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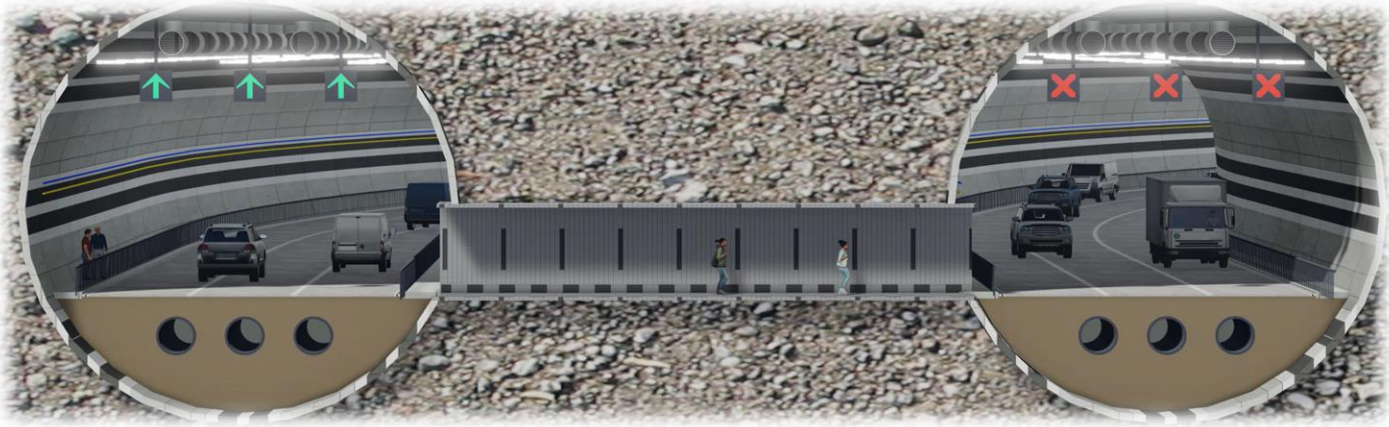
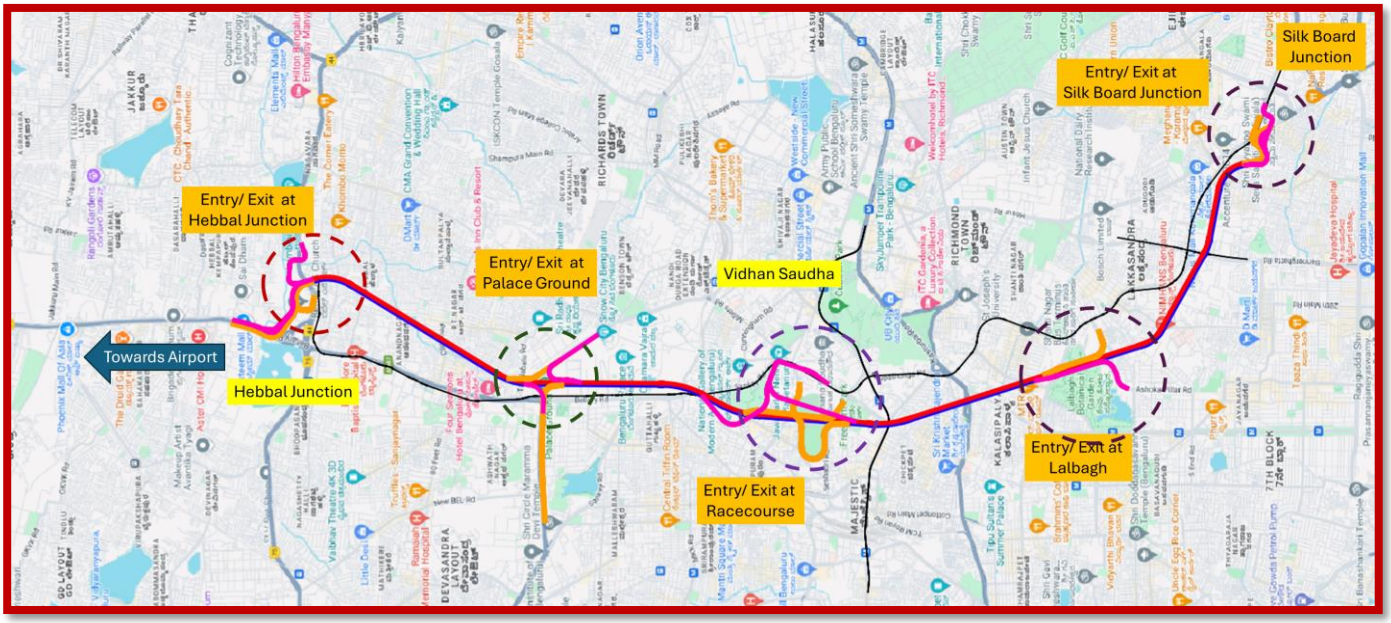


CONSULTANCY SERVICES FOR PREPARATION OF DPR FOR THE WORK OF CONSTRUCTION OF UNDERGROUND VEHICULAR TUNNEL FROM HEBBAL ESTEEM MALL JUNCTION TO SILK BOARD KSRP JUNCTION



DRAFT DETAILED PROJECT REPORT

VOLUME - II C
ELECTRICAL DESIGN REPORT

September 2024

Rodic
ENGINEERING. PASSION

RODIC CONSULTANTS PVT. LTD

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1.0 OPERATION PHILOSOPHY

The Operations Control Centre for the tunnel is located at the Portal Ends of the Tunnel. The operation of the tunnel equipment shall be done in such a way that it operates fully automatically without interventions from the Control Centre. The Control Centre shall supervise the automatic operation and optimise the operation manually.

The work for all automatic processes shall be split on Programmable Logic Controls (PLC) and distributed I/O units for the communication with connected PLCs. The local data transmission between the single equipment / appliances (like PLCs, distributed I/O units, etc.) shall be realized by use of an optical fibre cable “tunnel-ring”. To this tunnel-ring every appliance for data transmission at the electrical rooms as well as tunnel Niches.

This modular architecture guarantees that the function of the whole system cannot be lost caused by a single defect unit and the supervision and control of the tunnel can be still done in an adequate way.

If an error occurs in one PLC or I/O unit, the operation of all other PLCs and I/O units must not be influenced by the localized fault.

If an error (wherever) in a communication service appears while the communication service cannot be done on a redundant way (for example if the optical fibre cables of the tunnel-ring are damaged due to construction works), the various controls on both sides shall continue their operation as standalone controls automatically.

2.0 GENERAL CONDITIONS

2.1 General Information

These specifications shall be regarded as general specifications describing the required material, equipment, labour, etc. for the required installation such as Lighting, Ventilation, fire fighting etc.

The contractor shall check the accordance of the offered material, equipment, etc. with the requirements and standards presented in these specifications.

The contractor shall make the shop drawings according to the offered material, equipment, labour, etc. where the actual values such as cable diameters, voltage drop, power, etc. shall be shown with the actually used material.

Therefore, the contractor shall send detailed information of the used material (such as catalogues, instruction manuals, data sheets, etc.) to the Independent Engineer for his approval.

All systems and products, which were offered by the tenderer, must be available in India.

2.2 Scope of works

- 33kV System
- 11kV system
- 433/250 V – 50 Hz Power Supply
- Emergency Power Supply
- Earthing and Potential Equalization
- Tunnel Lighting
- Tunnel Fittings
- Fire Detection
- Telecontrol System / SCADA

2.3 Technical Conditions

2.3.1 Quality of Material and Workmanship

All goods, materials, plant and equipment incorporated in the permanent contract works shall be of approved reliability, well established design, of best quality of their respective kinds and shall comply with all relevant standards as given in this specification.

All plant and equipment shall be properly finished for the ambient conditions and circumstances of use.

The appropriate site conditions are between 15 °C and 35 °C, 55 % to 85% relative humidity.

All equipment shall be to the approval of the engineer; the contractor shall be responsible for any delays, caused by the submission of unacceptable materials in connection with such approvals.

Wherever different materials are used, attention shall be paid to the electrochemical reactions (electrolytic corrosion) of these different materials (e.g. copper / steel, aluminium /steel and so on). However, suitable steps shall prevent any of these electrochemical reactions.

"Stainless steel " shall be 316 S 11 or 320 S 31 according BS.

Galvanized steel shall be used only when definitely specified. "Galvanized steel" always is hot dip galvanized steel with zinc cover according to BS EN ISO 1461.

2.3.2 Paint

The colour of the coat shall be to the decision of the engineer using standard RAL-colours without change in costs.

Primary treatment of the metal:

The surface of the metal shall be treated according to BS EN ISO 12944-4 (for steel the rust shall be removed).

Painting layer:

2 layer of primer, each of about 40 micron thickness 2 layer of paint, each of about 60 micron thickness. The total thickness of the layers shall be about 200 micron

Quality of paint:

The paint shall be of two component type with high latticed polymerisation and low capillary development, adequate for tunnel atmosphere, resistant against salt water, high resistant against ultra violet light, resistant against oil, acid and leach, insensitive against fat and free from heavy metal.

The temperature demand is from 0 °C to 120 °C.

2.3.3 Submittals

Working detail drawings and descriptions of materials and equipment shall be submitted and shall include sizes, details and arrangements of numbers, method of assembly and testing, lists of materials and such other data as required permitting to the engineer to check the adequacy of the proposed installation.

2.3.4 Lightning Protection

The contractor shall take all the necessary and adequate precautions against influences and damages, which may occur due to lightning strikes in the region on all of the electrical equipment.

All low voltage and communication metallic cables entering the Service Buildings, electrical rooms or the Control Centre shall be protected against over voltages with special surge arrestor banks for control cables.

The contractor shall provide all measures of lighting protection and shall obtain the approval of the engineer and the employer.

2.3.5 Ground and Bonding

All exposed metal work and metal which is not current-carrying part of the electrical circuitry, including equipment enclosures, panels and supports shall be bonded together and to ground. Substantial non-ferrous ground lugs or studs shall be fitted for bonding cable shields or other adjacent equipment.

Where sections of distribution cabinets / panels shall be placed together to form a composite unit, a bonding strip shall be provided through the intermediate sections to provide a complete bonding between all sections.

The connections of grounding and bonding shall be stud- or clamp- type.

These requirements shall apply irrespective of the operating voltage and purpose of the equipment.

All required suppression chokes / filters shall be included and shall be capable of withstanding fault conditions. All cable shields shall be bonded together and shall be connected to the ground electrode. Particular attention shall be paid to the correct bonding and grounding of single core cable shields.

The earthing bus bar for the Electromechanical Installations shall be permanently connected to the main

earthing bus bar.

2.3.6 Standards and Regulations

Standards and regulations of the following organizations shall be applied for the completion of the works wherever applicable:

2.3.7 Indian Standards

Table 1: Indian Standards

Standard	Title
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers
IS/IEC 60947-3	Low voltage switchgear and control gear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS/IEC 60947-3	Low voltage switchgear and control gear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS 3427-1997	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IS 5082	Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS 1897	Copper strip for electrical purposes - Specification
IS 8084	Interconnecting bus bars for ac voltage above 1 kV up to and including 36 kV
IS 5578	Guide for marking of insulated conductors
IS 11353	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS 2705 PART1	Current transformers: Part 1 General requirements
IS 2705 PART2	Current transformers: Part 2 Measuring current transformers
IS 2705 PART3	Current transformers: Part 3 Protective current transformers
IS 2705 PART4	Current transformers: Part 4 Protective current transformers for special purpose applications
IS 3156 PART 1	Voltage transformers: Part 1 General requirements
IS 3156 PART 2	Voltage transformers: Part 2 Measuring voltage transformers
IS 3156 PART 3	Voltage transformers: Part 3 Protective voltage transformers
IS 3156 PART 4	Voltage transformers: Part 4 Capacitor voltage transformers
IS 1248 PART 1	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part : 1 General Requirements
IS 1248 PART 2	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 2 : Ammeters and Voltmeters
IS 1248 PART 3	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 3 : Wattmeter's and Varmeter's
IS 1248 PART 4	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 4 : Frequency Meters
IS 1248 PART 5	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 5 : Phase Meters, Power Factor Meters and Synchroscopes
IS 1248 PART 6	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 6 : Ohmmeters (Impedance Meters) and Conductance Meters
IS 1248 PART 7	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 7 : Multi-Function Instruments
IS 1248 PART 8	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 8 : Accessories
IS 1248 PART 9	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 9 : Test Methods
IS 1651-1991	Stationary cells and batteries, lead-acid type (with tubular positive plates)
IS 13010-	ac Watt hour Meters, Class 0.5, 1 and 2 - Specification

Standard	Title
IS 13779	ac Static Watt hour Meters, Class 1 and 2 - Specification
IS 8530	Maximum demand indicators (class 1)
IS 14415	Volt-Ampere hour meters for restricted power factor range - specification [superseding IS:722 (Part 5):1980
IS 14372	Volt-ampere hour meters for full power factor range [superseding IS:722(Part 7/Sections 1, 2 and 3)-1987]
IS 1554 PART 1	PVC insulated (heavy duty) electric cables: Part 1 For working voltages up to and including 1 100 V
IS 1885 : Part 32	Electro technical Vocabulary: Part 32 Electric cables
IS 8130	Conductors for insulated electric cables and flexible cords
IS 8130	Conductors for insulated electric cables and flexible cords
IS 2961	Chrome retan finished upper leather
IS 5819	Recommended Short-circuit Ratings of High Voltage PVC Cables
IS 5831	PVC insulation and sheath of electric cables
IS 694	PVC Insulated cables for working voltages up to and including 1100 V
IS 7098 PART 1	Cross linked polyethylene insulated PVC sheathed cables: Part 1 For working voltage up to and including 1 100 V
IS 7098 PART 2	Cross linked polyethylene insulated PVC sheathed cables: Part 2 For working voltages from 3.3 kV up to and including 33 kV
IS/IEC 60947-1	Low-voltage switchgear and control gear :Part 1 General rules
IS/IEC 60947-2	Low-Voltage Switchgear and Control gear - Part 2 : Circuit Breakers
IS/IEC 60898- IS 8828	Electrical accessories - Circuit-breakers for over current protection for household and similar installations : Part 1 Circuit-breakers for ac operation
IS 2062	Hot Rolled low, medium and high tensile structural steel
IS 1180 PART 1	Outdoor type three-phase distribution transformers up to and including 100 kVA 11 kV: Part 1 Non-sealed type
IS 1180 PART 2	Outdoor type three-phase distribution transformers up to and including 100 kVA 11 kV: Part 2 Sealed type
IS 1370	Transmission belting - Friction surface rubber belting - Specification
IS 13703 PART 1	LV Fuses for voltages not exceeding 1000 V ac or 1500 V dc: Part 1 General requirements
IS 13703 PART 4	Specification for Low-Voltage Fuses for Voltages not Exceeding 1000 V AC or 1500 V DC - Part 4 : Supplementary Requirements for Fuse Links for the Protection of Semiconductor Devices
IS/IEC 60947-1	Low-voltage switchgear and control gear :Part 1 General rules
IS/IEC 60947-3	Low voltage switchgear and control gear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS 13947 PART 4/SEC 1	Specification for Low-Voltage Switchgear and Control gear - Part 4 : Contractors and Motor-Starters - Section 1 : Electromechanical Contactors and Motor Starters
IS 2086	Carriers and bases used in rewirable type electric fuses for voltages up to 650V
IS 10027	Composite Units of Air-break Switches and Rewirable Type Fuses for Voltages Not Exceeding 650 V a.c. - Specification
IS 12640 PART 1	Residual Current Operated Circuit - Breakers for Household and Similar Uses: Part 1 Circuit-Breakers Without Integral Over current Protection (RCCBs)
IS 12640 PART 2	Residual Current Operaed Circuit - Breaking for Household and Similar Uses - Part 2 Circuit - Breakers with Integral Over current Protection (RCVOs)
IS 2075	Ready Mixed Paint, Stoving, Red Oxide Zinc Chrome, Priming - Specification
IS 8623 PART 1	Specification for Low-Voltage Switchgear and Control gear Assemblies - Part 1 : Requirements for Type-Tested and Partially Type-Tested Assemblies
IS 8623 PART 2	Specification for Low-voltage Switchgear and Control gear Assemblies - Part 2 : Particular Requirements for Busbar Trunking Systems (Bus way)
IS 8623 PART 3	Specification for Low-Voltage Switchgear and Control gear Assemblies - Part 3 : Particular Requirements for Equipment Where Unskilled Persons have Access for Their Use

Standard	Title
IS 9920 PART 1	High Voltage Switches - Part 1 : Switches for Rated Voltages Above 1 kV and Less Than 52 Kv
IS 9920 PART 3	Specification for Alternating Current Switches for Voltages Above 1 000 V - Part III : Design and Construction
IS 9920 PART 4	Specification for Alternating Current Switches for Voltages Above 1000 V - Part 4 : Type Tests and Routine Tests
IS 13947 PART 5/SEC 1	Low-Voltage Switchgear and Control gear - Specification - Part 5 : Control Circuit Devices and Switching Elements - Section 1 : Electromechanical Control Circuit Devices
IS 2675	Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000 V Ac and 1200 V Dc
IS 8084	Interconnecting bus bars for ac voltage above 1 kV up to and including 36 kV
IS 5561	Specification for Electric Power Connectors
IS 9921 PART 1	Specification for Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 V - Part I : General and Definitions
IS 9921 PART 2	Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 V: Part 2 Rating
IS 9921 PART 3	Specification for Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1000 V - Part III : Design and Construction
IS 9921 PART 4	Specification for Alternating Current Disconnectors (isolators) and Earthing Switches for Voltages Above 1000 V - Part 4 : Type Tests and Routine Tests
IS 9921 PART 5	Specification for Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 V - Part 5 : Information to be Given with Tenders, Enquiries and Orders
IS 15086 : Part 1	Surge Arresters - Part 1 : Non-Linear Resistor Type Gapped Surge Arresters for a.c. Systems
IS 3070 PART 3	Lightning Arresters for Alternating Current Systems - Specification - Part 3 : Metal Oxide Lightning Arresters Without Gaps
IS 9385 PART 1	High voltage fuses: Part 1 Current limiting fuses
IS 9385 PART 2	High voltage fuses: Part 2 Expulsion and similar fuses
IS 9385 PART 3	High voltage fuses: Part 3 Application guide for high voltage fuses
IS 9385 PART 3	High voltage fuses: Part 4 Determination of short-circuit power factor for testing of high voltage fuses
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers
IS 12729	Common Specification for High-Voltage Switchgear and Control gear Standards
IS 8187	D-type fuses
IS 7567	Automatic circuit reclosers
IS/IEC 60947-1	Low-voltage switchgear and control gear :Part 1 General rules
IS/IEC 60947-2	Low-Voltage Switchgear and Control gear - Part 2 : Circuit Breakers
IS 3427	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IS 3156 PART 1	Voltage transformers: Part 1 General requirements
IS 3156 PART 2	Voltage transformers: Part 2 Measuring voltage transformers
IS 6046	Specification for Gypsum for Agricultural Use
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers

2.3.8 International Standards

BSBritish Standards

ENEuropean Standards

IECInternational Electrotechnical Commission

IEEInstitution of Electrical Engineers

CISPRInternational Special Committee on Radio Interference CENELEC Comité Européan de

Normalisation Elektrotechnique

ITU-RComité Consultatif International des Radio communications ITU-T Comité Consultatif International Télégraphique et Téléphonique

Unless another standard is specifically mentioned in these specifications, all materials used and provided under the contract and all equipment, calculations and tests shall be in accordance with the standards mentioned before or in accordance with such authorities' standards appropriate to the country of manufacture as in the opinion of the engineer to ensure an equivalent or higher quality.

If the contractor offers materials, equipment, calculations, or tests which conform to standards other than the standards mentioned before, full details of differences between the proposed standard and the before said standards, as far as they affect the design or performance of the equipment, shall be submitted.

The works and all plant, equipment and materials forming part of these specifications shall comply (in all respects) with the rules and regulations of the supply authority and any other authorities having jurisdiction over any part of the work and on the method of performing such work.

2.3.9 Tests

2.3.9.1 General

Tests shall be generally divided into three sections:

- Factory Acceptance Tests (F.A.T) shall be carried out before the delivery of the plant / equipment
- Site Acceptance Tests (S.A.T.) shall be carried out after the plant / equipment is delivered and installed on site
- Tests on completion

The contractor shall submit catalogues of all equipment as well as a list of the tests proposed for all equipment. A general overview of each of the proposed tests shall be included in these documents. Any of these pre-given descriptions or documents shall not limit in any way the contractor's obligations to complete each and every test as specified and necessary to demonstrate the satisfactory performance of the system.

The schedules of each test, as well as the test procedures itself shall be prepared, based on the detailed description of the test previously submitted in accordance with the final system proposal and as approved by the engineer. No deviations are allowed without prior approval by the engineer.

The contractor shall submit for the engineer's approval all detailed test procedures and final schedules for the tests at least eight weeks prior to the scheduled commencement of the Factory Acceptance Tests.

Prior to this time the draft procedures shall be submitted and agreed by the engineer. The contractor shall indicate when these draft procedures shall be submitted.

In case of a defect being detected during one of the tests, the nature of the defect shall be explained in detail to the engineer. Based upon this information, the engineer shall decide, whether the defect is a minor fault or whether it must be corrected before testing can continue.

Minor faults are defects, which are found during testing, and which do not adversely affect the operation of the system in a broad sense and thus don't need be rectified / corrected before a test can be continued and successfully completed. If the defect is not a minor fault, the engineer shall decide which section of the test (or tests) must be repeated. The engineer shall have the right to require all tests to be repeated, if he decides that the defect has wider consequences.

All costs involved in any retesting shall be at the expense of the contractor including supervisory and employer's costs.

The engineer or his appointed representative shall have unrestricted access to the contractor's and supplier's premises for purposes of inspection and tests at all times and the contractor shall specify this requirement when placing all orders.

All relevant expenses (i.e. transportation, accommodation) of those who supervise the subject's tests and inspections (engineer and at least one additional representative of the employer) shall be at the expense of the contractor.

2.3.9.2 Factory Acceptance Tests (F.A.T)

Factory Acceptance Tests are divided into three parts:

- Environmental tests
- Technical tests
- System tests

Factory acceptance tests shall be conducted under the supervision of the employer and the engineer. The contractor shall group tests to minimize travel expenses if the engineer and / or the employer attends the tests.

After completion of the tests the results, certified by the employer or the engineer's representative, if present in any of such tests, shall be forwarded to the engineer. When the engineer has received the results and states that the plant / equipment has passed the tests, he will write to the contractor to inform him, and the contractor then may ship the plant.

If the engineer deems that the plant / equipment is not in accordance with the specifications, he may reject the plant / equipment and shall inform the contractor of the reasons in a writing within a reasonable time limit.

The engineer shall also inform the contractor in a writing if any minor faults are detected and which of these minor faults shall be corrected before shipment.

2.3.9.3 Site Acceptance Tests (S.A.T)

If each section of plant is installed, commissioning tests for each section shall be carried out on site.

At least six weeks in advance of any particular site testing, the contractor shall submit details of tests and details for the test equipment he proposes to use for that testing to the engineer for his approval.

As installation proceeds, the insulation resistance of cables shall be checked and recorded. The identification of the cores shall be confirmed from end to end of each cable end, in the case of communication-, alarm- and control-cabling, from end to end of each circuit. Tests on cables shall be completed and accepted by the engineer before the testing of the associated equipment starts.

All tests for statutory requirements and insurances including arrangements for such tests, inspections by authorized bodies, persons or insurers, as necessary and the provision of certificates in the prescribed and approved forms necessary to enable plant and equipment to be put into service, shall be made by the contractor.

On-site commissioning tests being subject of acceptance by the engineer shall include:

a) All equipment, cabling, distribution etc. is electrically and mechanically safe

b) All interlocks, isolators and door and cover securing mechanisms shall be properly fitted and adjusted.

c) All exposed metal work is properly bonded and grounded and that all connections and points required to be grounded for a safe and satisfactory operation shall be properly grounded in accordance with the manufacturer's requirements.

d) All cables, cores and terminations shall be secure, properly fitted and correctly identified and coloured.

e) All phases, polarities, neutral and common connections shall be correctly switched / connected as required, so that the power is correctly available at all points and that the voltage and frequency at all equipment is correct and in accordance with the requirements for correct work

f) All supplies shall be properly fused or otherwise protected, to give successfully discrimination and safe disconnection under fault conditions.

g) All contacts shall be properly aligned / adjusted and not subject to excessive wear or corrosion.

h) Batteries shall be correctly installed, connected and fitted and checked that the battery chargers are working correctly.

i) The insulation-resistance of all cabling and equipment shall not be less than specified.

j) All instruments and meters shall be energized with correct polarity and working properly.

k) All fault indications and alarms shall be working correctly.

l) In addition to all operational tests, required for a successful hand-over, the operation of all interlocks, sequences and protections which are not utilized in normal operations shall be subject of acceptance by the engineer.

The on-site commissioning tests shall be conducted under the supervision of the engineer.

The final acceptance tests shall begin after all on-site commissioning tests have been successfully completed and all defects detected during those tests have been rectified / corrected, which is accepted by the engineer. The tests shall include full operation tests on the works as a whole and selected technical tests on some or all of the equipment.

On completion of the site acceptance tests, the contractor shall forward the test results certified by him to the engineer. When the engineer has received the results and deems that the plant has successfully passed the tests, he will write to the contractor to that effect.

During the site acceptance tests the engineer shall inform the contractor of minor faults detected and which of these minor faults shall be corrected before the beginning of the tests on completion.

2.3.9.4 Tests on Completion

The contractor shall notify the engineer when the tests on completion shall be made. All minor faults detected during the previous tests shall be corrected to the satisfaction of the engineer prior to the start of the tests on completion.

The system shall be fully operational and shall operate successfully. During these periods, the whole system shall be available to the engineer.

Fire Test

To get an evidence of fully functional and right working tunnel ventilation in case of fire, in the tunnel a hot fire test shall be made.

This fire test shall be made during the testing time of the contractor in cooperation with the fire brigade, the employer, and the designer of the tunnel ventilation system.

The place(s) of the fire test shall be in agreement with the fire brigade and the employer (the test shall be made at the most unfavourable place for the tunnel ventilation).

The aim of the test is to:

- Prove the functionality of tunnel ventilation in case of fire
- Discover the exhaust capacity of the ventilation system
- Prove the different driving-programs of the ventilation system in case of fire and adapting / changing these programs, if the fire test results new cognitions.

These data shall be acquired:

- Air velocity in the tunnel (value and direction): before and during the test
- Controlling of the tunnel ventilation
- The rising temperature along the tunnel (in the area of the test)
- Video recording with the CCTV cameras in the tunnel
- Recording of all alarms and messages during the test

Additionally, these data shall be acquired: (therefor necessary equipment shall be included in this item)

- Detection of the spread of the fire and of the layering of the fume with two cameras (in each direction next to the testing place with one camera)
- Air velocity In each direction, approx. 50 m next to the testing place, the air velocity shall be measured with 3 anemometers; furthermore the air velocity also shall be recorded by a data logger as function over the time.

The progress, as well as all results of the fire test shall be documented. The protocol shall be handed over to the employer. The video recordings shall be handed over in mpeg-format.

2.3.10 Trial Operation

The trial operation shall occur with full responsibility of the contractor. The trial operation shall take place after finishing the tests on completion. For starting the trial operation, it is required, that all tests on completion are finished positive for the entire installation and shall occur within 21 days.

The trial operation shall show the evidence of a fully functional operation of the tunnel and that security is given during operation. Therefore, the trial operation shall occur without significant malfunctions.

The contractor shall test different operation cases during the trial operation (e.g. loss of different equipment etc.).

The contractor shall make organizational measurements during the trial operation, so that malfunctions can be rectified as soon as possibly (within max. 2 days).

The results of the different tests during trial operation shall be shown in a protocol. This protocol shall be signed by the contractor and the employer. If the protocol shows, that all contractual conditions are kept, the tunnel shall be taken over by the employer.

2.3.11 Staff Training

During the contract period, the contractor shall provide training manuals, as well as on-site training and training courses to ensure that the employer's staff associated with this project may

acquire full knowledge and appreciation / understanding of all aspects of the design, day to day operation, breakdown and routine maintenance and fault diagnosis of the power supply, the surveillance

and control equipment as well as the belonging hard- and software.

The contractor shall train the employer's personnel about all equipment in theoretical and practical way. Also the maintenance shall be trained.

The employer will nominate members of his staff, who are attending the training courses.

The contractor shall nominate qualified instructors. It shall be essential that prior approval of the engineer is obtained for the instructor and the instructor's qualifications in each case.

The contractor shall provide all relevant and necessary facilities which are needed for complete and effective staff training (such as video, TV, slide- and film-projectors and others).

The contractor shall provide all facilities including accommodation, transport and catering of all trainees.

Within two months after the signing of the contract, the contractor shall submit a detailed syllabus for the training courses for approval by the engineer.

2.3.12 Documentation

2.3.12.1 Stages of Documentation

- **Staff Training**

  - Project for execution
  - As-built documentation
  - Manuals for operation and maintenance

Final system manuals and instructions for operation and maintenance respectively compound project of executed works.

2.3.12.2 Project for Execution

- **Final System Proposal**

  The purpose for the final system proposal shall be to form a complete basis on which detailed work can proceed. Without the specific written approval by the engineer, the contractor shall not place any equipment on order or begin with the manufacture of any plant/equipment until the engineer has approved the final system proposal.

  The final system proposal shall be submitted for the approval of the Engineer.

  This final system proposal phase shall include specifications of:

  - All low-voltage power supply
  - ll emergency power supply
  - All earthing and potential equalization
  - All lighting
  - All tunnel fittings
  - All ventilation equipment
  - All fire detection system
  - All SCADA system
  - Acceptance testing

- Documentation of organisation
- Data and communication equipment

➢ **Software Final System Proposal**

The software final system proposal shall contain flow charts and descriptions of the whole software structure explaining the operation and interaction of the various programs. All operation functions and interfaces to be provided in each central and local system(s) shall be specified. The interfaces between single programs and data structures shall be designed. Critical timings shall be evaluated and displayed.

The document shall concentrate on producing and describing an adequate overall system design with unified systems of data modification, etc.

If standard programs are used, the detailed documentation for each program shall be provided. This shall include a functional description of the program(s), with flow charts, table structures, interfaces, definitions, timings, storage, and the source listings etc.

For off-the-shelf software packages, which shall be part of the completed application software, off-the-shelf software package's detailed documentation shall be supplied.

Control software shall support the operator with online help.

➢ **Hardware Final System Proposal**

The hardware final system proposal shall be written in conjunction with the standard items for the component processor and associated peripherals. If any of the hardware shall be designed or modified for this specification, the specified technical details shall be defined. The proposal shall include a detailed description of the processor system, the method of connection of the peripherals and the transfer of information, including the data transmission system. A full breakdown of the equipment shall be prevented with physical layout, interconnections, and power supply arrangements.

2.3.13 Acceptance Testing

All test specifications, schedules for acceptance tests to be performed at the various stages shall be finalised during the final system proposal stage. These shall form the basis on which detailed test procedures can be written.

- Hardware tests:

All hardware test schedules shall be defined. This definition shall include reviews and modifications from the contractor's standard factory tests if required. A review of the standard diagnostics shall be undertaken.

- Software and system tests:

This shall include all acceptance tests to be performed on the individual programs and the complete system. Detailed test specifications, schedules for all tests described elsewhere in these specifications and any other tests as necessary for demonstration of the performance, correct operation of the system, etc. shall be provided. The sequence of tests and the grouping of equipment for each test shall also be defined.

2.3.14 Manuals for Operation and Maintenance

In order to maintain the liaison between the contractor's organisation and the engineer, documentation concerning each part of the specifications shall be produced as part of each component job / work, in

such a form which can be issued immediately.

The contractor shall propose a modular system of build-up of this information.

Sections issued during the contract shall be regarded as a draft form, as subsequent jobs shall inevitably interact and require modification, documentation is vital even if several re-issues are necessary.

The contractor's proposal shall include provision for resources to produce the documentation throughout the contract.

Effort shall be given on recording and familiarity with the presentation of information maintained, by writing documentation issued during the contract in a form suitable for inclusion in the relevant final manuals.

A copied set of the standard, proprietary documentation of all the equipment supplied under this contract shall be provided within the first five months of the contract. It shall be acceptable if such standard documentation is submitted as part of the documentation forming the final system proposal. But finally, a number of at least 5 pieces of copied sets shall be handed over to the employer.

2.3.15 Final Documentation – System Manuals

The final documentation shall consist of the following parts:

- Software manual
- Programming manual
- Hardware, maintenance and servicing manuals, including all equipment
- Tunnel operators manual

Where appropriate, standard documentation and project documentation submitted during the contract shall be included in the final system manuals.

Not less than six weeks before the commencement of the site acceptance tests, three draft issues of the final system manuals shall be submitted to the engineer for information and approval. This draft issue shall have the same number of parts and format as the final system manual. Re- issues shall be provided if site commissioning and tests make this necessary.

When approved, one copy of the draft documentation, amended as required, shall be returned to the contractor.

Six complete sets of the final system manuals together with six copies of complete subject index shall be supplied before the issue of the taking over certificate (acceptance certificate).

2.3.16 Software Manual

The software manual shall be project oriented.

The software manual shall include the system's programs and the system's data records. A standard detailed programming assistance shall be left to the programming manual.

The information shall follow the specification of the final system proposals.

The manual shall explain the overall software structure with flow charts and descriptions, with particular attention to the points at which further user programs can be interfaces. It shall be essential that the complete operating structure is explained in such a way that it may be clearly understood, especially by any competent programmer who wishes to specify or interface a new program into the system. Each program shall have a general description with a related flow chart.

In the overall description, the allocation of the addressable storage of the component's jobs shall be

listed, with limits of spare capacity. A detailed description of each component's job in the operating system shall follow, including the executive-, handler- and user-programs (the newest version and inclusive updates).

The format of all data structures shall be described as a second part to the manual. The data records of diagram formats, variables etc., shall be listed in a form compatible with the data updating system.

Source listings for all software supplied, including standard and application program libraries, shall form part of this manual, except for off-the-shelf software packages for which only a right of use can be purchased.

2.3.17 Hardware, Maintenance and Servicing Manual

The manual shall contain a description of the complete hardware system followed by maintenance procedures. The maintenance procedure for tunnel shall contain that in case of maintenance or accidence, the tunnel management shall be done manually by the maintenance people at the Control Centre. For standard equipment, proprietary documentation shall be included.

The hardware description shall start with the overall configuration of the system, with layouts showing the location of every unit, with block diagrams and explanation of the operation.

Detailed descriptions of component units shall explain their operation. Block diagrams (showing the flow and interaction of data), logic diagrams, circuit diagrams (with component values) and layout diagrams including cabling diagrams (showing the interconnection between equipment) shall be provided. Part- and cable-lists shall be provided, but care shall be taken to avoid these obscuring the operational description. Maintenance procedures shall cover the diagnosis of faults, testing and set-up adjustments, replacement of units, routine mechanical servicing and operation of test equipment.

The use of test programs shall be explained with step-by-step instructions. The detailed listing of the programs itself shall be provided separately.

Step-by-step-description for the replacement of plug-in units of the computer system shall be given, with set-up values and checking of power supply voltages etc. where appropriate. Routine mechanical servicing shall be covered.

Sections on the following equipment shall be bound in separate volumes, as indicated below, for easier of use by the maintenance personnel:

- All Low-Voltage Power Supply
- All Lighting
- All Ventilation Equipment
- All Air Control System and Ventilation Control System
- All Fire Detection System
- All SCADA System
- All Room Ventilation and Climate Conditioning
- Control Centre

2.3.18 Tunnel Operator's Manual

This manual shall be written specially for use by the tunnel operators at the Control Centre. It shall consist of specific sets of procedures and instructions necessary for effective operation of the system.

The manual for the Control Centre shall include:

- Step by step instruction for fault conditions, fire alarm and all other alarm conditions
- Step by step instruction on use of all console equipment The manual shall be suitable for continuous usage.

2.3.19 Presentation of Documentation

All documentation shall be in English language.

All documentation shall carry a unique issue number and date.

All documentation shall be indexed, with a complete subject index in the final issue.

All documentation shall be produced in a uniform format in compliance with the employer's requirements. All diagrams relating to the final documentation shall be reduced to page height, bound and correctly referenced to the text.

The final documentation shall be delivered in durable hard cover-bindings. The bindings shall be in a loose-leaf form (ring-binders) and permit easy interchange or replacement of pages. Each ring binder shall be identified by an easily readable title applied / attached to both, the front face and the spine of the ring-binder.

Seven copies of each document shall be provided.

2.3.20 Contractor's Drawings

The contractor shall submit drawings in such a form as the engineer will require them for approval, copies as required of all drawings, diagrams and details of all equipment in part or in whole. The contractor shall make any drawings available to the engineer at all reasonable times. Wiring diagrams and other drawings as the engineer deems shall not be finally settled until satisfactory installation and testing has been made, this shall be approved in principle.

The contractor shall submit a schematic block diagram of the equipment showing the manner, in which the functional requirements of this specification shall work together.

Before the contractor begins installing of his parts of the contracts, the contractor himself shall check all civil works ensuring all equipment can be installed.

Within one month after the signing of the contract, the contractor shall submit a schedule including details of numbering, categories and drawing registers / indexes for the production, submission and approval during the period of the contract of drawings and also of any information, required for the engineer in connection with the design of the contract works.

This schedule shall be suited to the requirements of manufacture, delivery and installation of the contract works to meet the requirements of the contract and shall allow reasonable time (approx. 8 weeks) for study and approval by the engineer of all drawings, calculations and graphics submitted (and, as necessary, resubmitted) by the contractor.

No approval by the engineer of any drawing shall relieve the contractor of any of his obligations of liabilities under the contract or of his responsibility for ensuring that the work is satisfactory done and that all operational requirements shall be met.

The contractor shall provide drawings without undue delay, and in any case within twelve weeks of the award of the contract, these drawings shall include dimensions of equipment to be located in equipment rooms and details of cable routes and recesses / outlets, entry of equipment to cabinets, etc.

2.3.21 As -Built Drawings

Preparation of the as-built drawings shall be part of these specifications. As-built drawings will be

revised final design drawings of the project showing the actual work done.

The contractor shall provide the as-built drawings in one original and one reproducible negative produced from the original, with the names of the signature authorities of the employer, the engineer and the contractor. After they are signed for approval, five prints shall be taken from the signed original of each drawing. Also DVDs with all as-built drawings shall be handed to the employer.

Together with the as-built drawings, the contractor shall provide six sets of reduced size (e.g. A3 size) booklets of the as-built drawings. All details, dimensions, texts, etc., on the reduced size drawings shall be clearly recognizable and readable.

The contractor shall complete and obtain the engineer's approval on the as-built drawings and make the final submission of the as-built drawings together with the A3 size booklets latest within three months following the date of the Certificate of Completion.

All costs associated with the provisions mentioned above shall be deemed to be included in the contract price.

As-built drawings shall cover in general:

- For mechanical equipment:
- Construction drawings,
- Instruction drawings,
- Functional block diagrams
- For electrical installation:
- Installation drawings with circuit numbers and exact type-assignation of all installed equipment,
- Distribution diagrams with circuit numbers,
- Fault analysis and protection co-ordination settings the of protection system,
- Power consumption,
- Precise type numbering
- Earthing systems
- For distribution cabinets:
- Construction drawings,
- Circuit drawings as operating diagrams,
- Additional current flow-charts where required,
- Accurate lists of any installed equipment with precise description of this equipment,
- Adjustment tolerances of circuit-breakers, switches, etc.

For equipment:

- Construction drawings,
- Circuit diagrams,
- Functional block diagrams,
- List of quantities
- For cabling:

- Diagrams with dimensions, type of cables and power requirements with regular cross- section area and measured cable values shall be used for these diagrams.

3.0 TECHNICAL SPECIFICATIONS

3.1 33 KV SYSTEM

3.1.1 General

33 KV GIS substations shall be constructed at the tunnel portal by client. 33 KV cables will terminate at 33 / 11 KV grid substation. The 33kV switchgears assembly having CTs, PTs, Isolators, and circuit breakers shall be kept indoors.

The assembly shall have the following configuration:

- 2 nos. incomers for 33 KV cables from SEB
- 1 no Bus coupler
- 2 nos. outgoings for 33/11 KV transformers

33 KV switchgear panel shall be 3 phase combined & single bus type. CT ratio shall be X/1 amp and PT shall be 33000/√3 Volt / 110/√3 Volt. All the panels shall be operated and monitored through SCADA. Substation shall be capable to be controlled locally as well as from remote.

33 KV panels shall be controlled by 24-volt DC, by lead acid battery. The batteries shall be charged with an independent charger.

There is one no. 33/ 11 kV grid substation at each portal end of North-south corridor.

3.1.2 Scope of work

The high voltage supply system shall include the delivery, installation, required works, tests and all necessary equipment for the following materials:

- 33 kV Switchgear (panels / cubicles)
- 33 kV cables
- Protection System
- Transformers
- Accessories
- Potential equalization connection
- Wiring – Signalling for 33Kv

3.1.3 Technical Specification -33kv Gas Insulated Switchgear

The insulated, medium voltage switch gears shall be designed to equip indoor HV/MV, MV/MV or MV/LV Substations. The switchgear shall meet the criteria for indoor metal enclosed metallic partitioning, LSC2 accessibility GIS switchgear and control-gear for rated voltages above 1kV and up to and including 52kV, in compliance with the IEC 62271-200. In principle, the arrangement shall follow the latest modern engineering practice, to ensure optimum continuity and reliability of supply, as well as the safety of the operating staff. Design shall consider minimum space requirements, no maintenance in medium voltage part and minimized maintenance in the mechanisms. The switchgear shall be of modular design and minimized dimension gas insulated type (SF6).

The switchgear shall be designed for continuous operation under all system operating conditions

including sudden change of load and voltage and short circuits within its ratings. The equipment shall be designed to withstand normal operating voltage even if the isolating gas pressure decreases to atmospheric pressure. All switchgears and material provided with them shall be the standard products of the manufacturer, which are regularly designed, manufactured, tested and serviced for at least 15 years.

3.1.4 System Parameters

Table 2: System Parameters

Rated Voltage (System Highest Voltage)	36kV
Rated Power frequency withstand voltage	70kV
Rated lightning impulse withstand voltage	170kV
Frequency	50Hz
No. of phases	3
System fault current (Sym.)	25 KA for 3 sec.

3.1.5 Service Conditions

Switchgear shall meet the operating conditions, for indoor applications, according to the IEC 62271-1 standard where the environment:

- Minimum temperature::15ºC
- Maximum temperature::35ºC
- Altitude::upto 900 m
- Maximum relative humidity:55 to 85%

3.1.6 Compartment Arrangement, Functional Units

The switchgear shall be single busbar system. Each cubicle shall have the next compartments:

General Busbar compartment - tool accessible – touch proof solid insulated System (screened and earthed) containing:

- Main busbar, segregated phases
- Bus Mounted CT-s if applicable
- Bus Mounted VT-s if applicable
- Three position Disconnector (Closed-Open-Ready to earth)

CB compartment - non withdrawable and accessible - SF6 Gas Insulated Containing:

- Vacuum Circuit Breaker
- Three position Disconnector (Closed-Open-Ready to earth)
- MV Cable connection bushings

MV cable compartment - interlock accessible - in Air

- MV cables connection points
- Cable Side CT-s if applicable
- Line VTs as per as per IEC 62271-200- if applicable

3.1.7 MV Compartment

The switchgear shall be modular type. The Loss of Service Continuity class (LSC) shall be 2A (LSC2A) for all functional units. Gas insulated compartments must be segregated in each cubicle and from cubicle to cubicle by means of gas tight barriers. The busbar shall be insulated with single phase solid insulation, shielded and earthed through the entire switchboard making impossible any phase-to-phase fault and having the same advantages as the Gas insulated Busbars systems.

The general degree of protection must be IP-65 for all MV parts. All the cubicles must be factory filled and tested to assure a gas leakage of less than 0.1% per year, sealed FOR LIFE pressure system and guarantee no gas handling at a site during extension, removal and installation at site. SF6 gas used for insulation must comply with IEC 60376 / IS-13072-2013 and IEC 60480. The design of the switchgear shall be such as to enable extensions to be added at either right or left side, with the minimum of disturbance to the installed equipment. Every current-carrying part of the switchgear including Disconnector, Busbars, Connections and joints shall be capable of carrying its specified rated normal current continuously and in no part shall the temperature rise exceed the values specified in relevant IEC Standards.

Every part of the switchgear shall also withstand without mechanical or thermal damage the instantaneous peak currents and rated short-time currents pertaining to the rated breaking capacity of the switchgear.

3.1.8 Functional Type Requirement

Each functional unit shall contain all the elements needed to perform its function. Each functional unit shall be identified by a label which clearly indicates its functional and electrical characteristics.

The functional units shall be the following:

- Incoming / Outgoing feeder function.
- Bus-tie function (consisting of bus coupler and bus riser cubicles).
- Load Break Switch Disconnector cubicle.
- Busbar VT-s and CT-s will not need any specific cubicle and must be capable of being connected directly to the general busbar system.
- Load Break Switch Disconnector with associated fuses.

3.1.9 Construction/Architecture

Busbar Compartment

- Placed on the top part, inside the SF6 compartment.
- Containing main copper busbar system
- Containing also the 3 position Disconnector.
- Disconnector operating mechanism must be placed out of the SF6 gas atmosphere.

Circuit Breaker Compartment

- SF6 insulated compartment containing gas tight barriers.
- Containing also the 3 position Disconnector.
- Disconnector operating mechanism must be placed in the front of the switchgear and out of the SF6 gas atmosphere. Rear operation not acceptable.

- Containing Vacuum breaking technology CB.
- Placed on the middle side of the cubicle.
- CB operating mechanism must be placed in the front of the switchgear and out of the SF6 gas atmosphere. Rear operation not acceptable.
- Low voltage cables going through MV compartments are not acceptable.

Cables Connection

There is one type of cables connection for GIS switchgears:

- Outer cone bushings.
- Threaded connection. "C" type bushings according to EN 50181, IS2099, IS10314, IS-5621, IEC-60137 standard.

Cables Compartment

- Placed in the bottom rear part of the cubicle. Front access is a must with enough room for cable connection, rear access is not acceptable.
- Containing Connection points for the above mentioned cable connectors (refer to "CB compartment")
- Optionally it might contain ring type current transformers
- Optionally it might contain VT-s connected to the above mentioned outer cone type bushings.
- Containing also cable clamps and the earth connection for the cubicle enclosure.
- All MV components inside this compartment shall be insulated, shielded and this shield connected to earth.

3.1.10 LV Compartment

Placed in the top front part of the cubicle, front access complete front access to all elements permits the installation of the cubicles close to the rear wall. Each cubicle shall have four levelling bolts in order to provide accurate levelling during assembly. The switchgear shall be constructed of suitable material and thickness to withstand the mechanical and thermal stresses due to short circuits. For the rated duration of short circuit, reference shall be made to the design fundamentals and latest IEC recommendations.

Switchgear has to be internal arc withstand classified and the performance shall be as a minimum, IAC AFLR 25 kA as described in the IEC 62271–200 standard. The tanks containing all MV components and filled with SF6 gas shall be made stainless steel of least 2.5mm thick. All the accessible enclosure parts must be conveniently earthed to avoid any risk. All front and lateral panels shall be painted in textured RAL 9002. Rupture flaps shall be provided in main compartment to allow for pressure relief in a non-probable case of overpressure. Each switchgear bay shall be earthed through an appropriate copper earth bar, which is to run also along the full length of the switchgear with a minimum section of 200mm2.

Numerical Relay

Numerical relay shall be of modular type and have native IEC 61850 communication support for RTU/SCADA integration. Relay shall be with graphical LCD dot matrix display with single line diagram mimic with control, indication, programmable function key and LEDs.

Relay shall have minimum following protections 50/51, 50N/51N, 46, 86, 50ARC, 50NARC as native

function. Arc Flash protection shall be integral part of relay. Protection relay hardware, cables and separate arc sensors shall be included. Any arc flash fault in the cable compartment is selectively cleared by the feeder protection relay.

The relay should be with G3 conformal coating and suitable to work in Industrial corrosive environment and should have passed mixed gas test as per IEC 60068-2-60:1995, Part 2, Test, Method (Class 3). The test to include 21 days at 75% relative humidity or 5 days at 90% relative humidity and +30 deg C, exposure to elevated concentrations of H2S, NO2 and CI2.

3.1.11 Components

3.1.11.1 Circuit Breaker

Circuit breakers should be Vacuum type. They should be according to IEC 62271-100 standard. Rated operating sequence must be O-0.3Sec-CO-3Min-CO. Operating time for opening, breaking and closing, less than 100ms. Circuit breaker must be E2/M2/C2 type (electrical, mechanical endurance and capacitor breaking/making ability) according to relevant standard. Circuit breaker operating mechanism will be outside the SF6 tank, manually and electrically operated. Vacuum Interrupter shall be tested for min. 100 nos. of full short circuit operations at rated fault level. Vacuum interrupter must be GIS manufacturer's own make and should be type tested design. The operating mechanism should consist in the following items.

- Spring system that stores the necessary energy for opening and closing operation.
- Spring charging system (motor operated) that automatically recharges the springs after the main contacts of the CB have closed.
- Mechanical "charged-discharged" position indicator for CB opening and closing springs.
- Manually operated spring charging system (in case of lack of auxiliary power supply).
- Electrical system including:
  - Closing coil
  - Tripping coil
  - Anti-pumping relay
- Mechanical emergency trip pushbutton.
- Operation counter
- Spring charging indication contact.
- Mechanical indicator for Open / Closed position
- Minimum CB position auxiliary contacts

3.1.11.2 Disconnector

The Disconnector is a mechanical device which provides, in the open position, an isolating distance. The Disconnector is always operated with NO LOAD (zero current). The Disconnector will be placed between the CB and the busbar system in order to isolate the busbar system from the circuit side and earth the CB busbar terminals. The Disconnector shall be of three position types, Closed-Open-Ready to earth, in order to avoid the needs of interlocks between the busbar Disconnector and Earthing switch. Separated elements are not acceptable. The Earthing Disconnector will operate always de-energized and the making capacity is provided by the circuit-breaker, which is designed for these purposes.

The Disconnector must be according to the latest edition of the IEC 62271-102 and shall meet

requirements as specified RATINGS. The indication of the position of the Disconnector must be mechanical. This mechanical link must be kinematic chain tested. The Operating mechanism must be outside the SF6 atmosphere and accessible from the front.

As the Disconnector is not for operating purposes, the local manual operation by the operator is advisable against the remote-electrical one. Therefore, only manual operation is necessary. The Disconnector must be of single rotation-driving axis both for the Disconnector and the Earthing switch. It is mandatory that the operation from "closed to busbar" to "ready to earth" is made in two separate operations, closed - open and open - ready to earth. These are completely independent operations, with two separated operating access.

3.1.11.3 Busbar

Busbar shall be single phase or three phase SF6 gas encapsulated through the whole switchboard, in order to:

- Maintain the advantages of SF6 insulation not affected by ambient condition.
- Reduce the possibility of a fault due to external cause
- Reduce the dimensions

3.1.11.4 Voltage Transformers

Voltage transformers shall be completely touch-proof type suitable for mounting at the cable connection or on the busbar, outside the gas compartment

Instrument transformers shall be suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 45 deg. C.

Feeder voltage transformers must be disconnect-able to **ON-OFF switch inside Gas tank to** perform cable tests without having to remove the transformers.

Busbar voltage transformers must be designed to withstand 80% of the power-frequency withstand test voltage to enable repeat tests at the busbar without having to remove the transformers.

Current/voltage sensors, Rogowski coil and or other non-standard arrangements are not acceptable.

Common characteristics for all transformers:

- Permanent over voltage = 1.2xUn
- Voltage factor = 1.9 x Un/8 hours - 2.5Un peaks.

The following types and mounting possibilities will be accepted:

VT-s for Busbar Voltage metering

Location	Mounting
In Busbar Compartment	Directly connected to the Busbar system (Plug type connection) Over the Busbar. To place 3VT's is needed the wide of two switchgears.

