monitor and control modules.
3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed. In the event of CPU failure, all SLC loop modules shall fallback to degrade mode. Such degrade mode shall treat the corresponding SLC loop control modules and associated detection devices as conventional two-wire operation. Any activation of a detector in this mode shall automatically activate associated Notification Appliance Circuits.

9.13.3 Fire Alarm Control Panel - System Capacity and General Operation

A. The FACP shall be capable of communicating over a Local Area Network (LAN) or Wide Area Network (WAN) utilizing a peer-to-peer, inherently regenerative communication format and protocol. The network shall support communication speed up to 100 Mb and support up to 200 panels / nodes per network.

B. The control panel shall be capable of expansion of up to 10 SLC loops. Each module shall support up to 318 analog/addressable devices for a maximum system capacity of 3180 points.

C. The Fire Alarm Control Panel shall include a full featured operator interface control and annunciation panel that shall include a backlit 640-character liquid crystal display, individual, color coded system status LEDs, and a QWERTY style alphanumeric keypad for the field programming and control of the fire alarm system. Said LCD shall also support graphic bit maps capable of displaying the company name and logo of either the owner or installing company.

D. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.

E. The FACP shall be able to provide the following software and hardware features:

1. Pre-signal and Positive Alarm Sequence: The system shall provide means to cause alarm signals to only sound in specific areas with a delay of the alarm from 60 to up to 180 seconds after start of alarm processing. In addition, a Positive Alarm Sequence selection shall be available that allows a 15-second time period for acknowledging an alarm signal from a fire detection/initiating device. If the alarm is not acknowledged within 15 seconds, all local and remote outputs shall automatically activate immediately.
2. Smoke Detector Pre-alarm Indication at Control Panel: To obtain early warning of incipient or potential fire conditions, the system shall support a programmable option to determine system response to real-time detector sensing values above the programmed setting. Two levels of Pre-alarm indication shall be available at the control panel: alert and action.
3. Alert: It shall be possible to set individual smoke detectors for pre-programmed pre-alarm thresholds. If the individual threshold is reached, the pre-alarm condition shall be activated.
4. Action: If programmed for Action and the detector reaches a level exceeding the pre-programmed level, the control panel shall indicate an action condition. Sounder bases installed with either heat or smoke detectors shall automatically activate on action Pre-Alarm level, with general evacuation on Alarm level
5. The system shall support a detector response time to meet world annunciation requirements of less than 3 seconds.
6. Device Blink Control: Means shall be provided to turn off detector/module LED strobes for special areas.
7. History Events: The panel shall maintain a history file of the last 4000 events, each with a time and date stamp. History events shall include all alarms, troubles, operator actions, and programming entries. The control panels shall also maintain a 1000 event Alarm History buffer, which consists of the 1000 most recent alarm events from the 4000-event history file.
8. Passwords and Users: The system shall support two password levels, master and user. Up to 9 user passwords shall be available, each of which may be assigned access to the programming change menus, the alter status menus, or both. Only the master password shall allow access to password change screens.
9. Environmental Drift Control: The system shall provide means for setting Environmental Drift Compensation by device. When a detector accumulates dust in the chamber and reaches an unacceptable level but yet still below the allowed limit,

the control panel shall indicate a maintenance alert warning. When the detector accumulates dust in the chamber above the allowed limit, the control panel shall indicate a maintenance urgent warning.

10. Custom Action Messages: The system shall provide means to enter up to 100 custom action messages of up to 160 characters each. It shall be possible to assign any of the 100 messages to any point.
11. Local Mode: If communication is lost to the central processor the system shall provide added survivability through the intelligent loop control modules. Inputs from devices connected to the SLC and loop control modules shall activate outputs on the same loop when the inputs and outputs have been set with point programming to participate in local mode or when the type codes are of the same type: that is, an input with a fire alarm type code shall activate an output with a fire alarm type code.
12. Read status preview - enabled and disabled points: Prior to re-enabling points, the system shall inform the user that a disabled device is in the alarm state. This shall provide notice that the device must be reset before the device is enabled thereby avoiding activation of the notification circuits.
13. Custom Graphics: When fitted with an LCD display, the panel shall permit uploading of a custom bit-mapped graphic to the display screen.