VT-s for Line Voltage metering

Location	Mounting
In MV cables Compartment	Inside the enclosure of the switchgear Connection by a solid isolated plug-in type cable with plug in connectors in both ends.

3.1.11.5 Current Transformer

CTs must be ring type and manufactured according to IEC 61869-1, IEC 61869-2 and IS-16227 standards. Transformer's burdens and accuracy classes will be according to the relay characteristics and the protection system characteristics. In accordance with the requirements of currently available relays, the CT-s will be, preferably, with one secondary connection which includes protection and measurement in the same connection. Due to the low power requirements of the digital relays and the closeness between CT and relay, these ones will feature the minimum power output necessary for the protection system. Sensors in place of conventional CT / VT are not acceptable.

- **OPERATION AND INTERLOCKS**

Common operations in a substation must be available combining different functional units, such as:

- Connect line to busbar.
- Isolate line from busbar.
- Earth the line.
- Couple right busbar section to left busbar section (through bus tie).
- Isolate right busbar section from left busbar section (through bus tie).
- Earth right section of busbar (through bus tie).
- Earth left section of busbar (through bus tie).

The interlock system shall prevent any incorrect operation of the circuit breaker, switches and Disconnector. Mechanical and electromechanical interlocks are preferred over other type of interlocks. There shall be interlocks related to the switchgear itself and also related to all the switchgears in the substation, in order to maintain safety in all operations.

- **INTERLOCKS RELATED TO THE SWITCHGEAR ITSELF:**
- **DISCONNECTOR**

- Operating handle of the Disconnector can only be removed or inserted once the operation has been completely finished.
- It is not possible to go from "close" position (Disconnector connected to busbar) to "ready to earth" position (Disconnector connected to earth system) in one operation.

- **DISCONNECTOR & CIRCUIT BREAKER**

Disconnector only to be operated with the Circuit breaker in open position.

- Circuit breaker to be maintained in open position while Disconnector is being operated or operating handle is in inserted position.

- **EARTHING THE CIRCUIT**

A copper / aluminium earth bus of suitable size shall be provided at the bottom extending through the entire length of switchgear. Each stationary unit of the cubicle shall be earthed directly to the earth bus through a contact bar so that the carriage is earthed at all times except when the primary disconnects are separated by a safe distance. Suitable clamp type connectors shall be provided at both ends of earth bus to suit external earthing conductor. Also hinged doors of the cubicle base plate of C/T and P/T shall be effectively earthed. Earth bus shall protrude outside the extreme end panels and by at least by 100 mm.

One set of earthing accessories shall be supplied with the switchgear for earthing of the outgoing side of a feeder or 3 phase bus bars of the switchgear either through earthing facility which comprises truck to be inserted in place of circuit breakers, separate earthing trucks shall be supplied where earthing is achieved through circuit the earth device unless the circuit breaker is in open and isolated position.

- Line earthed position (Disconnector in earth position and Circuit breaker closed) can never be electrically removed. Circuit breaker can only be opened by means of mechanical pushbutton.
- Line earthed position must have a key lock to assure earth position in all moments.
- Access to the cable compartment will only be possible when the circuit is in earthed position.

➢ **ACCESS TO MV CABLE COMPARTMENT**

- It will be impossible to access the MV cable compartment unless the cables are conveniently earthed.

Table 3: Technical Datasheet – 33kV Gas Insulated Switchgear

Sl. No	Description	Technical Parameters
1	Switchboard	
2	Manufacturer's Name	By Bidder
3	Type	By Bidder
4	Standards Followed	IEC 62271-100/200
5	Main Bus bar	
	a) Current Rating	630A
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
6	Earth Bus bar	
	a) Current Rating	25kA
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
7	Continuous current Rating for Ambient Condition of site when installed in IP 4X Switch board	
	a) Main Bus bar at Ambient Specified	630A
	b) Tappings at Ambient Specified	630A
8	Temperature rise of Bus bars while	
	a) Carrying rated Current and Installed in IP4X enclosure at an Ambient Temp specified.	As per IEC-60694 Table-V, IS-12729-2004
	b) Under Short Circuit Condition	N.A
	Degree of Protection of Enclosure	SF6 gas chamber- Stainless Steel IP65 Drive-IP2X Low Voltage-IP3X
9	Minimum Clearance in Air	
	a) Between Phases	Since all parts in SF6, clearance is not applicable.
	b) Between Phase to Earth	Since all parts in SF6, clearance is not applicable.
10	Clearance required at the Back & Front of Panel	AFLR: 800mm @ rear 1700 mm @ front
11	Overall Dimension of the Switch Board (mm)	
	a) Length	In line with Switch Board Configuration

Sl. No	Description	Technical Parameters
	b) Width	By bidder
	c) Depth	By bidder
	d) Height	By bidder
12	a) Access Height (mm)	
	i) Maximum	By bidder
	ii) Minimum	By bidder
	b) Weight of Panel Board (kg)	
	j) Maximum :	By bidder
	k) Minimum :	By bidder
13	Insulation Level including all the Components	
	a) Power frequency withstand Voltage for 1 min	70 kV
	b) 1.2/50 µ sec Impulse Withstand Level	170 kV
14	Circuit Breakers	
(i)	Manufacturer's Name	
(ii)	Type	
(iii)	Manufacturer's Type reference	
(iv)	Closing Mechanism	spring
(v)	Normal Current rating in Air & corresponding	630A
(vi)	Ambient Temperature	40°C
(vii)	Derating factor for Ambient condition at Site	N.A
(viii)	Service Voltage & Frequency	33 kV, 50 Hz
(ix)	Maximum Voltage at which CB can Operate continuously	36 kV
(x)	Rated Making Capacity	25kA
(xi)	Rated Breaking Capacity	78kAp
(xii)	a) Symmetrical	25kA
(xiii)	b) Asymmetrical	
(xiv)	Short Circuit With stand Capacity	
	a) 3 Sec	25kA
	b) 1 Sec	25kA
(xv)	Total Make time	Within 80ms
(xvi)	Total Break time	Within 60ms
(xvii)	No. of Breaks per pole	1 No.
(xviii)	Total Length of Break per pole	
(xix)	No. of Auxiliary Contacts (NO/NC) for Employer's use	8
(xx)	Type of Arc Control Device	Vacuum
(xxi)	Arc Duration time	
	a) 100 % Load Current	Within 10ms
	b) 10 % Load Current	Within 10ms
(xxii)	Spring Charging Motor	
	a) Type	Universal Motor
	b) Voltage	230 V AC
	c) Rating in kW	By bidder
	d) Protection relay provided	Not Applicable
	e) Protective MCB s provided	Yes
(xxiii)	Power required for :	
	a) Closing	
	i) Momentary	250W
	b) Holding	N.A
	c) Tripping	250W
	d) Time taken for Charging Motor to Charge Spring completely	15 seconds
(xxiv)	Number of consecutive operation the breaker can	O-0.3Sec-CO-3Min-CO

Sl. No	Description	Technical Parameters
	withstand and the recommended interval between these operations:	
(xxv)	Number of short circuit current interruption after which the breaker requires attention & maintenance	100 @ 25 kA STC
(xxvi)	Number of normal operations after which the breaker requires attention & Maintenance	10000
(xxvii)	Rated capacitor breaking current of breaker/ contactor of each rating	N.A
(xxviii)	Confirm that trip and closing coils will be suitable for 110 V DC and the spring charging motor will be suitable for 240 V AC	Yes
(xix)	Maximum number of XLPE cables & sizes that can be terminated safely in the cable chamber without extension panel	
	a) Single core (Size & No. of Runs)	N.A
	b) Three core (Size & No. of Runs)	Max. 1 cable XLPE Three core 400 sq.mm
(xx)	Maximum no of cables that can be terminated in the cable extension box (Please state the dimensions of such cable extension Box)	N.A
(xxi)	Minimum available distance from the bottom of the panel to the terminals in cable box/chamber for terminating cables	By bidder
(xxii)	Weight of circuit breaker and truck	fixed mounted GIS
15	**Instrument Transformers**	
(i)	Makes	
	a) CTs	By Bidder
	b) PTs	By Bidder
(ii)	Standards followed	IEC / IS
(iii)	Confirm that CTs and PTs will be epoxy resin cast insulated	CT foil, VT metal-cast resin
(iv)	3 second short time current rating of CTs, kA.	25kA
(v)	1 second short time current rating of CTs, kA. :	25kA
(vi)	Dynamic current rating of CTs, kA :	78kAp
(vii)	Confirm that accuracy classes shall be as specified and ratios and capacities shall be as required	Yes/No
(viii)	Confirm that all protective, metering, control and annunciation devices, transducers as specified shall be provided	Yes/No
(ix)	Enclose technical particulars, data sheets, catalogues of all types of relays and other plant being offered by you	Yes/No
16	IP Rating	
	(a) Tank	IP 65 HV part
	(b) Cubicle assembly	IP 3X
17	SF6 Gas Pressure	As per bidder's type tested design
18	Gas Leakage Rate	< 0,1% per year
19	Gas handling Requirement at Site	No Gas handling allowed at site
20	**Cable Terminations**	
	Make	By Bidder
	Type	Outer Cone screen separable connector

Table 4: Technical Datasheet for Current Transformer

Sl. No.	Particulars	33 kV CT Unit
1	Nominal System Voltage (KV RMS)	33 **or 0.66KV incase LV CT used**
2	Highest System Voltage (KV RMS)	36 **or 0.72KV incase LV CT used**
3	Frequency	50 Hz
4	Rated Output (V.A. burden)	**As per suitable VA calculation**
5	Rated continuous thermal current	1.2 times of rated primary current
6	Short time current rating for 1 sec	25 kA for 1.0 seconds
7	Rated dynamic current (peak)	2.5 times of short time thermal current
8	Instrument security factor	Less than 5 (five)
9	Impulse withstand voltage (kV peak) (on CT)	170 **or not applicable for LT CT used**
10	Maximum temperature raise over max. ambient temperature of 45°C at rated continuous thermal current at rated frequency and with rated burden	As per IS 2705 / 1992 (part-II)
11	Maximum ratio error	Do
12	Maximum phase angle error	Do
a	Type	Dry type epoxy resin cast
b	No. of cores	One
c	Rated continuous thermal current	As per IS 2705 / 192
d	One minute power frequency voltage withstand test on secondary winding	3 kV
e	Class of accuracy	**0.5S or as per approved SLD**
f	Secondary termination	S1 & S2 shall be clearly engraved
g	Primary termination	P1 & P2 shall be clearly engraved

Table 5: Technical Datasheet for Potential Transformer

Sl. No.	Particulars	33 kV PT Unit
1	Nominal System Voltage (KV RMS)	33
2	Highest System Voltage (KV RMS)	36
3	No. of phases	3
4	Frequency	50 Hz
5	Transformation ratio (PT ratio)	33 kV / 110 V / √3 V
6	Rated Output (V.A. burden)	50 VA per phase
7	Impulse withstand voltage (kV peak) (on assembled PT)	150
8	One minute power frequency dry withstand voltage (on assembled PT set Primary (KV RMS) Secondary (KV RMS)	 70 3
9	Class of accuracy	0.2
10	Rated voltage factor and time	1.2 times continuous and 1.5 times for 30 sec.
11	System conditions	Effectively earthed system
12	Maximum temperature raise over maximum ambient temperature (which may be taken as 45)	Within limits of IS 3156 with latest amendments/revision
13	Maximum ratio error	Do
14	Maximum phase angle error	Do

3.2 11 KV System

3.2.1 General

11 KV System

There is a 11 KV GIS panel in the 33 KV grid substation at each portal The 11 KV GIS panel configuration shall have following feeders as per SLD drawing.

At Grid station(North and South Portal):

a) 11KV GIS Panel (Grid)

- 2 nos. incomer from 2 nos. Power transformers through 11 KV XLPE cable.
- 2 nos. incomer from 11KV DG Sync Panel through 11 KV XLPE cable.
- 1 no. bus coupler.
- 2 no. outgoings for Ring feeder 1 & 2
- 2 no. Spare feeders

b) 11 KV GIS panel (For DG System) will have following feeders:

- 2 nos. incomers from 2 nos. DG Sets through 11 KV XLPE cable.
- 2 no. outgoings to 11KV GIS Panel(Grid)
- Spare feeders

3.2.2 Scope of Work

The high voltage supply system shall include the delivery, installation, required works, tests and all necessary equipment for the following materials:

- 11 kV switchgears (panels / cubicles)
- 11 kV cables
- Protection system
- Instrument Transformers
- Accessories
- Potential Equalisation connections
- Wiring and signalling for 11kV

3.2.3 Technical Specification – 11kV GIS (11kV GAS-Insulated, Switchgears)

➢ **Indoor 11kv Modular, Gas-Insulated, Switchgears**

- BASIC SWITCHGEAR DESIGN

  A metal-enclosed, gas-insulated switchgear according to the currently applicable standards and provisions, prefabricated and type-tested, as single busbar system with stationary switching devices is to be implemented.

  The switchgear shall consist of modules, to be aligned side by side, to minimize the number of components subject to high electrical loads. The individual modules correspond to the single line, and the function units described below. The modules must also be connected so that the entire busbar assembly is completely enclosed in SF6 gas atmosphere. Possible

extension: on both sides. The IEC classes of the applicable standards and regulations must be specified in the offer and proved by test records.

- ECOLOGICAL CORRECT CONSTRUCTION

  The switchgear must satisfy to a high degree the ecological requirements in view of environmental protection.

  The consumption of material and energy during production is to be minimized in an optimum fashion. This applies especially to the utilization of insulating material. Ecologically safe, low-maintenance operation with a service life of min. 30 years must be possible. Use of recyclable materials for efficient and complete (100%) disposal at the end of the service life must be proved by a utilization data sheet. The offer must be accompanied by a certificate confirming that the quality requirements acc. to DIN ISO 9001 have been complied with. After the course of operational switchboard life, it must be possible to recover the complete SF6-gas of every gas-filled compartment by a serial recover valve. Special equipment of the switchboard supplier for recovering is permitted.

- GAS COMPARTMENT TECHNOLOGY AND GAS COMPARTMENT MONITORING

  The cladded gas compartments must be filled with the insulating gas SF6 and be designed as hermetically sealed pressure system according to IEC 60694 (IEC 62271-1), IS-12729-2004. The switchgear's high degree of leak- proofness regarding gas is to ensure that no insulating gas has to be added during the expected service life of the switchgear, under the normal operating conditions specified for indoor switchgear units. The complete busbar system, a central element of the switchgear, must be integrated completely and throughout within the gas-filled cladded compartment of the switchgear. The gas compartments are monitored via pressure gauges with remote signaling contact.

  To ensure maximum reliability and availability of the switchgear, the number of gas compartment seals, of static bushings and pressure relief devices must be kept to a minimum. All three breaker poles of a switching device should have a common, gas-tight rotary bushing. The gas compartments must be welded, and all static bushings must be sealed by pressure gaskets for operational life. The operational leak rate for gas insulation must not exceed 0.1 % per year and manufacture to guarantee no gas handling at a site during extension, removal and installation of at site.

- PRESSURE RELIEF FOR THE CLADDED GAS COMPARTMENTS

  The pressure relief device of each gas-filled cladded compartment should be affected via appropriate relief devices into a pressure relief area on the underside of the module. This pressure relief area must be partitioned against the cable connection compartment using a metallic cover. The preferred direction for pressure relief is, from the cable connection compartment to the bottom / top rear, and from the gas compartment of the module tank to the top rear / bottom. Appropriate flooring ducts are prepared by the Customer according to the Contractor's specifications before switchgear installation on site.

- DESIGN

  The switchgear must be designed with extremely small dimensions and for minimum space requirements.

- LOW-VOLTAGE CABINET

  Each function unit is to be equipped with a separate, closed, fully shrouded and arc-resistant

low-voltage cabinet with mechanical and electrical interface to accommodate digital protection relays and secondary equipment for control, measurement and counting/metering. The torsion-resistant door can accommodate devices. The dimensions of the low-voltage cabinet have a minimum height of 600 mm and a minimum depth of 350 mm. For transport reasons the low-voltage cabinet must should be easily removable and mountable. Mechanical drive elements must not be installed in the low-voltage cabinet.

- ON-SITE INSTALLATION AND POSSIBLE EXTENSION

  The individual modules or cubicles must be designed so that they can be lined up on site without any problems or work involving gas bottles. The in-line modular design is to reduce assembly time as much as possible. The specifications dictate that the switchgear must be designed so as to allow for subsequent extension without problems, without requiring interventions into the existing modules. This must be documented conclusively, e.g. by operating manuals and installation instructions.

- INTERNAL ARC CLASSIFICATION (IAC)

  The switchgear to be offered must be checked successfully for internal arc classification. To this effect, the currently applicable standards and provisions must be complied with. The proven short-circuit current must be at a minimum related to the value of the rated short-time current 25kA. The short-circuit duration is 3 s. The test report must be shown with the offer. The following arcing locations must have been realized in the scope of successful testing: gas-filled cladded compartment, preferably in the area of the outer cone-type bushings for cable connection busbar area / coupling chamber between the modules cable connection compartment.

- INTERLOCKING SYSTEM

  To ensure maximum operator safety, the switchgear must be equipped with a comprehensive interlocking system of excellent design. This interlocking system is to integrate the cable connection compartment and the HVHRC fuse compartment systematically. Actuation of the mechanical operating lever should follow the interrogation interlock principle.

- MECHANICAL INTERLOCKS

  The interlocking system regarding mechanical operating lever actuation must be designed according to the interrogation interlock principle. This means that an operating lever can only be inserted or that actuating forces may only act on the components if this is permitted by the appropriate operating condition of the function unit in question. Digital switchgear interlock units are not accepted by the Customer due to their high costs and as these systems depend on the switchgear's auxiliary voltage.

  The interlocking system used should comply with the following interlocking conditions, depending on the equipment installed:

- Double-acting interlock between busbar isolator and outgoing earthing switch
- Double-acting interlock between busbar isolator and circuit-breaker
- Double-acting mechanical interlock between the switch disconnector and the outgoing earthing switch
- Double-acting interlock between the cable compartment cover and the outgoing earthing switch(es) (for cable testing, specific equipment must be provided to eliminate the outgoing earthing)

- Double-acting mechanical interlock between the coupled outgoing earthing switches and the metallic fuse covers
- The fuses are only accessible when the earthing switches are ON
- The front cover can only be closed if the fuses are inserted correctly
- It must only be possible to remove or insert actuating levers in clearly defined positions

➢ **"CLOSE" or "OPEN"**

- VOLTAGE DETECTING SYSTEM ACCORDING IEC 61243-5(CAPACITIVE VOLTAGE INDICATOR)

  The test for zero voltage is performed by a plug-in Voltage Detecting System (VDS), which complies with the applicable standards and provisions. Coupling is affected from capacitive voltage dividers in the cable connection areas. Appropriate connections must be provided to enable phase comparison; these are covered in normal operating condition.

- TRANSFORMERS (VOLTAGE / CURRENT TRANSFORMERS)

  Inductive current and voltage transformers with minimum amounts of insulating material must be used. It must be possible to operate all commercially available, digital protection relays with the transformers.

- CURRENT TRANSFORMER

  CT is to be equipped in the outgoing circuit of the circuit-breaker units, with low-voltage ring core current transformers which are separately accessible in the cable connection compartment and which must be mounted outside of the gas compartment onto the extended outer cone-type bushings. Retrofitting or replacing of the current transformers is possible without intervention in the gas compartment from the switchgear front side. The measuring and protection cores are located in a common transformer block. For normal current measurement, the switch disconnector unit can be equipped with one cable-type current transformer per phase. These transformers are located in the metal-enclosed cable connection compartment. The power ratings of the cores must be dimensioned according to the measuring and protection equipment connected to them.

- VOLTAGE TRANSFORMERS

  Metal-enclosed or metallized, touch proofed and grounded inductive voltage transformers should be used. Voltage transformers on the busbars are directly plug-in to the switchgear outside of the gas- filled compartments.

  Instrument transformers shall be suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 45 deg. C.

  Feeder voltage transformers must be disconnectable using a ON-OFF switch to perform cable tests without having to remove the transformers.

  Busbar voltage transformers must be designed to withstand 80% of the power-frequency withstand test voltage to enable repeat tests at the busbar without having to remove the transformers.

  Current/voltage sensors, Rogowski coil and or other non-standard arrangement are not acceptable.

HT Fuse are not acceptable for Voltage Transformer.

- CORROSION PROTECTION AND PAINTING

  Corrosion-prone steel components of the switchgear cubicles – unless they are made of stainless steel – must be protected by zinc phosphate. Large-sized front components visible from the outside, such as doors or covers, should be coated additionally by scratch-proof textured paint. The colour coating should be provided in the colour RAL 7044 (silk grey).

- CIRCUIT BREAKER

  Circuit breakers should be Vacuum type. They should be according to IEC 62271-100 standard. Rated operating sequence must be O-3 Min-CO-3 Min-CO. Operating time for opening, breaking less than 80ms and closing, less than 60ms. Circuit breaker must be E2/M2/C2 type (electrical, mechanical endurance and capacitor breaking/making ability) according to relevant standard. Vacuum Interrupter shall be tested for min. 100 nos. of full short circuit operations at rated fault level. Circuit breaker operating mechanism will be outside the SF6 tank, manually and electrically operated. Vacuum interrupter must be GIS manufacturer's own make and should be type tested design. The operating mechanism should consist in the following items.

- Spring system that stores the necessary energy for opening and closing operation.
- Spring charging system (motor operated) that automatically recharges the springs after the main contacts of the CB have closed.
- Mechanical "charged-discharged" position indicator for CB opening and closing springs.
- Manually operated spring charging system (in case of lack of auxiliary power supply).
- Electrical system including:
- Tripping coil
- Anti-pumping relay
- Mechanical emergency trip pushbutton.
- Operation counter
- Spring charging indication contact.
- Mechanical indicator for Open / Closed position
- Minimum CB position auxiliary contacts
- DISCONNECTOR

  The Disconnector is a mechanical device which provides, in the open position, an isolating distance. The Disconnector is always operated with NO LOAD (zero current). The Disconnector will be placed between the CB and the busbar system in order to isolate the busbar system from the circuit side and earth the CB busbar terminals. The Earthing Disconnector will operate always de-energized, and the making capacity is provided by the circuit-breaker, which is designed for these purposes.

  The Disconnector must be according to the latest edition of the IEC 62271-102 and shall meet requirements as specified in RATINGS. The indication of the position of the Disconnector must be mechanical. This mechanical link must be kinematic chain tested. The Operating mechanism must be outside the SF6 atmosphere and accessible from the front.

As the Disconnector is not for operating purposes, the local manual operation by the operator is advisable against the remote-electrical one. Therefore, only manual operation is necessary. The Disconnector must be of single common rotation-driving axis both for the Disconnector and the Earthing switch. It is mandatory that the operation from "closed to busbar" to "ready to earth" is made in two separate operations, closed - open and open - ready to earth. These are completely independent operations, with two separated operating access.

- BUSBAR

  Busbar shall be single phase solid insulation, screened and earth through the whole switchboard, in order to:

- Reduce the SF6 quantity in all cubicles.
- Maintain the advantages of SF6 insulation not affected by ambient condition.
- Reduce the possibility of a phase-to-phase fault.
- Reduce the dimensions.
- Provide the possibilities of installing measuring instruments directly in the busbar system.
- EARTHING THE SYSTEM

  A copper / aluminium earth bus of suitable size shall be provided at the bottom extending through the entire length of switchgear. Each stationary unit of the cubicle shall be earthed directly to the earth bus through a contact bar so that the carriage is earthed at all times except when the primary disconnects are separated by a safe distance. Suitable clamp type connectors shall be provided at both ends of earth bus to suit external earthing conductor. Also hinged doors of the cubicle base plate of C/T and P/T shall be effectively earthed. Earth bus shall protrude outside the extreme end panels and by at least by 100 mm.

  One set of earthing accessories shall be supplied with the switchgear for earthing of the outgoing side of a feeder or 3 phase bus bars of the switchgear either through earthing facility comprises truck to be inserted in place of circuit breakers, separate earthing trucks shall be supplied where earthing is achieved through circuit the earth device unless the circuit breaker is in open and isolated position.

- LOW-VOLTAGE EQUIPMENT

  INDICATION AND ALARMS : All the specific indications and alarms, which are relevant for the switchgear, must be wired to terminals.

  REMOTE CONTROL : The remote control for the switching devices in the motor drive must be designed as lockable via a REMOTE ON-OFF switch. Each function unit concerned must be equipped with a remote on-off change-over switch.

  NUMERICAL RELAY : Numerical relay shall be of modular type and have native IEC 61850 communication support for RTU/SCADA integration. Relay shall be with graphical LCD dot matrix display with single line diagram mimic with control, indication, programmable function key and LEDs.

  Relay shall have adequate following protections (50/51, 50N/51N, 46, 86, 50ARC, 50NARC as native function). Arc Flash protection shall be integral part of relay. Protection relay hardware, cables and separate arc sensors shall be included. Any arc flash fault in the cable compartment is selectively cleared by the feeder protection relay.

The relay should be with G3 conformal coating and suitable to work in Industrial corrosive environment and should have passed mixed gas test as per IEC 60068-2-60:1995, Part 2, Test Ke, Method (Class 3).The test to include 21 days at 75% relative humidity or 5days at 90% relative humidity and +30 deg C, exposure to elevated concentrations of H2S, NO2 and CI2.

3.2.4 11KV Ring Main Unit (RMU)

General Specifications

RMU type, metal-enclosed indoor switchgears, shall be compact switchboard and comply to following requirements:

- Easy to install
- Safe and easy to operate
- Compact
- Low maintenance

The RMU shall be capable of operating normally within the following temperature range:

Maximum air temperature: + 40 ° C

Minimum air temperature: - 5 ° C

RMU to operate in air temperature higher than + 40 °C and the level of air temperature for which current derating is necessary.

The RMU shall be capable of being operated in electrically exposed locations.

The RMU shall be capable of being exposed to high relative humidity and ambient air pollution.

The RMU shall be capable of being installed in either concrete indoor substations or in compact metal substations and kiosks with an IP67 rating.

FUNCTION REQUIREMENTS

The following functions shall be available:

- Feeder with switch-disconnector

- Transformer protection with vacuum circuit breaker

Enclosure:

The RMU enclosure shall be made up of CRCA of 2 mm thickness. The high-voltage gas vessel shall be made up of non-magnetic stainless-steel grade SS304 or higher with minimum thickness of 2.5mm. The rating of enclosure shall be suitable for operation on three phase, three wire, 11 KV, 50 cycles, A.C. System with short-time current rating of 21 kA for 3 seconds with Panels. The complete RMU enclosure shall be of degree of protection IP 54. The enclosure shall provide full insulation, making the Switchgear insensitive to the environment like temporary flooding, high humidity etc. The active parts of the Switchgear shall be maintenance-free and the unit shall be minimum -maintenance.

The Switchgear and Switchboards shall be designed such that the position of the different devices is visible to the operator on the front of the Switchboard and operations are visible.

The RMU metal parts shall be made of high thickness high tensile steel which must be treated with 7 tank treatment and subsequently painted with pure polyester, the overall paint layer thickness shall be 100 microns (+/- 25 Micron).

Configuration requirements

Extensible range:

3 function unit :

Switch-disconnector - Switch-disconnector - Transformer protection with vacuum circuit breaker

The RMU shall meet the criteria for compact, metal-enclosed indoor switchgear in accordance with

IEC 62271-200:

Switchgear classification: PM class

Loss of service continuity class: LSC2

It shall include, within the same metal enclosure, the number of MV functional units required for connection, power supply and protection of transformers.

RMU BUSHINGS AND CABLE TERMINATIONS

Bushing

It is preferable to have all bushings accessible from the front of the RMU and should be site replaceable type. Bushings along the sides or the rear of the RMU are not acceptable.

For each cable compartment, the bushing shall be at the same height in order to facilitate a possible reversal of the cables

The bushing should be conveniently located for working with cables specified and allow for the termination of these cables:

- 630 A M16 bolted connectors for switch-disconnectors and vacuum circuit breakers functions
- 200 A plug-in connectors for transformer protection feeder with fuse combination.

The profiles of the cable connection bushings shall be in compliance with IEC-60137, IS-2099, IS-10314, IS-5621, IEC-60137 standard.

A cable clamp arrangement must be provided for all network cables terminated on the RMU.

PADLOCKING FACILITIES

Circuit breakers, fuse-switches combination, switches and earthing switches can be locked in the open or closed position by at least 1 padlock.

VOLTAGE INDICATORS AND PHASE COMPARATORS

Each function shall be equipped with a voltage indicator box on the front of the device to indicate whether or not there is voltage in the cables. The capacitive dividers will supply low voltage power to the lamps.

Three inlets can be used to check the synchronization of phases.

This device shall be in compliance with IEC 61958 standard or IEC 61243-5.

FAULT PASSAGE INDICATORS (FPI)

The FPI shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The FPI should be self-powered and should have internal lithium battery for external indication and setting of FPI in the absence of current.

The FPIs shall include:

Fault detection - Phase to phase and Phase to earth faults.

One potential-free output contacts for hardwiring to RTUs. On this basis, the SCADA will be able to monitor phase / earth fault condition.

Local fault indications - LCD display on FPI front panel along with LED indication on front panel of RMU enclosure.

Multiple reset option –

- End of time delay
- Remote reset (Via potential free input contact of FPI)
- Manual reset (Reset button on front panel of FPI)
- Automatic reset on current restoration.

The characteristics of the FPIs shall include:

- Phase fault thresholds configurable from at least 100 to 800 A
- Earth fault thresholds configurable from at least 20 to 200 A
- Multiple number of steps for adjusting phase and earth fault thresholds.
- Fault current duration range configurable

RMU should have VCB and interrupter of the same make of the RMU .

SAFETY OF PEOPLE

Any accidental overpressure inside the sealed chamber will be limited by the opening of a pressure limiting device in the lower part of the enclosure. Gas will be released to the rear or the bottom of the switchboard away from the operator. Manufacturer shall provide type test report to prove compliance with IEC 62271-200 Annex A, Internal arc classification class AFL with 21kA for 1s for the SF6 tank and cable box..

OPERATING LEVER

An anti-reflex mechanism on the operating lever shall prevent any attempts to reopen immediately after closing of the switch or earthing switch.

All manual operations will be carried out on the front of the switchboard.

FRONT PLATE

The front plate shall have suitable IP degree of protection. The front shall include a clear mimic diagram which indicates the different functions.

The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator.

The lever operating direction shall be clearly indicated in the mimic diagram.

The manufacturer's plate shall include the switchboard's main electrical characteristics.

CABLE INSULATION TESTING

It must be possible to test the core or the sheath insulation of the network cables while the busbar remains energized at rated voltage. The phase by phase testing shall be carried out through a built-in facility or through the cable connectors.

In order to avoid any risk of bad reassembly, it shall not be necessary to dismantle any earthing bar to

perform this operation

REMOTE CONTROL OF THE RMU'S

A limited number of applications for remote operation of the RMU are required.

Remote operation of the RMUs line switches must be possible using motors fitted to the operating mechanism.

It shall be possible to fit the motors either directly in manufacturing plant or on site when required. Installation on site shall be possible with the RMU fully energized and manufacturer should provide detailed instructions for installation to the control mechanism. Auxiliary contacts for remote indication of switch status are also required.

The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches. An auxiliary contact to prevent motorized operation of the mechanism while the operating handle is inserted into the operating point must also be provided

The device shall be fully designed for use in a hot, humid atmosphere and shall be low-maintenance. All metallic parts shall have rust protection.

Two lifting rings shall be installed on the top of the switchboards for handling.

TYPE AND ROUTINE TESTS

The switchboard, to comply with following tests (but not limited to):

- Impulse withstand test,
- Temperature-rise test,
- Short-time withstand current test,
- Mechanical operation test,
- Checking of degree of protection,
- Switch, circuit breaker, earthing switch making capacity.
- Switch, circuit breaker breaking capacity.
- Internal arc withstand
- Checking of partial discharge on complete unit

The test certificate to conform to NABL accredited testing lab certificate for carrying out internal inspection and testing. The manufacturer must carry out testing of the panel at NABL accredited testing lab or international lab.

The routine tests shall be backed by test reports and include the followings to conform with drawings and diagrams,

- Measurement of closing and opening speeds,
- Measurement of operating torque,
- Checking of filling pressure,
- Checking of gas-tightness,
- Checking of partial discharges on individual components,
- Dielectric testing and main circuit resistance measurement.

11kV SWITCHBOARDS

The switchgear and busbar shall meet the "sealed pressure system" criterion in accordance with the IEC 62271. The manufacturer certificate shall confirm that maximum leakage rate is lower than 0.1 % / year.

It shall provide full insulation, for switchgear insensitive to the environment (temporary flooding, high humidity, etc.), IP67 degrees of protection in accordance with recommendation IEC 60529 § 14.2.7.

The switchgear shall be maintenance-free and the switchboard shall be low-maintenance.

The switchboards shall be suitable for IP protection.

The cable compartment shall integrate:

- Adjustable cable fixing devices
- Earth connecting point
- Metal partition between cable compartments and tank pressure relief area.

The cable compartment shall be arc resistant and suitable for the following cable connecting systems:

- Partial insulated cable connectors
- Fully screened cable connectors
- Metal enclosed cable connectors according DIN EN 50181, IS-2099, IS-10314, IS-5621 and IEC-60137.

The colour shall be RAL 7035 as approved for the enclosure and mimic panel.

The switchgear and switchboards shall be designed so that the position of the different devices is visible to the operator on the front of the switchboard and operations are visible as well.

In accordance with the standards in effect, the switchboards shall be designed so as to prevent access to all live parts during operation without the use of tools.

EARTHING OF METALLIC PARTS

There shall be continuity between the metallic parts of the switchboard and cables so that there is no electric field pattern in the surrounding air, thereby ensuring the safety of people.

The substation frames shall be connected to the main earth busbar without dismantling any bus bars.

EARTHING OF THE MAIN CIRCUIT

The cables shall be earthed by an earthing switch with short-circuit making capacity, in compliance with IEC 62271-102 standard. The earthing switch can only be operated when the switch is open.

The earthing switch shall be fitted with its own operating mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

Mechanical interlocking systems shall prevent access to the operating shaft to avoid all operator errors such as closing the earthing switch when the switch is closed.

FEEDER WITH SWITCH-DISCONNECTOR

They shall be maintenance-free. The position of the power contacts and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with IEC 60265-1 & IS-9920 (Part-1)-2002 standard. In addition, manufacturer shall prove reliability of indication in accordance with IEC 62271-102 § 6.105 standard.

The switches shall be of the "increased operating frequency" in accordance with IEC 60265-1 § 3.104

standard. They shall have 3 positions, open-disconnected, closed and earthed, and will be constructed in such a way that interlocking prevents unauthorized operations. The switch-disconnector and earthing switch shall be equipped with two separate operating entry points.

Manual opening and closing will be driven by a fast-acting mechanism, independent of operator action.

Each switch can be fitted with an electrical operating mechanism in a specially reserved location, by addition of a motorization unit and without de-energizing the switchboard.

The switch and earthing switch operating mechanism shall have a mechanical endurance of at least 1000 operations.

TRANSFORMER PROTECTION WITH VACUUM CIRCUIT BREAKER

The circuit breakers shall be of the maintenance-free, vacuum type. The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with IEC 62271-102 standard and prove reliability of indication in accordance with IEC 62271-102 § 6.105 standard.

An operating mechanism can be used to manually close the circuit breaker and charge the mechanism in a single movement. An independent mechanism shall be fitted for the 3-position earthing switch and disconnector and include a local system for manual tripping by an integrated push button. The operating sequence of vacuum circuit breaker must be O-0.3sec-CO-3min-CO and mechanical endurance shall be 10000 nos of operation without any maintenance.

The circuit breaker shall be associated with an integrated protection unit that will operate without any auxiliary power supply and shall include:

Three toroidal transformers incorporated in the transformer tee-off bushings for protection and metering,

An electronic relay (Self Powered)

A low energy release

A system protection testing (with or without CB tripping)

MV METERING

MV Metering shall be carried out by a factory assembled.

Connection with adjacent cells will be direct through bus bar but MV cables shall be possible.

VT's and CT's to comply with type DIN 42600 standards and IS-3156, IS-2705, IS-16227 and the following configuration shall be available:

- 3 VT's phase-earth
- 1 nos. Aux VT , 1ph, 500VA, 11KV/230V AC

FEEDER REMOTE TERMINAL UNIT (FRTU)

The RMU remote control interface shall include all the functions required to monitor and control LBS and VCB in RMU.

Since, requirement is for Motorized RMU ,and looking at integration issues same vendor to supply FRTU and RMU and support for integration of FRTU with Scada, in order to avoid teething technical issues of integration while execution.

The monitoring and control enclosure shall meet following main requirements:

- Monitoring and control of medium voltage cubicles.
- Detection of amperometric faults, adjustable for each feeder.
- Load current measurement to the SCADA.
- Data transmission to the remote control centre.
- It shall be possible to view the most important information locally on the front panel of the enclosure and remotely from the control centres.
- Possible to retrieve and display on a laptop PC the time-stamped events recorded at the enclosure. Possible to retrieve information from the remote control centre also.
- Event storing capacity.
- Local remote switch

In remote control mode, the enclosure shall ensure:

- Transmission of remote measurements and time-stamped events.
- Possibility of electrical remote control.
- Inhibition of local electrical control pushbuttons.

In local mode, the enclosure shall ensure:

- Transmission of remote measurements and time-stamped events.
- Possibility of local electrical control of opening and closing operations by simultaneously pressing a pushbutton to select the unit to be operated and a validation pushbutton.
- Inhibition of opening/closing remote control.

FRTU POWER SUPPLY:

- Power from FRTU shall be sufficient to supply 24 V to at least all the switch cubicles.
- The standby energy shall be provided by a 12 V 24 Ah battery / as approved with a minimum autonomy of at least 9 hours for 10 opening and closing cycles.
- The FRTU power supply shall be protected against over voltages and over currents. The dielectric characteristics of the supply voltage input in accordance with IEC 60 25564 shall be available in the station is single-phase 220 V AC.

The control unit shall comply to following communication ports:

- One Ethernet port for interfacing with the IP compatible communication equipment.
- One Modbus RS485 port to connect field IED's / Energy Meters on RS485.
- One port for connecting external modem.

Table 6: Technical Datasheet for Ring Main Unit (RMU)

Network	Three phases - Three wires
Rated Voltage	12 kV
Service Voltage	11 kV
System Frequency	50 Hz
Lightning Impulse withstand Voltage • Phase to phase, phase to earth • Across the isolating distance	 75kV 85 kV

Power Frequency withstand voltage	28 kV rms - 1 min
Rated Normal Current • Line switch • Transformer feeder • Branch circuit breaker feeder	 630 A 200 A 630 A
Rated Short time current withstand (3 sec)	21 kA
Internal Arc IAC (SF6 tank and cable box)	21KA for 1 sec with AFLR classification
Rated Short circuit making capacity of line switches and earthing switches	62,5 kA peak at Rated Voltage
Number of operations at rated short circuit current on line switches, earthing switches and CB	5 closing operations
Rated load interrupting current Line switch	 630 A rms
Rated cable charging interrupting current Line switch	 30 A
Number of mechanical operations • Line switches and earthing switches • Switch-fuse combination • Circuit breaker	 1000 O/C 1000 O/C 2000 O/C
Number of electrical operations at full load breaking current	100 O/C
Number of operations at rated short circuit current on circuit breaker	10 breaking operations

All of the switchgear shall be capable of withstanding this current without any damage being caused, in accordance with the recommendations IEC 62271-1 and IEC 62271-200.

3.2.5 Protection System of 11 KV System

For the protection of the high voltage equipment, over current-time protection relay with feeder differential protection for cable connections shall be provided. Backward-lock-out shall shorten the time to trip.

During failure of time-overcurrent protection, a selective time interval, which is another type of protection trips, shall be provided.

A synchro-check unit shall be provided for the circuit breakers in the 11 kV feeder and cable panels. With this synchro-check unit the state at switching points shall be controlled for enabling an uninterrupted switching to normal net configuration in case of a failure.

All required OFC equipment for the protection system of 11 kV System shall be included in the price of protection system.

➢ **SPECIFICATION OF PROTECTING SYSTEM:**

By the protection system of the High Voltage Supply, the contractor has to take into account, that an Electrical selectivity/discrimination between the individually (sub) stations and the 33 kV-System shall be provided.

Basic conditions for the protecting systems are:

- Selectivity to the 33 kV-System
- Selectivity by faults in cables with automatic shift of the disconnecting point to the defect part of the system
- Insensitive and reliable protection system for tunnels
- Internal data-transmitting via optical fibre cabling

- **CURRENT TRANSFORMER**

  Current transformer for feeder panel or cable panel shall be three-pole, provided with measuring and protecting core. In the cable panel, toroidal core transformers shall be used provided as three-phase block-type current transformer. The current transformer ‘s load shall be adjusted to the arrangement of protection devices. The secondary terminals shall be situated on the terminal strip inside the panel.

- **VOLTAGE TRANSFORMER**

  For voltage measuring on the bus bar, three one-pole voltage transformers shall be used.

  For cable panels, three one-pole voltage transformers shall be used for measuring and earth- fault detection, with open delta winding. All voltage transformers shall be pluggable, metal- enclosed and shock proofed. The secondary terminals shall be realized by plugs inside the panel. Voltage transformers on the branch shall be removable for cable testings.

- **PROTECTION EQUIPMENT**

  All functions of the protection equipment shall be microprocessor controlled (microprocessor-based protection and control).

- **AUXILIARY POWER SUPPLY**

  For the required auxiliary power supply, a connection E&M contractor’s DC power supply shall be included. The power supply of the protection equipment shall be able to span an interruption of the auxiliary supply for ≤ 50 ms. A switching of ON / OFF of the auxiliary power supply shall not cause a malfunction of the protection equipment.

- **PILOT RELAY**

  For the transmission of signals, the contractor shall provide enough pilot relays. The assignment of the signals to the relays shall be freely selectable. Also the formation of common signal / common alarm shall be possible. The state of the relays shall survive a failure and recovery of the auxiliary supply.

- **STORAGE OF FAULT SIGNALS AND FAULT VALUES / ALARMS**

  The formed fault signals in the devices of the last three events shall be stored by SCADA.

  The beginning of a failure shall be marked with the real-time of the internal system clock. Within a failure the separate signals shall be provided with the relative time with a resolution of 1 ms.

- **DATE AND TIME**

  All protection devices shall be equipped with integral real-time clock (RTC) inclusive a calendar function. The clock shall be able to be synchronized and equipped with a buffer battery.

- **SELF-MONITORING AND SIGNALLING OF DEVICE-FAULTS**

  All protection devices shall be equipped with monitoring of the hardware and software. Minimum requirement of the monitoring is:

  - Monitoring of the internal auxiliary power supply for digital and analogue circuits
  - Monitoring of the analogue-to-digital conversion (offset, drift, accuracy)
  - Monitoring of the command circuit to the coil of the command relays (short circuit and failure / interruption)
  - Monitoring of the memory chips by using cyclic formation of checksum and comparing with

deposited checksum.

- Monitoring of the continuous program processing by time monitoring (watchdog)

➢ **FURTHER REQUIREMENTS**

The protection devices shall be designed as panel-plug-in devices with screw-type terminals on the back side and covering, and following front side display and control elements (minimal requirement):

- Illuminated LC-display, (at least) four lines, alphanumeric, for displaying of miscellaneous. information
- at least 6 free parametrizable LED displays with labelling field
- at least 4 free programmable function keys
- 4 navigation keys
- at least 12 numeric operator buttons
- special keys for parameterization

➢ **OVERCURRENT – TIME PROTECTION RELAY WITH FEEDER DIFFERENTIAL PROTECTION FOR CABLE CONNECTIONS**

- Nominal current: 1 A
- Nominal voltage: 80 – 125 V
- Nominal frequency: 50 Hz
- Auxiliary power supply: 240 VAC
- Local control:
  - 4-lined LCD-display with information text
  - Indication and count value
  - Operator and control keyboard
  - 4 free programmable function keys
  - 7 free programmable LEDs
- Communication:
  - Interface RS232 on the front side
  - System-Interface on the backside of the device
  - Interfaces for optical fibre cables (amount and types depends on used system)
- General functions:
  - Battery-maintained clock
  - Fault messages: the last 8 fault messages have to be stored
  - Operational message: the last 80 messages have to be stored
  - Self-monitoring
- In-/Outputs:

- 7 binary inputs
- 5 relay outputs
- 1 live contact

- Protection functions:
  - Phase-selective differential protection for two-ending-operation
  - Over current-time protection phase I>, I>>, Ip>>
  - Breaker intertripping
  - Thermal overload protection
  - Quick breaking step
  - Displaying of measurements for local and distant cable-endings
  - Operation by parameters
  - Lock-out
  - Trigger circuit protection
- Automatic functions:
  - Command conversation
  - Filter for messages
  - Locking of transfer function
  - Programmable logical functions

➢ **OVER CURRENT TIME PROTECTION FOR OUTGOING TRANSFORMER UNIT**

- Nominal current:1 A
- Nominal frequency:50 Hz
- Auxiliary power supply:240 VAC
- Local control:LCD-display for current measurements
- Communication:
  - Interface RS232 on the front side
  - System-Interface on backside of device
- Interfaces for optical fibre cables (amount and types depends on used system).
- General functions:
  - Battery-maintained clock
  - Fault messages: the last 8 fault messages have to be stored
  - Operational message: the last 80 messages have to be stored
  - Self-monitoring
- In-/Outputs:
  - 7 binary inputs

- 5 relay outputs
- 1 live contact

- Protection functions:
  - Over current-time protection phase I >, I >>, Ip >>
  - Over current-time protection earth IE >, IE >>, IEp >>
  - Inrush locking
- Automatic functions:
  - command conversation
  - Filter for messages
  - Locking of transfer function
  - Programmable logical functions

3.2.6 Accessories For 11 KV System

➢ **DISTRIBUTED I/O (PROVIDED BY CONTRACTOR OF E&M / SCADA)**

Distributed I/O's are required for using the advantages of a double-sided feeding at the 11 kV System. The distributed I/O's will be provided by the contractor of E&M/SCADA. All data points of the 11 kV-System run to the distributed I/O's .

➢ **FIRE EXTINGUISHER**

CO fire extinguishers shall be provided in E & M Niches, equipment room / Niches substation.

The fire extinguishers shall be made of galvanized steel and resistant against frost. Dry powder extinguishers only in rooms with lower voltages than 1 000 V are allowed. So, in the high voltage rooms CO2-fire extinguishers shall be required.

➢ **ACCESSORIES FOR 11KV (SUB) STATION**

Each 11 kV (sub) station shall be equipped with:

- Single Line Diagram of 11 kV-System of tunnel with glass-covering
- Sheet / Board including the instruction for first aid by electrical accidents
- Sheet / Board including the instructions for fire-fighting measures in electrical plants
- Prescription of operation of High Voltage Systems
- Suspension Device for accessories
- Warning Sign "Attention High Voltage"
- Voltage Detector
- Earthing Accessories

3.2.7 Operation Modes

All switching equipment, which shall be equipped with a remote-control switch, shall need a changeover switch. Therewith a switching between local- or remote-control is possible.

➢ **LOCAL CONTROL:**

If the changeover switch is positioned at "local control", all up streamed switching equipment has

to switch off the remote controlling. The whole switchgear interlocking shall also work at local control.

- **REMOTE CONTROL:**

At this position of the changeover switch the user shall be able to choose between different switch possibilities out of a predefined matrix. Generally, it shall be possible to decide which of the two feedings shall be switched.

A remote controlling of the high voltage power supply shall only be possible, if:

- No changeover switch is positioned at local control.
- No earthing switch is switched.
- No fault is stored.

Table 7: Technical Datasheet For 11kv Gas Insulated Switch-Gear

Sl. No	Description	Technical Parameters
1	Switchboard	
2	Manufacturer's Name	By Bidder
3	Type	By Bidder
4	Standards Followed	IEC 62271-100/200
5	Main Bus bar	
	a) Current Rating	630A
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
6	Earth Bus bar	
	a) Current Rating	25kA
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
7	Continuous current Rating for Ambient Condition of site when installed in IP 4X Switch board	
	a) Main Bus bar at Ambient Specified	630A
	b) Tappings at Ambient Specified	630A
8	Temperature rise of Bus bars while	
	a) Carrying rated Current and Installed in IP4X enclosure at an Ambient Temp specified.	As per IEC-60694 Table-V, IS-12729-2004
	b) Under Short Circuit Condition	N.A
	Degree of Protection of Enclosure	SF6 gas chamber- Stainless Steel IP65 Drive-IP2X Low Voltage-IP3X
9	Minimum Clearance in Air	
	a) Between Phases	Since all parts in SF6, clearance is not applicable.
	b) Between Phase to Earth	Since all parts in SF6, clearance is not applicable.
10	Clearance required at the Back & Front of Panel	AFR: 500 mm @ rear 1700 mm @ front
11	Overall Dimension of the Switch Board (mm)	
	a) Length	In line with Switch Board

Sl. No	Description	Technical Parameters
		Configuration
	b) Width	450m/ 600mm
	c) Depth	1400mm
	d) Height	2400/2800mm
12	a) Access Height (mm)	
	i) Maximum	1850 mm height of lock of LV box door
	ii) Minimum	830 mm height of cable box handle
	b) Weight of Panel Board (kg)	
	j) Maximum :	Approx. 900
	k) Minimum :	Approx. 700
13	Insulation Level including all the Components	
	a) Power frequency withstand Voltage for 1 min	28 kV
	b) 1.2/50 µ sec Impulse Withstand Level	75 kV
14	Circuit Breakers	
(i)	Manufacturer's Name	
(ii)	Type	
(iii)	Manufacturer's Type reference	
(iv)	Closing Mechanism	Spring
(v)	Normal Current rating in Air & corresponding	630A
(vi)	Ambient Temperature	40°C
(vii)	Derating factor for Ambient condition at Site	N.A
(viii)	Service Voltage & Frequency	11 kV, 50 Hz
(ix)	Maximum Voltage at which CB can Operate continuously	12 kV
(x)	Rated Making Capacity	25kA
(xi)	Rated Breaking Capacity	63kAp
(xii)	a) Symmetrical	25kA
(xiii)	b) Asymmetrical	27kA
(xiv)	Short Circuit With stand Capacity	
	a) 3 Sec	25kA
	b) 1 Sec	25kA
(xv)	Total Make time	Within 60ms
(xvi)	Total Break time	Within 60ms
(xvii)	No. of Breaks per pole	1 No.
(xviii)	Total Length of Break per pole	
(xix)	No. of Auxiliary Contacts (NO/NC) for Employer's use	8
(xx)	Type of Arc Control Device	Vacuum
(xxi)	Arc Duration time	
	a) 100 % Load Current	Within 10ms
	b) 10 % Load Current	Within 10ms
(xxii)	Spring Charging Motor	
	a) Type	Universal Motor
	b) Voltage	230 V AC
	c) Rating in kW	0.223
	d) Protection relay provided	Not Applicable
	e) Protective MCB s provided	Yes
(xxiii)	Power required for :	
	a) Closing	
	i) Momentary	250W
	b) Holding	N.A
	c) Tripping	250W
	d) Time taken for Charging Motor to Charge Spring completely	8 seconds

Sl. No	Description	Technical Parameters
(xxiv)	Number of consecutive operation the breaker can withstand and the recommended interval between these operations:	O-0.3Sec-CO-3Min-CO
(xxv)	Number of short circuit current interruption after which the breaker requires attention & maintenance	100 @ 25 kA STC
(xxvi)	Number of normal operations after which the breaker requires attention & Maintenance	10000
(xxvii)	Rated capacitor breaking current of breaker/ contactor of each rating	N.A
(xxviii)	Confirm that trip and closing coils will be suitable for 110 V DC and the spring charging motor will be suitable for 240 V AC	Yes
(xix)	Maximum number of XLPE cables & sizes that can be terminated safely in the cable chamber without extension panel	
	a) Single core (Size & No. of Runs)	N.A
	b) Three core (Size & No. of Runs)	Max. 1 cables XLPE Three core 400 sq.mm
(xx)	Maximum no of cables that can be terminated in the cable extension box (Please state the dimensions of such cable extension Box)	N.A
(xxi)	Minimum available distance from the bottom of the panel to the terminals in cable box/chamber for terminating cables	500mm.
(xxii)	Weight of circuit breaker and truck	fixed mounted GIS
15	**Instrument Transformers**	
(i)	Makes	
	a) CTs	By Bidder
	b) PTs	By Bidder
(ii)	Standards followed	IEC
(iii)	Confirm that CTs and PTs will be epoxy resin cast insulated	CT foil, VT metal-cast resin
(iv)	3 second short time current rating of CTs, kA.	25kA
(v)	1 second short time current rating of CTs, kA. :	25kA
(vi)	Dynamic current rating of CTs, kA :	63kAp
(vii)	Confirm that accuracy classes shall be as specified and ratios and capacities shall be as required	Pls. refer Technical Offer
(viii)	Confirm that all protective, metering, control and annunciation devices, transducers as specified shall be provided	Pls. refer Technical Offer
(ix)	Enclose technical particulars, data sheets, catalogues of all types of relays and other plant being offered by you	Pls. refer Technical Offer
16	IP Rating	
	(a) Tank	IP 67 HV part
	(b) Cubicle assembly	IP 3X
17	SF6 Gas Pressure	0.6 bar (0.06 MPA)
18	Gas Leakage Rate	< 0,1% per year
19	Gas handling Requirement at Site	No Gas handling allowed at site
20	**Cable Terminations**	
	Make	By Bidder
	Type	Outer Cone

3.3 Transformer

3.3.1 33/11 kV Transformers

The transformer shall be installed in the way that no vibration will be transmitted to the building/ construction. The Transformer shall be of kVA, 33/11 kV, oil filled type for normal application.

1. Requirement for two winding transformers with On Load Tap Changing Mechanism

- The two winding Power transformers shall be Natural Ester oil immersed transformers shall conform to IS 2026, IS-1180 and IEC 62770 standard for Natural Ester Oil filled trans

  This specification covers design, engineering, manufacture; shop testing, inspection, painting, packing, and supply of Distribution Transformers complete with all accessories for efficient and trouble-free operation of the proposed Substation.

  The design, manufacture and performance of equipment shall comply with all currently applicable statutory regulations, and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the E & M contractor of this responsibility. The Quality of Raw material, Manufacturing process & design parameters should meet the requirement so as to ensure quality of transformers former and shall have following specifications:

- The equipment shall conform to the latest edition of applicable standards as follows. In case of conflict between applicable standards and this specification, this specification shall govern.
  - IS 2026, for Tests & tolerance on Guaranteed Particulars
  - IS:3639 for Fittings and Accessories
  - IS:2099 for Bushings > 1000 V
  - IS:7421 for Bushings < 1000 V
  - IS:1271 for Electrical Insulation classified by Thermal stability
- Transformers shall accept, without injurious heating, combined voltage and frequency fluctuations which produce the 125% over fluxing condition for one minute.

➢ **GENERAL CONSTRUCTION:-**

All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

- Tank:

  The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of a flossy, oil and weather resisting non-fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.

- Steel bolts and nuts exposed to the atmosphere shall be galvanized.
- Unless otherwise stated, the tank together with radiators, conservator, bushings, and other fittings shall be designed to withstand without permanent distortion the following conditions:
- Full vacuum of 760 mm of Hg, for filling with oil by vacuum.
- Internal gas pressure of 0.35 Kg/cm2 (5 lbs/sq.in) with oil at operating level.
- The tank cover shall be suitably sloped so that it does not retain rainwater.
- The material used for gaskets shall be cork neoprene or approved equivalent.

- Core:

  Transformer shall be double wound, core type with low loss, non-ageing, high permeability PRIME GRADE , CRGO with M4 Grade or Better, perfectly insulated and clamped to minimize noise and vibrations. Followings should be Mandatory for any Manufacturer:-

- Transformer shall be of BOLTLESS core design
- Core shall be purchased Directly from Manufacturer or from their accredited Marketing organization of Repute & not through any agent. Bidder has to submit manufacturer's name during bidding having sufficient credential & Core has to be purchased from the approved manufacturer.
- Stage inspection of the core shall be done at manufacturer's premises & inspection call shall be given with following Documents:
  - Invoice of the supplier
  - Mill's test certificate
  - Packing list
  - Bill of landing & Bill of Entry certificate by customs
- Transformer manufacturer should have in-house core cutting facilities for proper control & monitoring of quality & to avoid mixing of Prime core with Second grade /defective core materials. Transformer Manufacturer should have inhouse slitting Machine so as, core is cut to width & stacked with minimum air gap thus ensuring Burr level less than 10Microns.
- Core shall be procured from one of the reputed Manufacturers. The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2000V for one minute.
- Windings: -
  - Winding shall be made with 99.9% pure electrolytic grade copper, insulated with thermally upgraded paper (Insulation Class A / Conductor Interturn insulation Class E). The HV & LV winding should be able to withstand thermal and mechanical stress in the event of short circuit.
  - Winding shall be carried in dust free area
  - The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.
- Oil: -
  - Transformer oil shall be as per IEC 62770 / IS-1180 - Natural Ester vegetable oil. Oil should be Environment friendly, Green & Biodegradable. It should also exhibit safety against fire hazards.
  - Oil shall be filtered and tested for break down voltage (BDV) and moisture content before filling.

➢ **TEMPERATURE INDICATOR:-**

One set of winding temperature indicators with necessary current transformer, heating coil and a detector element and one set of oil temperature indicator with maximum reading pointer shall be

mounted locally so as to be readable at a standing height from ground level. Each of the above indicators shall be provided with necessary contacts for alarm and trip.

- **TEMPERATURE RISE**

The transformers shall be designed for continuous operation at their rated power without exceeding the temperature rise as per IS 2026 – Part 2 & it shall be 50˚C - 55˚C, over an ambient temperature of 45 ˚C. In core and other metallic parts: Temperature shall in no case reach a value that will damage the core itself, other parts or adjacent materials.

With the given climatic conditions, the transformers shall be capable of operating continuously on any tap at their normal rating without exceeding following temperature rises:

70° C above ambient temperature for oil.

80° C above ambient temperature for winding.

The temperature of a hot spot in winding shall not exceed 130°C when calculated over max. annual weighted average temperature of 35° C.

- **BUCHHOLZ RELAY**

The Buchholz relay shall be provided with two floats and two pairs of electrically separate contacts for alarm and trip. The relay shall have facility for testing by injection of air by hand pump and with cock for draining and venting of air. The location of the relay shall be such that all rising gas will readily reach it.

- **BUSHINGS**

  - All bushings shall be homogenous, solid porcelain oil commissioning type, uniformly glazed and free from blisters, burns and other defects and shall be furnished complete with suitable terminal connectors of adequate capacity. The bushings shall be located so as to provide necessary electrical clearances between phases and also between phase and ground as specified in relevant standards.
  - Bushings rated for 400A and above shall have non-ferrous flanges and hardware.
  - All bushings shall have puncture strength greater than the dry flashover value.
  - Neutral CTs shall be furnished with its secondary leads wired up to the terminal blocks. The terminals for CT secondary leads shall have provision for shorting. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover.

The minimum phase-to-phase and phase-to-earth external clearances for LV & HV bushings shall be as per IS 1180 (part-2)

Table 8: External (Air) clearances between bushings mounted on transformers:

Nominal System Voltage	Phase to Phase clearance in mm	Phase to Earth clearance in mm
Up to 1.1 kV	75	40
11 kV	255	140
22 kV	330	230
33 kV	350	320

Table 9: Air Clearances in Cable Box

Nominal System Voltage	Phase to Phase clearance in mm	Phase to Earth clearance in mm
Up to 1.1 kV	25	20
11 kV	130	80

Nominal System Voltage	Phase to Phase clearance in mm	Phase to Earth clearance in mm
22 kV	240	140
33 kV	350	220

- **TERMINAL ARRANGEMENT**
  - Low voltage terminals of Power transformer shall be brought out to bushing inside Cable Box
  - High voltage terminals of Power transformer shall be in arrangement to connection of Cable inside cable box
  - The cable box shall be suitable for cable termination kits and shall be self-supporting, weatherproof, air filled type, complete with all hardware such as gland plate, brass glands, tinned copper lugs, armour clamps etc.
- **MARSHALLING BOX**
  - A sheet steel weatherproof marshalling box of IP 55 construction shall be mounted on the tank of transformer and shall accommodate all auxiliary devices except those which must be located directly on the transformer. All terminal blocks for external cable connections shall be located in this box. The terminal blocks shall be ELMEX 10 mm2 or approved equal.
  - The marshalling box shall have the following as a minimum:
    - Loads disconnect switch for incoming power supply for auxiliaries.
    - All outgoing connections from transformer viz. Buchholz relay, temperature indicators, fault contacts for annunciation system etc.
    - Wiring and termination points individually of the following trip contacts for remote alarm and trip.
    - Winding temperature high / very high
    - Oil temperature high / very high
    - Buchholz relay Alarm / Trip
    - Oil level low
  - Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided.
  - Marshalling box shall be designed to facilitate external cable entry from bottom. Removable gland plates shall be furnished with double compression type brass cable glands.
  - Sufficient space shall be provided to avoid sharp bending and for easy connection of cables. A minimum space of 200 mm from the gland plate to the nearest terminal block shall be provided.
  - Wiring shall be done with HR PVC 650 V grade wires. The wire size for CT circuits shall be 4 mm2 copper and for other circuits shall be a minimum of 2.5 mm2 copper. Not more than two (2) wires shall be connected to a terminal. 10% spare terminals shall be provided.
  - All devices and terminal blocks within the marshalling box shall be identified by symbols corresponding to those used in applicable schematic or wiring diagrams.
- **GROUNDING**
  - Two grounding pads, located on the opposite sides of the tank, shall be provided for

connection of Switchyard ground mat for each transformer. Grounding pads shall have clean buffed surface with tapped holes. M10 G.I. bolts, nuts and spring washer shall be provided.

- 2 Nos. Ground terminals each shall also be provided on marshalling box, cable box & OLTC panel to ensure effective earthing.
- The Neutrals of the windings shall be brought out through neutral bushings at suitable location. The neutrals shall be suitable for connecting 75x10 mm Copper flat.
- For conductivity of earth connection, all gasketed joints shall be provided with minimum two nos. of copper strip of adequate size.

➢ **ON Load Tap Changing Mechanism**

- Should be Separately mounted out tank type (CTR make)
- Should comprise of 20 Steps / 21 Positions: +10% to -15% @ 1.25%
- RTCC & AVR to be supplied along with the OLTC.

➢ **OLTC shall be as per following:**

- The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
- When a tap change has been commenced it shall be completely independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.
- Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An Oil surge relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.
- Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketed and bolted cover with lifting handles.

➢ **OLTC driving mechanism and its associated control equipment (local) shall be mounted in an outdoor, weatherproof cabinet with IP 55 protection which shall Include :-**

- Driving motor (433V, 3-phase, 50 Hz. AC squirrel cage).
- Motor starting contactor with Motor Protection Circuit Breaker, isolating switch and HRC fuses.
- Control switch: Raise/off/lower (spring return to normal type).
- Remote/local selector switch (maintained contact type).

- Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
- Limit switches to prevent motor over-travel in either direction and final mechanical stops.
- Brake or clutch to permit only one tap change at a time on manual operation.
- Emergency manual operating device (hand crank or hand wheel).
- A five digit operation counter.
- Electrically interlocked reversing contactors (preferably also mechanically interlocked).
- 240V, 50 Hz. AC space heater with switch and HRC fuses.
- Interior lighting fixture with lamp door switch and HRC fuses.
- Gasketed and hinged door with locking arrangement.
- Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
- Necessary relays, contactors, current transformers etc.

➢ **Control requirements for OLTC : The following electrical control features shall be provided:**

- Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.
- Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

➢ **Automatic Control of OLTC: Automatic OLTC control shall include the following items:**

- Voltage setting device.
- Voltage sensing and voltage regulating devices.
- Line drop compensator with adjustable R and X elements.
- Voltage setting device.
- Voltage sensing and voltage regulating devices.
- Line drop compensator with adjustable R and X elements.
- Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
- Adjustable dead band for voltage variation.

➢ **OLTC Panel:**

The OLTC remote control equipment shall be suitable for 30V DC supply and shall be housed in an indoor sheet cubicle to be located in a remote-control room. The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed

cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be Powder Coated RAL7032 respectively. Earthing bus shall be of 25 x 6 mm copper.

Control switch : Raise/ Off/ Lower (spring return to normal type)

Auto/manual selector switch : (Maintained contact type)

- **Tap position indicator:**
  - Facia type alarm annunciator with "accept" and "lamp test" facilities.
    - A.C. supply failure
    - Drive motor auto tripped
    - Tap change delayed
  - Necessary auxiliary relays
  - Lamp indications for:
    - Tap change in progress
    - Lower limit reached
    - Upper Limit reached
    - Cable glands for power and control cables
    - 240 V rated panel space heater with ON-OFF switch
    - Fluorescent type interior lighting fixture with lamp and door switch
    - HRC fuses
    - Terminal blocks
    - Internal wiring
    - Earthing terminal
    - Supply ON Indication Lamp.
    - Labels for Accessories.
    - Automatic Voltage Regulating Relay.
    - Heater Switch (Rotary Type)
    - Control Supply Switch (Rotary Type)
    - Hooter for Facia annunciator (230V AC)
    - Time Delay Relay for 'Tap Change Delayed' (110V AC)
    - H.V. Voltmeter (Digital Type)
    - H.V. Voltmeter Selector Switch (Rotary Type)
    - L.V. Voltmeter (Digital Type)
    - L.V. Voltmeter Selector Switch (Rotary Type)

- PT for AVR.
- Tap changer Counter for registering

➢ **Valves**

- Valves shall be of forged carbon steel above 50 mm and of gun metal for sizes upto 50mm. They shall be of full way type with screwed ends. They shall be opened by turning counter clock-wise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.
- Every valve shall be provided with open/close position indicators. The valves shall be suitable for pad locking in open/close positions. All screwed valves shall be furnished with pipe plugs for protection.
- All valves shall be provided with flanges having machined faces drilled to suit the applicable requirements.
- Oil tight blank flanges shall be provided for the following.
  - valves opening to atmosphere.
  - for each connection for use when any radiator is detached.
- Any special radiator valves tools required shall be supplied by the bidder.
- The Transformer shall provide with Nitrogen Fire Protection system so as to envisage complete safety from Fire Hazards

➢ **TESTS:**

The tests listed below shall be carried out and shall be deemed to be included in the BIDDERS scope. E & M offer shall include prices for carrying out all tests as specified.

➢ **ROUTINE TESTS – The manufacturer should have NABL accredited test lab.**

- Measurement of winding resistance
- Measurement of voltage ratio and check of voltage vector relationship
- Measurement of impedance of voltage (principal tapping), short circuit impedance and load loss.
- Measurement of no-load loss and current
- Separate source voltage withstand test
- Induced overvoltage withstand test (2 times the rated voltage)
- 2kV withstand test for all wiring
- Magnetic Balance Test

➢ **TYPE TESTS**

- Pressure & Vacuum test needs to carry out on 1unit of each rating
- Noise level test needs to carry out on 1 unit of each rating.
- Heat run and Impulse test shall be carried out on 1 unit of each rating…
- Short circuit report of similar / higher rating not older than 3 years

➢ **LOSSES:**

Losses shall be as follows: -

Respective Current density & Flux Density shall be to suit the required No load & loss levels

- All the measurement of losses shall be carried out by digital meters of class 0.5 or better accuracy and should be certified by the manufacturer. If the losses measured are found to be out of tolerance band as stated in Standard and guaranteed losses declared by manufacturer, the same shall be attributed to the manufacturer as per capitalization formula till the end of warranty period.
- One transformer of each rating, selected randomly from the lot shall be sent for measurement of losses, client reserves rights of cancellation & replacing equipment of proper specification by E & M contractor to comply as per contract agreement terms / condition

➢ **ACCEPTANCE TESTS**

- One transformer of each rating, selected randomly from the lot shall be sent for measurement of losses, declared by vendor (on data sheet) at third party / any NABL accredited lab.
- Oil Leakage test for acceptance shall be conducted at pressure of 0.35kg/sq.cm for one hour.
- Checking of weights, Dimensions, fitting and accessories, tank sheet thickness, oil quantity, material, finish and workmanship, Physical verification of core coil assembly and measurement of flux density on one unit of each rating of the offered lot with reference to the GTP and contract drawings.
- Temperature rise test on one transformer selected randomly to be sent at NABL accredited lab at contractor cost. If transformer fails, the test or found to be under rated the contract shall be terminated as per clauses of contract agreement.

3.3.2 11/.433 kV Distribution Transformers

- SCOPE OF SUPPLY & SERVICES

The scope of work for the “Distribution Transformers” and associated items covered under this specification shall include but not limited to the following:

Design, engineering, procurement, manufacture, fabrication, shop testing and inspection, supply, packing and forwarding, transportation to site, Unloading, Erection and Commissioning of Transformers.

All materials supplied under this contract shall be new and unused.

Inspection and expediting, handling, packing, forwarding, transporting, documentation including submission and approval of drawings, Commissioning, and performance testing of equipment.

Engineering of all the systems covered in this specification, including preparation and submission of detailed drawings & documents / calculations / reports as detailed and quantification of entire items included in scope.

Submission of drawings, documents, test certificates & calculations for information / approval of the PURCHASER / CONSULTANT, as elaborated elsewhere in this document, including those required for submission to Chief Electrical Inspector of Government.

3.3.2.1 SYSTEM DESIGN BASIS

- **INSULATION REQUIREMENT**

The insulation requirement of transformer windings shall be

Normal voltage (kV)	0.433	11
Highest system voltage kV (RMS)	1.1	12
Lightning impulse with stand voltage kV (peak)	-	75
Short duration power frequency withstand voltage kV (RMS)	3	28

- **DUTY REQUIREMENT**

The transformer and all its accessories like current transformers, bushings etc., shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 seconds. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

Source short circuit levels to be assumed for design with an operating time duration of 3 sec:

At 33 kV:25 kA

At 11 kV:25 kA

At 0.433 kV:50 kA

Transformer shall have mechanical and thermal capabilities for withstanding the short circuit current for the specified duration without any damages.

All the transformers shall be designed for the following over fluxing withstand capability:

110%:Continuous

125%:10 seconds for Distribution Transformer

The transformer shall be capable of being loaded in accordance with specified standards. There shall be no limitation imposed by bushings, tap-changer etc.

The overload capacity of the transformer and their emergency short time ratings called for in schedule shall be furnished.

- **IMPEDANCE**

The percentage impedance voltage at principal tapping on the ratio primary /secondary MVA base shall be as per technical data. The impedance shall be without negative tolerance.

To achieve the above percentage impedance value, no reactor either inside or outside the tank shall be used.

- **LOSSES**

Loss figures shall be guaranteed, without positive tolerance.

The no load loss in kW at the rated voltage and frequency and the load loss in kW at the rated voltage, rated frequency, rated output and at 75 Deg. C shall be quoted and these figures shall be guaranteed.

If the test figures exceed the quoted values, the transformer will be rejected.

The transformers shall be installed in that way, that no vibrations will be transmitted to the building / construction. The connecting of the 11 kV-cables at the transformers only shall occur with right-

angle connectors. Those right-angle connectors shall be calculated into the price of the 11 kV-cable.

1. DRY TYPE 11 / 0.433 KV TRANSFORMER (INDOOR PORTAL / NICHES SUBSTATION)
2. DRY TYPE 11 / 0.433 KV TRANSFORMER (NICHES/PORTAL SUB-STATIONS):

A) SPECIFIC REQUIREMENTS FOR DRY TYPE TRANSFORMERS

- **Temperature Rise**

  Temperature rise of winding measured by Resistance : 90 deg C

- **Constructional Features**

  - The transformer shall be of cast resin encapsulate type, but shall be naturally cooled (AN) and moisture proof. Insulating materials used in construction shall be of non inflammable. The transformer shall be housed in enclosure fabricated from sheet steel of minimum 2mm thick. Degree of protection for the enclosure shall be at least IP33. Screen shall be perforated sheet steel type. Mesh size shall be such that lizards, rats etc. cannot enter inside the enclosure.
  - The enclosure shall be adequately reinforced to ensure rigidity so as to permit transportation of transformer within enclosure. Base frame for moving the transformer shall be min. 4mm thick and shall be provided with bi-directional rollers/mounting skid.
  - Double leaf access shall be provided with concealed hinge and neoprene gaskets for easy access to H.V. links and also for withdrawal of core and coil assembly if required.
  - Enclosure shall be provided with lifting lug and grounding terminals. Further the enclosure door shall have provision of padlocking in door-closed position. The door should be easily but firmly lockable.
  - For all dry type transformers, following safety interlocks shall be provided:
    - A safety interlock shall be provided to ensure that the enclosure door can be opened only when transformer is de-energized.
    - Safety limit switches operated by door handle shall be provided for tripping HV & LV side breaker.
  - Similarly, the outer surface shall also be cleaned of all scale and then the primary coat shall be applied, immediately after cleaning. The second coat shall be of epoxy paint of shade conforming to Siemens Grey – RAL 7032.
  - Steel bolts if used, shall be parkerised. Terminal screws, studs, nuts and bolts shall be of non- ferrous material, threaded conforming to IS.
  - All fasteners exposed to weather shall either be nonferrous/Heavy duty type CPF/ZPF or hot dip galvanized or electroplated conforming to relevant I.S.

- **Core**

  - Core, its supporting steel and insulation shall be of such design, material and construction that harmful changes in electrical or physical properties shall not occur during the life of transformer. Limbs and yoke shall have similar section to minimize effects of transverse flux. Butt joints between yoke and limbs shall not be made. Generous cooling ducts shall be provided for core heat dissipation to ensure that maximum temp. Rise will not exceed

the temperature indicated in the technical data sheet.

- Core and winding shall be strongly braced, casted and held at respective places to prevent displacement or distortion during transportation or abnormal electrical conditions in service. Core grounding arrangement shall be located at the top for easy access from inspection hole.

- **Windings**
  - Each coil shall be high quality fibre glass insulated reinforced with epoxy resin, continuous smooth, high grade, electrolytic copper conductor, without sharp corners or bends and shall be adequately transposed to minimize eddy current losses and equalize current and temperature distribution. Abrasive damage and high dielectric stresses in insulation shall not occur. Similar coils shall be interchangeable. Liberal ducts shall be provided for prevention of 'hot spots' that may affect insulation life. Insulation of windings and other live parts should be adequate to sustain 110% of rated operating voltage continuously.
  - Coil supports shall be by permanently secured, highly compressed and dried regularly spaced insulating spacers. Coil clamping rings, if of steel shall each be earthed by connection to core clamping structure and shall otherwise be of insulating material built up from flat laminations.
  - Insulating material shall be of proven design. The insulating material shall be glass fibre reinforced conforming to class `F'. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and are suitable to withstand even the severest to temperature variation. Separate encapsulation for HV and LV winding shall be provided.
  - Winding assembly shall be dried in vacuum, thoroughly shrunk to final dimensions and resin casted. The whole assembly shall finally be held under compression of at least twice the thrust likely to be set up under a terminal short circuit.
  - Design, arrangement, insulation and assembly of the winding on core shall be so as to ensure uniform distribution of voltage surges amongst all coils and minimize stresses in winding due to terminal short circuit. No corona discharge shall result in the winding upon exciting the transformer for specified induced voltage test.

- **Earthing Arrangements**

  The core coil assembly shall be directly connected to this ground bus by removable bolted link for effective grounding. Earthing terminals shall also be provided on cable box and marshalling box to ensure its effective earthing.

- **Terminal Arrangement**
  - Terminal box shall be of air filled type. The cable box shall have all standard facilities envisaged for dry type transformer.
  - Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required. The bottom plate shall be of non magnetic stainless steel, brass or aluminium for all transformers on LV side requiring cable connections. The disconnecting chamber shall be air insulated, removable links and removable covers shall be provided for the disconnecting chamber. Plates through which high current carrying conductors pass, shall be of non magnetic materials.

- **Off-Circuit Tap Changer**
  - The off-circuit tap changing will be effected by change of links for dry type transformers. Arrangement shall be such that the contacts are correctly engaged. A warning plate indicating that change of links for tap changer switch shall be operated only when the transformer is de - energized shall be provided.
  - All contacts shall be silver plated and held in position under strong contact pressure to ensure low contact drop and avoid pitting.
  - The design of tap changing link for dry type transformers shall be such as to ensure that same tap is set on the three phase at a time.
- **Bushings / Support Insulators:-**
  - Bushings/Support Insulators shall be designed and tested to comply with the applicable standards.
  - Bushings shall have non- ferrous and non-magnetic flanges and hardware.
  - Fittings made of steel or malleable iron shall be galvanised.
  - All bushings/support insulators shall be supplied with terminal connector clamp suitable for supporting the bushing terminal & the PURCHASER'S conductor as specified in data sheet.
  - Minimum air clearance and minimum creepage distances shall be as per data sheet.
  - Bushing/support insulators material shall be porcelain.
- **Temperature indicator**

  Three numbers of programmable winding temperature indicator of digital type shall be provided. The Temperature indicator shall have a separate relay with 2 NO and 2 NC contacts for alarm and trip. The display shall be with LED type.
- **Marshalling Box**
  - Sheet steel vermin and weather proof marshalling box, shall be provided with a controlled metal clad heater to accommodate the following equipment.
  - Terminal boards and gland plates shall be with suitable glands for incoming and outgoing cables, meant for temperature alarm / trip, annunciation and lamp indication devices for remote panel, etc.

Technical data sheet / particulars

To be submitted with technical bid – schedule – technical particulars

Documents to be submitted after award of contract

- General outline drawing, showing front elevations and plan views of the transformer and all accessories and external features with detailed dimensions, weights, crane lift for un tanking and for erection / removal of bushings, size of lifting lugs and pulling eyes, HV and LV terminal clearances,live terminal to ground clearance, quantity of insulating oil and dimensional details for foundation.
- Terminal box drawings showing disconnection chambers / LT busduct flange.
- Assembly drawings of HV, LV and Neutral groundings.

- Core earthing details with disconnecting link
- Detailed calculation for radiator design and cooling fan capacity
- Schematic control and wiring drawing and drawings showing temperature indicator circuits and control system for cooling equipment.
- Drawing showing construction and mounting details of marshalling box.
- Drawing, giving details of name plate, terminal marking and connection diagram.
- Drawing on tap changer gear assembly and online OLTC oil filtration system.
- The magnetisation characteristic curves of the bushing current transformers, indicating the knee point voltage excitation current and secondary resistance.
- Drawing on terminal clamps.
- Core saturation curves.
- Calculation to demonstrate the ability of transformer to withstand dynamic forces due to short circuit.
- Detailed erection, testing & commissioning, operation and maintenance manuals.
- Detailed Instruction for storage of equipment at site.
- GA, Dimensions & Weight of Transformer during shipment.
- Any approval given to the detailed drawings by the PURCHASER shall not relieve the SUPPLIER of the responsibility for the correctness of the design, completeness of the equipment supplied and in the execution of the works in accordance with the terms of specification.
- Additionally, eight (8) sets hard copies of above drawing shall be submitted by the SUPPLIER for Client's approval purpose.

TESTING & INSPECTION

- **INSPECTION**
  - The accredited representative of the PURCHASER shall have access to the SUB-SUPPLIER's works at any time during working hours for the purpose of inspection of manufacture or testing and selection of samples of the materials going into the equipment. The SUPPLIER shall provide necessary facilities for such inspection or test.
  - The core and coil assembly shall be offered for PURCHASER's /CONSULANT's inspection prior to tanking and the readiness for such inspection shall be intimated at least 15 days in advance. The tanking of core and coil assembly shall be taken up only after approval by PURCHASER /CONSULTANT.
  - All the type / special / routine tests on the transformers as per of latest issue and indicated below will be witnessed by PURCHASER's / CONSULTANT's Engineers and all necessary facilities for inspection and testing shall be provided by the SUPPLIER. The transformer shall be completely assembled and tested at the SUPPLIER's factory.
  - The SUPPLIER shall ensure that the test instruments have calibration certificate issued by an approved standard laboratory, not earlier than six months from the date of testing.
  - The readiness of the transformers for testing and final inspection shall be intimated to the PURCHASER / CONSULTANT at least 15 days in advancefor deputing Engineers for inspection / witnessing the tests. The transformer

- will be accepted at site by the PURCHASER's / CONSULTANT's Engineer only on production of the approved test certificates.

- **FACTORY ASSEMBLY AND TESTS**
  - The following type tests (to be conducted on any one (1) of the Distribution transformer for each rating) as per specified standards shall be carried out in the presence of representatives from PURCHASER / CONSULTANT. The PURCHASER shall have the right to test the transformer at neutral agency or test the transformer at SUPPLIER's works through external agency :
    - Temperature rise test at the barest tap position at ONAN (Loss figures at corresponding tapping to be considered, for testing).
  - The following routine tests as per specified standards shall also be carried out on the all types of transformers, free of cost.
    - Measurement of winding resistance.
    - Measurement of voltage ratio and check of voltage vector relationship,
    - Measurement of impedance voltage / short circuit impedance (principal tapping) and load loss.
    - Measurement of no load loss and current.
    - Measurement of insulation resistance.
    - Dielectric tests (Power frequency voltage test and induced overvoltage withstand test).
    - Oil leakage test on transformer tank : The tank and oil filled compartments shall be tested for oil tightness by completely filling with air / oil of viscosity not greater than that of insulating oil, conforming to specified standards at the ambient temperature and applying a pressure, equal to the normal pressure plus 35 kN/Sq.m measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leakage shall occur.
    - Magnetic balancing test.
    - Measurement of no load current with 415 volts supply.
    - Check for polarity and ratio tests for knee point voltage and magnetising current for bushing current transformer.
    - Measurement of zero sequence impedance.
    - Measurement of harmonics of the no load current.
    - Measurement of tank and capacitance of each winding to earth (with all other windings earthed) and between all windings (connect together) to earth.
  - The test sequence shall be tests on transformer tank, heat run test, pressure test on the assembled transformer, routine tests and special tests.

- **TESTS AT SITE**
  - After erection at site, the transformers shall be subjected to the following testsby the CONTRACTOR, who will be engaged by the PURCHASER:
    - Insulation resistance test.

- Ratio and polarity test on all taps.
- Dielectric test on oil
- Open circuit and short circuit test
- Operation test of OLTC
- Operation test of protection devices and interlocks.

➢ Measurement of winding resistance at all taps.

➢ Any other test as may be insisted upon by PURCHASER / CONSULTANT.

- **TEST CERTIFICATES**

➢ Six copies of the test certificates on the above type tests / special tests /routine tests with the endorsement of the Inspecting Officer shall be furnished for approval.

➢ The test report shall provide the following information:

- Complete identification data, including serial no. of the transformer.
- Method of application where applied, duration, and interpretation ofresults in each test.
- Temperature data corrected to 75 deg C including ambient temperature.

➢ The equipment will be rejected if test results are not in conformity with the Guaranteed Technical particulars.

➢ Besides the above test certificates, SUPPLIER / SUB-SUPPLIER's test certificates in respect of the following accessories shall also be furnished in six copies:

- Off-circuit tap changer
- Bushings
- Bushing current transformers (with magnetisation characteristic curves)
- Buchholz relays & Surge relay
- Magnetic oil level gauge
- Winding temperature controller.
- Oil temperature controller
- Radiators
- Transformer oil
- Any other bought out components not specifically mentioned herein.

➢ The SUPPLIER shall also furnish test certificates to the effect that the transformer core has been tested after assembly and immediately prior to the despatch of the transformer for one minute at 2000 volts AC between all bolts, side plates and structural work.

Table 10: Technical Datasheet for Oil Immersed Type 33/11kv Transformer

Rated power	KVA as specified / as required
Voltage (primary side)	33 kV
Voltage (secondary side)	11 kV
Nominal Frequency	50 Hz
Cooling	ONAN
Tapping	20 steps (+10% to -15% @ 1.25%)

Internal gas pressure	0.35 Kg/cm2 (5 lbs/sq.in)
Core design	Boltless
Oil	Natural ester vegetable oil as per IEC 62770, IS-1180
Winding insulation	Thermally upgraded paper (Insulation class-A / conductor Inter turn insulation class-E)
Impedance voltage	7.0%
Vector Group	Dyn11
Location	Grid station
Primary connection	Totally insulated plug-in connector
Secondary connection	Connection safe to touch with connecting lug and insulating cover

Table 11: Technical Datasheet for 11/0.433kv Distribution Transformer at Portal and Inside Tunnel

S. No.	Description	Technical Parameters
1	**GENERAL**	
	Application/designation	Distribution transformer
	Service	Step down transformer
	Type	Dry type cast resin / two winding
	Installation	Indoor
	Degree of protection for transformers with enclosure as per IS:2147	IP-33
2	**RATINGS**	
	Rating	KVA
	Rated primary voltage	11000 V
	Rated no load secondary voltage	433 V
	No. of phases	3-phase on HV 3-phase with neutral on LV
	Frequency	50 Hz
	Vector group	Dyn 11
	Percentage impedance	6.25%,5.0%
	Permissible tolerance on impedance	± 10%
	System fault current for 1 second duration	HV Wdg : 25 kA (rms) LV Wdg : 50 kA (rms)
	Type of cooling	Natural air cooling (AN)
3	**SYSTEM VOLTAGE**	
	Nominal system voltage	11000 V
	Highest system voltage	12 kV for 11 kV winding 1.1 kV for 433 V winding.
4	**NEUTRAL EARTHING**	
	Transformer neutral earthing	LV Winding: Effectively earthed Note:-1) Additional neutral bushing should be provided for neutral earthing. Note: - 2) Neutral CT Shall be provided for REF Protection .CT Details shall be finalized during drawing approval stage.
5	**INSULATION WITHSTAND VOLTAGE**	
	Impulse (1.2/50 µ-sec. wave)	HV Winding : 75 kV peak for 11 kV winding
	One minute power frequency	HV Winding : 28 kV for 11 kV winding LV Winding : 3.0 kV
	Class of Insulation	F
6	**TEMPERATURE**	
	Reference Ambient Temperature (Design)	-15% to 30°C
	Temperature rise by winding resistance at lowest tap (Max)	90°C

S. No.	Description	Technical Parameters
	Temperature on enclosure by thermometer (Max)	50°C
7	**Noise level**	
	Permissible noise level (Max)	73 dB
8	**TAP CHANGING LINKS**	
	Taps required	Off-circuit full MVA rating at each tap
	Type	Bolted link (Tinned copper links)
	Tappings on windings	HV
	Total tapping range	±7.5%
	Steps	2.5%
	Parallel Operation	Momentary with similar transformer.
9	**BUSHINGS/SUPPORT**	
	Voltage class	a) HV line end - 11 kV b) LV line end / LV neutral - 1.1 kV
	Impulse (1.2/50 µ-sec. wave)	HV Winding : 75 kV peak
	One minute power frequency	HV Winding : 28 kV LV Winding / LV neutral : 3.0 kV
	Minimum creepage distance	25 mm / kV
10	**SURGE DIVERTER**	3 nos. of Polymeric Zinc Oxide surge Arrestors (10 kV , 10 kA , line discharge Class-2)
11	**MINIMUM CLEARANCE IN AIR**	
	HV phase to phase	230 mm
	HV phase to earth	180 mm
	LV phase to phase	25.4 mm
	LV phase to earth	25.4 mm
12	**TERMINAL CONNECTIONS**	
	HV line end terminal with HT cable box	Suitable for terminating 11 kV x 300sq.mm XLPE armoured earthed grade cables.
	LV line end terminal with LT cablebox	Suitable for terminating 0.415 kV x 300sq.mm XLPE armoured earthed grade cables.
	LV neutral bushing	LV neutral bushings as per specification
	PURCHASER's earthing	Two no's of 185 sq mm copper earth conductor
	Colour finish shade of enclosure Interior/ exterior Cable/bus entry (bottom/Top side)	Glossy finished RAL 7032 Bottom for HT Cables/Top for LT cables
13	**ENCLOSURE**	
	Details of enclosure material and thickness	As per specification
14	Orientation of HT and LT termination compartments.	90 deg displacement

3.4 Diesel Generator Sets

- **Standards**

The design, material, construction, manufacture, inspection, testing and performance of the Engine/ Generator sets shall comply with all currently applicable standard, regulations and safety codes in the locality where the equipment shall be installed.

Standards to which the equipment covered in this tender shall be designed, manufactured, inspected and tested are listed below:-

ISO – 3046 Parts 1 to 4

BS – 4999 all parts including part 71 / equivalent standards.

IEC Standards for electrical and electronic equipments.

A.S.M.E. Boiler and pressure vessel code for welding procedures and welder

Qualification for all diesel engine sub systems.

TEMA Standards for tubular heat exchangers.

- **Scope**

The specification covers Design, Manufacture and Testing at works of **2 Nos.2000 KVA, 11 KV Prime duty (No standby duty DG is recommended) Diesel Generator sets** with associated accessories including Synchronizing Panel, Neutral Isolator / Neutral Grounding Resistor Panel.

The D.G. Sets are intended for use as emergency sets to start on AMF (Automatic Start on Mains Failure) and capable of a minimum of 50 - 60% step load and prime power continuous rating as per BS 5514 not less than their rated capacities at 0.8 PF. The speed of D.G. Sets shall not exceed 1500RPM and shall be of four-stroke design for operation on high-speed diesel.

The D.G. Sets with Radiator mounted on the skid, shall be capable of achieving 100% rated within 15 seconds of initialling a start& 10% overload for 1hr in every 12hours of operation. The D.G.Sets are intended for operating in parallel with provision for auto synchronizing and auto load sharing. The offer for the D.G. Sets shall include well designed ventilation and fuel systems, start up batteries with associated chargers, interconnecting piping, system and protection earthling with neutral grounding resistor and isolating facility, local control & AMF, 11 KV DG switchgear, cabling to the switchgear and necessary gadgets for interfacing to Tunnel management system (SCADA) to make the generating system complete in all respects, including acoustic control to meet statutory requirements.

The scope of services include delivery at site, positioning on foundation (Civil works will be done by some other agency), erection, testing & commissioning of DG sets with associated 11KV switchgear, running of DG sets on full loads, performance testing of the complete system to prove guaranteed parameters for fuel oil consumption, acoustics and temperature rise, including but not limited to the following.

- Supply, installation, testing and commissioning of 11KV D.G.Sets Radiator mounted on Skid
- Silencers, Exhaust piping including the outlets, insulation up to chimney.
- Earthing system (system earthing & protection earthing) with earthing resistor.
- Heavy duty antivibration spring type movement for the DG sets including hardware.
- Pipe lines from Bulk fuel storage tank to intermediate tank, day tanks and spill tank with associated pumps, valves, including necessary level sensors /over flow controls, float valve in each day tank complete with support structures and civil works.
- Brush less exciter and voltage regulators
- Generator Lubrication systems including pumps, piping, oil coolers, oil filters and reservoir.
- RTDs, BTDs and Space Heaters in Alternator (Anti condensation Type)Exhaust Silencers (Residential Type) with Insulation.
- AMF and engine instruments and control panel comprising electronic governor, automatic voltage regulator, facility for auto synchronizing, auto-load and VAR sharing, basic minimum engine protection & annunciation, auto synchronizing and breaker control switch.
- Power DB for auxiliaries, with necessary accessories and interlocks.

- DC power supply through adequately rated DC Battery and panel mounted Battery Charger.
- Ventilation system as / if required to maintain the temperature of the DG room within 10 degree C + ambient, with all DG sets running continuously.
- Supply and installation of free standing Chimney to connect the Generators.
- Fuel required for load test shall be included.
- Post Load testing 990Lts of Diesel need to be filled prior to Handing over.
- All necessary consumables such as Diesel, Oil, Coolant, D.M.Water need to be in Vendors Scope.
- Load Testing 2Hrs.30mins 100% ie.rated kVA capacities need to be performed at Site independently.
- Synch of 4x2000kVA need to be performed and exhibited with 50% load sharing At site.
- Each D.G.Sets need to be load tested at 25%- 30mins, 50%- 30mins, 75%- 30mins, 100%- 30mins, 110%- 30mins prior to Synch between both the D.G.Sets.
- Post Synch all the D.G.Sets need to run for 1hour in synch mode.
- Preparation of shop drawings and getting approval, arranging inspection and obtaining safety certificate from the Electrical Inspectorate
- Submission of wiring diagram, operation, maintenance and installation manuals, Test Certificates, Technical Leaflets etc.,
- The offer shall include necessary start up spares, fuel and lube oil required for commissioning and trial running of sets until handover.
- Generator Neutral Isolator Panel with Neutral Grounding Resistor connected to earth pit (S) through separate cables.
- Laying of 11KV 3C Ar Aluminium XLPE Cable from Generator to the incoming terminal of the 11KV HT VCB DG Control Panel and to the NIS/NGR Panel.
- Terminal box on Generator AMF / Control panel, generator, 11KV VCB Panel & PLC panel with inter connections through control, instrument cables,
- Terminal box for SCADA interface (cabling to SCADA by other agencies)
- PLC panel (Separate or part of relay – metering panel) with auxiliary connections through control / instrument cables to Generator/Engine, 11KV VCB Panel, to have auto load dependent start-stop arrangement.
- Battery with charger,
- Incoming pipes flanges from underground storage tank to intermediate tank.
- Protection earthing grid with connections to earth pits and to the body of generator/Engine, DG Aux switchgear, DCDB, PB stations etc.,
- DG Aux switchgear incoming terminals, outgoing terminals connected to fans, pump motors through power cables/control cables as applicable.
- Emission Testing at site need to conducted during the Load Test by Approved Labs

- **Services**
  - Obtaining approval of local CEIG with regards to layout, clearances and earthing drawings and permission for energizing the DG Sets.
  - After installation, exhaust gas sample shall be collected and tested in a laboratory to see the conformance with the emission norms laid by PCB for this engine rating. Necessary data shall be furnished to the customer and / or their agency who are liasioning with PCB for clearance.
  - Required parameters for foundation to be provided by the DG vendor. Erection, testing and commissioning of the DG sets including all items covered under the scope of supply.
  - Load test at site on each set shall be for a minimum period of four (2Hrs.30mins). Fuel oil and all other consumable required for the test shall be supplied by the contractor.
  - Cleaning debris and scraps from DG premises equipment and auxiliaries on completion of the entire installation.
  - Minor touchup painting of the equipment under reference.
- **Site Conditions**

Reference Design ambient or Electrical equipment	15 degree C to 30 deg C
Attitude	900 above MSL
Relative Humidity	55 to 85 %
Design Humidity	100%
Environment	Moderate conditions.
Installation	DG sets indoor

3.4.1 Requirements of Diesel Generator Units

- **General**

Standard Diesel Engine Alternator sets and auxiliary equipments are as indicated in the product information published by the Manufacturer. Engine Alternator sets shall be suitable for parallel operation in conjunction with paralleling switchgear provided by others.

The engine power (KW) shall be sufficient to deliver full rated generator set KVA, when operated at rated rpm, equipped with all engine-mounted parasitic and external loads and operated at specified site conditions. The D.G.Set need to be for Prime Power operation as per IS3046.

Engine Alternator sets shall meet IEEE emergency power requirement to start and be on line within 15 seconds of to feed the distribution loads.

The Engine Alternator sets shall be assembled on a robust base by the Engine Alternator manufacturer. In addition the supplier shall provide dimensions of a concrete foundation block to match the generator set base, sized to dampen effects of disturbing vibrating forces. The foundation shall be isolated from the building structure. The generator set base shall be designed and built by the Engine Alternator manufacturer to resist deflection, maintain alignment, and minimize resonant linear vibration.

Vibration isolators shall be of resilient rubber design and installed between the Engine Alternator set base and the mounting surface. The isolators shall bolt to the Engine Alternator set base and foundation block. The pads shall be resistant to heat and aging, and antifreeze, diesel fuel, and cleaning compounds.

The Engine Alternator sets transient response shall conform to IEEE requirements.

- **Design Of Construction Requirements**

  Diesel generator sets shall be designed without harmful vibration stresses specially, during acceleration and deceleration.

  Harmful tensional vibration stresses shall not occur within the range 10% above to 10% below rated idle speed and from 15% above to 10% below rated synchronous speed.

  Moving parts shall be designed to withstand, without damage, 115% of the rated synchronous speed. However, the generator, exciter and flywheel shall be designed to withstand over sped of 25% without damage.

  DG Sets shall be able to withstand all stresses imposed during normal operation, testing and overload.

  Equipment shall be designed and manufactured to withstand damage during transit, storage at site and after installation under the specified conditions.

  All dimensions shall be in mm. All nuts, studs and bolts shall be designed and fabricated to metric units.

  Nuts shall be hexagonal and bolt holes shall be spot faced for nuts.

  Materials shall be as per specifications and shall be new and first class in all respects.

  Castings and forgings shall conform to their respective material specifications and shall be free from flaws, machined true and a workman like manner.

  Identical parts shall be interchangeable.

  The design shall provide for ease of access during inspection, maintenance, and repairs.

  Fuel oil and lube oil piping shall be located as far as possible away from engine exhaust lines. Pressurized lines shall be installed in such a way that damage to neighbouring equipment is prevented in the event of pipe break and pipe whip.

  Materials for expansion bellows on exhaust and pressurized combustion air cooler and engine, silencer and exhaust pipe down streamside of silencer shall be of suitable grade stainless steel.

  The coupling between engine and alternator may be rigid of flexible as required.

  Simplex filters with bypass filter for servicing shall be provided in lube oil circuits.

- **Base**

  The DG units shall be mounted on a rigid fabricated steel sub – caste. Latitudinal beams shall be rigidly cross braced to avoid warping or bucking in transit or installation and the complete assembly shall be machined and drilled where necessary.

  Anti-vibration mounding of an approved make shall be provided to absorb and damp out vibrations, which would otherwise be transmitted to the foundation and nearby structures.

- **Tools**

  A set general maintenance Basic tools shall be furnished for each DG set.

- **PIPING (As Applicable)**

  Piping for cooling water, oil etc, shall be designed fabricated and tested in accordance with IS / ISO pressure piping code.

  All terminal connections and all pipe joints shall as far as possible be of welded constructions,

screwed terminal connection shall be avoided.

Piping design and installation shall be suitable for periodic testing.

- **Protection During Shipment**

  Materials shall be handled and stored so that they are protected against corrosion, damage or ingress of foreign matter.

  Flanges, openings, nozzles and terminals shall be thoroughly cleaned and adequately protected to prevent entry of extraneous material during transit and storage. Parts shall be suitably marked to facilitate matching during erection.

- **Painting**

  Machined and finished surfaces shall be protected against formation of trust and corrosion by application of a rust inhibitor.

  All steel surfaces which are to be painted shall be thoroughly cleaned, degreased and given one shop coat of premier, prior to assembly.

  All castings shall be sand blasted, degreased and cleaned before painting. Primary and final painting for work done at factory and site should be done by contractor.

- **Inspection**

  The contractor shall have rigid inspection procedure laid down to ensure quality of workmanship, compliance with material specifications and drawings, mechanical accuracy of components, identity and acceptability of all terminal, parts and equipment, both in his and his sub contractors works.

3.4.2 Technical Requirements of The Diesel Engine and Auxiliary System

3.4.2.1 Diesel Engine

The diesel engine shall be four-stroke, single acting, mechanical injection type and shall furnished with at least the minimum equipment according to BS 5514 / ISO standard practices. The horsepower rating, required auxiliaries, guarantees of fuel consumption, parallel operation, governor characteristics and performance, torsional vibration and materials and workmanship shall be in accordance with BS 5514 / ISO standard practices.

The engine shall be equipped with a flywheel. The engine shall be provided with an exhaust gas turbo-charge with after – cooler and an integral air filter and silencer.

3.4.2.2 Design and Construction Requirements of Diesel Engine

- **BED PLATE**

Bedplates shall be of alloy cast iron or fabricated steel. In the case of steel bed plates, welding shall be done in a continuous process. The fabrication shall be stress relieved after welding.

- **CRANK CASE**

Crankcase shall be of alloy iron casting with integral transverse diaphragm or alternatively of fabricated steel construction provided with heavy steel inner side plates to form water compartments around the cylinders. Access to bearings, camshaft, governor drive and water jackets shall be provided in the webs, journals and bearings to carry lubricating oil under pressure to the main connecting rod bearings.

- **MAIN AND BIG END BEARINGS**

Main and big end bearings shall be detachable prefinished sheets with high-grade bearing materials and shall be easily fitted without scraping or hand fitting. The big end dimensions shall be such that the connecting rods can be withdrawn through the cylinder liners.

- **BALANCING GEAR**

Engine shall be inherently balanced. Where this is not possible, engine shall be fitted with a balancing system driven from the crankshaft.

- **CONNECTING RODS**

Connecting rods shall be I beam sections of high grade drop forged steel and shall carry the big end bearings.

- **CONNECTING LINERS**

The cylinder liners shall be of the separately inserted ‘ Wet ‘ type cast in alloy iron and specially machined in their bores to give an oil retaining surface. They shall be flanged at their up ends and secured by the cylinder heads, with the lower ends located and sealed in the crank case by rings of synthetic materials resisting oil, water and heat.

- **PISTONS**

Piston shall be forged aluminum alloy or cast iron alloy and machined on their outer surface to a system o graduated cold clearance to provide good heat transfer qualities and maximum bearings surfaces consistent with clearances. The pistons shall be fitted with compression rings and oil scraper rings of hardened cast iron alloy.

- **CYLINDER HEAD AND VALVE GEAR**

The valve operating gear assembly shall be oil lubricated and shall be oil totally enclosed in alloy iron castings bolted to the crank case with narrow joint washer interposed between the head and top of liner to provide a gas tight seal. Each cylinder head shall have inlet and exhaust valves of heat resistant steel, which seat on wear – resistant inserts. Each cylinder head shall also be fitted with a fuel injector, combined pressure relief and compression release device, if required . the combustion chamber roof part walls and fuel injector sleeves shall e accessible for cleaning purpose. Each valve shall be loaded by concentric coil springs and shall operate in long detachable valve guides.

The valves shall be operated from the camshafts one for each bank of cylinders, by roller tipped cam followers. The valve gear mechanism shall be enclosed by light detachable covers.

- **CAMSHAFT**

The camshafts, one for each bank of cylinders, shall be build up in replaceable sections of heat treated precision- machined steel with Chromium plating and jointed by muff-couplings, the outer diameters of each rotate in gun-metal. Bushes housed in the crank case casting. All cams shall have hardened profiles. Inlet and exhaust cams shall be in one piece and keyed to the soft. Fuel injection cams of the split removable type shall be down loaded in angler location.

- **CAMSHAFT DRIVE**

The camshaft may be either chain or fear driven. Gears shall employ in the “hunting tooth” principle to ensure even wear. In the case of chain drives chain tensioning gear shall be located so that it is readily accessible.

- **FLY WHEEL**

The fly wheel shall be of mild steel statically balanced after machining and shall have graduated markings around its periphery to facilitate checking of valve and fuel pump timing. Flywheel shall have sufficient mass and inertia to meet specified limits of variation of generator eliminates torsional vibration within the operating speed limits of the governor and over speed trip, barring slots shall be provided around the flywheel rim of hand barring.

- **EXHAUST MANIFOLDS**

Exhaust manifolds may be single/double branch type insulated design utilizing Ni-resist Casting to guard against high temperature growth and cracking.

- **FUEL OIL SYSTEMS**

Fuel oil will be stored outdoors in bulk oil storage tanks provided by the purchaser. The purchaser will provide pipe connections from the tank to the fuel-oil day tank.

The supplier shall provide a 990L day tank, fabricated out of sheet steel, for each DG sets. The day tank shall be situated out side a DG room on a suitable concrete Structure to be provided by the purchaser. The day tank shall be provided with necessary level controls to operate the alarm indications.

An engine driven pump shall be provided to deliver the fuel oil from the supply line through strainers containing closely oven filtering material to the injectors.

The supplier shall provide all necessary piping , fitting, supports, valves and accessories to complete the fuel oil system.

Each Day tank shall be provided with two [2] nos. level alarm switches for:-

High level (900 ltr) / Low level corresponding to 30 mts fuel capacity of tank or 150 ltr.