F. Network Communication

1. The FACP shall be capable of communicating over a Local Area Network (LAN) or Wide Area Network (WAN) or Fiber to Fiber utilizing a peer-to-peer, inherently regenerative communication format and protocol. The network shall support communication speed up to 100 Mb and support up to 200 panels/nodes per network.
2. List of Minimum Interface using IFU / Modules. Final list shall be discussed with client & based on plant operation philosophy it shall be expanded.
3. Fire Fighting System shall be interfaced with CCTV System Via Modbus TCP/IP Protocol
4. Interface List (Minimum services)
    - Fire Fighting Systems
    - Extinguishing Agent System if available
    - Access Control System
    - DCS/SCADA Networks
    - Building Automation System
    - AHU & Fire Dampers
5. The FACP shall be capable of communicating with a Distributed Control System
6. All FACP's shall be networked through Single Mode Fibre Optic Networking & also dedicated Fire fighting Central Control station shall be provided. Central control station shall communicate with DCMS via Modbus TCP/IP protocol

G. Central Processing Unit

1. The Central Processing Unit shall contain and execute all control-by-event (including Boolean functions including but not limited to AND, OR, NOT, ANYx,

and CROSSZONE) programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost with system primary and secondary power failure.

2. The Central Processing Unit shall also provide a real-time clock for time annotation, to the second, of all system events. The time-of-day and date shall not be lost if system primary and secondary power supplies fail.
3. The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.
4. The CPU shall provide an EIA-232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals.
5. The CPU shall provide two EIA-485 ports for the serial connection to annunciation and control subsystem components.

H. Display

1. The system display shall provide a 640-character backlit alphanumeric Liquid Crystal Display (LCD). It shall also provide eleven Light-Emitting-Diodes (LEDs) that indicate the status of the following system parameters: AC POWER, FIRE ALARM, PREALARM, SECURITY, SUPERVISORY, SYSTEM TROUBLE, OTHER EVENT, SIGNALS SILENCED, POINT DISABLED, CONTROLS ACTIVE, and CPU FAILURE.
2. The system display shall provide a QWERTY style keypad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels with up to ten (one Master and nine User) passwords shall be accessible through the display interface assembly to prevent unauthorized system control or programming.

I. Loop (Signaling Line Circuit) Control Module:

1. The Loop Control Module shall contain its own microprocessor and shall be capable of operating in a local/degrade mode (any addressable device input shall be capable of activating any or all addressable device outputs) in the unlikely event of a failure in the main CPU.
2. The SLC interface board shall receive analog or digital information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular device. Each SLC Loop shall be isolated and equipped to annunciate an Earth Fault condition.

J. Field Programming

1. The system shall be programmable, configurable and expandable in the field without the need for special tools, laptop computers, or other electronic interface equipment. There shall be no firmware changes required to field modify the system time, point information, equations, or annunciator programming/information.
2. It shall be possible to program through the standard FACP keyboard all system functions.

3. All field defined programs shall be stored in non-volatile memory.

9.13.4 Automatic Fire Detectors

Automatic detectors shall be of the fixed temperature and/or rate-of-rise heat detectors, optical smoke and/or ionization smoke detectors and ultraviolet and/or infrared flame detectors, subject to approval.

Each automatic detector shall be addressable. Actuation of any detector shall be displayed individually on the central fire alarm control panel.

Each automatic detector shall have a continuous condition supervision by using pulsing, trend evaluating or equivalent system techniques. The detector spacing on smooth surfaces shall not exceed the distance recommended by the approving authorities.

In areas, where irregularities occur, the detector spacing shall be reduced in such a way as to obtain approved spacing. Detectors generally shall be connected in groups to the central fire alarm control panel. The number of detectors installed on anyone signalling line shall be limited as recommended by the manufacturer. Signalling lines shall be designed as loop connections, unless otherwise approved.

The detectors shall be ceiling-mount and shall be plug-in mounted into a twist-lock base. These detectors shall be constructed of off-white UV resistant polymer and shall be detachable from the mounting base to simplify installation, service and maintenance. Mounting base wiring connections shall be made by means of SEMS screws. The detector shall allow pre-wiring of the base and the head shall be a plug-in type. Mounting base shall be mounted on junction box which is at least 1.5 inches (3.81 cm) deep. Mounting base shall be available to mount to standard junction boxes.