Each tank shall be provided with a calibrated transparent tube for indicating the fuel level. Each tank shall be provided with a manhole, vent and drain nozzles, over flow pipe. Details of nozzles and also their orientation shall be furnished. All pipes shall be connected through flanged joints.

- **FUEL OIL PIPING ROUTING**

Fuel oil piping routing inside the DG room shall be shown by the supplier. A single line diagram of the piping showing sizes of pipes, valves, etc., shall be furnished with the tender.

- **LUBRICATING OIL SYSTEM**

Automatic pressure lubrication shall be provided by a gear type pump at the free end of the engine and driven from the crankshaft. Pressure switches shall be provided to give alarm if the pressure falls below a set value and subsequently trip the unit when the minimum safe pressure limit is reached. A dipstick shall be provided for level measurement. All necessary accessories such as pressure gauges, temperature indicators, pressure relief valves, by pass valves, pressure switches for alarm and controls shall be provided by the supplier together with all interconnecting piping, fitting supports, valves etc.

- **ENGINE STARTING SYSTEM**

Starting of the diesel engine shall be by electrical means. The diesel engine shall be provided with adequately rated battery of the lead acid type complete with all accessories, stand, interconnection etc.

- **AIR INTAKE AND EXHAUST SYSTEM**

The supplier shall provide an air filter and residential type silencer with the turbo charger.

Air will be taken from the diesel room as started elsewhere in this tender.

The exhaust system shall consist of an exhaust gas driven turbo charger with lagged piping interconnecting cylinder head outlets with turbo charger inlets. Exhaust manifold shall be of fabricated steel and it shall be suitably lagged. Exhaust gas from turbo charger shall be led out through necessary pipes, adopters etc., to an exhaust gas silencer.

Expansion joints shall be provided to take care of thermal deformations. Pressure drop in the exhausts piping including silencer, bends, expansion joints etc., shall be compatible with exhaust gas leaving the engine. The exhaust piping shall be duty throughout the length from the engine outlet up to the outlet point inside the room with high temperature resistant thermal wool, with chicken mesh and on top lagged with aluminium sheet wrapping. Bending radius of bends shall be not less than 3 internal diameters of chosen piping. A drain plug shall be fitted at the lowest point for condensate extraction. Exhaust pipe shall be raised above the highest point of the building and shall meet the regulations of pollution control board. Suitable supports shall be provided for proper installation of exhaust pipe.

The silencer shall be mounted so that its weight is not supported by the engine. Exhaust pipe size shall be sufficient to ensure that the exhaust back pressure does not exceed the maximum limitations specified by the engine / generator set manufacturer. Piping size shall not be less than 10” dia with B Class MS pipes duly supported.

The muffler and all indoor exhaust piping shall include lagging to maintain a surface temperature not exceeding 65 Deg; C. The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fitting.

Engineering data sheets detailing silencer attenuation, construction materials and all relevant physical dimensions in detail shall be provided. Data shall include bends, necessary adapters, tail pipe, brackets, supports, joints, bolts, diameter of exhausting piping, size of thimbles for penetrating walls, type of insulation for silencer, etc.

Exhaust system shall consists of the following:

- Exhaust pipe & Bends : Class ‘B’ M S pipe,
- Special exhaust silencer insertion loss value 25 dB (A),
- Freestanding chimney as per the specifications .

3.4.2.3 Governing System

The digital governing system shall conform to accuracy class A1 as per BS 5514 : Part 4. In addition when a 93KW motor for 2000KVA having a starting current of 3 Full load current (FLC) is started, the frequency dip and recovery time shall not be more than 5% and 3 Secs respectively.

Governor shall have the following features.

It shall be capable of operating both as an ‘isochronous’ or a ‘speed droop’ governor. The speed parallel operation shall be adjustable from 0-5% of the engine.

The governor system shall be provided with electronic devices, which would sense change in generator kW load and initiate corresponding change in governor setting prior to a signal being received from normal speed governing.

Governor shall be suitable for operation without external source of power supply.

A KW load sensing facility shall be available in the engine governor / controller. A over speed trip shall be provided to automatically shut off fuel in case the set reaches 110% rated speed.

An engine mounted emergency stop push button shall be provided.

➢ **REQUIREMENT OF SPEED GOVERNOR**

Speed governor shall have steady state transient response and recovery times fully conforming to class A1 governors as per BS 5514 part-IV.

○ **MOTORS FOR AUXILIARY SYSTEMS**

Motors if any for the auxiliary systems shall be suitable for 3 Phase, 415 +/- 10%, 50Hz +/-3% AC supply. Motors shall comply with the requirements of BS 4999 and BS 5000 for power station auxiliary duty. Degree of protection of motors shall conform to IP 55.

3.4.2.4 Requirements of Generator and Excitation System

- **SCOPE**

This specification generally describes the generators and associated equipment, excitation system and voltage regulator.

- **STANDARDS APPLICABLE**

The Equipment and accessories covered by this specification shall be designed, Manufactured and tested incompliance with the following latest relevant standards in order that specific aspects under working conditions are taken care of:

1. a. IEC Publication No.34-1	: Recommendations for rotating electrical machines.
b. IEC Publication No.34-1A	: Supplement to publication No.34-1
British Standard 4999	: Specification and general requirements for rotating electrical machinery.
Indian Standard 4722:1968	: Rotating electrical machinery
IEEE: 115	: Test Procedure for synchronous machines.
IS 4691 / 1968	: Degrees of protection.

The equipment and accessories for which Indian standards are not available shall be designed, manufactured and tested in accordance with the latest standards published by other recognized national standards institution.

The equipment shall also conform to the latest Indian Electricity Rules as regards safety, earthing and other essential provisions specified there in for installation and operation of electrical plants.

- **GENERATOR SPECIFICATIONS**

The alternator shall be continuously rated, three phase. Three wire, rotating field, self-excited, brush-less type alternating current machine, direct coupled to the diesel engine prime mover. The whole unit shall be designed and constructed to operate as one unit. Mechanical degree of protection of alternator shall conform to IP-22.

The diesel engine and alternator shall be mounted on a common steel base frame for grouting into or floating on a concrete foundation for fitting to embedded steel channels. Coupling shall be provided with coupling guards.

The deviation factor of the open circuit line-to-line terminal voltage of the alternator shall not exceed 0.1.

Alternator shall be capable of withstanding, without damage a 30 second three phase short circuit at its terminals when operating at rated KVA and power factor at 5% over voltage, with fixed excitation.

Alternator shall be capable of carrying a one-minute overload of 50% of normal rated current with the field set for normal rated load excitation.

Alternator shall be designed to be capable of operating in parallel with other DG sets of similar rating

and / or grid.

Alternator winding shall be insulated with class F insulation. The machine shall be naturally ventilated. 3 wire type embedded temperature detectors for winding and bearing shall be provided.

Alternator shall have amply dimensioned terminal boxes for easy termination of aluminium power cables to terminate leads from space heaters; windings and bearing temperature detectors; to accommodate protection CTs.

Terminal box shall be suitable for cable entry from top bottom or sides.

- **GENERATOR REACTANCE:**

Sub-transient reactance shall be low to maintain fault contribution from the generation within permissible limits. The transient reactance should be as low as possible consistent with the need to limit voltage drop on sudden application of load.

3.4.2.4.1 Generator Construction

➢ **GENERAL**

All parts of the generator and accessories shall be capable of withstanding electrical, mechanical, thermal and other stresses experienced in operation and during short consistent with the need to limit voltage drop on sudden application of load.

Spacer blocks and wedges used in the construction of stator windings shall be made of non-shrinkable material. Binding of coils shall be non-continuous, preferable using glass cord or equivalent. Generator stator and field windings shall be insulated with class F insulation. Core plate insulation shall also be class F. All armature winding connections shall be brazed strand to strand to provide maximum margin against local overheating.

➢ **BEARING INSULATION**

Insulation shall be provided to break the paths of stray current at two places in series with provision made for determining the insulation resistance each insulation piece. The insulation under the bearing pads shall be made of non-hygroscopic material.

➢ **STATOR FRAME**

Stator frame shall be of one-piece construction, fabricated from heavy steel pipe and designed for minimum noise and vibration.

All stationary parts of the generator shall be designed to avoid resonance at 50Hz, 100Hz and 200Hz.

Generator shall be designed with B3 construction i.e., with two end shields and foot mounted.

➢ **ROTOR**

Rotor shall be properly balanced at rated speed, critical speeds over speeds.

➢ **VENTILATION**

Generator shall be air cooled with shaft mounted fan.

Shaft mounted fans shall be provided to effect air circulation through the ventilation system.

➢ **CONNECTION**

The 3 phase windings of the generator shall be arranged for star connection and shall be suitable for operation with the neutral grounded.

- **STATOR TERMINALS AND TERMINAL ARRANGEMENT**

The two terminals of each phase winding shall be brought out of the generator frame at approved locations. Terminal markings shall be in accordance with BS 622. The direction of rotation shall be marked on the suit purchaser's cables/ bus ducts and enclosed to safeguard against short-circuits by rodents etc., Suitable cable glands or cable sealing boxes as specified shall be provided on the enclosure to facilitate entry of the cables.

- **TERMINALS**

The lines and neutral ends of each phase winding of the generator shall be brought out two separate terminal boxes. The line end terminal box shall be phase segregated for HV machines and phase insulated for LV machines. Terminals boxes shall have facilities for mounting CTs specification on 6 suitable located terminals.

Cables sizes shall be as indicated in the Generator Data Sheet enclosed, if applicable.

Fault withstand capability of the terminal box shall be **21** KA for 1 Sec.

- **CURRENT TRANSFORMERS**

Current transformers, two per phase shall be provided at the neutral end of the generator with rating as in Generator Data Sheet for over current, differential and restricted earth fault protection.

Offer for current transformers shall be accompanied by Ratio and phase angle errors and complete error for protection class CTs

Magnetization characteristics extending at least up to 150% of the excitation current at knee point voltage for both class PS and protection CTs.

Current transformers shall have terminal blocks with facility for short circuiting grounding the secondary.

- **TEMPERATURE DETECTORS**

A minimum of two platinum resistance type temperature detectors shall be provided per phase of the generator, between the coils of the stator windings and two on bearings. The resistance value of the RTDs shall be 100 ohms at 0 deg C. The supplier may provide additional RTDs for measuring temperatures at specific points in the machine. In addition to RTD, supplier may provide additional monitoring equipment if required to monitor equipment condition.

Temperature detectors of resistance type shall be provided, in accordance with America Standard SpecificationC.50-1. One RTD shall be embedded in each bearing.

The detectors shall be installed at locations where the highest temperatures may be expected. The leads of the temperature detectors shall be brought in a neat and adequate manner to an easily accessible terminal box on the generator frame. The minimum size of the leads shall be 1.5 Sq.mm. The leads shall be protected against stray electrical fields mechanical damage.

The temperature detectors with their leads shall be accurately calibrated. Test reports giving results of the calibrations shall be submitted for purchaser's scrutiny.

A drawing indicating locations of the detectors shall be furnished.

- **SPACE HEATERS**

Space heaters of adequate capacity rated for 240V, 50Hz single phase service shall be provided for the generator, exciter, and associated cubicles to maintain inside temperature sufficiently above outside ambient so that condensation o atmospheric moisture is prevented when the equipment is not in service.

The heaters shall be mounted in an accessible location. In the case of the machines, they shall be located in the lower part. Terminals of the space heaters shall be brought out to a separate terminals box.

KW rating of the space heater shall be indicated.

3.4.2.4.2 Excitation System

- **BRUSH LESS EXCITATION SYSTEM**

The brush less excitation system shall have the following provisions: -

A revolving armature AC exciter directly coupled to the generator rotor at the outboard end shall be provided. The output of the AC exciter shall be rectified by the rotating diodes connected as a 3-phase bridge.

The rotating rectifier components shall be contained against centrifugal forces by adequately designed retaining ring. The rectifier design shall be based on one high power diode and fuse per parallel path. Suitably rated heat sinks which will also act as a fan shall be provided for each diode.

DC outgoing poles shall preferably be segregated by locating Rectifier Bridge on either side of the shaft. Each arm of the bridge shall be made of more than one high power diode arm arrangement in a suitable configuration to ensure that the cells withstand all fault conditions to which they may be subjected.

The total number of diode arms shall be such that failure of up to 25% diode arms will not cause restrictions on the unit operation at its rated condition, including field forcing. Suitably rated varistors etc.., shall be provided to give a path for the reverse polarity induced currents resulting from the generator pull-out, power swing and any other abnormal conditions. Diodes and associated protective devices shall be mounted radially. It shall be ensured that the rectifying junctions are held in compression under speed.

Excitation system shall have thermal capability equal to or better than the field of requirement of the generator, when operating at rated KVA and at any voltage between 5% below and 5% above rated voltage.

Exciter rated voltage shall be at least 110% of the rated machine excited voltage. Exciter ceiling voltage shall not be less than 130% of the exciter rated voltage.

Insulation of exciter shall be class F.

- **VOLTAGE REGULATOR**

The voltage regulator shall be automatic, high speed, non- band type with provision for current compounding. The voltage regulating system shall be suitable for automatic control of voltage.

Steady state accuracy of the voltage regulator from non-load to rated load shall be within +/-2.5% of rated generator voltage of any one phase at any p.f between 1.0 and 0.8 lagging from cold to hot variations.

The voltage regulator shall be capable of supplying excitation current in the event of a 3-phase short circuit at the generator terminals to facilitate operation of the protective devices and under all conditions of loading specified.

Alternator shall have a reliable 3 phase voltage sensing compound excitation system having:

Capability to build-up the voltage from residual magnetism.

Protection against low-speed operation.

Voltage / hertz responsive feature.

Provision to manually adjust the alternator voltage within +/- 5%

➢ **GROUNDING**

A non-corrodible metal pad shall be welded or brazed at two different locations on the frame and shall have a threaded hold at the center for connecting the cable lugs by means of hexagonal head bolts and spring washers.

Two independent grounding points shall be provided on opposite sides near the bottom.

Grounding points shall be suitable for the following grounding strip.

- Machine: 50 X 6mm Cu. Flat
- Power Panels : 25 X 6mm Cu. Flat
- Control Panels : 25 X 3mm Cu. Flat

3.4.2.5 Performance Requirement of the Diesel Generator Units

The DG sets and the associated auxiliary system shall be designed to provide a standby source of power of a high reliability.

The DG set shall be capable of starting from cold condition and reaching synchronous speed and ready to take load in a period of ten (10) seconds from the initiation of start impulses without suffering undue stress, wear and tear. The DG sets shall be capable of accepting the maximum rated load of the generator within a period of thirty (30) seconds from the initiation of start impulse.

The DG sets shall be capable of operating at rated load on the generator

- in isolation
- in parallel with similar DG sets.

Diesel generator shall be capable of delivering continuously at the terminals of the alternator **1600 kW Prime duty for 2000 KVA sets at 0.8 P.F at 11KV** when the ambient surrounding the alternator is between -15 deg c to 30 deg C, intake air for combustion 30 deg C.

The DG sets shall be capable of peak-output of 10% in excess of the rated output for a period of one (1) hour in every 12 hours of continuous running at rated load, without exceeding permissible temperature limits and with a faintly visible exhaust.

The DG sets shall be capable of meeting the specified performance when using commercially available HSD oil to as per IS: 1460-1974.

The DG sets shall be capable of starting on their own when external power supply is not available

Diesel generator shall maintain output accuracy of +/-1% of voltage and +/- 0.25% of frequency at the terminals of the alternator under steady state condition.

During recovery from transients caused by step load increase or resulting from the disconnection of the largest single load the speed of the D.G.set shall not exceed 115% of the nominal. Further, the transient following the complete loss of load shall not cause the speed of the unit to attain the over speed set point.

The sub transient and transient reactance of the generator shall be chosen to meet the above requirements.

The voltage and frequency of the generator shall be adjustable between + / - 5% and + / - 2.5% of the nominal values respectively from local D.G. control panel and remote-control panel.

3.4.2.6 Items of Guaranteed Performance

Following items of performance shall be guaranteed by the supplier in respect of the DG sets and auxiliaries, when operating under specified site conditions.

Net electrical power output at specified power factor and terminal voltage under specified conditions considering de-rating factors as given in ISO standards.

- Fuel oil consumption at full load.
- Lubricating oil consumption at full load.
- Jacket water temperature to and from engine. (As applicable)
- Lubricating oil temperature to and from engine.
- 10% overload for one hour in every 12 hour of continuous running at rated load.
- Generator efficiency at ½, ¾ and full load at specified power factor and terminal voltage.
- Governor response and over speed capability.
- Voltage regulator response.
- Contractor shall indicate the tolerance applicable to each of the guaranteed parameters above and the reference standard.

DIESEL ENGINE DRIVEN GENERATOR

The engine/generator sets shall meet the following parameters:

A governed speed of 1500 rpm.

- Rated 0.8-power factor for prime operation.
- To operate at 11000 Volts, 3 phase, 3 wires, 50 Hz at 5000 meters elevation above sea level.
- Temperature range of 15 Deg; C to 35 Deg C.
- Equip generator with a liquid cooled diesel engine.
- Engine-mounted radiator
- Alternators shall be of reputed make, salient pole, brush less, synchronous, revolving field, air-cooled and drip-proof and OPEN DELTA connected with a separately excited system using a permanent magnet generator.
- The alternators shall be capable of withstanding, without adverse effects. Over-speeds of 25 percent above the governed speed for the duration of one minute.
- Generators shall have the capability to provide minimum of 300 percent of rated three-phase current for 10 seconds.
- Engine mounted fuel filter.
- Phase segregated terminal box shall be provided which shall be suitable for terminating 11KV 3C Ar Al. XLPE, earthed type cable. The neutral terminal shall be brought out in a separate terminal box on the opposite end.
- THD at no load shall be < 3%
- 3 Nos. single phase 11 kV / 110 V /√3 PTS shall be supplied for AVR sensing.

- Exhaust System – Exhaust system shall be connected to a freestanding chimney. The chimney shall be suitable for connecting all Generators.

3.4.2.7 Requirements of 2000 KVA, 11 KV D.G.Set.

- **DIESEL ENGINE:**

Diesel Engine, Radiator Cooled, Turbo charged, with After Cooler, suitable for Generating Set applications, developing 2319 BHP for 2000 KVA DG SET @1500 RPM under NTP conditions of BS:5514, with an overload capacity of 10% for one hour, in any 12 continuous hours operation. The Engine is equipped with the following standard accessories as per the specification given in this Tender.

- **COOLING SYSTEM**

Consists of Radiator with Fan, Engine Mounted Water Pump, Thermostat, Corrosion Inhibitor Coolant and Self Control piping.

- **FUEL SYSTEM**

Consists of PT fuel pump, Injectors, Fuel Filters and Self-Contained piping.

- **LUBRICATING SYSTEM**

Consists of Oil Pump, Strainer Lube Oil Cooler, Oil Filter, Bypass Filter and Self-Contained piping.

- **AIR INTAKE SYSTEM**

Consists of Dry Type Filter, Air Cleaner Manifold with necessary connections and turbocharger with after cooler

- **EXHAUST SYSTEM**

Consists of Exhaust Manifold, Flexible and Residential Silencer.

- **GOVERNING SYSTEM**

Digital Governor Controller.

- **STARTING SYSTEM**

24V D.C. Starter Motor, Battery Charging Alternator with in-built regulator.

DG CONTROLLER PANEL (Near the DG set) Consists of the following parameters with Digital indication.

- Water Temperature.
- Lube Oil Pressure.
- Engine RPM.
    - Running Hours.
    - Fault code display
    - Emergency push button
    - Auto – Manual selector

Other feather touch switches:

In the Relay metering Panel

- Battery Voltage.

- Voltage between phases
- Current in each phase
- Power Factor
- KWhr
- Battery charger failure.

Trip Indication LED Red Display for

- High Water Temperature.
- Engine Over Speed.
- Low Lube oil pressure.
- Low Coolant Water Level.
- Battery charger failure.
- Sensor Fault.

Accessories

- Flywheel Housing.
- Flexible Coupling.
- Coupling guard.
- **ALTERNATOR**

Standard design Alternator rated at 1600 KW for 2000 KVA DG SET at 0.8 PF, 11 KV, 3Phase, 3 wires, 1500 RPM, 50 Hz. Brush less design in screen protected, drip proof, IP :22 enclosure with WTD & BTDs, Space Heater Insulation Class "F" Band of Voltage Regulation +/- 2.5% of rated voltage from no load to full load. The Alternator generally conforms to BS: 2613/5000.

- **BASE FRAME**

Sturdy, Fabricated, Welded construction, Channel Iron Base Frame for mounting the above Diesel Engine and Alternator.

- **FUEL TANK**

990 Liters capacity Fuel Tank for ONE each DF with supporting stands complete with level indicator, fuel inlet and outlet, air vent, drain plug, inlet arrangement for direct filling and set of 5 ft. long fuel hoses.

- **BATTERIES:**

Set of 4-Nos. 12 Volts, 27 Plates, Dry Uncharged Batteries.

- **ANTI VIBRATION MOUNTS:**

Set of Anti Vibration Mounting Pads.

Table 12: Generator Data Sheet

Rated frequency	:50 Hz
Number of phases	:3
Winding Connections	:Wye

Generator continuous outputs rating	:1600 KW(2000 KVA)
Rated Voltage of Generator	:11000V
Power factor	:0.8 lag
Over load capacity for one (1) h in every 12 h of continuous running at rated load	:10%
Type of insulation a. Armature winding b. Field winding Connections Core Insulation	: Suitable for 11000V : Suitable for 11000V : Suitable for 11000V : Suitable for 11000V
Temperature rise at max. Continuous Rating over 40 deg C a. Armature winding (by resistance) b. Field winding (by resistance) c. Core and mechanical parts in contact with adjacent insulation (by thermometer)	Temperature rises as per standards : 100 Deg C : 100 Deg C : 80 Deg C
Type of enclosure	Screen protected drip-proof IP22
Permissible voltage variation of voltage for satisfactory operation at rated KVA, rated Speed and rated power factor	+/-1.5%
Excitation system	Brush less type rotating armature, stationary.
Voltage regulator a. Voltage setting range of the regulator voltage. b. Steady state accuracy of voltage c. Quadrature droop circuit provided limit the reactive KVA	+ / - 5% of rated Less than + /- 0.5 of regulator from no-load to rated generator voltage full load : Yes
Maximum period to recover the Generator voltage to the set value for a step application or rejection of rated power factor.	: 0.5 sec

3.4.2.8 Technical Specification for Neutral Isolator With Neutral Grounding Resistor Panel

- **SCOPE**

This specification generally describes the neutral isolator and neutral grounding resistor panel and associated accessories.

- **STANDARDS APPLICABLE**

The Equipment and accessories covered by this specification shall be designed, Manufactured and tested incompliance with the following latest relevant standards in order that specific aspects under working conditions are taken care of :

IEEE-32 for Resistance rating & temp is concerned IS-2147 for the type of enclosure.

- **GENERAL CONSTRUCTION**

Free standing, Floor mounting, Indoor type, Panel fabricated out of CRCA sheet of 2mm thick with suitable reinforcements and with louvered sheets provided on outside and covered with fine mesh to make the unit vermin proof.

11 kV, 100A, vacuum contactors shall be used for the D.G. Set Neutral Isolation. The Neutral Grounding resistors shall be provided in the neutral earthing conductor to limit the fault current to 100A in the event of a line to ground fault.

The resistance shall be of Punched stainless steel material and rated 100A for 10 sec with resistor value of 63.5 ohms.

The top of the resistor portion will have a perforated sheet of 2.1mm hole to let out the heat dissipated by the NGR during fault conditions.

The paint finish shall be of Siemens gray as per shade RAL – 7032 both inside and outside.

Foundation holes will be provided in the bottom channel base of the unit for grouting the panel to foundation. The cable entry can be either from Top of Bottom through undrilled removable type Gland plates.

- **RESISTOR BANK CONSTRUCTION**

The grids will be of punched out of SS steel grade ASTM-A240-304. Grids thus will made will be assembled on to a threaded MS rods having interleaving porcelain separators as inter grid insulation. The Inter grid connection is by SS hardware. The resistance will be assembled in the form of banks and the number of banks will be stacked one above the other in the Resistance compartment.

- **REQUIREMENTS OF NGR PANEL**

The panel shall comprise the following components.

1 No. 11KV, SP, 400A Vacuum contactor rated suitably with aux.contacts.

1 No. 11KV Epoxy Cast Resin CT, Ratio 50 / 5, 5P10, 15VA for E/F Relay.

3 Nos. 11KV Epoxy Cast Resin CT, Ratio 150 / 5A, 15VA, PS class for Differential Protection.

1 Set of reputed make panel Lamp, Panel Heater, and Control Fuses.

1 Set of 100A Rated Aluminium Busbar.

Sets of Punched SS Grid Resistor unit of rating 100A, 63.5 ohms, 10 Secs with a Max.Temp.rise of 375deg C.

Sets of Green & Red Indicating Lights for Isolator ON / OFF.

Sets of CT & Control Terminals.

By using a combination of isolating devices as per the Single Line Diagram enclosed, flexibility of running the Generators in Solo & Parallel modes are possible. The remote switching of the Isolating devices may be done by using either a PLC or Contactor Logic and the scope of the same is to be included in the offer.

- **GUARANTEED TECHNICAL PARTICULARS**

(Of the Grid Offered – Punched SS)

Type of Grid	: Punched SS. ASTM-A240-304
Ohmic Value	: 63.5 ohms
Tolerance on cold ohms	: + or –7.5%
Duty Rating	:10 Secs
Rated voltage	:11 KV
Rated Current	: 100 Amps
Type of Cooling	: Natural Air
Type of enclosure	: IP-42 (Panel)
Installation	: Indoor
Interconnection	: 25 X 6 mm Copper Flat
Max.Temp.rise:	
Resistor	: 375 deg C as per IEEE-32
Enclosure	: 55 deg C as per IEEE-32
Type of protection for	: Resistor portion

- **TESTING**

The following tests shall be conducted at your works on each of the equipment and in house test

certificates shall be given in duplicate for reference & records.

- Cold Ohmic value test at room temperature (with in + or – 7.5% tolerence)
- Megger test between grids & ground by 2500V meggar.
- High Voltage withstand test of 2.5KV for 1 minute for LT circuit.
- High Voltage withstand test of 28KV for 1 minute for HT circuit.

3.4.2.9 DG Power Synchronisation System

- **FUNCTIONAL REQUIREMENT**

DG Monitoring and Controls including Synchronization, Load sharing between the DGs.

Communication with the DG Electronic Governors on hard wired interface.

Power monitoring and Breaker status monitoring at the main incomers of the DGs

Accurate Power monitoring at the various down side feeder points like AC Loads, Lighting loads, Water Treatment Plant etc., This should also enables Tariff Calculation Development wise / area wise.

Control and individual breakers up to the block loads to enable load shedding. The load shedding scheme should be in the order of priority / criticality.

Integration with SCADA System to enable effective ventilation system control and load shedding.

- **SYSTEM DESCRIPTION**

The system shall be equipped with load demand monitoring and control to automatically program the generator sets to start, parallel and share system loads, which includes the control of all outgoing changeovers. This shall include: Power monitoring of all Generators and transformer.

Auto Load sharing between the generators.

The switchgear load sensing circuits shall monitor station load demand and determine how many generator units are to run, when they are to be started, stopped, and at what levels of loads. The system load circuits shall be kilowatt sensing from the switchgear bus and completely adjustable.

Adjustable time delays shall be incorporated in the pickup and drop-off load sensing circuits to avoid unnecessary starting and stopping on load surges. Load sensing circuits shall be automatically passed to the next sequenced generator unit, if any safety shutdowns occur.

The system shall include automatic and manual, control to fully utilize the available power.

At no time shall the generators be paralleled with the utility.

- **PROGRAMMABLE LOGIC CONTROLLERS (PLC)**

All required logic shall be derived using a PLC. It shall have facility for monitoring the status of the generator parameters and breakers, generating alarms, controlling the breakers and for monitoring the power at every breaker. The output relay contacts shall have adequate making and breaking capacity. All necessary transducers for inputting the data to the PLC shall be in the supplier's scope.

- **SYNCHRONIZATION**

The PCC (Power command controller) or Generator Synchronizing Module (GSM) takes Current Transformer (CT) and Potential Transformer (PT) inputs from the synchronizing bus and PT inputs from the reference bus and shall perform the following functions:

a) Synchronization.

b) Load sharing (Active & Reactive).

c) Anti motoring.

d) Power monitoring.

This feature shall facilitate the automatic synchronization of generators onto a reference bus. The PCC / GSM shall compare the synchronizing and reference bus parameters continuously. When the synchronization conditions are met, the PCC / GSM shall issue a "close breaker command" to close the breaker.

When the system reaches the required limits the PCC / GSM shall give a command to the PLC or directly to close the breaker, in turn synchronizing the Generator with the other generator sets.

- **LOAD SHARING**

Apart from auto synchronization, the PCC / GSM shall have a built-in load sharing feature. Active load sharing shall be achieved by adjusting the engine speed via the governor, whereas Reactive load sharing shall be achieved by varying the AVR. These commands shall be generated by the PLC / PCC and the outputs given shall be potential free contacts.

- **POWER MONITORING**

In addition to the synchronization function, the PCC / GSM shall provide extensive array of monitoring information for systems wired in Wye Delta or open delta. The PCC / GSM shall monitor different electrical parameters of the synchronizing bus and parameters of the Reference bus.

- **COMMUNICATION WITH GOVERNOR**

The interface with the generator governors shall be of a format suitable for effective communication with the electronic governor fitted to the generators.

The interface shall be able to:

(a) Effectively raise and lower the speed of the engine.

(b) Provide all the engine related data including diagnostics and Alarm information from the engine.

3.4.2.10 Technical specification for relay, monitoring and annunciation panel:

- **SCOPE**

This section describes the requirement of control, instrumentation and protection for the diesel generator sets.

- **CODES AND STANDARDS**

The design, manufacturing and performance of equipment shall comply with all currently applicable standards, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the vendor of his responsibility.

Unless otherwise specified, equipment shall conform to the latest applicable Indian or IEC Standards. The Indian Standards is IS : 8623.

- **CONTROL AND ACCESSORY EQUIPMENT**

110V DC will be provided by the purchaser. If voltage other than 110V DC is required by the supplier, necessary arrangement shall be made by the supplier, necessary arrangement shall be made by the supplier, within the cubicle, to obtain the necessary voltage/s by providing transformers, inverter / Converter etc.

Control supply shall be controlled within the cabinet by adequately rated heavy duty, load break isolator / switch, HRC fuses, MCB etc., as the case may be.

- **AUXILIARY CONTACTOR FOR BATTERY CHARGER.**

A suitable auxiliary contractor shall be provided for connection the battery charger to the main supply. A contactor shall be provided with an isolating switch and shall be so arranged as to disconnect the battery charger during engine starting.

- **FUSES**

All fuses shall be of HRC cartridge conforming to IS : 2208 mounted on plug in type fuse bases having a prospective current rating of not less than 80 kA. Fuses shall be provided with visible operation indictors to show that they have operated. All accessible live connections shall be adequately shrouded, and it shall be possible to change fuses with the circuit live, without danger of contact with live metal. Insulated fuse pulling handle shall be supplied with each control cabinet.

- **INSTRUMENTAL TRANSFORMERS**

Current and Voltage transformers shall conform to the requirements o IS : 2705 and IS : 3156 respectively. Unless otherwise specified it shall be the responsibility of the vendor to ensure that the class and VA burdens of instrument transformers provided are adequate for the meters and relays connected to them. Facilities shall be provided to short circuit and ground the CT secondary in the CT secondary leads to carry out current and ground the CT secondary in the CT secondary leads to carryout current and phase angle measurements with CTs in service. Voltage transformers shall be provided with suitably rated primary and secondary fuses.

- **CONTROL TRANSFORMERS**

All AC control equipments shall be suitable for operation on 1 phase, 110V, 50Hz system. Suitable rated 415 / 110V control transformers as required shall be supplied as an integral part of the control cabinet. Each control transformer shall be complete with isolation facilities, primary and secondary HRC fuses. One end/ center point of the control transformer secondary shall be earthed.

- **INDICATING INSTRUMENTS & METERS**

Electrical indicating instruments shall be of moving iron type having 144mm square, 90 deg scale. These shall be mounted flush on the panel with only the flanges projecting. Dials shall be while with black numbers and lettering. Parallox free dial shall be provided. Ammeters measuring upto 10A shall be directly connected, while those measuring above 10A shall be connected through CTs. Voltmeters shall be connected through suitable selector switches and protected by the indicating instruments and meters shall be 1.0

- **RELAYS & TIMERS**

All protective relays shall be of rectangular in shape, suitable for flush mounting with only the dust tight covers projecting beyond the cabinet door. Relays shall be equipped with external reset, positive action operation indicator visible from the front. Voltage relays shall have sufficient capacity for continuous energisation, using external resistors, if necessary.

Unless otherwise specified, auxiliary relays can be of fixed type mounted inside the cabinet but shall be provided with individual dust-tight covers. Auxiliary relays shall be rated to operate satisfactorily between 70% and 100% of rated voltage.

Number of relays and timers shall be as pr requirement. The relay / timer coil voltage shall be 110V DC. There shall be adequate spare contacts which shall be exclusive for the use of purchaser. All

contacts on relays / timers shall be wired up to terminal blocks.

- **CONTROLS & SELECTOR SWITCHES**

Control and instrument switches shall be of totally type having enclosed contacts which are accessible by removing the cover and shall be provided with properly designated escutcheon plates. Clearly marked to sloe the operating positions. Control switches shall have momentary contacts, spring return to center, with pistol- grip handle. Instruments and selector switch shall have stay-put contacts. The number of contacts and their operation in each switch shall be as per the requirements of the connected circuit.

- **PUSH BUTTONS**

All push buttons shall be to push-to actuate type having 2 NO and 2 NC self reset contacts, they shall be provided with integral escutcheon plates, engraved with their functions.

- **INDICATING LAMPS**

Indicating lamps shall be of the filament LED type having double contact bayonet caps and low watt consumption. Lamps shall be provided with series resistors.

- **SPACE HEATER**

Strip type space heaters of adequate capacity shall be provided inside each cabinet to prevent condensation of moisture. Space heaters shall be rated for 1 ph, 240V, 50Hz supply. Heaters shall be complete with ON-OFF switches, HRC fuses in phase, link on neutral and a thermostat to control switching of the heater. Power supply shall be provided from purchaser's panel.

- **INTERIOR LIGHTING AND RECEPTACLES**

Control cabinet shall be provided with a 1 ph, 240V, 50 Hz lighting fixture for interior illumination controlled by an ON-Off switch. In addition to the above, a 1 ph, 240V, 50Hz, 3pin receptacle shall be provided.

- **ALARM AND SUPERVISION SYSTEM**

The alarm and supervision system shall have:

- A push button for clearing the audible alarm (visual annunciation will persist)
- A push button for clearing the visual annunciation after the fault has been cleared.
- A push button for testing the illuminated transparencies.
- All alarm devices shall be suitable for operation on 110V DC.

- **PANEL INTERNAL WIRING**

Control panel shall be supplied completely wired, ready for purchaser's external connections at the terminal's blocks. All wiring and cables shall be carried out with PVC insulated, stranded copper conductor wire / cables. Power circuits shall be wired with stranded copper conductors of adequately sized to suit the rated current. The minimum size shall be 4sqmm control, alarm indication circuits shall be wired with stranded copper conductors of size not less than 1,5 Sq. mm CT circuits shall be wired with stranded copper conductor size not smaller than circuits shall be wired stranded copper conductor size not smaller than 2.5 Sq. mm

Power and control wiring shall be separately run and neatly bunched.

Wiring affected by stray electromagnetic fields shall e suitably shielded or run as twisted pairs where applicable.

Wiring for control switches, lamps, meters etc., mounted on doors shall be bunched together and supported in a loop in order to prevent any excess strain being applied to the wiring when the door is opened.

All covers both internal and external, which are removable to allow access to compartments shall be inscribed 'Danger'.

Engraved core identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends shall not fall off when wire is removed. Spare auxiliary contacts of all relays, contacts etc., shall be wired to terminals blocks.

All wiring shall be terminated on terminal blocks using solder less crimping type tinned copper lugs. Insulating sleeves shall be provided at all the wire terminations. All wiring shall be nearly bunched and cleared within the cabinet. Wiring troughs shall be provided for vertical panel wiring and for interconnecting wiring between front and fear and rear section of the cabinet.

One piece moulded, 650 V grade terminal blocks complete with insulated barriers, terminals studs, washers nuts and lock nuts and identification strips shall be used. Terminals for power connections shall be adequately rated for the circuit current and the rated for other terminal blocks for control etc., shall not be less than 15A. At lest 20% spare terminals shall be provided. Terminal blocks for control, indicating etc., shall be suitable for connecting two conductors of purchaser's cables of following sizes:-

1.	Potential and control circuit	Two of 2.5 Sq mm stranded Copper conductor.
2.	CT Circuits	Two of 4 Sq mm or four of Sq mm stranded copper, conductors.

Terminal blocks shall be numbered for identification and grouped according to function. Terminal blocks for CT secondary loads shall be provided with short circuiting and earthing facilities. There shall e minimum clearances of 250mm between the first row of terminal blocks and the associated gland plate. Also the clearance between the first row of terminal blocks shall be minimum of 100 mm.

- **EARTHING TERMINALS**

Control panel shall have to separate earthing terminals suitable for necessary earthing conductors o size specified

- **CONTROL PANEL**

Panel shall be cold rolled sheet steel enclosed, of thickness not less than 2.5 mm free standing, floor mounting, indoor type, dust and vermin tight, degree of protection IP – 54, with front accessibility having concealed hinged doors, with key locked and handles and bolted rear and side covers.

Ventilation louvers shall be at the side and /or back and shall be fitted with fine mesh screens to prevent entrance of rodents or large insects.

Foundation channel with nuts, bolts, spring washers, 3mm thick undrilled gland plate, cable gland shall be part of the supply.

Components mounted on the panel shall be flush type. Arrangement of components shall be such as t render easy accessibility for maintenance and troubleshooting.

Heating emitting components like resistors shall be shielded from others by fiber glass sheet separators or similar materials.

- **MAINS OPERATED BATTERY CHARGING EQUIPMENT**

The battery charger shall be of the static type employing semi -conductor devices, the whole being enclosed in an adequately ventilated enameled corrosion resistant sheet steel case of an approved type. This shall be part of relay & monitoring panel, mounted inside the same.

The charger shall be incorporated within the control panel with its associated instruments and controls mounted on the control panel. The instruments and controls shall match those of the main panel.

The charger shall have an illuminated indicator on the panel front to show when the charger is switched on. The charger shall be of adequate size and shall at all times monitor the battery conditions and automatically control the charging rte to suit the state of the battery, maintaining it in a properly charged condition when not in use. Following a period of use,

the charger shall automatically re-charge the battery in the shortest practicable time consistent with battery welfare and the size and output of the charger shall match battery size and shall at all times monitor the battery conditions the charging rate to maintain the state of the battery, maintaining it in a properly condition when not in use.

- **PROTECTION**

The diesel generator shall be tripped under the following conditions: -

- 110V DC control supply failure.
- Over-speed of diesel generator set
- Low lube oil pressure
- excitation failure .
- Incomplete start after a present time.
- High jacket water temperature.
- DG differential protection.
- Reverse power protection.
- Earth fault protection.
- Emergency stop.

- **ALARM AND INDICATIONS**

Local Alarm on Panel:

The following alarms shall be included in the alarms and supervision system:

- High jacket water temperature (As applicable)
- Low lube oil pressure
- Generator bearing temperature high.
- Generator winding temperature high
- Fuel oil day tank level low.
- Fuel oil day tank level high.
- 110V DC control supply failure.
- Reverse power trip
- Over current trip
- DG earth fault .
- Emergency stop.

- Starting failure.

Local Lamp Indication on each Diesel Control Panel :

The following Meters shall be included in the Metering Chamber of the Panel

- 1 No. Ammeter with selector switch. (0 – 200A)
- 1 No. Voltmeter with selector switch. (0 – 12KV)
- 1 No. Frequency Meter.
- 1 No. KW Meter
- 1 No. KVA Meter
- 1 No. KWHr Meter
- 1 No. P F Meter
- 1 No. Trivector Meter

The Following Protection relays shall be included in the Relay Panel:

- IDMT Three O/C + E/F relay with highest
- Over / Under Voltage Relay.
- Reverse Power Relay
- Restricted Earth Fault Relay
- Differential Relay
- Auto Synchronizing Relay
- Auto Load Sharing Relay
- Thermal Overload
- Over / Under Frequency
- Loss of Field
- PT Fuse Failure

The following Auxiliaries shall be included

- 1 No. Multipoint Temperature Scanner for WTDs & BTDs.
- 1 No. Motorized Potentiometer for speed / voltage, raise / low.
- 1 Set of Indicating Lamps for Load ON DG & Load ON Mains.
- 1 No. Emergency Push Button.

3.4.2.11 Free Standing Chimney

Total Gas flow from 2 x 2000 KVA at portal: To be confirmed by vendor.

Temp - deg C	To be confirmed by vendor
Chimney material	: IS 2062
Design code	: IS 6533
Wind Load	: as per IS 875 (Part 3)-1987
Earth Quake stability	: as per IS 1893 – 2002

Foundation to be designed	: To withstand wind load and earthquake
Painting	: Anti corrosive black painting shall be carried out on the Inner surface of the chimney. Shall confirm to IS 158 – 1968.

Note: The exhaust from the Generators shall be directly exhausted to atmosphere without any treatment. This requirement shall meet the norms of State Pollution Control Board.

3.4.2.12 Battery and Battery Charger

- **BATTERY**

Batteries – 25 Plate, 180 AH, heavy duty

Batteries shall be of lead acid type, heavy duty Automotive power mounted near the generator. A corrosion resistant battery rack shall be provided for mounting. Battery shall have sufficient capacity to provide for the engine/generator safety circuits, for 24 hours without recharging. The batteries shall be suitable for 6 successive attempts each of 10 secs duration with a gap of 5 sec forward starters. The battery bank shall be provided with steel stand and a containment tray. Also a rubber mat shall be provided below the battery rack. Battery shall be confirming to IS : 1651.

- **BATTERY CHARGER**

A current limiting battery charger shall be provided to automatically recharge the batteries. Battery charger shall have boost and trickles charging features with built in voltage regulators. Battery Charger shall be suitable for operation on 230V AC, 50 Hz supply with variation of +/- 10%. The charger shall charge at 2.17 Volts per cell and float at 2.33 Volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC Ammeter, and fused AC input. The amperage output shall be not less than 10A. Each Generator shall be provided with separate battery charger.

The following indications shall be required:

Input supply on.

Battery charge/discharge current.

Output voltage.

Voltage free change-over contacts shall be wired to the outgoing terminal block of the unit to provide external indication of the following conditions:

Input AC supply fail.

The charger must be large enough to provide for a 100 percent increase in the charging needs of the batteries for future sets.

Battery charger with suitable cut-out circuit shall be provided for charging battery from EB mains when DG is not running. Suitable capacity dynamo shall be provided for charging the batteries when DG is in operation. A separate voltmeter and ammeter shall be provided for monitoring battery voltage and current.

- **CAPACITY**

180 Ah 12 V- 4 Nos.

3.4.2.13 Acoustic Enclosure

The acoustic enclosure is made of 1.6 mm thick CRCA sheets and structural/ sheet metal base frame painted in Munsell shade. The walls of the enclosure are insulated with fire retardant Rock wool.

The enclosure has the following features:

- Designed to have optimum power out of Genset with out any de-rating factor.
- Designed to have sufficient approach, operation and service space.
- Air inlet louvers specially designed to provide sufficient fresh air availability for operation of the D.G.set.
- Made on special purpose CNC machines for consistency in quality and workmanship
- Powder coated for long lasting service life and superior finish
- With UV resistant powder coating, withstands extreme environments
- Use of special hardware for longer life
- Insulation material meets exacting IS 8183 specifications for better sound attenuation
- Flush styling - no projections
- Fluid drains for lube oil.

3.4.2.14 Propeller Fans

Propeller fans shall have MS powder coated or epoxy coated diaphragm. The impellers shall be die cast aluminium or MS powder coated epoxy coated with adequate gauge sheet. The fans shall be statically and dynamically balanced. The fans shall be suitable for mounting vertically and should withstand higher temperatures. The fans shall be suitable for 3-phase operation as specified in the tender conditions. The vendor shall clearly determine whether propeller fans are required and confirm expressly at the time of tendering itself.

Note: Other than GI sheet of insulation works all other materials shall be powder coating.

3.4.2.15 Fuel Handling System

- **DAY TANK (990 L Capacity)**

The design and construction of the tank shall comply with:

- IS: 10987:1992 and the other complimentary and reference standards stated there in.
- Rules and Regulations of the Chief Inspector of Explosives
- India Petroleum Rules 1956.

All site welding shall be carried out by fusion welding. For all butt welds, the root run and final run shall be carried out.

The HSD tanks shall be of min 3 mm thick M S construction, horizontal, cylindrical in shape with plain ends and shall be suitable for storage of fuel up to a maximum temperature of 50 Deg C at atmospheric pressure. Tanks shall be painted externally to prevent corrosion and shall have a reflecting surface.

The external surface of the storage tanks shall be cleaved to remove rust, scale, etc. and apply two coat of zinc chromate anti-rust primer followed by two coats of finishing paint - epoxy paint.

The tank shall be designed for a pressure of 0.05 MPA when full of water. Minimum corrosion allowance of 1.5 mm shall be considered. The design temperature shall be the lowest one-day mean temperature where the tank is to be installed.

The following accessories shall be part of the tank:

- Filling point and Drain off point
- Dip Connection

- Vent pipe
- Over flow pipe
- Drain-pipe
- Continuous Level gauge with dial type indicator on top of the tank.
- 550 mm dia manhole with cover and locking arrangement.
- High /Low level sensors
- Lifting lugs
- Painting with Anti corrosive treatment.
- Spill tray to be located below the tank and all around it
- Metal Support structure, wear plates, stiffeners etc
- **PIPING**

All fuel piping shall be minimum 25mm dia M.S Class B and as per IS: 1978 and IS: 2062. All fittings shall be of heavy duty. Flanges shall conform to ASA-Class 150 weld neck. The piping shall generally be installed in already prepared underground trenches with fixing hardware as required.

- **VALVES**

All valves shall be ball type and of cast steel body with gunmetal or stainless-steel ball only. All the valves shall be pressure tested as per ASA-class 150. The valves shall confirm to IS 10611, IS 11792.

3.4.2.16 Inspection, Testing and Dispatch

Inspection and testing shall be carried out based on this specification and with approved drawings certified by the consultant / Client. The Client and their consultants shall have the right to carry out stage inspection and shop visit to review the manufacturing progress. All routine and type tests specified shall be carried out during final inspection. 15 days advance notice shall be given for carrying out the final inspection.

Any fuel charges for load testing shall be included in the offer, which shall be indicated separately in the Offer. Bidder shall ensure that a competent testing authority calibrates all meters and equipment used testing and the calibration certificates are valid at the time of carrying out test. After completion of inspection and testing Bidder shall furnish all as built documents in two sets. Only on receipt of final documents the release order for dispatch of equipment shall be issued.

3.4.2.17 Delivery And Handling

The engine/generator sets shall be delivered to site properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Factory- fabricated type containers or wrappings shall be utilized for engine/generator and components, which shall protect equipment from damage. Engine-driven generator equipment shall be handled carefully to prevent physical damage to equipment and components. Any damaged equipment shall be removed from site and replaced with new equipment.

3.4.2.18 Installation And Commissioning

Installation & Commissioning shall be carried out based on the latest requirement of the various statutory authorities such electrical inspector, factory inspector, pollution control board, regulatory authority, and any other statutory agency appointed by the purpose by the state / central / municipal bodies. The document / drawings required for obtaining the approval shall be prepared by the bidder.

The Bidder shall obtain the approval for the installation from all the above agencies. All official payment made for such approvals shall be reimbursed at actual on submission of original receipts.

After installation as per the final approved drawing, the Bidder shall carry out the site testing as specified in presence of consultant. DG shall be taken over by Client only on acceptance by the consultant and satisfactory test results.

The Employer shall witness the commissioning.

A minimum of seven working days notice shall be given to the Consultant / Employer prior to the start of commissioning.

A Specialist Agency approved by the Consultant / Employer shall be responsible for the testing and satisfactory performance of the complete synchronizing system.

3.4.2.19 Site Regulations for Installation Work

Site discipline shall be observed by all the Bidders / erection contractors personnel inside the premises of the site. The contractor and his personnel shall abide by all the rules and regulations laid down by the client. The contractor shall be required to carryout the installation work simultaneously with other installation work being executed by other contractors and shall extend all co-operation required.

Electrical Power required for construction, installation and commissioning of DG shall be provided by the client at one point near meter location. The Bidder shall have his own cabling and switch gear for power distribution to his work place. Cabling and switchgear arrangement shall be provided in accordance with rules and regulation duly approved by the consultant.

Purchaser/Client will not be responsible for any damages / compensation payable in case of any accident/injuries to any of the contractors personnel. In case of any accident at site in connection with the execution of work contractor shall report the accident within 24 hours to the client. All transports of material to and from site shall be marked clearly and visibly and shall be accompanied by appropriate documents.

3.4.2.20 Service

Manufacturers shall have established network of service centers capable of servicing the specified equipments. The Personnel shall be factory trained and shall be available for servicing

3.4.2.21 Proposed Layout

The diesel generator units and their auxiliaries will be installed in the DG Building ground floor. Supplier shall recommend his layout and indicate space requirement. The DG sets will be arranged to draw air from outdoors. Exhaust will be discharged through a vertical mounted muffler into individual exhaust pipe.

Contractor shall indicate the number of air changes required for site conditions for safe operation of DG set. Manufacturer shall indicate the heat load to be removed from DG set room.

3.4.2.22 Documentation And Testing

The following documents, drawings etc shall be submitted along with the offer:

- Technical document of AVR, Governor, etc…
- Schematic diagram of engine control panel with accessories like AVR on details etc.
- Single line diagram for the whole system – control and power
- Detailed specification sheet for all auxiliary components giving material specifications, make /

model, capacity, rating etc.

- Foundation details.

3.4.2.23 Testing

The following tests shall be carried out at the Bidders works for the assembled DG Set in presence of Consultants / Architects / Clients.

Routine tests shall be conducted in the presence of Client / Consultant at the factory before shipping by simulating faults to check the proper functioning of the Generators and Alternators.

Load test using water load shall be carried out in the presence of Client / Consultant to prove the efficiency of the system.

Alignment between engine and alternator by authorized representative from the company.

Operational test for satisfactory functioning.

Relay tests – wherever applicable.

Insulation resistance check on alternator and relay panel (if relay panel is supplied by DG vendor)

TEST ON ENGINE

25% load for 1 hour.

50% load for 1 hour.

75% load for 1 hour.

100% load for 1 hour followed by 30 min. running at 110% of load

TESTS ON CONTROL PANEL

Insulation resistance test

High voltage withstand test

Functional and operation test

Secondary injection test on meters & relays:

Mechanical testing of components.

SITE TESTING

(To be carried out by Bidder witnessed by Client if factory test is not conducted):

Load test for one hour at full load.

100% load for 1 hour followed by 30 min. running at 110% of load AMF sequence checking with all interlocks in line. Measurement of starting time from cold condition.

Load will be provided by customer. Consumables (for excess of first fill) will be provided by the customer.

3.4.2.24 Inspection, Operation, Maintenance Manuals

The bidder shall submit the type test and routine test certificates along with delivery of DG set. Bidder shall submit two sets of as built drawings, operation and maintenance manual, Spare parts manuals of all components duly certified by the consultants after installation.

3.4.2.25 As Built Drawings

Bidder shall submit dimensional drawing showing location of all equipments inside the acoustic room housing the DG set and the cable route.

3.4.2.26 Product Data Sheet

Enclosed elsewhere in this document, vendors go through and provide inputs wherever necessary and confirm parameters asked for.