As a minimum following list of main areas are to be covered by the fire alarm system:

S. No.	Building/Area/ Equipment	Detection Systems
1.	Intake pump station	Smoke detectors. Automatic fire alarm system and manual fire alarm stations
2.	Potable/permeate Water Pump Station	Smoke detectors. Automatic fire alarm system and manual fire alarm stations
3.	Chemical Buildings	Smoke detectors. Linear heat detectors. Automatic fire alarm system and manual fire alarm. Gas detector.
4.	Chemical Stores	Smoke detectors. Linear heat detectors. Automatic fire alarm system and manual fire alarm

5.	HV, MV, LV Switchgear Buildings housing switchgears. Electrical Buildings-RO building	Smoke detectors. Automatic fire alarm system and manual fire alarm stations
6.	All Oil Filled Transformers	Fusible bulb/quartzoid bulb as well as sprinkler head heat detectors. Automatic fire
7.	Diesel Generator	UV/IR detectors. Smoke detectors. Automatic fire alarm system and manual fire alarm stations.
8.	RO Buildings DAF/DMF buildings	Automatic fire alarm system and manual fire alarm stations. Smoke detectors.
9.	Workshop/ warehouse	Automatic fire alarm system and manual fire alarm stations. Smoke detectors.
10.	Storage buildings (RO membranes, mechanical, etc.)	Automatic fire alarm system and manual fire alarm stations
11.	Local Control, Computer, Electronic and Switchgear Rooms	Smoke detectors. Automatic fire alarm system.
12.	Cable Floors, Shafts and Tunnels, including 110 kV cable tunnels	Smoke detectors for ventilated cable floors and tunnels. Linear heat detectors for non-ventilated cable floors and tunnels. Automatic fire
13.	Battery rooms	Automatic fire alarm system and manual fire alarm stations. Smoke detectors.
14.	Administration Building / Engineering – Operation building / Laboratory/ computer building	Smoke and heat detectors. Automatic fire alarm system
15.	All other buildings and areas	Manual fire alarm stations

A. Photoelectric type smoke detectors

The intelligent photoelectric smoke detector shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

Photoelectric type smoke detectors shall be low voltage, two wire, solid state devices that provide for integral communication with microprocessor-based fire detection system. The detectors shall be able to communicate with the control panel regarding individual address, sensor type and analogue signals.

B. Heat Detector (Intelligent Thermal Detectors):

These shall be analog addressable, fixed cum rate of rise type and designed to operate when the ambient temperature rises beyond a fixed temperature or if the rate of rise is faster than the pre-determined rate and allowing the increase / rise for a specified period.

The detectors shall have the following features:

- Dual thermistors for fast response to temperature increases.
- Alarm temp. : Preferably within 10oC of max ambient temp.

The intelligent thermal detectors shall be series addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. A high heat thermal detector rated at 190 degrees Fahrenheit shall also be available. The thermal detectors shall connect via two wires to the fire alarm control panel signalling line circuit.

C. Multi Criteria Acclimating Detector or Combination Detector:

These detectors shall combine the principles of photoelectric and heat detection into single sensor head. detector shall be an addressable device, that is designed to monitor a minimum of photoelectric and thermal technologies in a single sensing device. The design shall include the ability to adapt to its environment by utilizing a built-in microprocessor to determine its environment and choose the appropriate sensing settings.

The intelligent multi criteria detection device shall include the ability to combine the signal of the thermal sensor with the signal of the photoelectric signal in an effort to react hastily in the event of a fire situation. It shall also include the inherent ability to distinguish between a fire condition and a false alarm condition by examining the characteristics of the thermal and smoke sensing chambers and comparing them to a database of actual fire and deceptive phenomena.

9.13.5 Manual Fire Alarm Stations or Manual Call Stations

Manual fire alarm stations shall be of the break glass push button operated type and individual addressable and displayable on the central fire alarm control panel if activated. The boxes shall be painted red with white or black lettering in the local language and in English.

The unit shall be addressable and communicate with the FACP like other detectors. Manual call points for outdoor mounting shall have IP-65 enclosure protection.

9.13.6 Annunciators or Hooters

Electronic hooters shall be used for audio alarm to alert people in case of fire and shall be fully solid state with audio output sufficient to be heard at a distance not less than 50m. Normally the hooters shall be loop powered using suitable addressable modules. The hooters shall have facility for adjustment of volume as per requirement at site. The units shall be located at vital places and shall have minimum audible level of 65 dB or 5 dB above noise level of the working area and in the plant area also. Outdoor type hooters shall have IP65 protection class.

They shall have a minimum noise level of 110 dB(A) at a distance of 1 m and shall be different in sound from other sirens, if any, installed in the area for other purposes.

The hooting must be audible throughout the entire premises.