3.4.2.27 Training

The Employer 's technical team shall be trained in all aspects of operation, maintenance and administration of the system

3.4.2.28 Statutory Clearances

The Bidder will be responsible for the statutory clearances from the electrical inspector, pollution control board (lab report), regulatory authority, and any other statutory agency appointed for the purpose by the state / central / municipal bodies. The documents / drawings required for obtaining the approval shall be prepared by the bidder.

3.4.2.29 Special Notes

Major civil works like RCC foundation etc in not included in the scope. However, All other works and materials, tools, tackles, hardware, consumables, fuel, oil etc. including grouting of the foundation bolts, metal support structure, scaffolding as required and necessary hardware to complete and commission the installation is deemed as included in the offer unless specifically stated and agreed to by the Client before the placement of order.

The Bidder shall be responsible for providing foundation drawings and load calculation to the Consultant / Client for making necessary foundations.

3.4.2.30 Energy Conservation Applications

Please furnish the various methods that have been adopted in the engine, alternator and fuel systems to produce maximum energy per litre of diesel consumed with statistical data’s.

3.4.2.31 Specific Requirements

I. **NOISE LIMIT FOR GENERATOR SETS RUN WITH DIESEL**

i. Noise limits for diesel generator sets, shall be as follows:

ii. Noise from DG set shall be controlled by providing an acoustic enclosure or by treating the room acoustically, at the users end.

iii. The acoustic enclosure or acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/acoustic treatment. Under such circumstances the performance may be checked for noise reduction upto actual ambient noise level, preferably, in the night time). The measurement for Insertion Loss may be done at different points at 0.5 m from the acoustic enclosure/room, and then averaged.

a. The DG set shall be provided with proper exhaust muffler with insertion loss of minimum 25 dB(A).

These limits shall be regulated by the State Pollution Control Boards and the State Pollution Control Committees.

Guidelines for the manufacturers/users of Diesel Generator sets shall be as under:

1. The manufacturer shall offer to the user a standard acoustic enclosure of 25 dB(A) insertion loss and a suitable exhaust muffler with insertion loss of 25 dB(A).
2. The user shall make efforts to bring down the noise levels due to the DG set, outside his premises, within the ambient noise requirements by proper siting and control measures.
3. Installation of a DG set must be strictly in compliance with the recommendations of the DG set manufacturer.
4. A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

II. REQUIREMENT OF CERTIFICATION

Every manufacturer or importer (herein after referred to as "supplier") of DG set (herein after referred to as "product") to which these regulations apply must have valid certificates of Type Approval and also valid certificates of Conformity of Production for each year, for all the product models being manufactured or imported from 1st July, 2003 with the noise limit specified in paragraph 1.

III. SALE, IMPORT OR USE OF DG SETS NOT COMPLYING WITH THE RULES PROHIBITED

No person shall sell, import or use of a product model, which is not having a valid Type Approval certificate and Conformity of Production certificate.

IV. NODAL AGENCY

1. The Central Pollution Control Board shall he the nodal agency for implementation of these regulations.
2. In case of any dispute or difficulty in implementation of these regulations, the matter shall be referred to the nodal agency.
3. The nodal agency shall constitute a Committee to advise it on all matters; including the disputed matters, related to the implementation of these regulations.

V. AUTHORIZED AGENCIES FOR CERTIFICATION

The following agencies are authorized to carry out such tests as they deem necessary for giving certificates for Type Approval and Conformity of Production testings of DG sets and to give such certificates:-

- Automotive Research Association of India, Pune
- National Physical Laboratory, New Delhi
- Naval Science & Technology Laboratory, Visakhapatnam
- Fluid Control Research Institute, Palghat
- National Aerospace Laboratory, Bangalore

VI. COMPLIANCE AND TESTING PROCEDURE

The compliance and testing procedure shall be prepared and published by the Central Pollution Control Board, with the help of the certification agencies.

EMISSION STANDARDS FOR DIESEL ENGINES (ENGINE RATING MORE THAN 0.8MW (800KW) FOR POWER PLANT GENERATOR SET APPLICATIONS AND OTHER REQUIREMENTS

1. Emission Limits

The emission limits for new diesel engines more than 800 kw, for gensets applications shall be as given in the Table below:

Table 13: Emission Limits

Parameter		Area Category	Total engine rating of the Plant (includes existing as well as new generators sets)	Generator sets commissioning date		
				Before 1/7/2003	Between 1/7/2003 And 1/7/2003	On or after 1/7/2005
Nox(as NO2) (AT 15% O2), dry basis, in ppmv		A	Upto 75MW	1100	970	710
		B	Upto 150MW			
		A	More than 75MW	1100	710	360
		B	More than 150MW			
NMHC (as C) (at 15% O2), mg/Nm3		Both A& B		150	100	
PM (at 15% O2), mg/Nm3	Diesel Fuels-HSD & LDO	Both A& B		75	75	
	Furnace Oils-LSHS & FO	Both A& B		150	100	
CO (at mg/Nm15%O23),		Both A & B		< 2%		
Sulphur content in fuel		A		< 4%		
		B				
Fuel specification		For A only	Up to 5MW	Only Diesel Fuels (HSD,LDO) shall be used		
Stack height (for generators sets commissioned after 1/7/2003)		Stack height shall be maximum of the following, in meter:				
		i. 14 Q0.3, Q = Total SO2 emission from the plant in kg/hr.				
		ii. Minimum 6m above the building where generator set isinstalled.				
		iii. 30 m.				

2. Applicability

These rules shall apply to all new diesel engines for genset applications (herein after referred to as 'engine') manufactured in India and all diesel engines for genset applications and diesel gensets (herein after referred to as 'product'), imported into India, after the effective date: Provided that these rules shall not apply to:

a. Any engine manufactured or engine or product imported for the outside India, or;purpose of export

b. Any engine or product intended for the purpose of sample only and not for sale in India.

3. Requirement of Certification

Every manufacturer of engine or every importer of engine or product must have valid certificates of Type. Approval and certificates of Conformity of Production for each year, for all engine models being manufactured or for all engine or product models being imported, after the effective date with the emission limit as specified in paragraph 1.

4. Sale, Import or "Use of Engine or Product Not complying with these Rules

No person shall sell, import or use an engine or a product which is not having a valid Type Approval certificate and Conformity of Production certificate as per paragraph 3.

5. Requirement of Conformance Labeling

i. All the engines (individually or as part of the product) shall be clearly engraved 'Genset Engine' on the cylinder block.

ii. The engine or the product must be affixed with a conformance label meeting the following requirements: -

a. The label shall be durable and legible;

b. The label shall be affixed on a part necessary for normal operation of the engine or the product and not normally requiring replacement during the life of the engine or the product.

iii. The conformance label must contain the following information:

a. Name and address of the engine manufacturer or the engine or product importer (if the address is given in the owner's manual, it may not be included in the label);

b. Statement that 'this engine or product conforms to the Environment (protection) Rules, 1986';

c. Type approval certificate number;

d. Date of manufacture of engine or in case of import, the date of import of the engine or the product.

6. Compliance with BIS Specifications

All engines up to 20 kw (individually or as part of the product) shall carry ISI mark and meet relevant BIS specifications (IS 1000 1).

7. Nodal Agency

The Central Pollution Control Board shall be the, nodal agency for implementation of these rules.

In case of any dispute or difficulty in implementation of these rules the matter shall be referred to the nodal agency.

The nodal agency shall constitute a Committee to advise it on all matters, including the disputed matters, related to the implementation of these rules.

3.4.2.32 Authorised Agencies For Certification

The following agencies are authorized to carry out such tests as they deem necessary for giving certificates of Type, Approval and Conformity of Production tests for Diesel engines and to give such certificates:- Automotive Research Association of India

3.4.2.33 Com-authorised Agencies For Certification

The compliance and testing procedure shall be prepared and published by the Central Pollution Control Board with the help of the Certification Agencies.

3.4.2.34 Fuel Specification

The specification of commercial fuel applicable for -diesel gensets shall be the same as applicable for commercial HSD (High Speed Diesel) applicable for diesel vehicles in the area, from time to time."

Bidder shall submit dimensional drawing showing location of all equipments inside the acoustic room enclosure housing the DG sets. The hard and soft copy of proposed DG set is to be enclosed with foundation details.

3.5 HT Cables & LT Cables

- **SCOPE**

This specification covers the technical requirements of design, manufacture, test at manufacturer's works, packing & forwarding, supply, storage, and erection of HT & LT cables.

- **GENERAL**

This specification covers the technical requirements of design, manufacture, test at manufacturer's works, packing & forwarding, supply, storage and erection of HT & LT cables

Principally all cables shall consist of one length. Connecting sleeves / joints are not allowed, except, the connection points are allowed by the Independent Engineer.

For energy cables the cable dimensioning shall be in accordance with the relevant standards, and shall have a diameter assuring, that voltage drop is not more than 10 % to the nominal voltage from the transformer to the most distant supplied electrical facility.

The cables shall also have such diameters that, if there is a short circuit at the furthest point to the circuit breaker, the circuit breaker cuts off efficiently without exceeding the cable's rated temperature rise.

Cables shall be brought to the site on cable reels or cable drums and shall be secured with close- fitting battens. Cables with kinks or abrasions will not be accepted for installation.

The installation of the cables is only allowed in / at the required cable routes. The contractor shall be fully responsible for the protection of the cables against damage while they are stored, installed, or worked with.

The contractor shall give complete information of all cables to the engineer for his approval.

All cables shall be installed generally along the routes and in the manner indicated on the drawings in accordance with the notes and instructions thereon.

Sufficient and adequate apparatus and equipment necessary for the unloading, handling, transportation and installation of the cables shall be provided by the contractor at his own expense, the apparatus and equipment must not be removed from the site without the authorization of the engineer.

The contractor shall take all necessary precautions to prevent damage to cables during laying / installation.

Whenever cables are installed during other work at this site still being incomplete, the contractor shall take all reasonable precautions to protect the cables against damage arising from the execution of other works.

All cables shall directly run from point to point without joints unless the needed cable length required is not obtainable in one piece from the cable manufacturers. In such a case, the engineer has to approve the position of each and every joint. No other joints shall be permitted unless they are specifically called for in this specification or at the drawings.

Where a cable shall change direction, whether horizontal or vertical, the radius of the bend must not be less than the minimum bending radius specified in the IEE Wiring Regulations and / or the cable manufacturer's specifications. So the bending radius of the cables shall be kept as large as possible.

Wherever a cable is cut, for whatever reason, the ends of both portions shall be immediately re- sealed.

Cables shall be sealed by means of an approved plastic cap embracing the armour wires and outer sheath. No other form of temporary capping shall be accepted.

- **APPLICABLE STANDARDS**

The equipment shall conform to latest relevant applicable Indian Standards. Equipment's complying with any authoritative standards such as British, U.S.A., V.D.E. IEC etc. will also be considered if it assures performance equivalent to or superior to standards listed below. In such cases, bidder shall clearly indicate the latest standard / standards adopted and furnish a copy of the English version / translation of the same. Should there be any dispute of design, standard the most stringent shall be followed: -

IS-8130	Conductor for insulated electric cables & flexible cords
IS-398(Part-IV)/1994	Aluminum Alloy Conductors
IS-5831	PVC insulation and sheath of electric cables
IS-7098 (Part-II)	Cross-linked polyethylene insulated thermoplastic sheathed Cables (Part-II)
IS-5216	Guide for safety procedures and practices in electric works
IEC-228	Conductor for insulated cables
IEC-502	Extruded solid dielectric insulated power cables for rated Voltages from 1 KV up to 30 KV
IEC-540	Test methods for insulations and sheaths of electric cables and cords.
NFPA 502	Standard for Road Tunnels, Bridges, and other limited Access Highways
IS-3975	Mild steel wires strips and tapes for armoring cables
BS-5468	Cross-linked polyethylene insulation of electric cables
IEC-840	Test for power cables with extruded insulation

Indian Electricity Rules

Indian Electricity Act

The Electricity Act 2003

The design, manufacture and performance of the equipment and services provided under this specification shall comply with the standards, rules, regulations and acts given in this specification.

3.5.1 HT Power Cables

- **GENERAL TECHNICAL REQUIREMENTS:**

This specification covers Design, Engineering, Manufacturing, Testing, Packing at manufacturer's works and Delivery of 11 KV (E), FRLS, PVC Insulated, XLPE insulated, galvanized steel flat wire armoured cable.

All cables shall be suitable for installation in air, conduits, ducts; open concrete trenches, for direct burial in either wet, or dry locations for normal operating conditions.

- **GENERAL CONSTRUCTIONS:**

The cross linked polyethylene insulated (XLPE) Cable shall be manufactured and tested strictly in accordance with the Indian Standard IS 7098 (Part – II) and its latest amendments.

All material used in the manufacturing of cables shall be new and shall be selected as the best available for the intended use.

3.5.1.1 Conductors

All conductors shall be of stranded construction complying with the requirement of class II of IS: 8130 with latest amendments. A conductor filling (strand blocking) is required to inhibit water migration along the conductor. This material may be viscous semi conductive liquid or swelling powder and capable of 90 degree Celsius continuous operation. The filling material shall be compatible with the semi conducting & insulating compounds in the cable. In addition, the filling shall have zero flow & no drip at temperature below 90 degree Celsius and it must not harm the electrical conductivity of the conductor or joint. The supplier shall describe the method of preparing the filled central conductor for jointing.

All conductors shall be of high electrical conductivity Aluminium conforming to requirement of IS: 8130 with latest amendments.

Before stranding, the conductor shall be circular in cross section, uniform in quality, solid, smooth and free from scale, sharp edges and other defects.

3.5.1.2 Conductor Screen

Conductor screening shall consist of a layer of extruded semi-conducting compound as per IS – 7098 (Part-II) with latest amendments.

The semi-conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

3.5.1.3 Insulation

The insulating material shall be Cross Linked Polyethylene (XLPE) as per IS-7098 and its latest amendments. The insulation shall be an extrusion cross linked polyethylene fire retardant material rated for 90 degree Celsius continuous operation.

The insulation properties shall be stable under thermal conditions arising out of continuous operation at conductor temperature of 90 degree Centigrade rising momentarily to 250 Degree Centigrade under short circuit conditions.

It shall be free from any foreign material or porosity visible to the unaided eye. The insulation shall be so applied that it fits closely on the conductor and it shall be possible to remove it without damaging the conductor.

The average thickness of insulation shall not be less than the nominal value as specified in IS: 7098 (Part II) with latest amendments. No tolerance on the negative side shall be acceptable.

The insulating material shall have excellent electrical properties with regard to resistivity, dielectric constant and loss factor and shall have high tensile strength and resistance to abrasion. This shall not deteriorate at elevated temperatures or when immersed in water. The insulation shall be preferably fire resistant and resistant to chemicals like acids, alkalies, oils and ozone.

3.5.1.4 Insulation screen:

Extruded Semi-conducting screening and metallic screening of copper tape shall be generally as per IS: 7098 (Part-II) with latest amendments.

The semi conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

3.5.1.5 Core identification:

Individual core of multi-core cables shall be colour coded and/or numbered for proper identification in

accordance with the IS: 7098 (Part – II).

3.5.1.6 Laying up of cores:

In three core cables, the cores shall be laid together with a suitable right hand lay. The interstices shall be filled with non-hygroscopic material.

Further, the compounds used with fillers shall be such as to have no deleterious effect on other components of the cable and to be stable at cable temperatures.

3.5.1.7 Inner sheath:

The laid up cores shall be provided with inner sheath applied by extrusion process. It shall be ensured that the shape is as circular as possible. It shall be applied to fit closely on to the laid up cores and shall be possible to remove easily without causing any damage to the underlying insulated cores and screens.

The thickness of the inner sheath shall be as per IS: 7098 (Part - II). No tolerance on the negative side shall be acceptable.

3.5.1.8 Armouring:

The armouring shall be of galvanized steel flat wires for multi core cables. The armouring shall be applied as closely as practical. The galvanized steel wires shall comply with the requirements of IS: 3975 with latest amendments. The dimensions of the galvanized steel wire shall be as per IS: 7098 (Part-II). No tolerance on the negative side shall be acceptable.

3.5.1.9 Outer sheath:

The outer sheath shall be of polyvinyl chloride (PVC) compound conforming to the requirements of Type ST 2 of IS: 5831 with latest amendments. The outer sheath shall be applied by extrusion process.

The thickness of the outer sheath shall be as per IS: 7098 (Part - II). No tolerance on the negative side shall be acceptable.

- **PACKING:**

Cables shall be furnished in the specified lengths. Drums (wooden or steel as specified) shall be strong, weatherproof, and non-returnable. Wooden drums shall be as per IS 10418-1982 and its latest amendments. The ends of the cable shall be suitably sealed by means of non-hygroscopic sealing material.

3.5.2 LT Power Cables

1.1kV grade, Copper conductor, Power cables

- **SCOPE**

This section covers the technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging, and delivery by road (properly packed in non-returnable steel drums), 1.1KV grade, Multi-stranded Copper conductor, XLPE insulated, extruded PVC inner sheathed, GI round-wire armoured, extruded FRLS PVC ST2 outer sheathed. Power Cables for effectively grounded system, conforming to the latest revisions of IS: 7098 (Part –I), 1988 & as per the technical specifications given below.

- **STANDARDS**

The design, manufacture and testing of the cable shall comply with the latest editions/amendments of the following Indian Standards, unless otherwise specified. Equipments complying with equivalent standards shall also be acceptable.

Table 14: Standards

IS-7098, 1998 (Part-I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto 1100V.
IS-3961	Recommended current ratings for cables
IS 8130-1984	Specification for conductors insulated electric cables and flexible cords.
IS-3975, 1999	Low Carbon galvanized steel wires, formed wires & tapes for armouring of cables
IS-4759	Specifications for Hot dipped galvanized coating on round steel wires
IS-5831	PVC insulation and sheath of electric cables
IS-10418	Drums for electric cables.
IS-10810 (Part 0 to 64)	Method of test for cables.

➢ **SERVICE CONDITION**

The cable shall be designed with the following service conditions into consideration:

a. Cables shall be capable of satisfactory operation under a power supply system frequency variation of +3% and voltage variation of ±10%.

b. Cables shall be suitable for laying in conduits, ducts, trenches, channels, trays, racks or for direct buried in ground in both dry and wet locations with chances of flooding by water.

c. The cables shall be suitable for the following ambient condition:

Ambient Air temperature: -15 deg C to +300C

Ambient ground temperature: 300C

d. The current rating shall be based on maximum conductor temperature depending on the type of insulation for continuous at the rated current.

e. The one second short circuit current rating values shall be furnished and shall be subjected to the purchaser's approval.

f. The cables will have current ratings and de-rating factors as per relevant

- **Indian Standards.**

Full technical details and descriptive literature shall be furnished indicating the construction details, standard applicable for the components of the cable and current ratings of the cables in air and ground. De-rating factors to be considered for the ambient temperature, ground temperature, de-rating due to cable location in air and ground shall also be furnished. The certificates for the type tests conducted on cables similar to the cables covered herein shall be submitted along with the tender.

➢ **DESIGN AND CONSTRUCTION PARTICULARS**

- **General**

The cables supplied under this specification shall be adequate insulated to operate continuously at the specified voltage with a high degree of safety and reliability throughout the life of the cables. The sheathing material shall be high quality PVC based compound. The construction of cable shall be as per IS: 7098 (Part I) - 1988.

Cable shall be designed and manufactured to prevent damage during transportation, installation & operation under all climatic & operating conditions to which cable may be subjected to.

Table 15: Technical Parameters of 1.1kv XLPE Cables

i.	Quantity	As per BOQ
ii.	Packaging	Steel drum packaging, each having single length cable ≥ 500 metres.
iii.	Cable Type	A2XWY/ 2XWY
iv.	No. of Cores	3/3.5/4
v.	Voltage Level	1.1kV
vi.	System Grounding	Solidly Grounded
vii.	Nominal System voltage	400V ±10%
viii.	Nominal System Frequency	50Hz ±3%
ix.	Maximum conductor temperature at rated current	90oC
x.	Maximum conductor temperature at Short-circuit	250oC
xi.	Conductor	
	Conductor Material	Electrolytic grade Copper, Purity > 99.97%
	Conductor type	Stranded with number of strands as per IS 8130 (Part-I) 1984
xii.	Insulating material	Cross-Linked-Polyethylene (XLPE) Compound
xiii.	Core Identification Strips	Red, Yellow, Blue & Black (for neutral)
xiv.	Material of Inner Sheath	FRLS, PVC ST-2 Compound
xv.	Armour	Single layer of Galvanized Steel Round Wire according to IS-3975
xvi.	Outer Sheath	FRLS, PVC ST-2 Compound according to IS-5831

- **Conductor**

  Copper:

  The conductors shall be made from high conductivity copper rods complying with IS: 613-1964. The conductor material used shall be electrolytic grade with high purity. Two sample conductor randomly selected from finished lot of cables, shall be tested for its purity at any 3rd party NABL accredited lab.

  Cable Joints:

  Joints shall be permitted in the individual wires of which the conductor is formed, but no joint shall be within 300 mm of any other joint within the same layer. The joints shall be made by resistance butt welding, fusion welding, cold pressure welding, electric welding, gas welding, brazing or silver soldering. No joint is allowed in the conductor after stranding. A maximum of two joint shall be allowed in any strand forming complete length of the cable.

  The conductors shall conform to appropriate dimensions, resistance and number of wire in the conductor (number of strands) as given in IS 8130 (Part I): 1984.

- **Insulation**

  The insulating material for power cables shall be extruded cross linked polyethylene (XLPE) compound as per IS-7098(Part-I)-1988. The minimum thickness of insulation shall not be less than the values specified in Table-2 of IS-7098 (Part-I)-1988. No negative tolerance shall be applicable for the thickness. The insulation of the cable shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions. The cores shall be identified as per the following colour scheme:

  3-Core - Red, Yellow & Blue

  3 ½ or 4-Core - Red, Yellow, Blue & Black

- **Inner Sheath**

The inner sheath shall be extruded FRLS PVC, Type ST2, compatible with thermal rating of insulation conforming to IS-6380-1984. The sheath shall have adequate thickness, mechanical strength and elasticity, as specified in IS 5831. The material shall be soft thermoplastic type, applied by extrusion method. The thickness of the inner sheath shall be as per IS: 7098 (Part I) and the color of the inner sheath shall be Grey. The inner sheath shall be so formed that it fits closely on the laid up cores and could be easily removed without damaging insulation. One or more layer of proofed plastic tape shall be provided over the laid up core before extrusion.

- **Armouring**

The armouring arranged over the inner sheath shall consist of one layer of galvanized round steel wires for all sizes of cable. The armour round wire used on the cable shall conform to IS: 3975 for all requirements. The direction of lay of armour shall be opposite to that of the cores. The zinc coating on the galvanized steel strip shall comply with relevant standards.

The joints in armour wires/strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm away from the nearest joint in any other wire/strip in the completed cable.

- **Outer Sheath**

Extruded outer sheath shall be provided over the armouring. The material used for sheathing shall be FRLS PVC sheath, Type ST-2 base compound conforming to IS 1554/ IS 5831 for power cable. The outer sheath shall be so formed that it fits closely on the laid up armour and could be easily removed without damaging the intermediate sheath and insulation. The colour of the outer sheath shall be black. The thickness of

outer sheath shall be in accordance with the IS 1554 (Part-I)-1988. Suitable additives shall be added to prevent attack by rodents and termites. All serving must be given anti-termite treatment.

Cables shall have suitable fillers laid up with the conductor to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the temperature of the cable and compatible with the insulating material. The material shall be of the best quality and workmanship. The fillers and sheath material shall be non-hygroscopic. All materials shall be new, unused and of the finest quality.

➢ **TESTS**

All the tests specified below shall be carried out in accordance with the Indian Standards by the manufacturer in the presence of Purchaser's representative. If the cable fails to pass the test specified, the Purchaser shall have the option to reject it. Shipping release shall be obtained from the Purchaser's representative. The Purchaser, however reserves the right to waive off the inspection.

The tests at works shall include electrical, mechanical and hydraulic tests in accordance with the appropriate clauses of Statutory Regulation, relevant codes and standards, in addition any test called for by the Purchaser or his representative to ensure that the equipment being supplied fulfils the requirement of the specification.

For test not covered by any code or specifically mentioned in this specification, the test procedures are to be agreed with the Purchaser.

Pre Dispatch Inspection:

The manufacturer shall be given at least 15 days advance notice prior to the commencement of testing, so that Purchaser's representative can plan to witness the tests.

All the tests indicated in the test clause of this specification shall be carried out in the presence of Purchaser's representative by the manufacturer and shall provide all the facilities and equipment for testing.

Six copies of the Test Certificate shall be furnished to the Purchaser for approval prior to dispatch of cables from factory.

Visual check to conform the details given in this specification is to be done. In addition to the above, the general workmanship of the cable drums and cables laid in drums shall be checked.

Manufacturer shall have proper test set up for testing all the routine tests & type tests on finished cables as per IEC.

- **Type Test**

Type tests on four randomly selected cable drums will have to be conducted in the presence of the department's representative. The test samples will be taken from finished cables. This test shall be in accordance to IS: 7098, Part-1,1988.

a. Test on Conductor

· Annealing test for copper conductors

· Tensile test for aluminium conductor

· Wrapping test for aluminium conductor

· Conductor Resistance Test

b. Test on Insulation

· Physical dimension measurement

· Tensile strength and elongation at break

· Hot set test

· Shrinkage test

· Ageing in air oven

· Water absorption test

c. Test on round Armour

· Physical dimension measurement

· Tensile strength

· Elongation at break

· Torsion test for round wires

· Winding test for firmed wire

· Mass of zinc coating.

· Uniformity of zinc coating

· Resistivity measurement, Resistance test for armour

d. Test on Sheath

- Physical dimension measurement
- Tensile strength & Elongation at break test
- Ageing in air oven
- Loss of mass in air oven
- Shrinkage test
- Hot deformation test
- Heat shock test
- Thermal stability test

e. Insulation Resistance Test

f. High Voltage Test at room temperature

g. Volume resistivity at room temperature & at 90o C. (IS-10810-Part 43)

h. Flammability test

i. Test requirement of FRLS inner and outer sheath

The inner and outer sheath of cables shall meet the following test requirements related to flame retardant, low smoke emission, low acid and toxic gas emission. The BIDDERs shall have proper test apparatus to conduct all the relevant tests as per the applicable standards:

- Flame retardant test on single cable
- Oxygen Index Test

The critical oxygen index value shall be minimum 29 when tested at 27+2ºC as per ASTMD-2863

- Temperature index test

Temperature index value shall be minimum 250ºC at oxygen index of 21 when tested as per NES 715.

- Flammability test
- Smoke Density Test

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than 60% when tested as per ASTM-D-2843.

- Acid Gas Generation test (halogen acid gas evolution)

The hydrochloric acid generation when tested as per IEC 754-1 shall be less than 20% by weight.

- Test for specific optical density of smoke
- Anti termite and rodent property test

The sequence of electric tests shall be as per the relevant Indian/International standards. The Bidder shall submit the sequence of tests for the approval of the purchaser before conducting the tests. A copy of the adopted standard shall also be supplied.

- **Routine Test (On each drum)**

  The following routine tests shall be carried out by the Manufacturer on each and every length of the cable in the presence of Purchaser's representative at manufacturer's works.

  a. Resistance test for conductors

  b. Insulation resistance test

  c. High voltage test

- **Conductor purity test**

Two samples of copper shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

Qualifying Criteria:

The test results should be within limits as per IS 7098. All the routine tests as per IS 7098 / IEC shall be conducted and passed as per the limits given in the standards. All the bought out certificates will be verified and the test results shall be as per respective standards.

➢ **IDENTIFICATION**

The following details shall be marked sequentially for each meter run length of the cable by non-erasable embossing on the outer sheath:

a. Reference to Indian Standard

b. Name of the manufacturer/ Trade Name

c. Name of the project: CWMF, BARC (K)

d. Configuration of the cable: viz. Voltage grade, no. of Core, Sq. mm, A2XWY/2XWY/YWY / YY as applicable

e. Year of manufacturing

f. Sequential marking of running meter length

The running length of the cable shall be identified at regular intervals of one meter (Increasing order from inner end to outer end of the cable)

➢ **PACKAGING**

· Each drum shall consist of single length cable ≥ 500 metres.

· The cable shall be wound on non-returnable steel drums of suitable size, packed and marked.

· Packing shall be sturdy to protect the cable from any injury during transportation, handling and storage. The cut ends of the cable shall be sealed by means of non hygroscopic sealing material preferably Heat shrinkable end caps.

· One end of the cable shall be brought out of the drum and suitably clamped to the drum flange with proper mechanical protection. Location of the other end may be marked on the drum.

· The cable shall be placed on drums in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. No undue stress shall appear on cables when laid on drums.

· The cable drum shall carry the following information stenciled on a metallic label, securely attached to each end of the drum:

i. Reference to the Indian standard
ii. Manufacturer's name, brand or trade mark
iii. Type of cable and voltage grade
iv. No. of cores
v. Nominal cross-sectional area of conductor
vi. Cable code
vii. Length of cable on drum
viii. No. of lengths on reel, drum or coil (if more than one)
ix. Gross weight
x. Country of manufacture
xi. Year of manufacture
xii. Direction of rotation of drum (an arrow)
xiii. ISI certification mark

➢ **GUARANTEE**

All the cables shall be guaranteed against faulty material, defective design & poor workmanship for a period of 18 months from the date of supply. The materials becoming defective during the guarantee period shall be replaced free of cost and the defects arising out of the works shall be rectified free of charge without delay.

3.5.3 Fire Survival Cables/Control Cables

The cables shall be multicore, colour coded, annealed stranded high conductivity copper, single conductor, insulated with PVC insulation, PVC sheathed, conforming to IS / relevant IEC standards.

Table 16: Technical Particulars of Fire Survival Cable

1.0	Type of Cable	EPR INSULATED FIRE SURVIVAL CABLES
2.0	Standard applicable in general(Latest amendment to be referred if any)	IS-9968(PART-1), IS-6380, IS -10810,IS 10418, IS-3975, ASTMD:2843, ASTMD-2863, IEC-60754-1, IEC-60331-1, IEC-60332, IEEE-60383,SS-424-1475
3.0	Voltage Grade	1.1 KV
4.0	Number of cores, cross sectional area of conductors and quantities	As per BOQ-Cum-Price Schedule
5.0		
(a)	Material	Copper
	Grade and Class	Stranded, Tinned annealed high conductivity, Class 2
(b)	Standard Applicable	IS - 8130
(c)	Shape	Compacted circular / Shaped
(d)	Min. number and diameter of strands for main and neutral conductor.	As per class -2 of IS 8130
(e)	Fire Barrier tape (separator tape)	Glass Mica tape in two layers with minimum 50% overlap
6.0	**INSULATION**	
(a)	Material	Heat resistant Elastomer compound , type IE2
(b)	Standard Applicable	IS : 9968(Part-1),IS -6380
(c)	Continuous withstand temperature	90°C
(d)	Short-circuit withstand temperature	250°C

(e)	Method of application	By extrusion; sleeve extrusion not permitted.
(f)	Method of curing	Dry/Steam/Gas/Sioplas
(g)	Nominal Thickness of insulation	As per IS : 9968(Part-1)
(h)	Fire proof tape	Two Layers of plain Glass Fibre Binder Tape
7.0	**CORE IDENTIFICATION**	Colour coding as per IS : 9968(Part-1)
8.0	**INNER SHEATH**	
(a)	Material	Heat resistant, oil resistant , flame retardant (HOFR) Elastomer compound
(b)	Grade and type	Extruded Type SE-3
(c)	Standard Applicable	IS : 9968(Part-1)
(d)	Colour	Black
9.0	**ARMOUR**	
(a)	Material:	
(i)	Single core cables	Single layer of Hard Drawn Aluminium Round Wire of H4 grade
	Standard Applicable	IS 8130
(ii)	Multi-core cables	Galvanised Steel Round Wire / Galvanised Steel Formed Wire Strip
	Standard Applicable	IS-3975
(b)	Gap between armour wires	Shall not exceed one armour wire space (No cross-over/ over-riding)
(c)	Minimum Coverage	90%
(d)	Breaking load of joint	95 % of normal armour
		Zinc rich paint shall be applied on armour joint surface of GS wire
10.0	**OUTERSHEATH**	
(a)	Material	Heat resistant, oil resistant , flame retardant (HOFR) Elastomer compound
(b)	Grade and type	Extruded Type SE-3
(c)	Colour	Black
(d)	Marking	Cable size (cross section area and no. of cores) and voltage grade, IS 9968-Part II @ 5m (by embossing) Word “EPR” “FS” etc, @ 5m (by embossing) Manufacturer’s name and/ or trade name, and year of manufacture @ 5m (by embossing) ‘NFR and ‘CUSTOMER’ Name @5m (by embossing) Progressive sequential marking @ 1m (by embossing/ printing)
11.0	**HOFR CHARACTERISTICS**	
(a)	Oxygen index	≥30 (as per ASTMD 2863)
(b)	Temperature Index	≥350ºC (as per ASTMD-2863)
(c)	Acid gas generation	≤ 2% by weight (as per IEC-60754-1)
(d)	Smoke density rating	≤ 20% (As per ASTMD 2843)
(e)	Water absorption test	IS 10810-28
(e)	**Flammability Test**	
(i)	Flammability test for single cable	As per IEC-60332 Part-1
(ii)	Flammability test for bunched cables	As per IEC-60332 Part-3 CAT-B
(iii)	Flammability test for complete cable	As per IEEE-60383
(iv)	Swedish Chimney test	As per SEN-SS-424-1475-F3
(f)	**Fire survival test**	As per IEC -60331-11 for min 3 Hrs at 950ºC
12.0	**Allowable Tolerance on OD**	±2 mm (max.)
13.0	**CABLE DRUMS**	
(a)	Type of Drum	Wooden Drum as per IS 10418 / Steel Drum As per Annexure I to Section II
(b)	Standard drum length	500m (±) 5% (as specified in BOQ-Cum-Price Schedule)
(c)	Painting	Entire surface to be painted

(d)	Outermost Layer	To be covered with water-proof polyethylene
(e)	Particular information on Drum	Both the end of cables shall be properly sealed with heat shrinkable PVC / rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage & erection. Wood preservative anti-termite treatment shall be applied to the entire drum.

NOTE: Suitable fire retardant material fillers shall be used for filling in the interstices. Two layers of plain glass binder tape should be applied over the laid up cores.

3.5.4 Cable Trays

Cable Tray and Cable Ladder systems are intended for the support and accommodation of cables and possibly other Electrical equipment in Electrical/Instrumentation/Communication systems.

3.5.4.1 Design and fabrication of cable Trays / Ladders:

The cable trays / ladders shall be fabricated according to the design specified by IEC 61537 and should be tested for Safe Working Load (SWL). The relevant details of SWL and the load chart with respect to SWL, supporting distance and the deflection should be according to the following chart.

Safe Working Load (SWL) with a span length up to 3 meters

Description	Side Height (in mm)	Width (in mm)	Span length (in meters)			
			1.5m	2m	2.5m	3m
			Permitted Load (in kg/meter)			
Perforated Cable Tray	35	50 – 300	125	90	50	-
	60	50 – 600	150	100	50	-
	85	100 – 600	175	110	50	-
	110	100 – 550	185	130	75	60
Cable Ladder	45	200 – 600	180	140	100	55
	60	200 – 600	-	225	150	100
	110	200 – 600	-	310	200	140

Safe Working Load (SWL) with a span length up to 10 meters

Description	Side Height (in mm)	Width (in mm)	Span length (in meters)						
			4m	5m	6m	7m	8m	9m	10m
			Permitted Load (in kg/meter)						
Perforated Cable Tray for long span distance	110	200 - 300	160	110	75	-	20	-	-
		400 - 600	200	150	100	-	40	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
Cable Ladder for long span distance	110	200 - 300	160	110	80	40	-	-	-
		400 - 600	210	150	100	70	-	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
	200	200 - 600	-	-	300	250	200	140	100

Fabrication of Tray / Ladder and accessories at site and welding is not permitted. In unavoidable circumstances, If any cut or holes are made in the trays/Ladder/ accessories, zinc spray need to be applied over the surface. The metal edge has to be protected by edge protection sleeves to avoid cable damage. Edge of the supports has to be protected with plastic END caps. Screwed connections and internal fixing Devices should not create any damage to the cable when correctly fixed. Sudden or jerky motions shall not be used to tighten reusable screw connections.

Cables shall run in cable tray/ladder mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures using mounting accessories.

The cable tray and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications & should have a Base Perforation Class B according to IEC 61537. The cable trays shall be supplied in standard lengths of 3000mm and the width of the tray shall be as follows.

Width: 50, 100, 150, 200, 300, 400, 500, 600 & 750 mm.

All the cable tray accessories like Bend's, TEES's, Cross over's etc should be designed in accordance with IEC 61537 and shall be factory fabricated. The accessories shall be from the same material as of the tray and modular type, it should be connected with the trays by using fasteners. Typical details of trays, fittings and accessories etc are shown in the enclosed drawings.

For Cable trays designed, tested and confirming to IEC 61537, thickness of cable tray should be according to the manufacturer's catalogue. For locally fabricated and non-tested tray, thickness should be 2 mm up to span length of 1.5 meter, 2.5 mm for span length between 2 to 3 meter and 3 to 4 mm for span length between 4 and 10 meter

Cable Ladder:

The cable Ladder and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications & should have a Free Base Area classification Y according to IEC61537. The cable ladders shall be supplied in standard lengths of 3000/6000 mm and the width of the tray shall be as follows.

Width: 200 to 1200 mm in multiples of 100 mm

Maximum rung spacing in the ladder shall be 300mm. The rung's should be made of C profiles suitable to fix cables by special metal clamps according to the drawing. The ladder shall be of riveted and foldable type for easy transportation and to avoid damage during transportation and storage. All the ladder accessories like Bend's, TEES's, Cross over's etc should be designed in accordance with IEC 61537 and shall be factory fabricated. The accessories shall be made from the same material as of the ladder and modular type; it should be connected with the ladder by using fasteners. The details of ladders, fittings and accessories .etc are shown in the enclosed drawing.

For Cable Ladders designed, tested and confirming to IEC 61537, thickness of cable Ladder should be according to the manufacturer's catalogue. For locally fabricated and non-tested Ladder, thickness should be 2.5 mm up to span length of 1.5 to 2 meter, 3 mm for span length between 2.5 to 4 meter and 3 to 4 mm for span length between 5 and 10 meter

3.5.4.2 Specification For Hot Dip Galvanizing Process

(for Mild Steel Used For Earthing, Cable Trays Or Junction Boxes For Electrical Installation.)

General Requirements

I. Quality of Zinc

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS:209-1992.

II. Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square metre shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions,

bare patches black spots, pimples, lumpiness, runs, rust stains bulky white deposits, blisters.

Mild steel flats / wires shall undergo a process of degreasing pickling in acid, cold rinsing and then galvanizing.

3.5.4.3 Cover For Cable Trays / Ladders

Cover for trays/ladders to protect the cable insulation from falling objects, water droplets, harmful effects of ultraviolet rays and accumulation of dust. The cover shall be made either from Hot Dip Galvanized sheet steel or superior quality Double Dip Galvanized Sheets. For Outdoor application, Double dip Galvanized material shall be used. The covers should be fitted properly to the Ladder / Tray by using pre fixed and tested locks which ensure that covers are fitted rigidly to Tray / Ladder. For outdoor application in high wind areas, additional cross over beadings to be used for fixing the cover on tray / ladder of width more than 500 mm.

3.5.4.4 Mounting Accessories (Supports And Brackets):

The mounting accessories shall be fabricated from steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications and should be of completely modular type.

All supports and Brackets should be factory made, hot dip galvanized after completing welding, cutting, drilling, other machining operations and tested according to IEC 61537 according to the arrangements in the enclosed drawing. The system shall be designed such that it allows easy assembly at site by using Bolts and Nuts. The main support and brackets shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hard ware etc to form various arrangements required to support the cable trays. Welding of the components at the site shall not be allowed.

Joints

Joints shall be smooth and without projections or rough edges that may damage the cables.

The Contractor will be required to cover joints with rubber cement or other non hardening rubberised or plastic compounds if in the opinion of the Department joints may damage cables.

Joints shall as far as possible be arranged to fall on supports. The two cable tray ends shall butt tightly at the centre of the splice and the splice shall be bolted to each cable tray be means of at least 8 round head bolts, nuts and washers. Splices shall have the same finish as the rest of the tray.

3.5.4.5 Fixing To Supports

Trays shall be bolted to supports by at least two round head bolts per support. Bolts shall be securely tightened against the tray surface to avoid projections which might damage cables **during installation.**

3.5.4.6 Fixing to the Structure

Where installed on concrete or brick, the supports for cable trays and ladders shall be securely fixed by means of at least 2 heavy duty, expansion type anchor bolts. Cantilevered trays shall be supported by a minimum of two expansion bolts per support.

It is the responsibility of the Contractor to ensure that adequate fixing is provided since cable trays and ladders that work loose shall be rectified at his expense. The fixing shall take in to account site conditions that prevail during installation.

Horizontal trays and ladders shall in general be installed below slabs, ceilings, etc. to facilitate access during installation of cables.

Multiple runs shall be spaced at least 300 mm apart unless a different spacing is specified.

Corrosion Protection:

The cable tray / ladder/accessories shall be of HOT DIP Galvanized (ISO 1461-1999) for installations in corrosive atmospheres both indoor and outdoor application. Sample tray / ladder / accessories / mounting accessories and supports should be salt spray tested according to ISO 9227 for > 500 hours. (*550 hours according to class 6 for Hot dip Galvanized surface as per ISO)

3.5.4.7 Testing and Certification if Installation :

Cable tray / Ladder, bend, T Bend, cross, and all supports are to be tested for Safe Working Load (SWL), deflections, Impact resistance, Salt Spray & Electrical continuity test according to IEC 61537. The cable tray/ladder should not deflect more than 1/100th of the span length at SWL in Mid span and the transverse deflection of all mounting accessories at SWL shall not exceed 1/20th of the length. The cable tray / cable ladder should be tested up to 1.7 times SWL at minimum and maximum room temperature. The temperature classification of cable tray system should be - 5 to + 150°C.

3.5.4.8 Marking, Documentation, Compliance and Inspection:

Each system component shall be durably and legibly marked with:

-the manufacturer's or responsible vendor's name or trade mark or identification mark;

-a product identification mark which may be, for example, a catalogue number, a symbol, or the like.

When system components other than cable tray lengths and cable ladder lengths are supplied in a package, the product identification mark may be, as an alternative, marked on the smallest package unit.

Marking shall be applied, by moulding, pressing, engraving, printing, adhesive labels, or water slide transfers. Compliance is checked by inspection and, for marking on the product, by rubbing by hand for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cotton cloth soaked with petroleum spirit. Marking made by moulding pressing, or engraving is not subjected to the rubbing test. After the test, the marking shall be legible.

If a system component is stored and transported at a temperature outside the declared minimum and maximum temperatures, the manufacturer or responsible vendor shall declare the precautions and the alternative temperature limits. Compliance is checked by inspection.

The manufacturer or responsible vendor shall provide in his literature all information necessary for the proper and safe installation and use of the cable tray system and cable ladder system. The SWL and impact resistance is valid for the whole temperature classification declared. The information shall include

3.5.4.9 Fire Retardant Cable Paint & Fire Barrier

The fire retardant paint / barrier shall be listed by independent test agencies such as UL, FM or OPL and be tested to, and pass the criteria of ASTM E 814 (UL1479) standard test method for fire test through- penetration fire stops and ASTM E 1996 (UL 2079) standard test method for fire resistive joint system/

3.5.4.10 Fire Retardant Cable Paint

The Fire resistant cable coating / painting shall be intumescent / ablative, water based compound, The coating shall expand up to 10 times, supplied in a manufacturer seal container indicating manufacturing and expiry dates. The coating material shall be non-toxic, asbestos free, & halogen free and shall have good mechanical strength. The colour of paint shall be white and density of coating shall be 1.3kg/ltr, coating shall have a snap time of 30 minutes, the expansion shall begin at 230 deg.C and it shall have a oxygen index of 41%.

Coating shall be applied by ordinary paint brush after cleaning the cables of dust and oil deposition. A minimum textured finish of 3 mm wet film thickness shall be achieved by applying the material in 2-3 layers leaving intervals of 2 to 8 hours depending upon the moisture and thickness, moisture and temperature hours between each coat.

3.5.4.11 Fire Barrier Sheet for Floor and Wall Sealing

The framing & fixing part of fire barrier sheet shall be very simple & directly fixed around walls & floors by help of anchored bolts & washer. For 2 hour fire rating the fire barrier sheet shall be minimum 7.62 mm thick and shall be cut as per the profile of penetration and opening. The small gap left around the penetration shall be closed with fire rated soft & mouldable putty. Fire barrier must be design on the intumescent technology to seal larger penetration through the fire rated walls & floors.Fire barrier must be a composite construction with the quality incorporated with organic/ inorganic fire resistive elastomeric sheet with specific gravity of 1.6 gm/ cubic centimeter.

3.6 LT Panel

3.6.1 General Requirements

This specification covers requirements for Supply, Erection, Testing and Commissioning of LT Panels. The equipment offered by the Contractor shall be complete in all respects. Any material and component not specifically stated in this specification but which is necessary for trouble free operation of the equipment and accessories specifically excluded. All such equipment / accessories shall be supplied without any extra cost. Also, all similar components shall be interchangeable and shall be of the same family type and rating for easy maintenance and low spare inventory.

The general power supply of the 433 / 250 Volt-level to the different equipment will occur from the Electrical room in the Control Centre on both ends of the tunnel to the Niches and then further to the ultimate consumers through field distribution boards.

At the Control Building one low voltage main distribution cabinet is situated for Grid and one for the UPS from where the Grid and UPS power is supplied to the Niches and then further to the ultimate consumers.

All power and control units shall be installed into distribution cabinets, all different voltages (e.g. main power, UPS power, different control units and so on) shall be placed in separated cabinets.

3.6.2 Code And Standards

Compliance with all applicable Indian standards, Indian Electricity Act and Indian Electricity rules.

IS 5039	:	Distribution Feeder Pillars
IS 375 / 1963	:	Making and arrangement for switchgear, bus-bars, main connections & auxiliary wiring
IS 694	:	PVC insulated cables for working voltages up to and including 1100V.
IS 13779	:	A.C. Static Electricity Meters.
IS 1248	:	Electrical Indicating instruments.
IS 1567 / 1960	:	Metal clad switches (Current rating not exceeding 100A)
IS 1951 / 1916	:	Polyvinyl chloxide sleeving for electric purposes.
IS 2147 / IS 12063	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS 5	:	Colors for ready-mixed paints and enamels.
IEC 60947/ IS 13947 (Part-2)	:	A.C. Circuit breakers.
IS 8828	:	Miniature Circuit breakers.
IS 12640	:	Residual Current Operated Circuit breakers.

IS 2448 / 1962	:	Adhesive insulating tapes.
IS 2551	:	Danger Notice Plates.
IS 2705	:	Current Transformers.
IEC 60947/ IS 13947	:	Contactors and motors starter for voltages not exceeding 1000 V AC or 1200 V DC.
(Part-4, Sec-1)	:	
IS 13947 (Part-5, Sec-1)	:	Control Circuit Devices and Switching Elements
IS 13947 (Part-1&5)	:	Actuators, Indicators
IS 13947 (Part-1&5)	:	Timers
IS 3043	:	Code of practice for earthing.
IS 3072	:	Installation and Maintenance of switchgear.
IS 3202	:	Code of practice for climate proofing of electrical equipment.
IS 3231/ IS 8686	:	Electrical relays for power system protection.
IS 4237	:	General requirements for switchgear and control gear for voltages not exceeding 1000 V.
IS 5082	:	Wrought Aluminum & Al alloy for electrical purposes.
IS 6875	:	Switches and push-buttons.
IS 8623	:	Specification for factory built assemblies of switchgear & control gear for voltages up to & including 1000 V AC.
IS 10118	:	Code of practice for selection, installation and maintenance of switchgear and control gear.
IS 11353	:	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS 12021	:	Specification of control transformers.

Equipment in line with any other authoritative / internationally recognized standards such as IEC, British, USA and German etc. shall also be considered if it ensures performance equivalent or superior to Indian Standards. Prior approval shall be obtained from Consultant for use of this equipment / material. In such cases the decision of Consultant shall be final and binding.

3.6.3 Quality Assurance

Manufacturers regularly engaged in manufacture of panel boards and enclosures, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years

3.6.4 Guarantee

Manufacturer shall provide guarantee for work under this section. However, such guarantee shall be in addition to and not in lieu of all other liabilities which manufacturer and Contractor may have by other provisions of the contract document.

The Panel Boards shall be guaranteed against trouble free operation, defective workmanship, materials and design for a period of 18 months from the date of supply or 12 months from the date of erection and commissioning, whichever is earlier. Any defects during this period shall be rectified free of cost.

3.6.5 Submittals

Contractor to submit general arrangement diagrams with front, side, top and bottom view and inside view.

General arrangement diagrams shall include outline and dimensions, voltage, main bus capacity, circuit breaker details and their arrangement / sizes.

All drawings shall also indicate location / description of all operating / indicating components mounted on the front / rear of the panel for all feeders / starters.

Typical control schematic diagram for each type giving designation to be refereed on Single Line Diagram/BOQ.

Terminal block details for all feeders / starters power and control terminals provided for external as well as internal wiring connections.

Panel board foundations with necessary dimensions.

Details of shipping sections along with all dimensions.

Bill of material giving make / rating / catalogue number of all components of the complete switch board

Shop drawings to scale of the room layout indicating the panel location

3.6.6 Delivery

All panels shall be carefully packed to avoid damage during transit. Panel boards shall be wrapped in polyethylene sheets for local shipment, whereas for outstation delivery in addition to polyethylene sheet the panels shall be packed in wooden crates to prevent damage to the finish.

3.6.7 Panel Board Enclosures And Accessories

Constructional Details of Panel Boards

All Panel Boards shall be metal enclosed, indoor, floor / wall mounted, free-standing type.

All Switchboards frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2.0mm. Frames shall be enclosed in cold rolled sheet steel of thickness not less than 2.0mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6mm. Stiffeners shall be provided wherever necessary. Rear doors shall min 2.00 mm thick CRCA and provided with three pin handle and lock.

All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge / bend by the weight of maintenance personnel working on it.

The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cutouts shall be true in shape and devoid of sharp edges.

All LT Panels shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 54 as per IS: 2147.

All Feeder Pillars and Secondary Panels shall be of dust-proof, vermin-proof and weather-proof construction and shall be provided with a degree of protection of IP : 55 as per IS : 2147.

All cutouts shall be provided with synthetic rubber gaskets. The gaskets, wherever specified, shall be of good quality synthetic rubber with good aging, compression and oil resistance characteristics suitable for panel applications. Preference shall be given to Heat resistant – EPDM Gaskets.

Panels shall be supplied with base frames made of structural steel sections, along with all necessary provision for fixing to foundation / floor as required. The base frame height shall be such that floor finishing to be done by Owner after erection of the switchboards does not obstruct the movement of doors and cover etc.

All Panel Boards shall be divided into vertical section, comprising of various compartments as mentioned below. However, these compartments may be combined in case of Feeder Pillars and Secondary Panels.

Feeder Pillars and Secondary Panels shall have canopy on the top. Canopy shall have slope so as not to let the rainwater accumulate on the same. The canopy shall extend beyond the panel body to avoid any

rainwater falling inside the panel.

Bus-bar Compartment

A completely enclosed bus-bar compartment shall be provided for the horizontal and vertical bus-bars. Bolted covers shall be provided for access to horizontal and vertical bus-bars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. All bus-bars shall be in separate compartment. Covers shall be provided with name plates indicating “Danger - Bus Bars” on it. Colour of the plate shall be White with letters in Red of danger name plates shall be inscribed with 6 mm size lettering.

Shrouding for Bus Bar with above 1250 A current rating shall be provided. These shrouds located near conductors shall be made using non-magnetic materials.

Switchgear / Feeder Compartment

All equipment associated with an incomer or outgoing feeder shall be housed in a separate compartment of the vertical section. The compartment shall be sheet steel enclosed on all sides. The front of the compartment shall be provided with the hinged single leaf door with “Master Key” lock. The feeders compartment door shall have two number anodized inscription plates. One inscription plate shall bear the feeder number and feeder rating and fixed to the door with rivets. The other inscription plate shall bear the feeder name and shall be fixed by screws. The feeder name plates shall be interchangeable.

Cable Compartment Or Cable Alley

A full-height vertical cable alley of minimum 300mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with Bus-bar compartment. Cable terminations located in cable alley shall be suitably shrouded to prevent accidental contact by falling of tools etc. It shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination. The Contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged. Cable alley door shall be provided with name plates indicating “Cable Alley” on it.

Control Compartment

A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.

Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboards, except for the horizontal Bus-bar compartment. Synthetic rubber gasket shall be provided between the panel sections to avoid ingress of dust into panels. Each shipping section shall have full metal sheets at both ends for transport and storage.

After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the Busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section, insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

All 415 V switchgear (circuit-breaker) panels shall be of single-front type. All Panels shall also be of single-front construction. All single-front switchboards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with ‘Danger’ labels. All panel doors shall open by 90deg. or more. The panel door shall be openable only after switching of the incoming power supply.

Complete shrouding / segregation shall be provided between incoming and outgoing bus links of

breakers. In case of bus coupler breaker panels, the bus-bar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live.

All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to consultants approval and shall be provided with bakelite shrouding.

The tentative power and control cable entries (top/bottom) required are indicated in the "Bill Of Quantity". However, the Owner / Consultant reserve the right to alter the cable entries, if required during detailed engineering, without any additional commercial implication.

Each switchboard shall be provided with un-drilled, removable type gland plate, which shall cover the entire cable alley. Contractor shall ensure that sufficient cable glanding space is available for all the cables coming in a particular section through gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.

Gland Plates

Gland plates for 2 Core, 3 Core, 3½ Core, 4 Core Cables shall be 2.5 mm thick CRCA zinc passivated. Thickness of zinc passivation shall be 100 microns. Wherever, the size of gland plates exceeds 600 mm same shall be split into two parts and provided with adequate supporting arrangement. Earth continuity between cable armour and panel body shall be maintained. Single core shall have aluminum gland plates of min 6mm thick.

Clearances

The minimum clearance in air between phases and earth for the entire run of horizontal and vertical busbars and bus-link connections at circuit-breaker shall be 25mm. For all other components, the clearance between "two live parts" shall also be twenty-five (25) mm throughout. For a live part and an earthed part the clearance shall be twenty (20) mm minimum. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for horizontal and vertical bus-bars the clearances specified above should be maintained even when the bus-bars are sleeved or insulated. All connections from the bus-bars up to MCCB / SFU / FSU shall be fully shrouded / insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits.

Power Bus-bars and Insulators

All 415 V Panel Boards, shall be provided with three phase and neutral bus-bars. Entire Bus-bar system shall be insulated with colour coded, heat shrinkable PVC sleeves.

All bus-bars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.

The cross-section of the bus-bars shall be uniform throughout the length of switchboard and shall be adequately supported and braced to withstand the stress due to the specified short circuit currents. Neutral Bus-bar short circuit strength / cross section shall be same as main bus-bars up to 400 Amps.

All bus-bars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fiber glass moulded insulators. Separate supports shall be provided, for each phase and neutral Bus-bar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Bakelite / Hylam, shall not be accepted. The Bus-bar insulators shall be supported on the main structure.

All copper to aluminum joints shall be provided with suitable bi-metallic washers. Alternatively direct

Bus Bar joints can be made between copper and aluminium Bus Bar if tinned copper Bus Bars are used.

All bus-bars shall be colour coded as per IS: 375.

All bus-bars shall have PVC sleeves (not tapes) wherever called for in the specification.

Earth Bus and Earthing

A galvanized steel / aluminum earth bus of suitable size shall be provided at the bottom of each panel and shall extend throughout the length of each Panel. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar.

The earth bus shall have sufficient cross section (250 sq. mm. minimum) to carry the momentary short circuit and short time fault current to earth, without exceeding the allowable temperature rise.

Suitable arrangements shall be provided at each end of the horizontal earth bus for bolting earthing conductors. The horizontal earth bus shall project out of the Panel ends and shall have predrilled holes for this connection. All joint splices to earth bus shall be made through at-least two bolts, and taps by proper lug and bolt connection.

All non-current carrying metal work of the Panel shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.

All metallic cases of instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire / braids. Insulation colour code of earthing wires shall be green.

CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit can be removed without disturbing the earthing of other circuit.

All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire / braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges / hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.

Switchgear:

a) **LT Air Circuit Breakers (ACB's)**

Technical Parameters

The ACB shall conform to the requirements of IEC 60947-2 / IS 60947-2 and shall be type tested & certified for compliance to standards from–CPRI, ERDA / any accredited international lab. The circuit breaker shall be suitable for 415 V + 10%, 50Hz supply system. Manufacturer should submit **Combined sequence test certificate** from CPRI/ERDA

The circuit breakers shall be for continuous rating at -15 to 30 deg C ambient temperature. The Rated insulation voltage shall be 1000 volts AC & Rated impulse withstand Voltage shall be 12kV for main circuit.

Rated service short Circuit Breaking capacity shall be 50KA and should be equal to the Rated ultimate Short circuit breaking capacity (Icu) and short circuit withstand values (Icw) for 1 sec.

Constructional Features

The ACB shall be 3/ 4 pole with modular construction, horizontal draw out type, manually or electrically

operated version as specified in BOQ and fully interlocked.

Main current carrying contacts of ACB shall be silver plated and suitable arcing contacts with proper arc chutes shall be provided to protect the main contacts. Arc chutes shall be provided for each pole, and these shall be suitable for being lifted out for the inspection of the main and the arcing contacts without using any tools.

The ACB shall be provided with a **door interlock** i.e. door should not be open when circuit breaker is closed and breaker should not be closed when door is open.

All 4 Pole ACBs should have 100% neutral rating.

Cradle

The Circuit Breaker cradle shall be designed and constructed to permit smooth withdrawal and insertion. The movement shall be free of jerks, easy to operate and positive.

The draw out Circuit Breaker shall have the following 3 distinct and separate positions wrt cradle.

"Service" -- Both main and secondary isolating contacts closed

"Test" -- Main isolating contacts open and secondary isolating contacts closed

"Isolated" -- Both main and secondary isolating contacts open

Circuit Breaker Interlocking

It shall not be possible for the Breaker to be rack out / withdrawn from the cubicle when in the "ON" position.

It shall not be possible for the Breaker to be switched "ON" until it is either in the fully inserted position or, for testing purposes, it is in the fully isolated position.

It shall not be possible for the Circuit Breaker to be plugged in unless it is in the OFF position.

Circuit Breaker Auxiliary Contacts & accessories

The Circuit Breaker shall have minimum 4 NO/NC auxiliary contacts rated at 16 amps 415 volts 50 Hz. These contacts shall be approachable from the front. They shall close before the main contacts when the Circuit Breaker is plugged in and vice versa when the Circuit Breaker is Drawn Out of the cubicle.

All accessories of ACBs like shunt trip coil, under voltage trip coil, closing coil etc. shall be click fit type and front mounted. It should be possible to know the control voltage ratings for all electrical accessories without opening the panel door.

External Neutral CT should be provided for all 3 pole ACBs for Earth Fault sensing & to avoid nuisance tripping due to unbalance loads.

Mechanical operation counter to be provided for all ACBs

Protective Devices

All ACBs (except bus couplers) shall be provided with micro-controller based release to offer accurate and versatile protections with complete flexibility and in the following zones:

- Overload (Phase & Neutral) protection with adjustable time delay.
- Short time protection with intentional delay.
- Instantaneous protection.
- Ground fault protection with intentional time delay.

The release should provide local LED indication for identification of type of fault, without requiring using external power supply.

The release shall draw its power from the main breaker CTs and shall require no external power supply for its operation, There shall be provision for aux. supply for display of parameters during off or lightly loaded conditions.

The release should display actual % loading at any instant.

Release shall be password protected to prevent unauthorized access to protection settings

Releases shall have 2 storable sets of LSIG protection settings to provide adequate protection against loads varying as per time & source changeover from Transformer to DG.

The release shall meet the EMI / EMC requirements.

Metering & Communication: Release should have LED/LCD display for of Phase & Neutral currents and last 20 fault / trip history.

Transformer & DG set Incomer ACB releases shall have LED/LCD display showing all Power & Energy Parameters (I, Imax, %loading, Iavg, V, Freq, PF, W, VAr, VA, Wh, VArh, Vah, MD-Active, MD-Reactive, MD-Apparent, Temperature in each Phase)

The release shall also give additional protection against Current & Voltage Unbalance, Under Voltage, Over Voltage, Under frequency, Over frequency, Lead/Lag PF, Maximum Demand, Phase Sequence etc

All Main Incomer ACBs shall have inbuilt Temperature rise protection for protection against abnormal Temperature rise at terminals.

The Release shall be provided with RS485 communication port on MODBUS RTU protocol

Safety Features

I.Draw out ACBs shall be provided with automatically operated safety shutters to prevent accidental contact with live contacts when breaker is withdrawn from the Cradle.

II.For safety of users, interlock should be provided between breaker operating mechanism & the arc chutes to prevent closing in case the arc chutes are not properly secured.

IIIThe insulation material used shall conform to Glow wire test as per IEC60695-2-1

IVThe racking shutter should open only when ACB is OFF to avoid unauthorized racking operation.

VMechanical and electrical anti pumping devices shall be incorporated in the electrically operated ACB's as required.

b) Moulded Case Circuit Breakers (MCCB's)

The Moulded case circuit Breaker (MCCB) shall confirm to the latest IS 13947 (Part-2) and IEC 60947-2. The MCCB shall comply with the isolation function requirement of IEC 60947-2 Section 7.12 & marked as suitable for isolation and disconnection to facilitate safety of operating personnel while the breaker is in use.

The MCCB shall have a rated service short circuit breaking capacity (Ics) not less than 25/40/50/65 KA rms at 415V, 50 Hz AC, 400 A & 250 A as specified in SLD.

The Service breaking capacity (Ics) shall be equal to ultimate breaking capacity (Icu) unless otherwise specified.

MCCB's shall be suitable for rated operation voltage upto 690 V AC, 50 Hz & rated insulation voltage

upto 750 V AC, 50 Hz.

MCCBs shall be of triple pole / four pole construction. Operating mechanism shall be quick-make, quick-break and trip-free type. The "ON" , "OFF" and "TRIP" positions of the MCCB's shall be clearly indicated and visible to the operator when mounted as in service. Front of door operating handle shall be provided with pad lock and door interlock. Front of door operating handle shall be provided with door interlock defeat mechanism to facilitate inspection of the MCCB during 'ON' position.

The MCCB shall be current limiting type. MCCB shall have Arc extinguishing device contained in a compact, high strength, heat resistance, flame retardant, halogen free insulating moulded case with high withstand capability against thermal and mechanical stresses.

The trip command of releases in MCCB shall over ride all the other commands. The MCCB shall employ maintenance free double break contact system to minimise the let through energies and capable of achieving Discrimination up to the full short circuit capacity of the downstream MCCB. The MCCB shall not be restricted to line / load connections. MCCB shall be provided with test trip Push Button to check the proper function of tripping mechanism.

MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 8 milliseconds.

Where mechanical interlocking is called-for between two Incomer and Bus Coupler or between two Incomers without Bus Couplers, proper arrangement for built-in Ronis/ Coded key interlocking shall be provided.

MCCB terminals shall be shrouded and designed to receive Bus Bar Links /cable lugs for cable sizes relevant to circuit ratings.

Protection

MCCBs shall be provided with Thermo-Magnetic / microprocessor type releases 400 & 250 A, TPN.

The MCCB's above 250 Amps shall be provided with fully interchangeable thermo-magnetic / microprocessor based overload and short circuit release. Load indication LED shall be integral part of electronic releases. All electronic releases shall be EMI / EMC compatible.

Microprocessor Releases shall have Thermal Memory i.e. when the breaker shall re-close after tripping on overload, then the thermal stress caused by the overload if not dissipated completely, shall get stored in the memory of releases and this thermal memory shall ensure reduced tripping time in case of subsequent overloads and earth fault. Realistic Hot/Cold curves shall take into account the integrated heating effects to offer closer protection to the system.

Where Earth fault protection are indicated they shall be integral with MCCB's and have adjustability from 20% to 100% of rated current with adjustable time delays to aid discrimination on earth faults. The integrated system shall be immunized against nuisance tripping as per IEC 61000-4 standards.

In case of 4 Pole MCCB the neutral shall be defined and capable of offering protection upto full rating (0/50/100% value of phase current). In case of critical supply feeder, neutral protection shall be 0/80/160% of phase current.

Accessories

The MCCB shall have common field fittable snap-on auxiliaries for entire range & above 160 Amps the accessories like tin plated spreaders and phase Barriers should be integral part of MCCB's.

Indicating Instruments (Digital Type)

All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96mm. Square size Digital Type with Built-in Selection, and shall have an accuracy class of 1.0 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction. Digital meters to be provided for single phase Panels shall not incorporate Built in Selector Switch.

All instruments shall be compensated for temperature errors and factory calibrated.

Instrument Transformers

All current transformers shall be tape insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated condition and the specified ambient temperature. The class of insulation shall be 'E' or better.

All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block where star point formation and earthing shall be done.

CT shorting links are to be provided to avoid burning / damage of CT's in case of opening of CT terminals.

Current transformers may be multi or single-core type. All CTs shall be provided with supports independent of Bus-bar/Bus-bar supports.

The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shut down of adjacent feeders.

Selector Switches

Selector switches shall be of rotary type, with plates clearly marked to show the function and positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.

Contacts of switches shall be spring assisted and shall be of suitable material to give a long trouble free service.

Push Buttons

Push-buttons shall be of spring return, push-to-actuate type. Their contacts shall be rated to make, continuously carry and break 10 A at 240 V AC and 1 A (inductive) at 220 V DC.

All push-buttons shall have one normally open (1 NO.) and one normally closed

(1 NC) contact, unless specified otherwise. The contact faces shall be of silver alloy.

All push-buttons shall be provided with integral plates marked with its function.

The colour of the button shall be as follows:

Green for motor Start / breaker Close.

Red for motor Stop / breaker OPENS.

All push-buttons on panels shall be located in such a way that Red push-buttons shall always be to the left of Green push-buttons.

All emergency push-buttons shall have mushroom knobs.

Indicating Lamps

Indicating lamps shall be of the panel mounting, Led type and low watt consumption. The Led lamps shall have plates marked with its function, wherever necessary.

Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

Red for R-Phase / MCCB "ON" / Contactor 'ON'

Yellow for Y-Phase

Blue for B-Phase

Green for Contactor 'OFF'

Amber for Breaker / Starter 'TRIP'

Lamp cover shall be easily replaceable from the front of the cubicle.

LED indicating lamps should be located just above the associated push-button / control switches. Red lamps shall invariable be located to the right of green lamps.

Internal Wiring, Control Terminal Blocks, Name Plate / Labels and Painting

Internal Wiring

All switchboards shall be supplied completely wired internally up to the terminals, ready to receive external cables.

All intercubicle and inter panel wiring and connections between panels of same switchboard including all bus wiring shall be provided by Contractor.

All auxiliary wiring shall be carried out with 1100 V grade, single core, stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm2 (min.) for control circuit wiring & 2.5 mm2 (min.) for CT's.

PVC insulated, standard copper wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the door shall be properly sleeved or taped.

All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and blocks.

All internal wiring terminations shall be made with solder less crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component-to-component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible.

Engraved core identification ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The ferrule shall be of self-locking type. The wire identification marking shall be in accordance with IS:375.

Wiring for equipment, which are to be supplied by the Owner and for which the Contractor has to provide mounting arrangement in his panels, shall also be provided by the Contractor, up to the terminal blocks.

All connections from vertical bus bars for individual modules above 100 A shall be by Copper / Aluminum links only. The cable connections for module up to 100 A shall be selected in such a way that there will not be any melting / shorting in case of a short circuit inside the module and the cable shall have current rating to carry the let through energy of the corresponding breakers in case of a fault. For power wiring colour coded wire insulation / tapes shall be provided.

Control Terminal Blocks

Control terminal blocks shall be of 1100 Volts grade, rated for minimum 10amps and in one piece molding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams.

All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size up to 2.5 mm2 each.

All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provide on the terminal blocks.

Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links.

Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks. The minimum clearance between the first row of terminal blocks and the associated cable gland plate shall be 250 mm.

Name Plates and Labels

All Panel Boards shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation.

All name plates shall be of anodized aluminum with white engraved lettering on black background.

Painting

All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate surfaces shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, two coats of finishing synthetic enamel paint on panels shall be applied. Finishing paint on Panels shall be Powder Coated, Siemens Grey, shade RAL–7032 throughout Orange Peel Finish with Electrostatic method or as approved by the Owner's / Consultant while approving the shop drawings.

LT Switchgear:

Standard: IEC 60947 / IS 13947 amended to date.

Only approved makes of switchgears shall be used.

LT switchgears shall be provided with necessary in built over-current, and short circuit releases

Energy meter:

3-phase, 4-wire LT CT operated static energy meters (5A) (Class 0.5) with associated CT's (400/5 A, Class 0.5, 15 VA) shall be provided for each incomer to record energy consumption. Only owner's approved makes of energy meter & CT's shall be used.

MULTI-FUNCTION INSTRUMENT

Multi-function instruments (for installation in the distribution cabinet's-door), shall be suitable to measure:

- current of all phases (L1, L2, L3)
- voltage of all phases (phase-neutral, phase-phase)
- active power

- apparent power
- reactive power
- power factor (cos φ)
- kWh
- kVarh

The multi-function instruments shall be equipped with an electric measuring element and a busable interface.

Further, the multi-function instruments shall be connectable to the current transformer (nA/5A), and they shall be equipped with a digital display and a keyboard for controlling. They also shall be equipped with a peak-value-memory.

Ammeters:

Moving iron spring controlled type, flush mounted, 96 sq. mm. and 90 degree scale and clearly readable. Range 0- 400A. Only Owner's approved makes shall be used.

Voltmeters:

Moving iron spring controlled type, flush mounted, 96 sq. mm. and 90 degree scale and clearly readable. Range 0- 500V. Only owner's approved makes shall be used.

The configuration of LT Panel shall be as per SLD and detailed design of the Contractor, subject to approved of the Independent Engineer.

3.6.8 Distribution Cabinets - Jet Fans

The jet fans shall be fed through reversible soft starter panels The soft starter shall be suitable to perform following tasks and specifications:

- adjustable launching ramp, stooping ramp, launching voltage
- adjustable current limiting
- wear-free semiconductor switches
- continuous operation
- overload-able up to 15 % at continuous operation
- including bypass-contactor
- floating contact
- LED-indications on the device for fault diagnosis and operating diagnosis

Electronic execution with operation element, serial interface for remote control and status indication; the soft starter shall be completely programmed.

Technical Data:

Motor nominal voltage:3 x 433 V; 50 Hz

Rated motor output:at least 55 kW

(Auxiliary)Supply Voltage:250 V AC

Degree of protection:at least IP 20

Number of operations per hour:at least 10

Mode of Operation:

The soft starter shall be used for start / run up of the jet fans. After the sequence of starting the bypass-switch shall be activated. The soft starter and the bypass-switch shall be wired in a form, so that the motor of the jet fan also can be started using the bypass-switch in case of failure or the soft starter.

3.6.9 Power Factor Correction

Static power factor correction of suitable rating shall be deployed at the 415 V bus

The power factor correction shall ensure a power factor better than cosφ = 0.95 ind.

Just low-loss, self-healing capacitors are allowed. The capacitors shall be equipped with an overpressure protection device. The capacitor losses shall not overstep the value of 0.2 W / kVar. Each capacitor shall be equipped with an according discharge device.

3.6.10 Tests

The panels shall be completely assembled, wired, and tested for operation under stimulated conditions to ensure accuracy of wiring, correctness of control scheme and proper functioning of all equipment. The LT switchboard shall be tested as per relevant standard at the factory in the presence of owner's Engineer.

The Bidder shall furnish copies of Type test certificates. Following type tests should have been carried out in certified Test laboratory during the period not exceeding 3 years from the date of opening the bid.

a)Short time current test

b)Temperature rise test

c)One minute power frequency voltage withstand test.

Following Routine Tests shall be carried out

a)Mechanical operations test

b)Dielectric tests.

3.7 Earthing System

3.7.1 Introduction

An Earthing System is a basic requirement of any electrical & electronics installation as it forms a primary line of protection for equipment and the operator. The object of an earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. A well-designed low resistance earthing system is necessary for dissipation of heavy fault current and electrical surge to protect the equipment & user with minimizing the downtime, service interruption and replacement cost etc.

3.7.2 Scope

This document covers technical specification and designing for making Earthing Layout for Road Tunnel. The specification will cover the scope of work which will includes design, supply, installation and testing of Earthing Arrangement & its Components. The material offered shall conform to relevant standard with high quality and good workmanship capable to perform continuous and satisfactory operations in the actual service conditions at site.

The specifications will consist of the details of the Earthing Grid designed with Earthing Rod i.e. Copper

Bonded Steel Rods, an Earth Enhancement Compound and permanent earthing joint solutions Exothermic Weld along with the procedure for constructing the earth pit for the maintenance free earthing system to ensure that the resistance to earth is near to acceptable values (<1Ω) throughout the life without any frequent maintenance or any replacement. The earthing system to be adopted for electronics equipment should be able to save the system components which are more susceptible to damage due to surge, transient and over voltage encountered due to various reasons.

3.7.3 References

This specification will meet the requirements of mentioned documents & also working as a reference standard:

IEEE 80:2013IEEE guide for safety in AC Sub-Station Grounding

IEEE 837Standard for qualifying permanent connections used in substation grounding.

IEC 62561-7Requirements for Earthing Enhancing Compounds

IEC 62561-2Requirements for Conductors and Earth Electrodes

UL-467Standard for Grounding and Bonding Equipment

3.7.4 Earthing Arrangement For Road Tunnel

All the earthing arrangement shall be interconnected with each other. Proper equipotential bonding shall be done. The earth resistance of the whole system shall be less than 1 ohm for-

1. Portal Substations
2. External Substations
3. Internal Substations/ Niches/E&M Niches
4. Control Room Stations

3.7.4.1 Required Parameters For Earthing Grid

ERT report for the soil resistivity values and to understand type of site

1. Fault Level for which grid shall be designed.
1. Duration of fault current to get earthed
2. Availability of Earthing area
3. Duration of Fault
4. Resistivity of Surface Material
5. Material of Earth Mat Conductor
6. Earthing Mat Geometry

3.7.5 Earthing Design For Portal Substations, External Substations & Control Room Stations

An earthing grid with a combination of horizontal & vertical conductors along with exothermic welding joints shall be designed as per the fault current requirement and availability of area. The calculations shall be done using CDEGS software as per IEEE 80:2013. The earth resistance for the portal/external station grid shall be less than 1 ohm. Proper soil treatment is recommended in the areas of high soil resistivity using carbon based earth enhancement compound.

3.7.6 Earthing Design For E&M Niches, Niches, Internal Stations & Other Niches Stations Inside Tunnel

An earth mat with the horizontal conductors shall be laid under the niches and the complete mat shall be interconnected with the portal/external stations earthing grid using the earthing conductor laid inside the tunnel so that the system will act as an integrated earthing system. The conductor sizing shall be done as per the fault current requirement as mentioned in IEEE 80:2013.

3.7.7 Earthing Design For Tunnel Body, S&T Equipments Installed In The Tunnel

A conductor of suitable size shall be laid through the overall length of the tunnel on both the sides. At every crossing or at every 100-meter spacing (whichever is nearest) the conductor on the opposite sides shall be interconnected with each other for equi-potential bonding. Also, an equi-potential bus-bar shall be installed at every crossing, which will again connect through these conductors. All the S&T equipments and other equipments shall be connected to these bus-bars for the earthing and equi-potential bonding.

For the tunnel body earth, the civil contractor need to leave a point at every crossing for connecting the reinforcement of the tunnel with the earthing conductor for proper equi-potential bonding and for cathodic protection.

3.7.8 Earth Grid Design

Earthing System in an Earth Grid comprises of-

1. Horizontal conductor in the form of mesh
2. Vertical Earth Pit
3. Earth Enhancement Material
4. Exothermic Welding

3.7.8.1 Earth Mesh: Copper/Copper Bonded Steel Conductors

An earth mat shall comprise of copper or copper bonded steel round conductors. The conductor shall be suitable to achieve calculated fault current. The manufacturer shall provide the conductor sizing calculation which shall be done as per IEEE 80:2013.

Based on conductor sizing calculation, the cross section of conductor is determined and the length of the copper conductor shall depend upon the required mesh size.

3.7.8.2 Earth Rods: Copper/Copper Bonded Steel Solid Rods

The earth electrode/rod is the main component of the earthing system which is in direct contact with the ground and thus provides a means of releasing or collecting any earth leakage currents. The material should have good electrical conductivity and should not corrode in a variety of soil conditions. For an effective earthing system.

Acceptable earth resistance values: The acceptance earth resistance of an earth grid (Combination of Multiple Earthing connected in parallel shall be designed as per Soil Resistivity Report) shall be <1 ohm for power components & <1 ohm for electronics component.

3.7.8.2.1 Test Certificate and Approval for Copper/Copper Bonded Steel Conductors & Rods

- The laboratory test must be in accordance with IEC 62561-2:2018.
- As per IEC 62561-2, Earth rods shall be mechanically robust to ensure correct installation. The material of choice shall be sufficiently malleable to ensure that no cracking of the rod takes place during installation. It shall also exhibit good corrosion resistance.

3.7.8.3 Earth Enhancement Compound

Role/ Need of Earth Enhancement Compound:

As per IEEE 80: 2013, clause 14.5, Pg. No.- 78, "It is often impossible to achieve the desired reduction in ground resistance by adding more grid conductors or ground rods. An alternate solution is to effectively increase the diameter of the electrode by modifying the soil surrounding the electrode. Thus, the Ground Enhancement Material are typically placed around the rod in an augured hole or around grounding conductors in a trench, in either a dry form or premixed in slurry".

As per IEC 62561-7:2018, clause 4.3, Pg. No. 8, "the material of the earth enhancing compound shall be chemically inert to subsoil. It shall not pollute the environment. It shall provide a stable environment in terms of physical and chemical properties and exhibit low resistivity. The earthing enhancing compound shall not be corrosive to the earth electrode being used.

Earth enhancement material is a superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It improves conductivity of the earth electrode and the ground contact area. It shall be tested and confirm to the requirements of IEC 62561-7 having the following characteristics: -

- RoHS tested Earth Enhancement Compound tested by NABL accredited lab in compliance to IEC 62561-7 with a resistivity some with a resistivity of 0.12 ohm-m.
- An earth enhancing compound shall be tested for Leaching Test, Corrosion Test, and Resistivity Test & Sulphur Test as per IEC 62561-7.
- It shall be a carbon-based material and shall be free from bentonite and other hazardous substances. It shall be permanent and offers +25 years of life.
- It shall be a non-corrosive material which does not leach out any chemicals into the ground. It shall retain moisture even in high soil resistivity areas. It shall lower an earth resistance value and shall offer a constant desirable performance.
- Shall be carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties.
- Shall have high conductivity, improves earth's absorbing power and humidity retention capability.
- Shall be suitable for installation in dry form or in a slurry form.
- Shall not depend on the continuous presence of water to maintain its conductivity.
- Shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.
- Shall be thermally stable between -100 C to +600 C ambient temperatures.
- Shall not dissolve, decompose or leach out with time.
- Shall not require periodic charging treatment nor replacement and maintenance.
- Shall be suitable for soils of different resistivity.
- Shall not pollute the soil or local water table and meets environmentally friendly requirements for landfill, shall not be explosive & shall not cause burns, irritation to eye, skin etc. In this regard "Safety Data Sheets" shall be submitted by the manufacturers.
- Marking: The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity etc.

3.7.8.3.1 Test Certificate and Approval for Earth Enhancement Compound

- The laboratory test must be in accordance with IEC 62561-7:2018.
- The compound shall be tested for Leaching Test, Sulphur determination Test, Resistivity Test, and Corrosion Test.
- Earth enhancement compound shall be tested for ROHS Restrictions of Hazardous Substances.
- As per IEEE 80, the compound shall be carbon based and shall have resistivity less than 0.12 Ω-m.

3.7.8.4 Exothermic Welding System

Electrical jointing or connection reliability is critical to the long-term integrity of the electrical system. Over the period of time, due to ageing, less maintenance and changing weather conditions the joints are becoming low performing joints as it gets corroded or loosen due to temporary jointing techniques.

Recommended by IEEE 80, BS 7430, NBC 2016, an exothermic welding system is used for making electrical connections of copper to copper, copper to steel or copper to cast iron for grounding and cathodic applications. An exothermic welded connection shall be suitable for exposure to the elements of direct burial in earth or concrete without degradation over the lifetime of the grounding system.

An Exothermic Welding System complying IEEE 837, has come up as a robust solution for these problems. Today, Exothermic Welding is a globally accepted method to make reliable and safe connections between two or more conductors. This technology is highly portable and does not require any external source of heat to make a joint offering in permanent molecular bonding among metallic conductors.

- All the buried joints shall be exothermically welded.
- The molecular bonding shall offer complete surface contact hence an electrolyte cannot penetrate between the conductors which provide integrity to the joints.
- Permanent molecular bonding protects against humid or chemical environments or bonds directly buried in the ground.
- Exothermically welded connections achieve 100% surface area which eradicates possibilities of leakage current.
- The melting temperature of Exothermic Weld connection is higher than the melting temperature of copper (1083°C) offers high fault current carrying capacity.
- Exothermic Weld connections form a solid bond around the conductors assuring continuity.
- Standard Exothermic Weld has a cross section greater than that of the conductor to be joined, the weld will always remain cooler than the conductor under fault conditions.
- Superior electrical conductivity of the conductors themselves.
- Does not corrode, oxidize or degrade with time and is resistant to galvanic coupling.
- Able to withstand repeated electrical discharges.
- Has greater mechanical and squeezing resistance than the conductors themselves.
- No environmental impact.
- Water proof and corrosion resistant joints.
- Compared to other forms of welding, exothermic bonds have a higher mechanical strength.

3.7.8.4.1 Testing of Exothermic Welding

- The laboratory test must be in accordance with IEEE 837.

3.8 Distribution / Sub-Distribution Boards

3.8.1 Scope

This specification covers Design ,engineering ,manufacturing ,testing ,supply ,delivery ,erection ,installation .testing & commissioning of triple pole and neutral out door Type , Out Door Installation , Minimum IP 54, (TPN) Distribution feeder pillar suitable for 415 v AC 3 Phase 4 wire system as per ISS: 5039 /8623/1977 with latest amendments ,if any.

3.8.2 Standards

The distribution feeder pillars shall conform in all respect to the relevant Indian /International Standard specification, with latest amendments thereof; some of them are listed below.

Indian standard	Title
IS- 5039	Distribution Feeder Pillars
IS -8623/1993	Low Voltage Switch gear and Control gear assemblies
IS-13947	Degrees of protection provided by enclosures
IS-5/1961	Specification for colours for ready mixed paints
IS- 11353	Guide for uniform markings and identification of conductors and apparatus terminals
IS-6005	Code of Practice for Phosphating of iron and steel
NFPA 502	Standard for Road Tunnels, Bridges, and other limited Access Highways

Material conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above would be acceptable. In case the bidders who wish to offer materials conforming to the other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. Four copies of such standards with authentic English translation shall be furnished along with the offer.

3.8.3 Construction

Feeder Pillars shall be suitable for outdoors installing and to have maximum protection from inclement weather. It should have compact construction with a degree of Protection IP-55 in accordance with IS-13947 with latest amendments.

FP & SP shall be made out of sheet steel of minimum 2 mm thick with proper support members so as to make it robust in operation. Bidders can also offer heavy gauge fire resistant poly propylene (FRPP) enclosures of thickness not less than 4mm for body frame and 2.5 mm for door panel.

Suitable mild steel reinforcement (frame) shall be provide which shall be coated with FRPP.Then the body of box shall be casted over the steel reinforcement by suitable mould

The FRPP panel shall be rodent proof, fire retardant and UV stabilized.

3.8.4 Doors

Double –hinged doors should be provided on front as well as on rear to enable installation and inspection of cable connections and other equipment .Three heavy duty inside hinges shall be provided per door leaves .The design shall permit the doors being completely removed when necessary.

3.8.5 Locks

The front and back doors should be fitted with separate 65mm size MS locks (with special keys) such that unless door is closed (both leaves) it cannot be locked and unless it is locked, key cannot be out.

3.8.6 Canopy

It should so be sloping so that rainwater does not accumulate. The canopy should extended beyond the feeder pillar body to avoid any rainwater falling inside the pillar.

3.8.7 Mounting

To mount on brick cement concrete plinth. the construction of the plinth is included in the scope of work.

3.8.8 Apron

Lower part should be made of angle iron reinforcement of 50x50x6 mm frame work (coated with FRPP) of 300 mm height covered with 315mm. Thick FRPP panel on all side s and bottom.

3.8.9 Angle Iron Stand

The apron shall be mounted on angle iron stand. The stand should be of angle iron 75x75x6mm (coated with FRPP) to provide strong supporting structure to the shell.

3.8.10 Weather Proofing And Ventilation

The canopy shall project over the side and doors and sides shall be lower than the top of side section of the shell to avoid ingress of water.

The side section shall be folded to form a water drawing channel for easy drainage of water through the sides and not through front or back.

The angle section shall project above the sides section to provide a gap (3.0mm between the), section and canopy to facilitate ventilation.

Ventilation Louvers cell type ventilation louvers covered with welded mesh screen and filter inside section of the shell.

3.8.11 Bus Bars

Bus bars should be in one piece for each phase and neutral of electricity. Aluminium of size 50x12mm, (or as per the current capacity with current density as 0.7 A/sq.mm) PVC sleeved /taped suitable with red, yellow and blue for the phase and green for neutral. All live joints shall be PVC taped .All bus bars taping and markings shall be in accordance with IS-11353 .The bus bars should be mounted on insulators and fixed with riveted joints .Hylam barriers between the bus bar of each phase and between the bottommost phase and the neutral shall be provided. The bus bars should withstand thermal stress and dynamic forces in the event of short circuit and it should be supported and arranged so as to withstand any damage or deformation at specified short time current of 36KA for one second as per IS-5039/1983 with latest amendments.

3.8.12 Circuit Ways

The configuration of Distribution/Sub-Distribution Boards shall be as per the detailed design of the Contractor, subject to approved of the Independent Engineer.

3.8.13 Earthing

Earthing shall be provided with two separate earthing terminals on its casing on either sides of the apron over and above all other means of earthing (i.e. earthing through armouring of current carrying cables).The earth terminals shall be complete with galvanized bolts, nuts and washers of size 6 x20mm.

The terminals shall be identified by means of proper sign marking in legible manner adjacent to the terminal.

One aluminium earth bus bars shall be provided with suitable holes and nuts and bolts for connecting cable armouring to earth through it. The connection shall be through cable sockets to be provided. The size of the earth bus bar shall be 250 sq. mm and material shall be electrolytic aluminium.It shall be running along the feeders pillar from one end to the other and connected to then earth terminals at the ends .

3.8.14 Pillar Lighting

A lamp holder and CFL lamp complying with IS -1258 operated by an internal piano switch a service fuse in the lamp circuit shall be fitted in each pillar for internal illumination .in addition a 3- pin 15 A plug and socket Shall Be Provided With A Switch.

3.8.15 Danger Plate

An enameled sheet danger plate of approved design shall be fixed on the front and rear doors of the pillar.

3.8.16 Iron Casings

All angle iron/reinforcement shall be coated with FRPP.

3.8.17 Tests

Verification of temperature rise limits as per IS-8623

Verification of short circuit strength at 40KA for one second as per IS -5039/1983/3623/1977 with latest amendments.

Verification of degree of the protection as peer IS -13947 with latest amendments

3.8.17.1 Routine Tests

Feeder pillars shall be subjected to following tests as per IS.

a) Verification of dielectric properties with test voltage 2.5 KV rms for one minute between:

- Poles
- Poles and neutral
- Current carrying and non- current carrying metal parts.

b) Insulation resistance test between poles and body should be minimum 50Mega ohm

c) Continuity test by providing incoming 3 phase supply and checking the Power availability on the outgoing and feeder circuits.

3.8.18 Foundation For Distribution Boards

The contractor shall submit the design of foundation of pillars for approval of client/consultant The pillar shall be mounted on brick cement concrete plinth foundation.

Finish level of foundation shall be 50 cm above ground level.

No foundation is necessary for steel tubular pole (1/6th pole length shall be buried inn the ground) but it needs muffing with cement concrete upto 100 mm below ground and 150 mm above ground.

3.8.19 Earthing Of Distribution boards

The distribution feeder pillar and the service pillars shall be earthed and such earthing is a part of the scope of work. Earthing shall also conform to the provision in design criterion and the attached earthing arrangements.

3.9 Tunnel Lighting

3.9.1 Scope Of Work, Terminal Points & Exclusions

Scope of Work

The scope of work for the "Tunnel and Road Lighting System" and associated items covered under this specification, shall include but not limited to the items / requirements specified in the subsequent sections.

Scope

Engineering, design, manufacture, assembly, shop testing including type tests as per IEC 60529, IEC 60598, IEC 62384, IECNA LM 79, ANSI 8750 at manufacturer's works.

- Providing all labors, materials and equipment for factory testing.
- Special tools and tackles, as required, for operation and maintenance, inspection and repair of the equipment / systems offered.
- All materials supplied under this contract shall be new and unused.

Services Under Scope of Supply

- Inspection and expediting, handling, packing, forwarding, transporting to site, documentation including submission and approval of drawings.
- Engineering of all the systems covered in this specification, including preparation and submission of detailed based on codal requirement specified in IRC SP:84 2014, IRC SP:91 2011, CIE 88: 2004 and MORTH Guidelines for Expressway and quantification of entire items included in the scope.

Scope of supply and services of basic equipment

- This section details out the scope of supply and services for "Tunnel and Road Lighting System" with associated auxiliaries. Components and services not specifically mentioned here but necessary to complete the work in all respects, regardless of any omission in this specification or drawings, is deemed to have been included in this section.
- Submission of Lighting layout for Tunnels and Road portion covered under the complete project stretch and approval of drawings.
- Submission of inputs regarding operating philosophy, design of circuit distribution scheme and any other inputs for completion of lighting system detailed engineering.
- The design, manufacture, Factory Acceptance Test (FAT), transportation to site, Site Acceptance Test (SAT) and Supervision of Erection, testing and commissioning of the complete Lighting System for Tunnel and Road.

Spares

- The SUPPLIER shall include the commissioning spares along with the equipment for replacement of damaged or unserviceable parts during the execution of the project at site. The SUPPLIER is expected not to fall back on the PURCHASER from their stocks (for such replacements) which are meant for two (2) years of trouble free operation after the equipment are taken-over.

Terminal Points

- LT Power - 230 V, 1 Ph: At the terminals of light fittings

Exclusions

- Cabling
- Lighting Distribution Boards
- Installation

SPECIFIC REQUIREMENT OF ILLUMINATION SYSTEM

- The luminaries shall be confirm to IS 2149-1970, IS 1913-1978 and 1944-1970 (parts I and II). The luminaries shall be totally enclosed, dust and watertight, shock resistant and specially designed to house the specified lamps, electrical gear and accessories. The body shall be made of dust painted stainless steel.
  - The colour of all lamps shall be Natural White 4000 K.
  - The colour rendering index Ra shall be ≥ 80.
  - Luminaire/system efficacy (incl Optical and driver efficacy) shall be > 124 Lm/W
  - Electrical Insulation shall be Class I or Class II
  - IK rating shall be IK 08
  - Fittings shall be with ingress protection of IP 66.
  - System Surge Protection shall be 6/10kV
  - Life span shall not be less than 50,000 hours.
  - Higher efficiency long life LED shall be envisaged.
  - Free from UV and IR radiations.
  - LED Driver Specification
  - Input operating voltage shall be 200-260 V.
  - Electronic control gear shall be with THD ≤ 10%.
  - The power factor shall be better than 0.95.
  - Power efficiency shall be greater than 85%.
  - Other Parameters
  - Working humidity shall be 10% - 90% RH.
  - Working temperature shall be between -40 to 55 Deg C.
  - All light fittings shall be of water proof and Corrosion proof.
  - Fitting shall be suitable for connection to LSOH type cable
  - Higher rated lamps shall be provided with aluminum heat sink body with fins for better heat dissipation.
  - Epoxy powder coated aluminium channel housing shall be provided for all tube light fittings
  - The mounting brackets shall be made from stainless steel and have longitudinal slots for horizontal and vertical adjustment. The minimum numbers of mounting brackets are four per luminary.

- Phase selection shall be possible at the terminal blocks without any further modification of the wiring inside the housing/luminary.
- The housing shall be suitable for mechanical cleaning.
- BIDDER shall have to select suitable light fittings to suit Tunnel Threshold Zone, Transition Zone, Interior Zone, Exit Zone, Cross passages, E&M Niches, Lay Bye and Road illumination level calculated based on codal requirement as specified in the document. Lth Values to be considered for Illumination Level calculation for tunnels .
- No light shall be directed with flow traffic to avoid shadow effect.
- Drawings & Documents to be submitted along with the bid document:
  a. Illumination level calculation for each Tunnel
  b. Layout arrangement along with type fittings for each Tunnel
  c. Catalogue details of offered light fittings with technical specification
  d. Drawings related to High Mast pole & its Junction boxes.
  e. Tunnel wise power consumption
  f. Type Test Certificates
  g. Quality Assurance Plan

3.10 UPS Emergency Power Supply

3.10.1 General

This article covers the UPS emergency power supply of all required equipment, materials, accessories, and all labour for the complete emergency power installation.

The Uninterruptible Power Supply in Control Buildings shall feed the following system::

- All surveillance equipment
- Fire detection system
- Data transmission equipment
- Emergency Tunnel Lighting
- Control systems

3.10.2 Scope Of Work

The UPS shall include the delivering of material, feeders, complete installation, commissioning, tests and equipment of the following:

- Lighting UPS at portal ends at ___ kVA(N+1) and inside tunnels at __ kVA(N+1) of virtual power over a period of 120 minutes for tunnel loads.
- Critical Power UPS at portal ends at ___ KVA(N+1) and ____ KVA(N+1) respectively and ___ kVA(N+1) inside tunnel shall provide virtual power over a period of 30 minutes.

The UPS has to be fed from the main power supply (433 / 250 V, 50 Hz) and shall supply the connected equipment via rectifier, battery and inverter.

In the event of a main power supply failure the equipment has to be fed from the battery and inverter system without any interruption.

The UPS shall be equipped inclusive bypass switch and an interface for Telecontrol System.

3.10.3 Technical Specification (Ups Components)

3.10.3.1 Inverter Battery Bank

Batteries:

Maintenance-free NiCd (Nickel Cadmium) power batteries of voltage as required by the UPS-system.

The battery capacity at the following stations shall ensure supplying the needed load for at least 60 minutes.

Batteries shall be of rugged design in order to provide a heavy-duty operation of at least 10 years with low internal resistance and minimal maintenance.

Allowed temperature range: 15° to 30° C

Interconnection Bus Bars:

The bus bars shall be made of copper according to the relevant standards, mentioned herein.

Suitable size to provide a minimum voltage drop

PVC clad to provide protection against accidental contact.

Battery Stands / Racks:

The batteries shall be mounted on steel racks to provide a compact arrangement, with easy installation and access for servicing.

The racks shall be made of steel with electro statically deposited powder coating.

The coating shall be resistant against acid, saline and highly resistant against scratching and / or impact.

All other required materials shall be highly resistant against environmental conditions as experienced in battery rooms.

An electric ventilation and climate shall ventilate the battery room. The complete air shall be changed a minimum of five to six times per hour.

RECTIFIER / CHARGER UNIT

This unit has to be equipped with output current limiting, whereby the maximum output current shall be limited to 125 % of the nominal output current rating.

This current limit shall be adjustable from 100 % up to 125 %.

Power semiconductors in the rectifier / charger unit(s) shall be fused with fast blowing fuses, so that a loss of any one-phase semiconductor shall not cause cascading failure.

Each fuse shall be controlled by a fuse monitoring circuit leading to an indicator light on the UPS's control panel as well as to a common fault indication.

The output filter shall minimize the ripple of the current in the batteries. Under normal conditions the ripple of the current in the battery shall exceed 3% RMS.

The filter shall be adequate to ensure that the DC output of each rectifier / charger shall meet the input requirements of the inverter.

The UPS shall have the capability of operating the inverter directly from the rectifier with the batteries being disconnected.

Quick charging equipment shall be capable of charging fully discharged batteries within six hours.

Input:433/250 VAC, 3-phase, 4 wire, 50 Hz +/- 2 %

3.10.4 Inverter Unit

Input: Output from the rectifier / charger unit (batteries).

Output:433/250 V sinusoidal AC.

Maximum of total harmonic distortion: +/- 1 % at power factor 1 from no-load operation to full load.

50 Hz +/- 1 % at power factor 1 from no-load to full load.

Maximum dynamic Voltage deviation: +/- 5 % during power failure +/- 10 % during major load change.

Recovery to a maximum deviation of +/- 3 % within 50 ms and to +/- 1 % within 100 ms.

Total harmonic Distortion:3 % maximum

The rectifier shall be able to operate 10 minutes at 125 % overload at power factor 1 after the working temperature has been stabilized at the nominal workload.

Under normal conditions, the surrounding temperature will not exceed + 40 °C.

A self-protecting current limiting circuit shall limit the inverter output to 125 % of the rated load or respectively in case of a short circuit.

Constant synchronisation of the oscillator shall define the converter frequency and its stability during stand-alone operation.

During normal operation, the inverter shall be synchronised by the main supply. In case of mains failure or frequency-deviation larger than +2 % / -1 %, the inverter shall automatically switch-over to its interior oscillator.

Upon return of main supply, resynchronisation shall be started automatically. Resynchronisation at full load and / or full voltage shall be achieved within 30 seconds.

The deviation from 50 Hz shall never exceed +/- 1 Hz.

The power semiconductors of the inverter shall be fused with fast blowing fuses to prevent cascading failures.

Each fuse shall be controlled by fuse monitoring circuit leading to an indicator light on the UPS's control panel as well as to a common fault indication.

3.10.5 Protective Devices and Filter Circuits

A DC (direct current) smoothing equipment shall enable the system to achieve a total harmonic distortion, which isn't larger than 3 % RMS of the output.

Protective devices shall avoid any damage or failure on the UPS caused by excessive overload, short circuits, high voltages caused by lightning activity and/or other conditions.

3.10.6 DC Circuit Breaker

The UPS shall contain a DC circuit breaker. If open, the battery shall be completely disconnected from the rectifier / charger and the inverter.

3.10.7 System Bypass Switch

The UPS system shall be by-passed automatically in case of overload. The static switch detection and transfer time shall not exceed 5 ms.

3.10.8 Static Transfer Switch

The static transfer switch shall be equipped with a manual selector switch to allow manually controlled switching between the UPS and the bypass source for maintenance and service purposes.

The static transfer switch shall be rated higher (power, respectively current) than the inverter current limiting rate and shall have a short circuit current and time rating equivalent to the fault level of the bypass source at the static transfer switch.

3.10.9 Auxiliary Equipment

- Emergency flash light with battery charger installed in the battery room.
- All facilities required for handling of acids and gasses.
- Warning notices concerning the handling of the whole UPS system in English language.
- Working instructions for UPS

Warning notices and working instructions shall be in two separate and properly indicated pockets on the inside of the UPS switchboard as well inside the battery room.

CABLING

Cable dimensioning shall be in accordance to the relevant standards and shall have a diameter that the voltage drop is not more than 10 % to the nominal voltage from the transformer to the furthest supplied electrical facility. Also the cables shall have such a diameter that, if there is a short circuit at the furthest point to the circuit breaker, the circuit breaker cuts off without the cable exceeding its rated temperature.

MAINTENANCE

The emergency power supply shall be designed for continuous reliable operation such that the "Mean-Time-Between-Failures" (MTBF) for individual modules of the UPS through the rectifier / charger unit, inverter unit and static switch etc., shall be more than 80,000 hours.

To ensure a minimum down-time, the "Mean-Time-To-Repair“ (MTTR) of the emergency power supply shall not exceed 24 hours for the UPS.

The MTTR shall be the time, excluding travel time, required to diagnose the fault and restore the emergency power supply to normal working condition by means of modular replacement at the tunnel site.

The travel time must not exceed 12 hours.

3.11 Erection, Testing & Commissioning of Electrical Equipments

3.11.1 Scope

This section covers the procedures & recommended practices for erection and commissioning of Electrical Works at Tunnel & auxiliary equipment, accessories, associated civil works & other materials for the commissioning.

a) Indian Electricity Rules.

b) Tariff advisory committee

d) IS-6600: Code of practice for installation and maintenance of Transformers.

e) IS-3043: Code of practice for earthing

f) IS-7098: Code of practice for installation and maintenance of cross linked polyethylene insulated PVC sheathed cables.

g) IS-2309: Code of practice for protection of building and allied structures against lightning

h) IS-732: Code of practice for electrical wiring installation

i) IS-6665: Code of practice for industrial lighting

3.11.2 Transports For Erection

The contractor shall provide, at his own cost and expenses, all labour, plant and materials necessary for unloading and erection at site and shall be entirely responsible for its efficient and correct operations. The contractor shall setup his own material stores for the storage of all materials maintained by their qualified store personnel.

The contractor is responsible for all the transport facilities, loading gauges and ensure that the equipment required to be transported shall conform to these limitations. The contractor shall also be responsible for verifying the access facilities required for the transportation.

3.11.3 Erection Work

The installation shall be carried out by an electrical contractor holding a valid license & grade as required by the State Government. The successful bidder shall provide particulars of the license held by him (or) his subcontractor to the purchaser. The installation shall require approval of the Chief Electrical Inspector and it is the responsibility of the contractor to get this approval and the purchaser shall provide necessary assistance in this connection. The contractor shall also fully assist the purchaser in obtaining approval from any other statutory authority if necessary, for the successful commissioning of the township.

Any modification in the equipment or installation that may be demanded by the inspector shall be carried out by the contractor at no additional cost to the purchaser.

In accordance with the specific installation instructions as per the manufacturer drawings or as directed by the purchaser, the successful bidder shall unload, erect, assemble, install, wire, test and commission all electrical equipments included in this contract. Equipments shall be installed in a neat workman like manner.

Erection materials, tools, tackles, crane, rigging items, testing instruments or any other machinery required for erection shall not be supplied by the purchaser. The successful bidder shall arrange for the same in a timely manner and shall not be allowed to claim for any delay or extra cost of any nature.

Consumable materials of any nature required for the erection job shall also have to be arranged by the successful bidder.

Clearing the site after completion of erection as well as regular clearance of unwanted materials from site, returning all packing material and excess material supplied by Purchaser back to Purchaser's stores shall also be covered under the scope of work. Any damage done to buildings, structures and plant (or) property belonging to the purchaser and their parties shall be made good at the contractor’s expense.

All equipment and instruments of indoor and outdoor type shall be inscribed with number, nomenclature, Danger Boards and other instructions.

The successful bidder shall do touch up work on the surface of equipment, which are scratched and/or damaged during transportation and erection. The paint used shall match exactly with the surface being touched up.

The successful bidder shall employ skilled and semi-skilled labourers for erection & installation testing as required. All Electricians, cable jointers, wiremen, welders and others employed shall be suitably qualified possessing valid certificates / licences recognized by the competent authorities.

The successful bidder shall also furnish a list of Engineers / Supervisors and staff employed by him for erection and installation jobs, giving in brief, qualification and experience of such staff and indicating whether they hold such competency certificates / licenses to supervise the electrical installation jobs as required under Indian Electricity Rules & State Electrical Inspectorate Rules.

The successful bidder shall set up his own workshop and other facilities at the allocated place at site to undertake fabrication jobs, pipe bending, threading etc.

The successful bidder shall be responsible for recording of all readings and observations during erection, testing and commissioning, in registers or in prescribed Performa. These shall be carried out in the presence of Purchaser's representative. All such test data and records shall be duly signed by the successful bidder's Engineer and Purchaser's representative and shall be submitted to Purchaser in triplicate.