9.13.7 Human Machine Interface (HMI)

One HMI Station shall be supplied with the system for showing the graphics related to system connection, Detector layouts etc. and for carrying out the FAP programming functions. The software shall be suitable for operation with Windows XP / 2003 OS or latest versions.

The system shall be supplied / loaded with the necessary software for operation of the panel as per the desired sequence / scheme of operation / specification / system configuration, smoke detector environmental compensation, detector pre-alarm, history logging, output control by event, check & change time based control, detectors sensitivity, alarm verification device or zone, system operations passwords etc.

9.14 IP Telephone and LAN Systems Overview

As part of this project it is essential to provide IP Telephone extensions and LAN network in RO Building, Guard house, Substation buildings, administration buidings and other utility areas.

The IP Telephone exchange shall be located in RO building and shall be digital with open architecture equipped with PSTN trunk interfaces, voice mail system (VMS) and Windows based configuration, diagnostic and billing software.

As part of this project scope, the PSTN network shall be extended from a local service provider to RO building of SIWP facility over fibre optic network. Telephone and LAN services shall further be extended to the end users within the buildings mentioned above over Optical fibre and UTP/STP structured cabling system.

The number of wall sockets in the Buildings shall be finalized based on the building architecture and furniture layout.

9.14.1 IP Telephone System Overview

An IP telephone network shall be provided to provide voice services to the facility. The IP telephone network shall be based on a distributed architecture, with a main IP PBX exchange and Cisco switches, using the Fibre Optic infrastructure for interconnection.

The system shall be capable of providing services for voice, data (via modems) and fax communications inside and outside the plants, and voicemail facility.

As a minimum IP telephone system shall provide for the following:

- Calling to/from the public switched telephone network (PSTN),
- PA System Access

The system shall comprise but not be limited to the following equipment:

a) A main IP exchange located in the RO building Engineering room with duplicated cards/modules and in-built redundant power supply with automatic changeover in the event of failure.
b) The system shall be designed to accommodate specific requirements as well as future developments. It shall be modular in design so that should the system require expansion, units can be added without substantial system changes.
c) Cisco switches with POE located in the buildings of the facility. The switches will be connected to the main IP PBX through a dedicated LAN, using FO infrastructure. The switches will be sized according to the number of extensions to serve, including the 25% of additional active extensions.
d) Internal IP telephone sets for office use. The phones will be desk mounted type except specific locations in substations where wall mounted type is required.
e) Fax machines
f) Operator Console for operator assistance.
g) Networked voice mail services for all telephone users.
h) Dedicated PC workstations for local management, maintenance, configuration, accounting and supervisory
i) Connection of the internal phones and fax machines through the structured Cabling System between the outlets and the switches.
j) Provision of STP & UTP Cat 6 cables, CAT6 Patch panels, Patch cords and RJ45 socket outlets in the buildings.
k) Provision of modem/ Interfaces for connection to local service provider telephone network and international gateway. Liaise with local service provider for connection to PSTN is also part of this project scope.
l) Software licences and associated documentation and programming manuals required to operate, configure and programme the IP PBX system, and all individual equipment, cards and modules within the system. The software shall be compatible with and suitable for operation with the provided system.

All the IP telephone system equipment shall be fed from 240V AC UPS which shall comply with the autonomy of 2 Hours.

9.14.2 IP PBX System Description

- The IP PBX must be of physically duplicated configuration for control, processing, memory, power supply without any single point of failure and in a full hot standby operation mode.
- The IP PBX must be SIP enabled system with capability for 100 subscriber lines with a provision of expandability minimum up to 200 subscribers lines without changing or cascading multiple IP PBXs to achieve the future capacity. The IP Exchange must have capability for connecting of 5 numbers of 2Mbps trunk lines with redundancy.
- In hot-standby operation mode, during changeover from active module to standby, any active/ongoing calls across the entire network/locations must not be interrupted or affected. There must not be any restriction on number of endpoints being backed up in case of failure.
- The standby module must be in automatic synchronization with the active one and must be able to take over the database and telephony functions seamlessly in case of failure of main active one without any need of manual configuration & administration.
- The call processor at the core must be standard SIP based and must be able to register SIP phones directly to it and supports the standards-based principles of IP Multimedia Subsystem (IMS) to allow custom core services to be delivered to each user in the enterprise.
- The IP PBX, gateway and IP Phones must support IPV4 and IPV6.
- The IP PBX shall support DECT and Wifi.