3.11.4 Equipment Erection

The contractor shall assemble, install and connect all the equipments with all accessories including terminal clamps, with proper alignment required to complete the job and these shall be as per equipment manufacturer’s instructions. Equipments shall be erected with proper clearances from nearby walls / other equipments / beams / column etc as per statutory requirements.

The Electrical equipment shall be done by tools & tackles as recommended so that no injury is made to the equipment. The handling during erection shall be done as per best erection practices using the necessary tools & other required materials like Vanila ropes, wooden supports etc.

3.11.5 Erection Of Steel Structures / Poles

The contractor shall Supply, fabricate and carryout erection of all steel structures required to mount the equipment, gantry structures, lightning mast, any other miscellaneous supports required to complete the job with proper alignment designated on drawings duly approved by the Independent Engineer.

Structures shall be erected on foundations until atleast 14 days after placing of the concrete in foundations. All structures shall be strictly fabricated as per drawings.

The nut & bolted type structure shall be assembled & proper tension with torque ranches shall be applied as per recommended torque charts for each type & size of bolts.

The Structure shall not be welded and if required in exceptional case, proper paint shall be applied, preferably Zinc Rich Paint or Aluminum paint of proper coat shall be applied to the satisfaction.

Control interlocks shall be provided in order to prevent the inverter from being manually switched back to the essential bus (main power) without synchronisation.

3.11.6 Erection Of HT Cable, Auxiliary Power And Control Cable

Contractor shall transport the cable to the installation location, laying, fixing, and terminating of cables to the required satisfaction of purchaser / consultant.

Cable laid shall be neatly dressed and clamped 1050 mm deep from the FGL. For buried cables, Cable route markers shall be installed along the cable route at every 30 meter interval, at all road crossings and joint locations.

Whenever cables pass through any floor or wall, suitable manhole/cutouts shall be made. The openings shall be sealed using suitable fire resisting materials to prevent the fire spreading.

Standard cable installation tools shall be utilized for cable pulling. Maximum pull tension shall not exceed the manufacturer’s recommended value. Cable grips, rollers or pulleys used shall be properly lubricated. The lubricant shall not injury the overall covering and shall not set up undesirable conditions

of electrostatic stress.

Sharp bending of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified by manufacturer.

Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to (physically) segregate them shall be employed.

Where cables cross roads, water, oil, gas or sewage pipes, the cables shall be laid in reinforced concrete pipes. For road crossing, the pipe for the cable shall be buried at not less than one metre depth. Cable shall be protected at all times from mechanical injury and from absorption of moisture.

Cable that are directly buried in ground at 1050 depth from the FGL. Keep Center to center distance two dimension (2D). (Refer the Road Section Drawing for Details)

Some extra length shall be kept in each cable run at a suitable point to enable one or two straight through joints to be made at a later date, if any fault occurs.

Cables shall be laid in proper sequence so as to avoid unnecessary crossing of other cables upon entering or leaving a run of tray. Cable splices shall not be permitted.

Metal sheath and armour of the cable shall be bonded to the earthing system of the station.

Each cable shall be identified with its identification number as indicated in the drawing.

Cable clamps shall be of 3mm thick galvanised M.S. spaced at every 1.5 M interval.

Suitable cable aluminium tags shall be tied at every 30mtrs and at every bend along the cable length, when the cables run in bunches in the cable tray / trench / buried, for easy identification.

3.11.7 Cable Supports and Accessories

Cables supports shall be run in concrete trenches. Cable supports shall be installed in cable trench at 750mm interval when cable tray are not used and if cable trays are provided, it shall be supported at every 1 meter interval.

Cables shall be clamped to the cable supports in both horizontal runs and vertical runs by suitable site fabricated clamps.

All cable sleeves shall be sealed at the outlet of cables from the cable trench for protection towards entry of foreign particles.

3.11.8 Erection Of Lt Panel, Other Panels and DB:

All panels & boards shall be installed on finished surfaces. The correct level shall be ascertained before final grouting.

The contractor should take utmost care in handling delicate equipments, instruments and relays. Dragging shall be avoided as far as possible. Wherever the instruments and relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned.

The contractor shall also carryout the following:-

- Prepare a mounting base for equipments including leveling.
- The clearance on all sides of the panels shall be as per the drawing & shall comply local statutory conditions.
- Free movement of the breaker truck in each cubicle of interchangeability of breaker trucks shall be checked before final fixing of cubicles.

3.11.9 Erection Of Earthing System

Contractor shall arrange for measurement of soil Resistivity at the award of contract of arranges to furnish earthing design calculation for purchaser / consultant approval. The contractor shall submit earthing layout, equipment earthing details for approval. The entire earthing system shall be carried out inline with the specification and as per the approved drawings

The entire earthing of substation shall be carried out inline with the specification and as per the approval drawings.

3.11.10 Contractors Tools and Equipment

The Contractor shall provide all necessary tools and equipment that are required to complete the works. The contractor shall also submit along with bid details of tools, tackles & equipments to be employed by them.

3.11.11 Field Testing & Commissioning

3.11.11.1 Scope

This part of the specification covers the guidelines for testing and commissioning at site of all outdoor and indoor electrical equipment covered in this package.

3.11.11.2 Standards

The testing & commissioning covered by this specification shall comply with the requirements of the latest editions of Indian Standards / regulations.

The manufacturer's recommendations for testing and commissioning shall also be followed.

3.11.11.3 General

Tests as detailed shall be carried out in the field prior to commissioning tests to demonstrate that the equipment's performance guarantees are met, equipment are properly installed, correctly adjusted and suitable for commercial operation.

Tests shall include those specified and any other necessary to demonstrate compliance with the specification.

All testing kits / instruments used by the successful bidder shall be calibrated prior to commencement of the tests and the calibration certificate to be produced to the Engineer at site.

3.11.11.4 General Checks

The following physical checks shall be carried out on all the equipment.

a) Check for physical damage

b) Check for tightness of fixing bolts, nuts, clamps etc.

c) Check for oil level and oil leakage.

d) Check for air / hydraulic / gas pressure where ever applicable.

e) Check for earth connections

f) Check for cleanliness of insulators

g) Check for name plate details as per specifications

h) Any other physical check as recommended by equipment manufacturer / Indian Standards / Codes of practice.

Outdoor panels

a) Check for proper fixing of all components as per G.A drawing and other relevant drawings.

b) Check for tightness of connections.

c) Check for continuity of wiring.

d) Measurement of insulation resistance.

e) Check for correct operation of closing and tripping devices, alarm annunciation, indications and interlocks as per relevant drawings.

f) Check for meter and relay calibrations

3.12 Fire Detection

3.12.1 General

This covers the complete fire emergency facilities (for detecting fire in and outside the tunnel, as well as equipment for firefighting), the whole automatic Fire Detection System (linear fire detection inside the main tunnel tube and sensors inside the equipment room & Niches(with E&M equipments)) including all required equipment, materials, labour and accessories. Also all necessary accessories, required for transmission and indication of the given signal (potential free contact) at the Control Centre and Equipment Room shall be included in the scope of work.

All interface equipment which is necessary for the data-transmission to / from the Control Centre shall be included in the central connection element.

The observation of the tunnel is divided into two central units:

- Fire detection system (equipment room, Niches(with E&M equipments), substation Niches, Control Centre)
- Linear fire detection system (tunnel tube)

The whole fire detection system shall be proofed by an accredited laboratory. The contractor shall hand over a protocol of this examination to the Client.

Any kind of fire detection equipment shall be supplied by the UPS-system.

3.12.2 Scope of Work

3.12.2.1 Fire Detection System

Fire detection unit with subunits in the tunnel tube

- With interface to linear fire detection system
- Manual alarm push button “FIRE” at the Niches(with E&M equipments) & equipment room
- Optical smoke detectors in the equipment rooms, control room (raised floor and ceilings)
- Alarm, control and indicating panel(s)
- Cabling for power supply, control, and monitoring
- Interface for corresponding automatic controls of the telecontrol system (SCADA) which distributes the command(s) to the CCTV System, the Control Centre, the Ventilation Control System, the Lighting Control System, etc.

3.12.2.2 Linear Fire Detection System

The linear heat sensor cable shall run through the tunnel tube and mounted on the ceiling of the tunnel tube.

The linear heat sensor cable shall be controlled by a linear heat detection unit. The detection units shall transfer the alarms to the main linear fire detection unit, and further on to the Fire alarm Control Panel in the equipment room / control room. From the Niches(with E&M equipments)/ equipment rooms / niches substation, the fire alarms shall be transmitted to SCADA.

The detection system shall measure the absolute temperature, the increase of temperature over time and shall hand over this information to the belonging linear fire detection (sub) unit. The linear fire detection system shall be able to check, if the rising of the temperature is caused by a fire, or if there may be a fault.

The linear heat detection (sub) unit shall determine the local temperature values as follows:

- Current absolute temperature.
- Increase (change) of temperature per minute.
- Temperature profile.

The time between registration of a fire alarm and activation of the necessary automatically operations shall take place within 1 minute.

The localization of fire shall be specified with an accuracy of 5 m.

Spurious / false alarms caused by temperature fluctuation shall be avoided by appropriate precautions.

The exact location of the linear heat sensor cable shall be defined by the manufacturer or the contractor, as the exhaust temperature of the diesel locomotive can affect the detection of the cable.

Linear Temperature Detection System/ Liner Heat/ Fire Sensing Cables

- Linear Temperature detection central unit with subunits and temperature sensitive cabling
- Fire Alarm, control and indicating panel(s)
- Cabling for power supply, control and monitoring
- Interface to fire detection unit and further on transmitting of information to SCADA

3.12.3 Fire Detection & Alarm System

General

This section of the specifications includes the furnishing, installation, and connection of a multiprocessor controlled, intelligent fire alarm and integrated emergency voice evacuation system required to form a complete coordinated system ready for operation. The specification covers the complete fire protection System (for detecting fire in and outside the tunnel, as well as equipment for fire -fighting), the whole automatic fire detection system (linear fire detection inside the main tunnel tube and sensors inside the Electrical Control Station) including all required equipment, and accessories. Also, all necessary accessories, required for transmission and indication of the given signal (potential free contact) at the Control Centre SCADA and niche substation / Equipment Room shall be included.

- All interface equipment which is necessary for the data-transmission to / from the Control Centre (SCADA) shall be included in the central connection element.
- The observation of the tunnel is divided into following central units:

- Fire detection system with heat/ smoke detectors (Control room)
- Linear heat detection system (tunnel tube), the whole fire detection system shall comply with standards of accredited laboratory and shall be UL listed FM approved.
- Emergency Voice/ Alarm Communication / The intelligent fire alarm and emergency voice evacuation system.
- Emergency & Service Telephone System

The whole fire detection system shall be proofed by an accredited laboratory. The contractor shall hand over a protocol of this examination to the Client and the intelligent fire alarm system shall comply with requirements of NFPA 72 / IS-2189:2008 Standard.

Any kind of fire detection equipment shall be supplied by the UPS-system.

3.12.3.1 Scope

It shall include, but not be limited to, intelligent alarm initiating devices, alarm notification appliances, auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.

3.12.3.2 Technical Specification - Detection Units

Fire Detection Unit And Sub Units

The fire detection inside the tunnel tube, as well as for automatic fire detection at the Electric Control rooms, a fully electronic system shall be provided.

All optical smoke detectors (situated in the electrical rooms) and emergency MCP's shall be controlled/connected by a common fire detection unit and Intelligent analogue addressable Fire Alarm Panel located in Control Room. Each alarm from the MCP's and sensors (of the fire extinguishers in the fire extinguisher panels) shall be detected by the associated detection (sub) units. The detection subunits shall transfer the alarms to the main fire detection unit in the Equipment Room and further to SCADA.

Electronic Hooters and one central siren shall be provided.

Every evaluated fire alarm shall cause:

- Tunnel lighting of the whole tunnel tube shall be switched on automatically. The alarm shall be transmitted to the Control Centre.
- The appropriate tunnel ventilation fire program shall start automatically.
- The firefighting water pumps shall be switched on automatically to standby but shall be used only if required.
- All necessary information shall be displayed at the Control Centre and the control panel.

For automatic operation of tunnel, the Smoke/heat Detection System / Fire Alarm Panel shall be provided with an interface, giving potential-free signals whenever a fire-detection from the various detectors occurs.

The reset of a fire alarm is only possible directly at the appropriate fire detection unit in the Electric Control rooms/ equipment room.

All devices of the fire detection system shall be supplied by the uninterruptible power supply.

3.12.3.3 Fire Detection System

The main purpose of automatically activating a detection system in a tunnel is to trigger an alarm upon fire detection, which is relayed to a constantly attended location in order to organize prompt emergency response, including evacuation and firefighting. Automatic fire detection systems can also be used to trigger automatic fixed fire protection systems.

Different systems may be considered, ranging from standard smoke and fire detectors (ionic, optical), flame detectors (UV/ IR), laser beam detectors (smoke) and linear detectors (conductors in insulator), to highly sophisticated early detection systems based on air sampling and CCTV imaging software.

3.12.3.4 Fire Safety Equipment

- Automatic fire detection system in tunnel
- Fire alarm system in buildings
- Emergency telephone niches

To ensure higher system reliability, automatic fixed water-based fire-fighting systems in conjunction with Manual hose based fire- fighting system should therefore be installed in tunnels as part of an integrated approach to the management of fire and life safety, unless it can be proved that existing early fire detection systems, combined with efficient emergency response, are enough to ensure life safety and to adequately mitigate property loss in a given tunnel. This should be considered on a case-by-case basis.

3.12.3.5 Linear Fire Detection Unit

The linear fire detection unit shall be situated at S/S (Electrical/SCADA Control Station).

A fully electronic linear fire detection unit shall continuously detect the maximum temperatures, temperature gradients over time and temperature differences over the entire cable length. Therefore, optical time domain reflection method with computer-aided alarm analysis shall be used.

The detection units shall be self-monitored. In case of breakage or malfunction an automatic fault-message shall be given to the Control Centre.

The linear fire detecting system shall be able to check, if the rising of the temperature is caused by a fire, or if there may be a fault.

The linear fire detection system shall be able to differ between hot exhaust of the moving vehicle and a “real” fire. A running or parking vehicles shall not result in a fire alarm. Only systems are allowed which have past positive test procedures in road tunnels with vehicles. The results of the test procedures shall be provided.

An unrestricted software which parts the sensor cable in zones of about 100 m length, shall be used. In event of fire alarm, so-called hot spots shall be localized.

Also, programmable alarm-thresholds per zone shall be provided. To limit the possibility of a breakdown of the linear fire detecting system, the sensor cables shall be connected at both sides to a fire detecting unit. If the sensor cable is on both endings connected to detection units, a maximum length of about 4 500 m of each sensor cable is permissible as per manufacturers recommendations.

The information of the zone which contains to the fire alarm, the direction of fire-spread / - propagation as well as the size of fire shall be transmitted to the Control Centre.

Remote adjustment and monitoring/ testing e.g. from Control Centre shall be possible.

The linear fire detection units shall include the necessary power supply unit with all required voltages

with surge suppressors. A display with 4 rows (displays the messages as plaintexts) and self-monitoring shall be included in the detection units.

The linear fire detection unit shall have an automatic microprocessor unit with control panel and indicating panel. The distributor of the linear fire detection unit in the electrical rooms shall be equipped clearly, so that the display of the fire detection unit can be seen easily.

The linear fire-detection unit shall have interfaces to the fire detection unit depending on the offered system.

The fire detection & alarm system shall include following, but not be limited to, intelligent alarm initiating devices, alarm notification appliances, auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.

- Heat detection unit with subunits in the tunnel tube with interface to linear temperature detection system/Linear Heat Sensing Cables
- Manual Call Points (MCP) in the tunnel in proximity to the Electric Control Stations, at Tunnel/ portals.
- Optical smoke detectors in the Service Electric Control Stations (raised floor and ceilings)
- Fire Alarm, control and indicating panel(s), intelligent analogue addressable type
- Cabling for power supply, control, and monitoring , FRLS
- Interface for corresponding automatic controls of the tele-control system (SCADA) which distributes the command(s) to the CCTV System, the Control Centre, the Ventilation Control System, the Lighting Control System, etc.

Inside the tunnel emergency push buttons “FIRE” shall be mounted at Niches(with E&M equipments) and panels installed in tunnel.

All optical smoke detectors (situated in the electrical rooms) and emergency push buttons “FIRE” shall be controlled by a common fire detection unit.

Each alarm from the push buttons and sensors (of the fire extinguishers in the fire extinguisher cabinets) shall be detected by the associated detection (sub) units. The detection sub units shall transfer the alarms to the main fire detection unit and further to SCADA

Every alarm shall be indicated audio-visually at the Control Centre. After verifying the alarm (true / false) by the operator by using the CCTV-System (installed by the EPC contractor), the operator manually forwards the alarm to the fire department, to evaluated fire alarm causes:

- CCTV camera of the affected area is connected to the alarm / video screen, for surveillance the incident.
- Tunnel lighting of the whole tunnel tube is switched on automatically.
- The alarm shall be transmitted to the Control Centre.
- The appropriate tunnel ventilation fire program is started automatically.
- The fire- fighting water pumps are switched on automatically, but only if required
- All necessary information is displayed at the Control Centre and the control panel in the Control Room s.
- For automatic operation of tunnel, the designer of the Fire Detection System has to provide an

interface, giving potential-free signals whenever a fire-detection from the various detectors occurs.

- The reset of a fire alarm is only possible directly at the appropriate fire detection unit in the Equipment Room , or control room.

3.12.3.6 Emergency Push Button "Fire"

The emergency push buttons "FIRE" shall be installed to enable a manual fire-alarm. They shall be placed at the following locations:

- At niche with E&M equipments & portal substation
- At every S/S
- One emergency push button "FIRE" beside the entrance door to a low voltage room of the equipment rooms, niches(with E&M equipments) & control centre

The size of the housing of the FIRE push buttons shall be approximately 130 x 130 mm (w x h). Further on, the housing shall be made of red coloured aluminium, shall have a breakable glass front and a lockable door. The degree of protection of push buttons shall be at least IP 54.

All push-buttons bear the symbol for FIRE integrated on the housing. Also, an indication in Hindi and English shall be visible.

All push buttons shall be connected to the fire detecting loop via a coupling element. The coupling elements shall be included in the price of the push buttons.

3.12.3.7 Fire Detectors

Optical Smoke Detector

Optical smoke detectors, resistant against high humidity, shall be provided. The electronic device shall be sealed, shielded and highly resistant against electrical interference. Degree of protection: IP 43

Optical smoke detectors shall be installed:

- Detectors in Equipment room
- Detectors in raised floor in the low voltage rooms, control rooms and entrance corridors of the Electric Control Stations and Control Centre; with substructure for mounting on lower edge of the panels of raised floor.

The optical smoke detectors and the push buttons "Fire" shall be connected to the fire detection (sub) units with loops. The type of cabling depends on the used system "System-Cable" .

3.12.3.8 Power Cable Thermal Monitoring Management Solution

DTS Power Cable Management Solution Combines All Of These :

- Distributed Temperature Monitoring
- Asset Visualization
- Alarm Management
- Central Database
- Reporting & Analysis Functions
- Real Time Thermal Rating

Capabilities in one fully integrated solution package. It automatically detects hotspot locations, provides

alarms if critical limits are exceeded, and produces a temperature profile report.

All data is stored in a central database and are available for reporting and analysis ,see where the bottlenecks are and derive valuable information to make the best decisions regarding future power grid upgrades.

The alarm management signals when limits are exceeded and your assets are at risk. Sections of the cable route cab be flexibly defined as different zones; different alarm levels and type can be assigned to each zone.

The system offers a quick and easy overview of the thermal status of your circuit with an easy to use graphical user interface. Circuit layouts are mapped and the various sections are colorized according to the measured cable surface. Temperature graphs and hotspot tables are easily accessed .

3.12.3.9 Emergency Manual Call Point (MCP)

The emergency buttons "FIRE" Manual call Points shall be installed to enable a manual fire-alarm. They shall be placed at the following locations:

- One MCP in proximity to the entrance door to a low voltage room of the Electric Control Stations.

Further on, the housing shall be made of red coloured aluminium, shall have a breakable glass front and a lockable door. The degree of protection of push buttons in the tunnel tube shall be at least IP 54. In the Electric Control Stations a lower class may be used.

All MCP's shall bear the symbol for FIRE engraved on the housing. Also, an indication in Hindi, English and a local language shall be visible.

All MCP's shall be connected to the fire detecting loop via a coupling element.

3.12.3.10 Wiring

The transmission of data of the fire detection (sub) units runs via a single mode fibre cable (A-DF(ZN)2Y 12x12 E9/125). Only a few fibres are reserved for the Fire Detection System.

"Fire Survival armoured / unarmoured e-beam cables with annealed copper conductor having Cross linkable Low smoke zero halogen insulation / or protected with Fire Rated Glass Mica tape with low smoke zero halogen inner and outer sheath. Armoured cables should comply to BS 7846:2009 (latest edition) & unarmoured cables to BS-7629 (latest edition). Both armoured and unarmoured cables should meet fire performance circuit integrity test as per standards.

- Wiring for signal line circuits shall be 1.5 mm2 minimum and subject to the circuit load.
- Wiring for Notification Appliances circuits shall be 2.5 mm2 minimum and subject to the circuit load.
- Wiring for speaker circuits shall be 2.5 mm2 minimum and subject to the circuit load.
- Wiring for telephone circuits shall be 2.5 mm2 minimum and subject to the circuit load.

3.13 Integrated Tunnel Control Systems

3.13.1 General

This Specification describes the minimum standards of the Integrated Tunnel Control System (ITCS) for Tunnel Control Building & Tunnel network. The Works to be executed under the Contract include the design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete ITCS to fully integrate the control, monitoring, and supervision of Low Voltage Power & Distribution, Emergency

Power Supply-DG sets and UPS, Fire Alarm System, Hydraulic System (Bore Well Pumps etc.), and other nominated Building Services Systems. The ITCS shall also interface with the requirements for control, monitoring, and supervision as required at the Tunnel Control Centre (TCC).

The ITCS is to be designed manufactured, supplied, installed, tested and commissioned by the Contractor and shall meet all performance and functional requirements as defined in the Specification. This specification contains a description of the system concepts and major components, and sections covering definitions, requirements for interfaces with other contracts, general mechanical and electrical installation design/performance requirements, and testing requirements.

The emphasis is to explain the requirements of work, interfaces with other contractors for achieving an efficient & safe working system commensurate to the best international standards and practices. Every effort has been made to cite the design requirements very clearly, however in this contract, the contractor shall follow acceptable standards & design procedures akin to the best adopted practices in ITCS system, wherever this is not explicitly mentioned.

3.13.2 Scope

The services to be performed by the contractor shall include, but not be limited to, the following:

a) Design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete ITCS , including all PLC/RTU Equipment, CPU's, Modules, Sub Modules, Power Supplies, Local Control Panels, PC Work Stations, Printers, Local Area Network (LAN), Ethernet Hubs and Switches, Remote Fireman's Control Panel, electrical containment and wiring systems, and other components, to fully integrate the control, monitoring, and supervision of Low Voltage Power & Distribution including Energy Metering, remote relay setting of ACBs, Diesel Generator System and strategic emergency power supply from DG sets, UPS, Lighting Control System, Fire Alarm System, Lift and Escalators, Hydraulic System (Raw Water pumps, Domestic water pumps and Fire Water pumps etc.) and other nominated Building Services Systems , as required whether or not specified , necessary to deliver the requirements of this Specification. The scope has been further given in detail as per I/O list with this document. The ITCS shall also interface with the requirements for control, monitoring, and supervision, as required at the Tunnel Operational Control Centre (TOCC). The system should be capable of independent functioning as well as seamless integration with centralized ITCS system.

b) Earthing of Programmable logic controller and Work Stations to the clean earth. Earthing drawing will be submitted to the employer's representatives for approval.

c) Integration of ITCS with other ITCS at TCC.

d) Presentations, reviews and audit support as specified in the Specification;

e) Interface management as specified in the Specification;

f) System operations and maintenance support services;

g) Training for the Employer's Engineers and Training Instructors, operations staff, maintenance staff and Engineering staff;

h) Dismantling, removal and/or disposal of Temporary Works;

i) Warranty period after commissioning.

j) Transfer of Technology

k) Warranty and Maintenance Support System-AMC

The list is not intended to be complete and the contractor shall supplement it adequately for obtaining a satisfactory working ITCS System.

3.13.3 Standardisation

The Contractor shall, in establishing his design, follow the principles provided below in the design and specification of all plant, equipment and components:

i. Similar plant and equipment shall be replaceable/interchangeable, modular in design, adaptable and extendable.

ii. The technical specifications and design standards shall be uniform. Uniform standards for clear spaces, working clearances, protection of equipment and physical dimensions of equipment and interfacing with other systems.

iii. Test standards and standardized equipment shall be selected or built or framed carefully, bench marked, designated and explicitly marked.

iv. A standard procedure shall be followed for identification of each category of equipment explicitly (suffixing or prefixing while marking and numbering for each category of equipment).

v. The operating system shall be uniform for all systems/sub systems.

vi. Standards for maintenance planning shall be uniformly categorized.

vii. Uniform standards shall be designated for procurement, replacement stocking and availability.

viii. Equipment and accessories shall be provided with uniform standard spare capacity, protection.

ix. Piping, cabling etc. shall be suitably colour coded for identification and categorization for each kind of use/type. The cable terminations should be tagged and numbered as per the standards.

3.13.4 Quality control of equipment, components and material

The contractor shall furnish the following information for each item of equipment as applicable:

i. Manufacturer.

ii. Type and model No. of equipment.

iii. Nominal capacity

iv. Power supplies i.e. Voltage & Frequency at which the equipment operates.

v. Type of Frame and foundation required for the equipment.

vi. Space requirements

vii. Controls & Protection

viii. Indications/alarm/annunciation

ix. Standards

x. Insulation class

xi. EMC Conformance and certification.

xii. Any other technical information related to the equipment.

The contractor shall provide a list of tools and test equipment for the installation, testing and repair of any special apparatus and proposals for conducting system acceptance testing and to support the extended period of trial running.

3.13.5 Submission of Drawing & Details

a) The contractor shall state the number and scales of all the drawings it intends to produce in support of the works under this contract. The detailed/schematic drawings to be furnished by the Contractor may include but not be limited to:

b) Schematic drawings

c) Interlock drawings

d) Erection drawings

e) Wiring drawings

f) As erected/finished drawings

g) Any other drawings

h) I/O Schedule and Cable Schedule

i) A complete schedule of drawings to be produced by the contractor shall be submitted to the Employers representative within one month (30 days), of contract award.

3.13.6 Design Considerations

a. The complete installation shall be in strict accordance with the national and local electrical codes.

1. All system components are to be designed and built to be fault tolerant:
2. Satisfactory operation without damage at 110% and 85% of rated voltage and at +3 hertz & -1.5 Hz variation in line frequency.
3. Static, transient, and short circuit protection on all inputs and outputs.
4. Communication lines protected against in-correct wiring, static transients and induced magnetic interference.
5. Bus connected devices to be a.c. coupled or equivalent, so that any single device failure will not disrupt or halt bus communication.

b. All equipment, cables and wiring shall be designed, manufactured and installed so as to secure a service life as shown below:

1. Control Panels30 Years
2. Cables30 Years
3. Tray, trunking and supports30 Years
4. Sub-assemblies and components30 Years
5. All other equipment20 Years minimum

c. Switchboards, equipment, and other control components shall be rated for operation in ambient temperatures of 15 deg to 35°C and humidity up to 55 to 85% and shall have degree of protection IP- 65.

d. In the design of switchboards, local control panels, Cabinets of PLC, an allowance of 20-25% spare space capacity shall be provided for possible future expansion and all panels shall be user friendly, modular and aesthetic design, termite and vermin proof. Spare capacity of 30% shall be provided for all cable trays, trunking, wire ways, (raceways), and brackets, for future expansion.

e. Parameters for control and monitoring for the various equipment location

Table 17: Parameters for control and monitoring for the various equipment location

Functions	PLC (Plant Room)			TCR		TCC
	Condition		operation	Status	Alarm	Remote Data
Tube well pumps at station	Liquid level in the underground tank low.		Start Pump	Lowwater levelin underground tank	Warning goes OFFwhen underground tank full	Warning
(1+1) MainStandby	– / +	Manual Switch remote / Bypass localor	Log at PLC	Red Graphics forlocal, grey for remote		
	Pump Running		-	Pump		
	Pump Failure		-	ON (OFF)	Standby pump fail warning	Warning
	Water level in the underground tank		If full stop Pumping Log at PLC	-	-	-
	A defined time of pumping completed		Alternating pump starts	Standby Pump is ON		
	Hoursof operation		Log at PLC	-	Not run for more than a week, A Pump running for more than a defined time (Alarm)	Warning (Not Run for more than one week)
	Voltage		Log at PLC	-	No Warning / Volt	-
	Pump Tripped		Log at PLC		warning	Warning
Raw water pumps at station	Liquid level in the raw water tank low			Lowwater levelin underground tank (Raw)	Warning, goes OFF when underground tank (Raw water) full	Warning
(1+1) Main Standby	– / +	Maual Switch remote / Bypass local or		Red Graphics forlocal,grey for remote	-	-
	Pump Running		-	Pump		

Functions	PLC (Plant Room)		TCR		TCC
	Condition	operation	Status	Alarm	Remote Data
	Pump Failure	-	ON (OFF)	Standby pump fail warning	Warning
	Water level in the Underground tank	If full stop Pumping Log at PLC	-	-	-
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours of operation	Log at PLC	-	Not run for more than a week, A Pump running for more than a defined time (Alarm)	Warning (Not Run for more than one week)
	Voltage	Log at PLC	-	No Warning / Volt	-
	Pump Tripped	Log at PLC		warning	Warning
Domestic water pumps at station	Liquid level in the Domestic water tank low	Start pump	Low water Level in Domestic water tank	Warning, goes OFF when underground tank (Raw water) full	-
(1+1) Main Standby – / +	Maual Switch remote / Bypass local or	Log at PLC	Red Graphics f local, grey for remote	-	-
	Pump Running	-	Pump		
	Pump Failure	-	ON (OFF)	Standby pump fail warning	Warning
	Water level in the Domestic water tank	If full stop Pumping Log at PLC	-	-	-
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours of operation	Log at PLC	-	Not run for more than a week,A Pump running for more than a defined time (Alarm)	Warning (Not Run for more than one week)
	Voltage	Log at PLC	-	No Volt Warning	-
	Pump Tripped	Log at PLC		warning	Warning
Fire Fighting Pump	Hydrant Pressure fall (Major)	Start Pump	-	warning	warning
(1+1) Main Standby +					
	Manual bypass local or auto		Different graphics colour for local or auto	-	-
	Pump Running	-	Pump 1/2 ON (OFF)	-	-
	Pump Failure	Start standby automatically		First Pump fail warning	Warning

Functions	PLC (Plant Room)		TCR		TCC
	Condition	operation	Status	Alarm	Remote Data
	Standby pump fail	Main pump starts automatically	-	Second pump fail alarm	Alarm
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours of operation	Log at PLC	-	Notrunfor morethan a week.	Warning
Jockey Pump	Hydrant Pressure fall (Minor)	Start the Pump	-	Warning	-
	Manualbypass local or auto		Different graphics colourfor local or auto	-	-
	Pump Running	-	Pump ON (OFF)	-	
	Pump Failure	-		pumpfail warning	Warning
	Hours operation	Log at PLC	-	Notrunfor morethan a week, (Alarm)	Warning
DG set	Incoming HT supply to Grid 1 & 2 transformers OFF	Bus Couplers OFF,start DG set, load breaker ON	Starting DG set	Warning supply failed	Warning
	Start command from control panel	Start DG set, load		-	-
	Startcommand fromlocalor remote	Breaker OFF		-	-
	DG set running		ON(OFF)		
	Incoming HT supply to ASS transformers ON	DG set OFF Bus couplers ON		-	-
	DG set failed to start or tripped			Alarm	Alarm
	Hours of operation	Log at PLC	DG set ON in casenot running more than 15 days	Not run for more than 15 days (Alarm)	Alarm
	StarterBattery Voltage	If low Log at PLC		Warning, Maintenance required	Warning
	Lube oil Level	Continuous monitoring			
	Fuel level	Continuous monitoring			
	Radiatorwater level	If low Log at PLC			
	Output voltage	Log at PLC	Within range, Indicateon Load	Alarm, if out of range	Out of range alarm
	Output Frequency	Log at PLC			
	Fuel Consumption	Log at PLC	Weekly report generation for	-	Weekly report generation for

Functions	PLC (Plant Room)		TCR		TCC
	Condition	**operation**	**Status**	**Alarm**	**Remote Data**
			fuel consumption rate vs. energy output		fuel consumption rate vs. energy output
	Energy Output	Log at PLC	Continuous monitoring	-	Continuous monitoring
UPS(Electrical)					
	Input Voltage	-	Continuous monitoring in decimal value		
	Battery Voltage		Continuous monitoring in decimal value		
	Charging Current		Continuous monitoring in decimal value		
	Output Voltage		Continuous monitoring in decimal value		
	Output Frequency		Continuous monitoring in decimal value		
	Load%		Continuous monitoring in decimal value		
	Staticbypass/ manual Maintenance Bypass		Different graphics Statusfor Various status		
	Mains failure		Alarm		
	Lowbattery Alarm		Alarm		
	Overloadand over temperature		Alarm		
Battery Charger (ESR)					
	Input Voltage	Log at PLC	Continuous monitoring in decimal value		
	Battery Voltage	Log at PLC	Continuous monitoring in decimal value		
	Charging Current	Log at PLC	Continuous monitoring in decimal value		
	Output Voltage	Log at PLC	Continuous monitoring in		

Functions	PLC (Plant Room)		TCR		TCC
	Condition	**operation**	**Status**	**Alarm**	**Remote Data**
			decimal value		
	Mains failure		Alarm		
	Lowbattery Alarm		Alarm		
	Overloadand over temperature		Alarm		
	Charging/Load/B oost Charging Status		Different graphics Statusfor Various status		
	Staticbypass/ manual Maintenance Bypass		Different graphics Statusfor Various status		
Entry/ Exit/ Forecourt, External (Road) Lighting	Voltage	-	ON (OFF) in defined time period	No volt Alarm	Alarm
	Current	If less than 80%of nominal value in any circuit		Lamp replacements due	
	Hoursof operation	Log at PLC	-	-	-
	Energy Consumption	Log at PLC	Decimal Value	-	Decimal Value
Fire Detection and Alarm System					
All zones Public Areas	Alarm Situation	Signal at FACP	-	Warning	Warning
All zones Non-Public Areas	Alarm Situation	Signal at FACP		Warning	Warning
All zones Non-Electrical Installatio ns	Alarm Situation	-	GasRelease monitoring	Warning	Warning of fire at zones and gas release
All zones Non-Hazardous Areas	Alarm Situation	Signal at FACP	-	Warning	Warning
FACP	System Fault	Fault Indication	ON	Warning	Warning
	External Fault	Fault Indication	ON	Warning	Warning
	Processor fault	Fault Indication	ON	Warning	Warning
	Devicefault/ Device isolated	Fault Indication		Warningat fixed interval	Warning
	Voltage	Log at LDC		Novolt warning	-

Functions	PLC (Plant Room)		TCR		TCC
	Condition	operation	Status	Alarm	Remote Data
Sprinkler	Risein Temperature	Start Pump	ON	Warning	Warning
Hydrant	Low pressure	Start Pump	ON	Warning	
Electrical Panels					
	Manualbypass local or auto		Different graphics Colouror auto		
	DB running	-	DB ON(OFF)	Warningfor No volt in EPP	Warning
	Energy Consumption	Log at PLC	Continuous monitoring in decimal value	-	Continuous monitoringin decimal value
	Voltage	Log at PLC		No volt alarm	
	Trip	Log at PLC	Red colour in graphics	Alarm	
	Communication andsettingof ACB Relays	Log at PLC		No volt alarm	Controland setting of ACB relays
	ControlSupply failure	Log at PLC		No volt alarm	
Lighting system					
	Manualbypass local or auto		Different graphics colourfor local or auto	-	-
	LightCircuit ON/OFF Command	-	Light ON (OFF)	-	
	LightCircuit Failure	-		Circuitfail warning	Warning
	LightCircuit ON/OFF Status	-	Light ON (OFF)	No 'ON' status alarm	Warning

The workstation pc with recent configuration and operating system shall be supplied and installed in the station control room of each station. This shall be a standalone PC.

3.13.7 Programmable Logic Controller (PLC)

a. Necessary PLCs shall be installed to provide the most economic configuration based upon cost balances between PLC modularity and cabling costs, consistent with the performance requirements of this specification.

b. Location of PLCs shall be chosen such that minimum length of cable will be required between PLC and power DB.

c. PLC can be opened freely, so sufficient distance from the wall or obstruction will be maintained.

d. Cables shall be kept at a distance of 300 mm from the power cable trays/conduits at all places as entry/exit to DB, PLC etc.

e. Hubs / switches — these will be installed in separate enclosures near the, PLCs/ workstation.

f. Repeaters- these will be installed in separate enclosure at a distance of 90 meter from hub/ repeater of the communication cable to boost the signal.

g. Field sensors- sensors will be located on, or adjacent to, that equipment which is being monitored. For example, i t could include sensing the electrical load, water level etc. that changes within building.

3.13.8 Facility

i. The ITCS system shall be centralized and comprise of a powerful central computer. This shall run highly sophisticated programs, which operate in 'real-time'. Workstation shall have continuous communication between the central or main operator station's central processing unit (CPU) and the remote field processing units (PLCs). The CPU is continuously updated with the conditions being monitored by, and control actions being taken by, the PLCs. It will therefore be able to implement global actions with the minimum time delay, across the whole system. However, configuration of PC and hardware components given in subsequent paras of this specification.

ii. A central database management and communications system, to communicate with the PLCs and local workstations over the communications link shall be provided and to maintain a database regarding health and operation of all system points. The system should be able to log the defective sub-systems, communication failures/ breaks and also update the data on restoration of the fault.

iii. Bulk data server facilities for software back up and historical data, including equipment history of maintenance & frequent defects shall be provided at Tunnel & T.C.C. Maintain equipment history of maintenance and frequent defects. The backuphistorical data shall be available minimum for a month at a time and backup rate shall be fortnightly.

iv. The ITCS should activate designated alert for the attention of operations and maintenance Tunnel passengers (for example lighting system, escalators). SMS to Mobile phones of DGM (O&M) and other designated officials of employer regarding high priority alarms, energy audit reports and specific fuel consumption of DG sets.

v. Provide clear, comprehensive displays and printed logs of equipment status to each operator workstation.

vi. Provide comprehensive displays and printed logs based upon historical data, with the option of overlaying data from earlier periods.

vii. Time-tag all events detected by the ITCS system, to 1 millisecond Resolution for selected high-speed inputs, and to present this information in logs as a true system- wide sequence of events.

viii. Generate routine maintenance schedules automatically, based upon elapsed time and equipment operation times. Also record the maintenance activities carried out including the maintenance block taken, persons attending or having access to the plant rooms.

ix. Operating systems based on a Graphical User (GUI) format incorporating the widely used WIMPs procedures (windows, icons, menus, and pointing device), where one display can overlay another shall be provided. WYSIWYG (what-you-see-is-what- you-get) display printing and print previewing features shall be provided.

The following primary facilities shall be available at each workstation:

1. Visual and Audible Alarms and event logging and printing.
2. Operator acknowledgement of alarms.
3. Selective display and printing of alarms and of events lists.

4. User friendly group display on a single Screen of various E&M systems.
5. Execution of operator commands with access code security.
6. Provision of user-friendly operator sequences.
7. Operator entered text messages.
8. Access to historical data files of plant status.
9. Generation of tabular displays based upon spreadsheets.
10. Generation of graphical displays based upon mimic diagrams.
11. Generation of printed reports and printed copies of display pages.
12. Utilities consumption monitoring and check metering.
13. Operator entered data, including tagging, manually entering values and the forcing of status points.
14. Automatic logging of selected displays at specified times.
15. System timekeeping.

3.13.9 Specification/requirements for hardware components

The requirements and specifications for hardware components of the PLC is as follows:

I. Components of PLC

a) PLC consists of main CPU, I/O modules, DC/DC converter and terminal blocks. It collects data from the process, pre-processes and transmits the same, using suitable protocol (MODBUS RTU or similar), to the TCR Workstation which in turn communicates to the Central Server at the TCC via an optimized and event-based TCP/IP protocol.

b) PLC shall be an intelligent modular, compact system that allows suitable expansion, minimum from 14 up to 1000 I/Os using the same set of basic components. The PLC shall be programmed for local control by implementing specific logic in the PLC. Input and Output modules are connected serially to make it a complete compact and modular data acquisition system. The PLC shall communicate with TCR workstation through MODBUS Protocol, using the RS232/485 port. PLC shall have a local 'intelligence' so that in the event of a breakdown in communications with the CPU, the points connected to that unit continue to be controlled according to the time schedules initially provided by the CPU.

c) The Contractor shall ensure that the PLCs are compatible with the input/output signals from the Workstation and other Subsystems. Power supplies for interrogation of volt-free contract shall be provided as part of the PLC.

d) PLC terminals shall be of the clamp type preferably of cage -clamp and shall be provided with isolating links

e) PLCs shall be supplied complete with 30% spare capacity for handling additional input and output signals. Expansion by at least 50% shall be possible simply by adding more I/O modules and reconfiguring the software. A further 100% expansion shall be possible by adding additional interfacing equipment in additional cabinets, etc. and reconfiguration of the software.

f) A manual switch inside the PLC cabinet shall be provided as a hardwired facility to disable the operation of control outputs. Change of switch status shall be registered as a system event.

g) The Contractor shall establish the I/O requirements and provide the most economic configuration of PLCs based upon cost balances between unit modularity and cabling costs for individual

stations.

h) The PLCs shall be suitable for either wall or floor mounting and shall be suitably robust for operation in Electrical switchgear room/ Pump room areas, to IEC529 IP54 enclosure standard Wall mounting is preferred. PLC shall be of the same make and type at all sites and individual components shall be interchangeable between PLCs at different sites.

i) The PLCs shall be suitable for operating in the environment described in the General Specification clause.

j) The PLCs shall be able to be interrogated fully and be fully reconfigured from operator workstations. The Employer's personnel shall be able to re- configure fully the PLC hardware and software after completion of the training courses provided under this Contract. However, a nominated person with authorized password should have access for making such change with using proper authorization from DGM/ TUNNEL or TCC, EMPLOYER.

k) It shall be possible to disable an individual PLC locally or from an operator workstation for servicing or reconfiguring without affecting other PLCs. When disabled or enabled, a change of status condition shall be announced on the Control Center monitor and the changed log as an event.

l) Internal architecture of PLC

1) Microprocessor base CPU
2) Input and output interface modules suitable for a mixture of digital, analog and pulse inputs and outputs.
3) Terminal for external cable termination
4) Thermostat for temperature control
5) Power indication lamps
6) Document holder
7) MCBs for modules, Fan, Tube lights
8) Door switches
9) Fuses for digital output, input and analogue input terminals
10) Power supply unit

a) The PLC processor will have minimum Salient features as following:

1) 34 KB user program memory RAMS and Flash.
2) 0.4 ms/kobo bit processing
3) Integrated ports: 2xMODBUS or 1xMODBUS.
4) 2 interrupt inputs and 2 cyclic tasks.
5) Direct access to I/O for fast response.
6) Real-time clock.
7) It shall have real time clock & time resolution of the clock should be lmsec.
8) PLC shall have separate battery for the above clock. PLC shall be capable of time stamping the event before communication to ITCS.
9) The event scanning resolution of PLC should be of 1msec.

b) The PLC processor will have the capability to support the following language structures:

1) Structured Text

2) Sequential Function Charts

3) Ladder Logic

4) Function Block

The processor shall support the Advanced Instruction Set that includes basic and advanced ASCII string instructions, and advanced math functions.

The processor shall support a system protection environment with passwords and privileges and support a form of backup communications module.

c) PLC Interface Modules

The following hardware described will interface to the field mounted sensors and equipment for control and monitoring.

Digital inputs:

12 VDC, 24 VDC, 50 VDC, 110 VDC, 110 VAC, 240 VAC (1.5 kV isolation)

Digital Outputs (relay):

Volt-free contact, 24 VDC, 30 VA Volt-free contact, 240 VAC, 125VA Analog inputs:

0-10 VDC, 0-10 mA, 4 -20 mA with electrical isolation from ground DC 12-bit resolution minimum

>60dB interference rejection at 50Hz

Analog Outputs:

0-10 VDC, 4-20mA

Pulse Inputs:

12 VDC, 24 VDC up to 10 pulses/sec (2kV isolation)

Serial Link:

RS 485, RS 232 / V24, RS422

II. PLC Hardware Requirements

PLC Operating Voltages: The PLC must be able to operate at 100% from the following power sources:

100 VAC — 250 VAC

24 VDC — 100 VDC

Note: The PLC must operate at the nominal supply frequency of 50 Hz with a 15% variation.

III. PLC Programming

a) The PLC shall be programmed with manufacturer proprietary software, IEC 1131.3-compliant, mixable and reversible List language and Ladder language. The software shall feature Windows-based editing functions and integrated online help.

b) An original copy of the latest manufacturer's proprietary software shall be provided to EMPLOYER upon completion and handover together with all generated site-specific data.

c) PLC should be remote programmable from TCR workstation.

IV. PLC communications

Although the PLC processor specified above will have the capability of communicating directly with an ITCS system via Modbus over TCP/1P protocol. In addition to the above, the PLC shall have the capability to be monitored directly using the HTTP protocol.

I. PLC Cabinet and Panel Internal Wiring

a) PLC is compact and modular in design. All the components inside the panel are din-rail mounted. PLC cabinets will be freestanding type and will have colour matching with Electrical Panel.

b) Control panel, switchboards and distribution boards wiring shall be clearly identified in accordance with the Definitive Design Drawings using cable core markers. Cable core markers shall read left to right or top to bottom.

c) Wiring shall be enclosed in metal ducts or neatly loomed with nylon ties or spiral binding as required. Wiring ducts shall be filled to a maximum space factor of 50%.

d) Where wiring is required to connect to devices mounted on doors it shall be arranged such that opening and closing of the door is not impeded whilst minimizing flexing of the wiring loom. The loom shall be effectively fixed at both ends of the door opening with insulated saddles or clamps.

e) Wire colours shall comply with the following requirements: PhasesRed, Yellow, Blue

NeutralBlack

AC ControlGrey

DC PositiveOrange

DC NegativeLilac

EarthGreen with Yellow trace

f) Terminals shall be clearly numbered, and shall be rail mounted, adequately sized to suite wiring size and provided with 20% spare rail space. The bridging of terminals shall be provided by the use of terminal bridging links as supplied by the terminal manufacturer.

g) Control wiring shall be terminated using pre-insulated pin or spade type crimp lugs. Conductors terminating to study type terminals shall be fitted with spade type crimp lugs.

h) A separate earth bar shall be provided for the termination of all earth wires. Only one wire shall be connected into each termination point.

i) Minimum conductor size shall be 1.5mm2.

j) Cable glanding plates shall be earthed directly to the control panel earth bar.

k) Panels shall be fitted with a suitable pocket to contain circuit diagrams and other relevant Definitive Design Drawings. An "as installed" set shall be provided with the panel.

II. ITCS MAIN Server

SCADA Server shall be provided with minimum following requirement:

a) Processor - 3.2 GHZ Intel Xeon 64 Bit Processor (Latest series available) with heat sinks

b) RAM size – DDR3/DDR4 based 2X16GB

c) 4 GB dedicated graphics card.

d) Hard disk- Total storage of 3TB each, with RAID-6 or suitable hard disk controller.

e) Visual Display Unit- 19-inch rack integrated LED or equivalent.

f) Video Card- Standard Graphics controller.

g) Multimedia with accessory- Not required.

h) DVD R/W- Dual Drives: 16x DVD-ROM Drive + 16 x DVD+/-RW double layer write capability.

i) EMI immunity- As per IEC 801.

j) Inbuilt Network Interface Ethernet Ports

k) Built in dual gigabit port, Ethernet GB Lan Card

l) USB ports- 3.0 USB (4 Nos)

m) Server Management software- Complete with the server management software & Tool for server diagnostics and troubleshooting, including other drivers for the server.

n) Accessories- Accessories Including all cables/ connectors/ Keyboard/ accessories to achieve the complete working of the system.

o) Power Supply-Fully Redundant Power Supply & Fan Unit

p) Operating System- Microsoft Window server Windows server 2016/ Windows server 2019 or latest windows server

q) External Hard Disc- Not Required

r) Tape Drive – For backup Required

III. Personal Computer

The Standalone commercial grade Work Station shall be a personal computer (PC) based central, with a minimum feature of full 32 bit processor, features latest Intel I7 , 5th Gen processor with 3.0 GHz or higher, 8 GB RAM, 1TB Hard Disk drive, ATI/NVIDIA graphics card , DVD R/RW, Dual LAN card, 2GB Dual Video Accelerator, Dual Monitor support, 2 Nos. spare USB ports, SATA/SCASI disk drive crashworthiness, and all other miscellaneous components including communication interface RS-232/485 card (MOXA Card with minimum 8 ports) to meet the requirements

and specifications. Notwithstanding the foregoing guidelines, the Work Station shall be to the latest state-of-the-art performance for similar systems and shall be operated by

the use of a USB mouse (Optical) connected to the station without the need of keyboard entry. To ensure hardware quality, computer clones shall not be acceptable. The PC shall be supplied with 24” VDU, One Laser Printer and with latest operating system software.

The PC shall be configured such that external media of any kind may not be loadable at Operator level, which could pose the threat of external virus infection or compromise the operating system.

The Work Station shall be complete with detached 101-keys keyboard, which includes full upper/lower case ASCII keyset, a numeric keypad, dedicated cursor control keypad, and a minimum of 30 programmable function keys.

IV. Colour Monitor

The Work Station color monitor shall be Colour monitor shall be minimum 22- inch diagonal antiglare, antistatic flat LED screen, high resolution of 1280x1024 and 16 Million colour support, on screen control support, Vertical & Horizonal viewing angle 160O, Tilt Swivel Support as per specifications etc. as required Work stations shall include all accessories needed to comply with UL requirements for listing under the appropriate standards as specified in UL864 and UL916.Further, all accessories shall be included to satisfy the local authorities having jurisdiction over the system. UL listed cards (originals preferred or photocopies) shall be provided to support the documentation that such listing is in effect.

V. Printers

The sub-contractor shall provide printers as specified for recording alarms, operator transactions and system reports. To ensure hardware quality, printers shall be internationally branded, warranted, and technical support, spare parts and consumables should be freely available from the manufacturers authorized distributors.