9.14.3 Expansion Capabilities

All critical & common IP PBX's modules including microprocessor, power supply, network switching, etc. shall be duplicated (Hot standby automatic changeover).

The equipped capacity of the IP PBX's shall be the initial working line and trunk requirement, plus a minimum of 25% (installed and already wired) spare equipment for future use.

9.14.4 Interfaces

The following type of interfaces shall be provided on the main IP PBX:

a) Interfaces to connect to other systems like PA system.
b) Interfaces to connect to local service provider telephone network and international gateway.
c) Interfaces to connect to PSTN for direct lines
d) Gigabit Ethernet interface (optical module 8 nos.) for connection via Fibre Optic Cabling Network.

9.14.5 System management and maintenance

The IP PBX shall be equipped with a Maintenance Terminal consisting of a standard PC with LCD monitor, keyboard and printer installed in the Engineering room.

The Maintenance Terminal shall incorporate all facilities required for configuring the IP PBX, for automatic troubleshooting and for maintenance.

A call accounting software on a dedicated PC shall be provided. Traffic management software shall also be provided to produce various traffic analysis reports and graphs.

9.14.6 Numbering plan

The Numbering plan of all extensions and IP PBX ports will be provided by CMWSSB so that the Vendor can program the system during the procurement phase.

9.14.7 Voice Mail System

The IP PBX shall be equipped with integrated voice mail system to enable one mailbox to each subscriber.

9.14.8 Operator Console

Two Operator console position shall be provided for the Plant, that shall have standard IP telephones installed complete with a display unit, hands free operation and user programmable personal keys.

Access to the PA system, shall be made available from the operator positions.

One Operator console shall be installed as part of the management terminal in the Engineering Room of RO building. Another Operator console shall be installed in the Reception area of the RO Building. Both these consoles shall be PC based and shall have access to a directory database that shall include subscriber names, designation, department, class of service and other allied information. Both terminals shall be password protected to prevent unauthorised personnel from accessing the operational facilities.

The console shall also give access to pre-defined IP PBX management functions, with visibility of traffic, configuration data and alarm report of the IP PBX. Day/night service shall be configurable.

9.14.9 Equipment Specifications

9.14.9.1 *Common Systems Provisioning*

The IP PBX supplied shall use the latest proven technology. Proven technology shall be taken as being in full production and systems operating in a commercial environment. All utilized hardware components shall be the latest commercial release version.

The equipment shall be modular in design. All critical systems shall be duplicated and operate in a hot-standby mode, with automatic switching between active and standby sub-systems.

The switching network shall be non-blocking.

Operation in a 100% Direct Inward Dialling / Direct Outward Dialling mode shall be supported since operator service may not be available on a 24-hour basis.

9.14.9.2 *Software System Requirements*

Software shall be of the latest issue commercially released and be modular, upgradable and flexible.

Beta release level software shall not be acceptable. Software shall have a User-friendly graphical environment with plug and play detection of boards, easily manageable database, automatic configuration, hardware diagnostic routines, Remote line testing, billing, reporting and other standard features.

User defined configuration and assignment data shall be changeable. No configuration data shall be fixed in the software load.

9.14.9.3 *Direct Inward Dialling*

Direct inward dialling shall be possible from all incoming calls to all lines on the IP PBX.

By the assignment of service classes it shall be possible to exclude specific lines from the direct inward dialling facility.

9.14.10 Direct Outward Dialling

Direct outward dialling shall be possible from all lines to all outgoing calls on the IP PBX.

By the assignment of service classes it shall be possible to exclude specific lines from the direct outward dialling facility.

9.14.11 General Subscriber Facilities

Facilities to be made available on the IP PBX shall be, but not necessarily limited to, the following:

- Call Forward – All Calls
- Call Forward – Busy
- Call Forward – No Answer
- Hold
- Call Transfer
- Call Waiting
- Conference
- Do Not Disturb
- Executive Override
- Follow Me
- Group Call Pickup

- Hotline
- Hunting
- Ring Back When Available
- Ring Back When Free
- Speed Call – Individual
- Speed Call – System

9.14.12 Conference

Meet-me and progressive conference capabilities shall be provided on the IP PBX. Conference groups of up to six (6) subscribers shall be provided.

Multiple separate conferences shall be possible at the same time.

9.14.13 Internal IP Telephone sets and Faxes

All the telephone sets are IP type and will be located inside buildings. Majority of telephone sets are desk mounted. However, a number of telephone sets will be wall mounted type.

The telephones shall be fully compatible with the IP PBX system and shall include a full range of features and functions. The IP phones will be equipped with LCD display and hand-free facility as a minimum features.

The fax machines shall be from the latest models range of the market and shall include a full range of features and functions, not limited to: storage, plain paper printing, distribution to multiple destinations, calls log, password restriction.

Labels shall be affixed to each telephone indicating Tag Number and extension number. A phone directory will be provided.

9.14.14 IP Telephone Sets

The IP phones shall support the following minimum features:

- Graphical TFT colour display, 16-bit colour depth, 320 x 240 effective pixel resolution, with backlight.
- Support for wideband (G.722 codec, adherence to TIA 920), including handset, headset, and speakerphone.
- G.711a, G.711, G.729a, G.729ab, G.722, and iLBC audio compression codecs shall be supported.
- Full-duplex speakerphone with acoustic echo cancellation.
- Provides direct access to voicemail using message keys.
- Internal 2-port Ethernet switch allows for a direct connection to a 10/100/1000 BASE-T Ethernet network through an RJ-45 interface with single LAN connectivity for both the phone and a collocated PC. System administrator can designate separate VLANs (802.1Q) for the PC and phone, providing improved security and reliability of voice and data traffic.

- Shall support differentiated services code point (DSCP) and 802.1Q/p standards.
- IP address assignment can be statically configured or configured through the DHCP client.
- Support both SIP & H.323 protocol.
- PoE Class (IEEE 802.3af) registers as class 1 device.
- Hard buttons for messages, call history, home, navigation cluster, contacts, headset, volume, mute, speaker etc.
- Wideband audio for both handset and headset.
- LEDs for speaker, mute, call history, message etc.
- Message waiting indicators.
- Desk/wall mounted type with all installation accessories.

9.14.15 Office Lan Network Architecture

All the equipment and relevant software required for Office LAN network at plant is part of this project scope.

This shall include but not be limited to:

- Provision of server switches.
- Provision of Router for connection to local service provider network
- Provision of STP & UTP Cat 6 cables, CAT6 Patch panels, Patch cords and RJ45 socket outlets in RO building and Guard house.
- Provision of LAN distribution and access Cisco Switches.
- Connection of Switches to server switches in RO Control Room.
- Provision of the required telecom cabinets to house telecom equipment.

Liaise with local service provider for connection to service provider network is also part of this project scope.

All the conduits, CAT6 cables, LAN sockets, Computer PCs with monitor, keyboard and mouse and other materials to provide extensions in RO building and Guard house required for Office LAN network at Sohar IWP plant shall be provided as part of this project.

The equipped capacity of the Office LAN network shall be the initial working line plus a minimum of 25% (installed and already wired) spare equipment for future use.

All Office LAN system components shall be powered from 240V AC UPS which shall comply with the autonomy of 2 Hours.

9.14.16 LAN Distribution/Router Switch

The LAN distribution switch for the plant shall be reputed make core switch and shall meet the following minimum requirements.

- Fast Ethernet modules (with IEEE 802.3af Power over Ethernet [PoE])
- Gigabit Ethernet modules (with IEEE 802.3af PoE)

- 10 Gigabit Ethernet modules
- Multiprotocol Layer 3 routing supports
- Redundant Control Channel to increases resiliency to protect against backplane control channel failures.
- Redundant supervisor engine to increase availability
- Redundant power supply option
- Supports both AC and DC power supply options, including AC and DC mixing. One of the power supplies shall be 48VDC and the other 240VAC.
- Hot swappable fan trays
- Front-to-back air flow to support hot aisle or cold aisle designs.
- Supports NEBS L3 compliance

9.14.17 LAN Access Switch

The LAN access switches shall meet the following minimum requirements:

- 12 and 24 10/100/1000 PoE+ models
- 4 x 1GE Network Module
- Industry first PoE + with 30W power on all ports in 1 rack unit (RU) form factor
- Support for dual redundant, modular power supplies and fans
- Media Access Control Security (MACsec) hardware-based encryption
- IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware.
- Enhanced Cisco Energy Wise for operational cost optimisation by measuring actual power consumption of the PoE devices, reporting, and reducing energy consumption across the network.
- USB Type-A and Type-B ports for storage and console respectively and an out-of-band Ethernet management port.
- Cisco Stack Power technology: Feature for sharing power among stack members.
- Cisco Stack Wise Plus technology for ease of use and resiliency with 64 Gbps of throughput.