VI. Laser Printer

A hard-copy multi-color graphics laser printer shall be provided for recording graphic displays and associated dynamic data. Printer shall meet minimum requirements as follows:

a) Print speed — Black: up to 20 ppm; color: up to 4 ppm

b) First page out — 18 seconds black, 29 seconds color

c) Resolution- 600 by 600 dpi

d) Memory — 64 MB built-in SDRAM; expandable to 192 MB with one open memory SDRAM DIMM slot

e) Duty cycle — 30,000 pages per month

f) Media — Media handling 125-sheet multipurpose tray 125-sheet multipurpose tray, 250-sheet input tray 2 — Letter, legal, statement, executive, No. 10 envelopes, Monarch envelopes

g) Output — 125 sheet face down bin

h) Types Paper (plain, letterhead, prepunched, bond, color, rough, preprinted, recycled)

i) Glossy Media, Cover Paper, Color LaserJet Transparencies, labels, envelopes, and card stock

j) Compatibility - InterfacesHi-SpeedUSB2.0port,IEEE1284-B compliant parallel port

k) Hi-Speed USB 2.0, IEEE 1284-B compliant parallel port

l) Languages PCL 6 and Postscript level 3 emulation with automatic language switching

m) Font capabilities — 80 TrueType TM internal scalable PCL 6 fonts; 80 TrueType internal scalable HP postscript fonts

n) Client operating systems — Microsoft Windows 98, 2000, Me, XP, NT 4.0 Mac OS 9.1, X v.10.1 and later; UNIX®, Linux, and OS/2 (limited functionality) vista, Windows 7, Windows 10.

o) Network operating systems — Microsoft Windows 98, 2000, NT 4.0 Me, XP; Mac OS 9.x, OS X Vista, Windows 7, Windows 10.

p) Network protocols supported — TCP/IP

VII. Network Switches, Modems, Hubs, Gateways

All modems, hubs, switches, gateways and other serial equipment to be used in the application of system networks must be of industrial grade quality to meet the following criteria:

a) Can tolerate up to -40 to 85 deg C

b) Can tolerate 5-95% humidity

c) Provides vibration resistance (1E68-2)

d) Withstands power surges (IEEE-472)

e) Provide easy DIN-rail mounting

f) Are powered directly from 230V AC/110V DC

g) Not less than 8-port 10/100 Dual-Speed ports-up to 200Mbps

VIII. Communication

The suitable communication protocol shall be adopted for various communication links. The communication Protocol can be classified as per following requirements:

a) The communication between E&M equipment to PLC: MODBUS Protocol

b) The communication between PLC to the TCR Workstation: MODBUS Protocol over TCP/IP.

c) The communication between Multifunction Meters and Energy meters and their communication to PLC/Workstation: MODBUS Protocol on RS 232/485 port.

d) The communication between Dimming Light Control Panel, Fire Alarm Control Panel, and MDB & Electrical panels, Escalator Panels/MCCBs, AMF Panel etc. to the PLC/TCR Workstation: MODBUS Protocol on RS232/485 Port.

e) Communication between TCR Workstation to TCC: TCP/IP protocol on optic fiber link through TER.

f) Supply of the hardware essential to integrate all systems for communication link as above.

g) The communication link between TCR workstations and the TCC shall be done using TCP/IP based protocol. All the TCR workstations and TCC shall be connected in LAN TCP/1P that is being provided at TER by the main communication contractor.

h) Communication software in each PLC or workstation node on the network shall enable peer-to-peer operation, such that failure of any node shall not affect other nodes on the network.

i) The system should provide instant alarm to the operator about the communication failure.

j) The healthy operation of all PLCs shall be verified at intervals not exceeding 30 seconds. PLC failure shall be displayed on the appropriate workstations as a system alarm.

k) In the event of a failure of the main communications system, local operation from

control panel at each station shall be maintained. Updating of the central database at the TCC shall take place immediately on restoration of the communications link.

l) Operational changes and expansion will be made without shutdown the system.

m) Cables

3.13.10 All types of cables used in this project shall be Armoured.

a) Cables installed between PLC and DB/Sensors shall be Fire resistant low smoke Zero Halogen (FRLSZH)

b) Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq mm copper.

c) Ethernet cables for networking of PLCs and Workstation shall be provided.

d) 2#3C shielded cables (communication bus) shall be provided over RS232/485.

I. Moxa card/ Router

a) For communication with RS 485 port of different panels Moxa card of minimum 8 ports/Router shall be installed with the ITCS workstation.

b) Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq. mm copper.

3.13.11 Specification/Requirement for System Software

I. Software features

a) It is necessary to provide a time and date for alarms, which occur, and other significant events, including operator commands.

b) Software will allow the database (points) and operating parameters (time, temperatures, limits etc.) to be modified on-line, by the operator.

c) When a binary contact goes from open to closed, or vice versa, the 'change of state' is reported by the system.

d) Some alarms may, however, be critical and should never be locked out. It should be possible to define these alarms when they are entered into the system in such a way that it is impossible to lock them out.

e) On start-up of certain plant, it takes a finite time before stable conditions are reached and the ITCS should allow for automatic lockout of alarms for a pre-set period following start-up.

f) If, either as a result of time programming, or an operator command, several large electrical items are called to start at the same instant, this may cause overloading. ITCS shall have capability to overcome this by defining these items as 'heavy' electrical items, and introduce a delay time to prevent starting of the next load until delay time has elapsed.

g) Logging of important status information will be provided. The list of such important items shall be provided by contractor for approval of ER.

h) This should contain, in plain language, identification of the point, status and other data, plus time, date etc.

i) It should be possible to call up logs for various 'levels'.

j) It should be possible to cancel logs under certain conditions.

k) Facility of summary logs, i.e. the ability to call for a print out, for example, of all points in alarm, all points off normal, all motors which are running, all points which are locked out, etc.

l) It should be possible to log system advisory messages, e.g. malfunctions within the management system itself, such as hardware failures, power loss, failure of a point to respond to a command, communication errors etc.

m) Operator will be allowed to define the engineering units, e.g. voltage, kWh, degrees centigrade, etc., and the ranges over which they are to be measured.

n) An alarm should be reported in case of breaking the pre-set limit of analogue points such as voltage, current etc.

o) To avoid nuisance alarm, the software should have flexibility to allow varying the differentials or introducing time lag. For example, if a space temperature alarms at 25°C high and has a 0.1°C differential, it will be constantly going in and out of alarm between 25°C and 24.9°C. It would probably just as acceptable to have a 2°C differential which would reduce the number of alarms reported considerably and furthermore, when they did occur, would be more meaningful to the operator.

p) It should be possible to lock out analogue alarms, both by the operator and automatically, during start-up maintenance operations if nuisance alarms are to be avoided.

q) It should allow start/stop commands to be set up at precise times, with daily variations as well as allowing holiday programming.

r) The system will keep a record of how many hours a plant has been running or how long a point has been running or how long a point has been in a normal or off-normal condition.

s) Limits to be set which can be used to alert the operator to the fact that maintenance is necessary or perhaps can automatically switch from one pump to another after a present period.

t) A record of consumption of things such as litters of fuel used, kWh etc. will be kept.

u) English language for both input and output will be accepted.

v) The output information should be grouped in accordance with the make-up of the `services' systems in the station building rather than the location of the field hardware.

w) "Prompting' feature will be provided, which takes the operator through the operation step by step, prompting and teaching him as he does it.

x) Dynamic colour graphics will be used to show the schematic diagram of the system.

y) Different colours will be used to bring particular conditions to the attention of the operator. The contractor should submit scheme in this regard for approval of Employer's representative.

z) The operator will have the facility to generate or draw his own graphics on the VDU and have a library of standard symbols available to him held in the memory of the system.

aa) Password will restrict access to certain important areas, so it is necessary to control who has access to a ITCS, at what level and through which operator devices.

bb) Number of characters of password will not be less than five. cc) Password time-out will be not more than half an hour.

cc) "Database save' feature to copy the system database onto a separate storage medium, usually a disk, will be provided.

dd) Equipment’s will run on its requirement; in the rest time it will be possible to be switched off to save the energy.

HMI software- On the front Screen icons for all systems shall be shown. Healthy and unhealthy status

of these systems shall be shown by dynamic colour change of these icons.

II. General

a) The PLC shall be application-software controlled, with the software assembled from proven software modules, and shall be capable of the following function and facilities:

1) Local time tagging of events.

2) Alarm handling from discrete inputs derived parameters.

3) Combining of digital inputs Boolean functions to give conditional outputs.

4) The equipment shall be self-monitoring for fault conditions, and shall generate an alarm on the appropriate operator workstations in the event of a fault arising.

b) PLC- software shall be capable of being reconfigured, under password control, either locally from the portable-programming device to be supplied under the Contract, or remotely over the communications links from operator workstations.

c) Event processing shall have the following order of precedence, but shall be re-configurable:

1) Receipt of manual commands from operator workstations, each of which shall have an assignable level of command priority.

2) Pre-defined control sequences.

3) High-speed alarms.

4) Normal alarms.

5) Digital events.

6) Clock synchronization (With the master clock at TCC).

7) Analogue events.

III. Design and performance requirements

Equipment or systems comprising several components shall be controlled through the ITCS with suitable control regimes to achieve desired operation normally automatically but with provision for manual intervention. The automatic operation shall conform to the operational, functional and overall system needs as specified in this specification.

a) The contractor shall prepare in clear and logical form documents describing the functions transmitted and the operations carried out at the stations control room workstation and that at TCC. The control and transmissionscheme shall be submitted for the consent of the Employer or his representatives.

b) The equipment shall also have arrangements to log and record various parameters on a regular basis and store the results for at least six months.

c) The ITCS supplier/ contractor may propose the use of a serial data link instead of voltage free contacts. In this case the physical characteristics and data transmission protocol proposed shall conform to an internationally recognized publicly available standard. If there should be a match between the ITCS supplier's proposal and the capabilities of the electrical/mechanical equipment in the field for serial data link to be adopted with the consent of the Employer. The contractor shall interface with other electrical and mechanical equipment supplier, as per the interface matrix.

IV. Design Coordination Requirements

The Contractor shall submit a list of all design review documents for the review of the Employer's Representative.

V. Applicable Design standards

a) IEC – 1131

b) IEC-6206

c) IRC SP; 87-2013.

d) IRC SP 91.

VI. Application of specification

The above specifications shall be applied in a manner altered, amended or supplemented by this specification and the latest Indian Electricity rules wherever applicable.

VII. Lightning

a) The contractor shall ensure that all equipment's are fully protected against the effects of mains surges and direct and indirect lightning strikes. Protection such as high voltage cut outs or high current cut outs shall be applied to incoming mains power supplies and to input and output signal lines to externally located sensors, transducers, actuating equipment, etc. or to any other equipment likely to be affected.

b) Lightning protection systems shall be in accordance with BS 6651 — "Lightning Protection" or an equivalent Indian/international standard.

c) All surge suppression equipment shall be self-contained and self-resetting.

VIII. Alarm

a) All alarms generated by the installation including processor alarms, power supply alarms, and control equipment alarms, shall be sustained until cleared. Alarm handling shall be implemented through the ITCS system.

b) Alarms will flash on the present Screen and be audible to the station controller; it will be messaged to the mobile phone of the station controller and other concerned EMPLOYER authorities, as decided by the Employer.

c) The Alarm shall be in a form of a hooter positioned at SCR, near to the ITCS system

IX. Selection of equipment's

a) The contractor should select the equipment's, subsystems of the ITCS keeping in view the requirements given in this specification.

b) In their technical bid, the bidders should provide details of systems, its subsystem, components etc.

X. Installation

a) It should be ensured that the noise within the communication links between the PLC and the TCR Workstation is avoided.

b) Proper installation techniques should be employed to ensure adequate quality of signals from analogue sensors (transducers) to PLCs.

c) Adequate measures shall be taken by the contractor to mitigate potential problems confronted

due to the various forms of interference.

d) A semi-rigid, shielded cabling, which is, to a certain extent, self- supporting, can be used for signal and communication wiring.

e) The Contractor shall supply and install all materials including but not limited to cable tray, brackets, and supports and execute all other works needed for supporting and routing all cabling and wiring relating to ITCS. The contractor shall interface with Building/ Civil Contractors will make provisions in structures to accommodate the fastenings.

f) The PLCs should preferably be wall mounted. All floor mounted PLCs will be grouted in the floor, so that vibrations due to tunnel vehicle movement can be born. If the problem persists then rubber AVMs can be used.

g) Separate tray, trunking and conduits will be used by the contractor for ITCS cabling.

h) All cables will be laid in tray, trunkings, and conduits as appropriate etc. Saddling of cables on the wall shall not be permitted.

i) Dressing of cables will be done in such a manner that all cables will be laid parallel without laying/ crossing on each other. All the cables shall be properly tagged and marked on both ends and along the cable.

j) Bunching of cables near PLC entry, Power feeder entry and anywhere not permitted.

k) All trays, trunkings and conduits will be marked with a definite colour and tray will be marked clearly as ‘ITCS Control'.

l) A separate team of experienced ITCS installation engineer, Software engineer, Electrician, Unskilled persons etc. will be kept for ITCS work, for work completion as per schedule in the contract. A list of such team will be submitted to the Employer's representative one month before of the start of work.

m) Scaffold, welding machine, soldering iron and other tools/special tools &plants required for execution of works under this project shall be arranged by the contractor.

n) Installation, testing schedule will be provided one month before start of work and weekly progress will be submitted to the Employer's representative.

o) Without complete installation, tray marking, cable tagging and dressing etc., no test will be allowed.

p) Where cables cross the track, wall or are in any part external to cable trough routes, then they shall be suitably protected through PVC conduits encased in concrete. Advantage shall be taken, in consultation with the Civil Contractors, to incorporate such additional protection into the basic construction of the concrete structures.

q) All cables except main power supply cables, entering or leaving equipment rooms and wayside apparatus boxes shall be terminated in order of their core number on combined terminal/disconnection or terminal/fuse links.

r) Each wire shall be capable of being disconnected and isolated without removing the wire itself. These links shall be easily accessible for inspection and test. Each link or terminal shall be identified with the designation of the circuit it carries.

s) All electronic equipment shall comply, as a minimum, with IEC 571 or equivalent international specification. All components used shall be purchased from suppliers complying with internationally recognized quality management and reliability certification procedures. The

Contractor shall declare in his offer the specifications to which he proposes to comply.

t) Printed circuit boards shall be used to mount electronic components. The boards shall be of sufficient thickness to ensure mechanical rigidity. They shall not be the sole support for connectors, fascia panels, handles etc.

u) All components shall be identified either by carrying a manufacturer's designation or part reference number or unique value in a standard format.

v) All metal enclosures shall be provided with an earthing terminal. The Contractor shall ensure that all the equipment's are properly and adequately earthed in accordance with safety standards and its rules.

II. Testing General Requirements There will be five type of tests-

a) Factory Acceptance test for PLC, Workstation and Printer- During the test all logics shall be demonstrated with simulator and sample PLC, Workstation and printer.

b) Installation test- After delivery of the PLC at the site, this test shall be arranged to check the physical healthiness of the hardware.

c) Functional test- This test shall be arranged -to test the functioning of PLC, workstation and printer and communication network.

d) System acceptance test- This test shall be arranged to test all automation and 1/0 list, with integration of communication network.

e) Integrated test- This test shall be arranged to test the integration of the ITCS server at TCC and all workstations of different stations.

However, indicative S.A.T document shown in this specification, but it is contractor's responsibility to submit the separate test document for each type of test to the approval of Employer's representative. All tests shall be in sequence and on completion of previous test, next test shall be arranged. Before installation test, all QA/QC document shall be submitted to the Employer's representative for the approval.

Basic monitoring and control functions will be demonstrated on a point-by- point basis. Checking out the software features is much more difficult and many of the programs will only be proved correct or otherwise by closely monitoring the ITCS operation over an extended time period. The contractor shall provide necessary support till the time the system is reasonably established.

A re-commission or check out of the operation of the ITCS at the end of twelve months shall be carried out.

The following requirements are intended to supplement and explain the general specification requirements without in any way limiting their application.

a) The testing philosophy for the ITCS System shall ensure that the equipment functionality is thoroughly verified and validated at the Contractor's premises before delivery and commissioning. The test methodology shall be in line with the design methodology and the two shall be developed in parallel.

b) The principle of testing shall be that, at stages throughout the work, formal tests shall be performed and recorded against written test specifications, to provide a high level of confidence to the Contractor and the Employer's Representative that subsequent stages can proceed.

c) The responsibility for specifying, conducting and recording tests shall be with the Contractor,

but all aspects must be to the satisfaction of the Employer's Representative. The Employer's Representative will at his discretion witness any tests. The degree to which the Employer's Representative intervenes in the process will depend upon the level of confidence built up during the project.

d) This document does not constitute a Test Specification or Test Procedure for any part of the system; rather it sets out the stages at which tests are required and the subjects, location and purpose of each stage. Inspection of incoming goods and components, and subassembly testing, shall be undertaken by the Contractor in accordance with the procedures set out in the Contractor's own Quality Management Plan and are not described here.

III. Responsibilities for Testing & Commissioning

a) All test documentation associated with a subsystem or system test shall be submitted for review by the Employer's Representative at least 30 days prior to the scheduled commencement of the associated test.

b) The Contractor shall revise and re-submit any documents to which the Employer's Representative has raised an objection such that all test documentation associated with any testing has achieved letter of no objection from the Employer's Representative prior to the commencement of the corresponding testing.

c) The Contractor shall successfully carry out all pre-tests according to the finalized test procedures and correct any errors prior to any (associated) witnessed acceptance tests.

d) The Contractor shall produce permanent records of all test progress and results in a formal systematic manner and submit to the Employer's Representative for his review.

e) The Contractor shall carry out all remedial work and re-testing found to be necessary in order that equipment shall pass the tests.

f) Each of the above responsibilities shall be discharged to the satisfaction of the Employer's Representative, but no objection by the Employer's Representative shall not imply any diminution of the Contractor's responsibilities.

IV. Production Testing

a) Inspection - Inspection of incoming goods and component, and subassembly tests, shall be performed in accordance with the Contractor's Quality Management Plan and shall include software production and integration testing.

b) Product Inspection - Contractor's System Integration Testing - This is the contractors own internal and un-witnessed testing on the complete ITCS System, including all simulation programs necessary to prove the totality of functionality, prior to offering them up to the customers witnessed test(s).

V. Acceptance

a) The Contractor shall complete all relevant Production testing before offering any Item, Subsystem or the System as a whole for any witnessed acceptance test. All documentation covering the results of Production tests shall be referenced in the notice of witness testing submitted by the Contractor. The acceptance test stages follow the requirements of the GS clauses of the contract.

b) All parts subject to wear, such as electromechanical peripherals, may be omitted from the tests if agreed by the Employer's Representative. The printing and recording equipment needed for conducting the test shall be run throughout the test. All refills should be supplied during the

period up to final handing over.

c) Tests shall be conducted to prove the individual and integrated functioning of the system hardware and demonstrate performance in the face of various contingencies.

d) Integrated system tests shall be conducted to prove the functionality of all applications software in the context of the complete integrated system, equipment and software configuration. The contractor shall develop system test

VI. Training

a) The contractor shall provide training to Employer's staff. The training should be designed for few different levels of staff viz. operator of the system and engineers/technical managers.

b) Contractor shall train the following minimum staff of EMPLOYER.

1) Operator staff — 30 Nos.

2) Engineers/ Managers- 5 Nos.

c) The Man weeks required for training of above staff shall be indicated by the ITCS contractor in their BID.

d) Operator training will be carried out on site and at the supplier's own training school, as required.

e) Engineer/ Manager Training should concentrate on making them familiar with the capabilities of the system so they he can take full advantage of the ITCS in running station building.

f) They should be trained for system administration i.e. allocating passwords and password levels, adding points to, and deleting points from, the system, setting up management reports on energy usage, cost and efficiency for major plant items, defining load shedding priorities and so on.

VII. Input/output List (Indicative)

The ITCS system shall provide monitoring and control of the following sub systems, as specified in the respective clauses of this specification. It is the responsibility of the contractor to interpret the entire requirements of the specification and to provide input/output interfaces as required which may be described separately throughout this specification.

Table 18: Monitoring and Control of the following Sub Systems

S.No	I/O	Source	Event	Remarks
Analog Inputs				
1	Fire water line pressure	Jockey Pumps		THROUGH VFC
2	SCR Temp			THROUGH VFC
3	SCR Humidity			THROUGH VFC
4	TPER temp.			THROUGH VFC
5	TPER Humidity			THROUGH VFC
6	TER temp.			THROUGH VFC
7	TER humidity			THROUGH VFC
8	Lux Level			THROUGH 4-20 MA
	Electrical Panels			Energy Meter
1	Voltage-Phase 1			Through RS 485
2	Voltage – Phase 2			Through RS 485
3	Voltage – Phase 3			Through RS 485
4	Frequency			Through RS 485
5	PF-3 Phase equivalent			Through RS 485

S.No	I/O	Source	Event	Remarks
6	Current-3 Phase equivalent			Through RS 485
7	Current - Phase 1			Through RS 485
8	Current - Phase 2			Through RS 485
9	Current - Phase 3			Through RS 485
10	Powerfactor3phase equivalent active power			Through RS 485
11	Powerfactor3phase equivalent Reactive Power			Through RS 485
12	Powerfactor3phase equivalent Apparent power			Through RS 485
13	Energy 3 phase equivalent Active Energy			Through RS 485
14	Energy 3 phase equivalent Apparent Energy			Through RS 485
	UPS			
15	Input Voltage			Through RS 485
16	Battery Voltage			Through RS 485
17	Charging Current			Through RS 485
18	Output Voltage			Through RS 485
19	Output Frequency			Through RS 485
20	Load %			Through RS 485
21	Bypass Voltage			Through RS 485
22	Bypass Frequency			Through RS 485
	Battery Charger (ESR)			
23	Input Voltage			Through RS 485
24	Battery Voltage			Through RS 485
25	Charging Current			Through RS 485
26	Output Voltage			Through RS 485
	Digital Input			
	DG set			
1	DG set ON			Through RS 485
2	DG set OFF			Through RS 485
3	DG set TRIP alarm			Through RS 485
4	DG room exhaust fan ON status			Through RS 485
5	DG room exhaust fan OFF Status			Through RS 485
6	DG room Fresh air fan ON Status			Through RS 485
7	DG room Fresh air fan OFF Status			Through RS 485
8	Auto/Manual switch			Through RS 485
9	Lube Oil pressure low Alarm			Through RS 485
10	Enginewatertemphigh Alarm			Through RS 485
11	DG set Battery voltage Low alarm			Through RS 485
12	DG fuel low level			Through RS 485
13	DG fuel high level			Through RS 485
SN	I/O	Source	Event	Remarks
	Pumps			
14	Raw Water Pump 1 Run Status			Through Voltage free contact (VFC)
15	Raw Water Pump1 Auto/ Manual Switch Status			THROUGH VFC
16	RawWaterPump2Run Status			THROUGH VFC
17	Raw Water Pump2 Auto/ Manual Switch Status			THROUGH VFC
18	DomesticWaterPump1 Run Status			THROUGH VFC
19	Domestic Water Pump1 Auto/ Manual switch Status			THROUGH VFC
20	Domestic Water Pump2 Run Status			THROUGH VFC
21	DomesticWaterPump2 Auto/ Manual switch Status			THROUGH VFC
22	Tube well Pump1 Run Status			THROUGH VFC
23	TubewellPump1Auto/ Manual Switch Status			THROUGH VFC
24	Tube well Pump2 Run Status			THROUGH VFC

S.No	I/O	Source	Event	Remarks
25	TubewellPump2Auto/ Manual Switch Status			THROUGH VFC
26	Fire Pump 1 Run Status			THROUGH VFC
27	Fire Pump1 Auto/ Manual Switch Status			THROUGH VFC
28	Fire pump2 Run Status			THROUGH VFC
29	Fire Pump2 Auto/ Manual Switch Status			THROUGH VFC
30	Jockey Pump1 Run Status			THROUGH VFC
31	Jockey Pump1 Auto/ Manual Switch Status			THROUGH VFC
32	Domestic water tank1 25% level			THROUGH VFC
33	Domestic water tank1 50% level			THROUGH VFC
34	Domestic water tank1 75% level			THROUGH VFC
35	Domestic water tank1 100% level			THROUGH VFC
36	Domestic water tank2 25% level			THROUGH VFC
37	Domestic water tank2 50% level			THROUGH VFC
38	Domestic water tank2 75% level			THROUGH VFC
39	Domestic water tank2 100% level			THROUGH VFC
40	Flushing water tank1 25% level			THROUGH VFC
41	Flushing water tank1 50% level			THROUGH VFC
41	Flushing water tank1 75% level			THROUGH VFC
42	Flushing water tank1 100% level			THROUGH VFC
43	Flushing water tank2 25% level			THROUGH VFC
44	Flushing water tank2 50% level			THROUGH VFC
45	Flushing water tank2 75% level			THROUGH VFC
46	Flushing water tank2 100% level			THROUGH VFC
47	Fire water tank 1 25% level			THROUGH VFC
48	Fire water tank 1 50% level			THROUGH VFC
49	Fire water tank 1 75% level			THROUGH VFC
50	Fire water tank 1 100% level			THROUGH VFC
	RoadTunnelLighting/ External Lighting			
51	Status of MCCB operating Road Lighting LDB			THROUGHVFC, Microprocessor Based Release
52	Status of Contractor operating Road Lighting LDB			THROUGHVFC, Microprocessor Based Release
53	StatusofContractor operating External Lighting			THROUGHVFC, Microprocessor Based Release
	MDB (RS485)			
54	Incomer #1 On status			THROUGHVFC, Air Circuit breaker Based Release
55	Incomer #1 OFF status			THROUGHVFC, Air Circuit breaker Based Release
56	Incomer #2 On status			THROUGHVFC, Air Circuit breaker Based Release
57	Incomer #2 OFF status			THROUGHVFC, Air Circuit breaker Based Release
58	Bus Coupler On Status			THROUGHVFC, Air Circuit breaker Based Release
59	Bus Coupler On Status			THROUGHVFC, Air Circuit breaker Based Release

S.No	I/O	Source	Event	Remarks
60	Incomer#1ShuntTrip status			THROUGHVFC, Air Circuit breaker Based Release
61	Incomer#2ShuntTrip status			THROUGHVFC, Air Circuit breaker Based Release
62	BusCouplerShuntTrip status			THROUGHVFC, Air Circuit breaker Based Release
	EPP (RS485)			
63	Incoming MCCB from DG AMF Panel on Status			THROUGHVFC, Microprocessor Based Release
64	Incoming MCCB from DG AMF Panel on Status			THROUGHVFC, Microprocessor Based Release
65	Incoming MCCB from DG AMF Panel Shunt Trip Status			THROUGHVFC, Microprocessor Based Release
66	Incoming MCCB from MDB Panel On Status			THROUGHVFC, Microprocessor Based Release
67	Incoming MCCB from MDB Panel OFF Status			THROUGHVFC, Microprocessor Based Release
68	Incoming MCCB from MDB Panel Shunt Trip Status			THROUGHVFC, Microprocessor Based Release
	A/C PANEL			
69	Incoming MCCB On Status			THROUGHVFC, Microprocessor Based Release
70	IncomingMCCBOFF Status			THROUGHVFC, Microprocessor Based Release
71	Incoming MCCB Shunt Trip Status			THROUGHVFC, Microprocessor Based Release
	PA PANEL			
72	Incoming MCCB On Status			THROUGHVFC, Microprocessor Based Release
73	IncomingMCCBOFF Status			THROUGHVFC, Microprocessor Based Release
74	Incoming MCCB Shunt Trip Status			THROUGHVFC, Microprocessor Based Release
	FWP PANEL			
78	Incoming MCCB On Status			THROUGHVFC, Microprocessor Based Release
79	IncomingMCCBOFF Status			THROUGHVFC, Microprocessor Based Release
80	Incoming MCCB Shunt Trip Status			THROUGHVFC, Microprocessor Based Release
	WPP PANEL			
81	Incoming MCCB On Status			THROUGHVFC, Microprocessor Based Release
82	IncomingMCCBOFF Status			THROUGHVFC, Microprocessor Based Release
83	Incoming MCCB Shunt Trip Status			THROUGHVFC, Microprocessor Based Release
	UPS			
90	Main failure alarm			THROUGH RS 485
91	No load			THROUGH RS 485

S.No	I/O	Source	Event	Remarks
92	Low battery alarm			THROUGH RS 485
93	System fault			THROUGH RS 485
94	Overload			THROUGH RS 485
95	Over temperature			THROUGH RS 485
96	Bypass mode for Inverter			THROUGH RS 485
97	Mains ON			THROUGH RS 485
98	Mains faulty			THROUGH RS 485
99	Inverter ON/OFF			THROUGH RS 485
100	Inverter faulty			THROUGH RS 485
101	Bypass mode for battery			THROUGH RS 485
	Battery Charger (ESR)			
102	Mains ON			THROUGH RS 485
103	Charging/ discharging/boost charging status			THROUGH RS 485
104	Battery low status			THROUGH RS 485
105	Mains failure alarm			THROUGH RS 485
106	Low battery alarm			THROUGH RS 485
107	Overloadandover temperature alarm			THROUGH RS 485
	Digital Output			
	Pump			
1	Raw Water Pump1 Start			THROUGHVFC, Microprocessor Based Release
2	Raw Water Pump1 Stop			THROUGHVFC, Microprocessor Based Release
3	Raw Water Pump2 Start			THROUGHVFC, Microprocessor Based Release
4	Raw Water Pump2 Stop			THROUGHVFC, Microprocessor Based Release
5	DomesticWaterPump1 Start			THROUGHVFC, Microprocessor Based Release
6	DomesticWaterPump1 Stop			THROUGHVFC, Microprocessor Based Release
7	DomesticWaterPump2 Start			THROUGHVFC, Microprocessor Based Release
8	DomesticWaterPump2 Stop			THROUGHVFC, Microprocessor Based Release
9	Tube well Pump1 Start			THROUGHVFC, Microprocessor Based Release
10	Tube well Pump1 Stop			THROUGHVFC, Microprocessor Based Release
	DG SET			
11	DG start			THROUGH RS 485
12	DG stop			THROUGH RS 485
	ESPP/A/CP			
13	Incomer ON			THROUGHVFC, Microprocessor Based Release
14	Incomer OFF			THROUGHVFC, Microprocessor Based Release

And I/O for dimming and FACP panel.

VIII. Automation

a) When water level becomes lower than a predefined mark, pump will start to fill it.

b) When water level reaches to up-to-mark, pump will stop.

c) Fire water level will not be less than 90%, at such situation Tube well pump will start and alarm will be generated.

d) If main water supply pump fails, then standby pump shall be started automatically.

e) Based on the detailed design, the Contractor shall develop a detailed ITCS input/output point list for all equipment's to be monitored and/or controlled subject to the approval of the Employer's Representative.

f) Control and monitoring shall be provided primarily at the TCR. It shall be possible, however, to enable secondary control and monitoring of equipment's from TCC

g) Description of basic functions is given in Table below:

Table 19: Basic Functions

Category	Functions	
	Specified Categories	**Description**
Monitor and Supervision	CRT- based supervision	Window functions are available, enabling display of plural supervisory Screen at the same time.
	1) Status display of units	Displaying position symbol of units with the shape, color, flickering
	2) Fault Display	Displaying position symbol of units with the shape, color, flickering
	3) Telemetry value display	Display major telemetry values of voltage, current etc.
	4) Ready for command	Graphics colour will be yellow
	5) Running status	Graphics colour for green
	6) High/Low limit check	Supervision and display of deviation of voltage, current and such telemetry data from High/Low setting values.
	7) Trip	Trip status of the breaker will be shown by specific color (Red)
Control	Local	NocontrolfromITCSworkstation, graphics colour will become Red
	Remote/Auto	Workstation control available, Graphics colour becomes yellow. In auto state controlled by predefined logic.
Recordand Reporting	1) Reporting management	Automatic collection of various achievement data for editing and listing of operational achievement documents.
	a) Daily Report	Reporting and printing out a daily report of data arising from hourly telemeter and incidence occurrence
	b) Monthly Report	Reporting and printing out a monthly report of data arising from daily report
	c) Annual Report	Reporting and printing out an annual report of data arising from Monthly report
Recordand Reporting	2) Messagesummary record	Reporting and printing out a message list, supported by sorting and editing functions based on specific factors, such as time and facilities.
	a) Message list Record	Reportingthecontentsofequipment operation status change and alarming
	b) Memo recording Screen	Reportingthecontentsofequipment operation status change and alarming
Other Functions	1) Change over remote control to manual control and vice versa	Security protection by log-on password checks (operators, system managers, programmers)

Category	Functions	
	Specified Categories	**Description**
	2) Rightofoperation supervision and setting. a) Security Protection b) OperationPrivilege setting	Setting up the scope of right-of –operation with a user name to cover supervisory control objectives.

Note: All software needed for proper functioning/operation shall be supplied by the contractor with adequate license and if any supplied software goes defunct by any way, the same shall be restored by the contractor during defect liability period free of cost. All software to be supplied shall be latest version at the time of tender.

3.14 Closed Circuit Television System

3.14.1 General

The tunnels shall have CCTV cameras for continuous monitoring on the vehicular movement which will be linked to central control system. Camera shall be IP type. The CCTV will provide also support to early detect a fire inside the tunnel and to verify alarms coming from the automatic fire detection systems. CCTV system shall be provided with image analysis function to detect incidents (Video Incidents Detection System), wrong-way driving, car stopped or other anomalous conditions. The portals and external areas will be equipped with minimum two sets of dome dynamic colour video camera. Inside the tunnel sets of zoom dynamic auto iris colour video cameras shall be installed with a regular distance of (minimum) 150 meters. A detailed study of coverage shall be provided by the Contractor in order to have full coverage inside the main tunnel and the most critical area (layby, cross passages etc.). Considering the importance of data and to store large amount of data securely, Network Video Recorder system shall be provided.

The CCTV System allows the tunnel operator a surveillance of the situation and the conditions inside the tunnel and at the free field areas. Thus, the operator is able to recognize abnormal conditions and can inform the people in the tunnel via the Public Address System.

CCTV cameras shall be installed within the tunnel tube and outside the tunnel:

- Inside the main tunnel tube:fixed cameras
- In front of the main tunnel portals: fixed outside cameras.
- The outside cameras shall be mounted on a column at a height of 5 m.
- In front of the portals of the Accesses: outside Dome Cameras

The outside cameras shall be mounted on a column at a height of 5 m. The direction orders shall be controlled from the Control Centre or Equipment Room (Control Panel).

The video signals shall be transmitted via multiplexers to the equipment Room / Control Room and further via optical fibre cables to the tele control system (SCADA). Between the cameras and the multiplexer **Ethernet cable** shall be provided. Optical fibre cable cores shall have a wavelength of 1310 to 1550 nm. At the equipment Room / Control Room the signals shall be presented/prepared and demultiplexed.

Generally, all pictures shall be available at the Control Centre.

In the Control Centre, the provided CCTV-screens (e.g. 5 pieces.) shall be available for supervising the tunnel inclusive portal areas/ etc. Five of the CCTV-screens shall show fixed pictures of the tunnel (about every 1000 m), the main portals and the access portals. The no. of screens shall be finalized by EPC / EM Contractor as per final design to suit site requirements.

One of the provided screens shall be defined as emergency screen. The emergency screen shall show the emergency / alarm image, which shall be switched on automatically if an incident occurs, therefore a separate output of the CCTV-picture switchboard shall be available, where the emergency / alarm screen shall be connected.

The other screens shall be freely selectable showing any chosen picture. So every picture shall be available on every screen to make all pictures / screen combinations selectable and re-programmable from the local CCTV Control Panel, manually.

At the equipment Room / Control Room and also CCTV-screens (alarm screens) shall be provided.

There shall be a digital video recording unit at the Control Room which records all camera pictures continuously and stores (records) the signal of the camera activated under alarm condition automatically (emergency / alarm picture).

With the aid of the colour CCTV System, the operator(s) at the Control Centre shall have clear, intelligible visual information of the tunnel.

The quality of pictures displayed on the screens shall permit the recognition of person's activity (e.g. repair work, running persons, etc.) clearly at any point within the tunnel.

The cameras (and screens) shall be of solid state-type, modular components shall be employed where practical and the circuitry shall be assembled in such a way that instructed staff can replace defective modules easily.

AII equipment shall be protected from damage by lightning surges and over voltages. An intelligent video control system shall be provided.

The interface between the CCTV-System and the Tunnel Control System is the video switch port, and prevent system faults from causing a deterioration of the monitoring functionality, the whole system shall be designed to have a high degree of availability.

Anywhere in the CCTV System a failure or a malfunction occurs, this must not have any defects / repercussions to any other parts of the CCTV System.

The CCTV System described in these specifications shall meet the following minimum performance standards.

3.14.2 Scope Of Work

The CCTV system for tunnel shall have outdoor fixed box cameras installed at every 150m interval along the entire length of the tunnel. There shall be 2 HD outdoor PTZ cameras at both portals of the tunnel.

The CCTV system shall have a Video Management Software with redundant Management Servers. The primary management server shall be installed at Control station -1 and Backup management server shall be placed at Control station - 2 to provide HOT redundancy at management server level between Control station -1 and Control station - 2. There shall be multiple recording servers at Control station -1, each recording server capable of handling suitable cameras. All cameras shall be configured to provide live view at 1080p, 25fps with H. 264 compression. All cameras shall be recorded for minimum 30 days 24x7 at 1080p, 25fps with H.264 compression. All recordings shall be done inside the Control station.

Control station - 2 shall act as disaster recover (DR) site of Control station -1. Control station -2 will have Backup management server, three recording servers and storage for 30 days similar to Control station -1. The second video stream at 1080p, 25fps with H.264 compression for all cameras shall be configured in three recording servers at Control station -2. All cameras shall be recorded for minimum 30 days at Control station -2 and the recordings shall be used in case of failure of Control station -1.

When there is no motion in the field of view of the camera, the recordings shall happen at 1080p, 5fps with H.264 compression. In case of motion is detected by the camera, recordings shall happen at 1080p, 25fps with H.264 compression. The system shall have pre-record and post record feature configurable for each camera from 5 sec to 60 sec. All secondary recordings shall be done inside the Control station.

All cameras inside the tunnel shall have IR of 100m illumination range to cover entire tunnel.

Video analytics shall be configured on the cameras inside the tunnel. Software based Video Analytics shall be preferred. There shall be additional servers for Video Analytics. The EM contractor shall provide full compliance on technical specification of VMS and cameras as given below:

- CCTV Cameras
- Camera distribution boxes
- Multiplexers / Demultiplexers
- Video Switch
- Video amplifier
- CCTV picture switchboard at Control Room
- CCTV control panel at the Control Centre
- CCTV screens at the Control Centre
- Video recording unit
- Video detection unit
- Cabling
- Camera Column

3.14.3 Technical Specifications-CCTV Cameras

GENERAL

The camera shall be a colour CMOS type. It shall be capable of operating under a wide range of lighting conditions, varying from brilliant sunshine to night-time with minimal lighting.

Each camera shall allow any alphanumeric insert text into the picture. The text shall consist of at least 10 digits, adjustable by at least two buttons. Each digit can be a number or letter, which shall define the position of the camera for example by km - chainage.

Each IP based fixed camera unit shall consist of a CCTV camera, camera housing with a mounting bracket and a heating unit. The dome camera in the free field area shall be vandal-proof camera with pan/ tilt and zoom function.

3.14.4 Video Management System

GENERAL DESCRIPTION

The Video Management System (VMS) shall be a scalable Microsoft Windows-based video management and surveillance system consisting of four primary components, as follows:

- A core server application to maintain the database of cameras and recording devices and to provide a web-based administrative portal to manage the video surveillance system
- A media gateway application to route video traffic to users as requested and appropriate

- A client presentation application to allow users to view and manage live and recorded video.
- A storage management application server to manage the video storage resources on the network.

SYSTEM FUNCTIONS AND CAPABILITIES

The VMS shall be designed for reliability through fault-tolerant, distributed architecture, and multiple levels of redundancy.

The VMS shall provide an open interface that facilitates the creation and deployment of user interface plug-ins including mapping, video information overlays, access control, and license plate recognition.

VIDEO CAPABILITIES

Support recording of MJPEG, MPEG-4 and H.264 IP video streams

Support megapixel video cameras up to 28 Megapixel resolution

Support for ONVIF S and G profiles

Aggregate independent VMS deployments across multiple networks and manage all video through a single system while preserving local operation.

Analytic capabilities integral to VMS

- Motion - Detection of objects that move within, enter, or exit a scene and triggering an event
- Alarm - Detection of physical alarms from cameras within the system, triggering an event
- Each VMS component shall operate on standard commercial off-the-shelf (COTS) hardware.
- VMS software updates shall be downloadable from a publicly available website.
- The VMS shall indicate system performance and operation status utilizing a variety of reports including csv and pdf formats.

The Manufacturer shall offer a mobile application with the capability to access live video from up to 500 cameras.

CORE SERVER APPLICATION

The core server application shall have central management responsibility, with the following functions and characteristics:

- Maintain a database of cameras and recording devices
- Provide an administrative Web interface
- Define and administer level user accounts, their associated roles, and permissions for the system functions and devices users can access
- Provide basic access to video streaming resources, ensuring that users with appropriate permissions can view video from the system without installed video client software
- Continually search the network for relevant devices
- Assign resources to video recording pools
- Store videos that operators elect to export from network storage devices for safe keeping, supporting the storage of video clips relevant to an investigation independent of standard recording devices
- Create and assign “tags” to efficiently organize cameras and devices within the system

- Configure and respond to events within the system
- Download reports from the system in csv format contained within a ZIP archive
- Perform daily backup at a specified time

DEPLOYMENT OPTIONS:

Independent core server working with an independent media gateway application server to provide systems functions

- combined single server also hosting the media gateway application
- distributed cluster to provide fault tolerance, scalability and load balancing
- virtual machine

3.14.5 Hardware Requirements

- Processor: Intel i-3, i-5 or latest
- Operating System: Microsoft Windows 2012 Server / Windows 8/10 or latest
- RAM: 32 GB DDR RAM ECC
- SSD Storage: 480 GB
- HDD: 2 TB
- Video
- Graphics: Intel HD Graphics P47400
- Outputs:
- Display Port (2)
- DVI-D
- VGA
- Resolution Capability:
- Display Port: 3840 x 2160 @ 60 HZ
- DVI-D, VGA: 1920 x 1200 @ 60 HZ

MEDIA GATEWAY APPLICATION

Based on a successful determination by the core server application of a user's permissions, the media gateway connects the user with the appropriate camera, encoder, or recorder device.

The media gateway shall be deployed within the VMS in modular fashion to allow expansion of system capabilities or to build redundancies within the system to maximize video availability.

DEPLOYMENT OPTIONS:

- Independent core server working with an independent core server application to provide systems functions
- combined single server also hosting the core server application
- virtual machine

CLIENT APPLICATION

The Client application shall be Windows-based, providing an environment from which authorized users can watch live and recorded video on a computer in which the application has been installed.

The Client shall be comprised of a main control panel, which may be hidden, working in unison with a series of windows (workspaces), each providing a tab based experience.

WORKSPACES AND TABS

- The Client interface shall be based upon workspaces and tabs.
- A tab shall be a configurable layout populated with sources of content and plug-ins contained in cells.
- A collection of one or more tabs shall constitute a workspace.
- The Client shall allow configuration and recall of complete workspaces.
- An operator with appropriate permissions shall be able to send a saved workspace to other clients, causing their system to launch the saved workspace.
- Any layout of video can be saved as tab to be later recalled by an operator.

An operator with appropriate permissions shall be able to send a saved tab to other clients, causing their system to launch the saved tab.

Cells shall have the capability for system management, live view, and playback search options.

Remote Tab Push: an operator with appropriate permissions can choose to send a saved tab one or more operators' clients, causing their system to launch the saved tab.

3.14.6 Live View and Playback

A list of video and audio sources which users are authorized to access shall be displayed.

The client computer shall be able to connect to an unlimited number of recorders simultaneously to display live and recorded video.

The client shall allow video streams to be selectable from a system tree on an individual camera, individual system, client defined local groups, or from pre-defined recorder based groups.

Users shall be able to seamlessly switch between live and recorded video on the fly.

LIVE VIEW

For live view, cells 1/4 the size of the tab or larger will use the primary stream from a video source, and cells smaller than 1/4 the size the tab shall use the secondary video stream.

3.14.7 Pan Tilt Zoom(Ptz)

Digital Zoom - An operator shall be able to digitally zoom in a video stream in live or playback mode.

Optical Zoom and Pan Tilt Control: Operators shall be able to use a mouse or joystick to control PTZ cameras.

PLAYBACK

The Client application shall enable simultaneous playback for up to (9) synchronized cameras.

The Client application shall have the capability to playback non-synchronized cameras at one time in different cells.

For viewing recorded video, cells 1/4 the size of the tab or larger shall display full-frame rate video, and cells smaller than 1/4 the size of the tab shall playback only I-Frames to conserve bandwidth and processing power.

When hovering over a recorded video time bar, an operator shall see a thumbnail representing the contents of the video stream at that point in time.

Available playback control functions:

- date-time selection
- synchronized playback of selected cells within a tab
- play video at normal speed
- pause video and advance one frame
- pause video and rewind one frame
- fast forward video at speeds up to 16x
- rewind video at speeds up to 16x
- rewinds video 30 seconds and initiates playback
- forward video to live playback
- take snapshot of the current frame

Hovering over a video playback cell with a mouse shall display the playback control menu.

INVESTIGATIONS

An investigation mode shall be available to provide a 2 x 2 layout with synchronized playback controls, allowing users to fully investigate a scene from multiple angles.

- The investigation mode shall open in a new tab.

The investigation mode shall enable operators to synchronize video playback and export investigative playlists covering scenes of interest in forward or reverse at speeds up to 128 times normal playback.

Users shall be able to create playlists from multiple video clips encompassing selected scenes from an investigation.

Operators shall be able to save a current investigation, preserving the associated device list and any created clips for later recall.

- Saved investigations shall be capable of being shared with other operators' similar tabs.

Operators shall be able to export individual video clips or entire playlists to the Core application, storing clips relevant to their investigation independent of the system's network video storage for evidentiary safe-keeping and quick access.

EXPORT

An operator shall be able to create and export a JPG snapshot image of the current frame of video in a cell.

The Client application shall enable video export to any system-accessible media including locally to HDD, CD/DVD, Flash USB device or to network storage.

- Exported video shall be subject to check sum verification.

DISPLAY

- The Client application shall have both built in video decoding and the ability control separate hardware video decoders, providing virtual matrix functionality.
- The Client application shall allow multiple monitor support for up to 6 displays per client workstation, with the use of hardware video decoders.
- The Client application shall allow up to 4 1080p, 30 fps streams per monitor.

EVENTS

- The Client application shall have an operator to respond to events.
- Certain events shall be configurable for acknowledgement.

ACKNOWLEDGEMENT OPTIONS:

- snooze
- in process
- acknowledged
- Authorized operators shall have the ability to derive additional information about an event from the core application.
- Plug-ins – The Client application shall support modular plug-ins for enhanced functionality.
- System and Device Information

Information management

- The Client application shall provide a mechanism to create and assign
- A primary device list shall be apparent in the Client application.

The device list shall be sortable by device name or device ID.

The device list shall be able to be filtered by the following terms:

- simple text-based filter, matching the device name or device ID
- tag based filtering, showing devices matching the intersection of all assigned tags
- status based filtering, showing devices with a particular status

User Roles, as assigned by a System Administrator, shall define the limits of a user's ability to access live or recorded video and to export video and other standard client operations.

Authorized users shall be able to share views, including window arrangements and camera selections, with other users, for purposes of collaboration.

When using a mouse to hover over a device in a listing, a popup shall appear with the following information:

- Device state
- Device name
- Device ID
- Thumbnail image

- Associated tags
- IP Address

Hardware Requirements:

- Processor: Intel i-3, i-5 or latest
- Operating System: Microsoft Windows 7 Ultimate SP3 / Windows 8/10 or latest
- RAM: 32 GB DDR RAM ECC
- SSD Storage: 480 GB
- Optical Drive: DVD ± RW
- Video
- Graphics: Intel HD Graphics P47400
- Outputs:
- Display Port (2)
- DVI-D
- VGA
- Resolution Capability:
- Display Port: 3840 x 2160 @ 60 HZ
- DVI-D, VGA: 1920 x 1200 @ 60 HZ

3.14.8 Storage Management Application Server

The storage management application server shall incorporate both server functions and storage elements into a purpose-built chassis.

The storage management application server shall not require removal from its rack installation when hard disk drives or power supplies must be replaced.

The storage management application shall record video and audio streams from IP cameras and video encoders on the network.

Video:H.264 in High, Main, or Base Profile streams from both standard resolution and megapixel cameras

The storage management application shall have the following further functions and characteristics:

- Employ the Windows Server 2012 operating system
- Use RAID 6 parity across the storage drives to protect recorded data against a hard disk drive failure
- Use enterprise-level hard disk drives specifically rated for operation in RAID systems
- Employ the following redundancy features
- redundant, hot swappable power supply modules
- redundant, hot swappable system fans

Designed for online service and maintenance and cannot be removed from the rack when hard disk

drives or power supplies must be replaced.

Guaranteed recording throughput: 450 Mbps and up to 300 total cameras per storage device under normal and error (RAID rebuild) conditions

Guaranteed downloading throughput: 175 Mbps per storage device under normal and error (RAID rebuild) conditions.

- The storage server shall natively support Optera cameras any combination of cameras from third-party manufacturers supporting ONVIF Profile S.
- Support continuous, scheduled, alarm/event (including analytic), and motion
- Pre- and -post alarm periods shall be configurable
- Support bookmarking of video content
- Support privacy tools that allow administrators to establish maximum retention times for video
- Ability to report all diagnostic events, including software status diagnostics to a centralized user interface
- Fully manageable from a remote workstation, including the ability to configure settings and update firmware and software Capable of interfacing with a UPS using a USB connector
- The network video recorder shall receive status and control signals from the UPS when it is in backup mode, informing the operator about the amount of charge remaining and triggering a controlled shutdown when the charge becomes zero.

Hardware

- System Specifications
- System Drive: 200 GB SSD
- RAID Level: RAID 6
- Storage: Up to 96 TB
- Drive Interface: SAS/SATA II
- Network Interface (2) :Gigabit Ethernet 1000Base-T (RJ-45 connection)
- USB 2.0:2 on rear panel; 2 on front panel
- USB 3.0:2 on rear panel
- Electrical - Power
- Voltage Input: 100 to 240 VAC, 50/60 Hz, auto ranging
- Power Supply: Internal, dual-redundant, hot-swappable
- Environmental
- Temperature
- Operating: 10° to 35°C (50° to 95°F) at unit intake
- Storage: -40° to 65°C (-40° to 149°F)
- Operating Humidity: 20% to 95%, non-condensing
- Mounting: Desktop (feet); Rack, 3 RU per unit

3D Mouse Controller

The 3D Mouse must be compatible with all network video management components.

Six-degrees-of-freedom sensor – Intuitively and precisely navigate digital models or camera positions in 3D space.

Advanced ergonomic design – The full-size, soft-coated hand rest positions the hand comfortably, and 15 large, soft-touch, function keys allow quick access to frequently used commands.

Quick View Keys – Fingertip access to 12 views makes it easier to switch cameras.

Intelligent Function Keys – Easy access to 4 application commands for an optimized workflow.

On-Screen Display – Provides a visual reminder of function key assignments on your computer screen.

3D Space Mouse Modifiers – Fingertip access to Ctrl, Shift, Alt and Esc keys saves time by reducing the need to move your hand between mouse and 3D Mouse.

Virtual Num Pad – Allows direct numerical input into your application using your standard mouse rather than the 3D Mouse.

The 3D Mouse must be part of an integrated system and shall be configured so any number can be added to the system. When combined with user interfaces (UIs), network storage managers (NSM's), encoders, IP cameras, and video consoles, the 3D Mouse forms an integral part of a complete network-based video control system.

Hardware

- Power Supply
- Input Connector Type : Universal, interchangeable
- Connectivity
- 3D Space Mouse Interface: USB2.0
- Cable : USB
- Module Specifications
- 3D Space Mouse Keypad
- Joystick : Fully proportional PTZ, variable speed; with zoom, iris, and focus controls
- Environmental
- Operating Temperature: 0° to 40°C (32° to 104°F) air intake of unit
- Storage Temperature : –40° to 65°C (–40° to 149°F)

Enterprise and Scalable Management Platform

The VMS shall be an enterprise solution and scalable to support unlimited number of cameras. VMS should support latest Windows Server operating system on Server machine. It should support latest Windows OS on Client machine, independent of what operating system is there in the servers. VMS should support SQL/ MySQL/ Oracle DBMS.

Distributed Architecture and Openness

The VMS shall support distributed video architecture which seamlessly integrates the video operations of numerous systems onto one virtual platform, allowing security operators to view and control all cameras, whether across a single facility or across the multiple locations. The VMS shall support

ONVIF profile and integrate all cameras supporting ONVIF profile.

Standards for Software

The VMS shall be designed and developed to the following standards:

ISO 9001-2008

ISO/IEC 15504 Level 3 or higher (SPICE 2.0 Software Process Improvement and Capability Determination)

SEI CMM Level 5 (American Software Engineering Institute - Capability Maturity Model)

Server-Client Architecture

The VMS shall have Enterprise Database servers, Recording Servers, Analytics Server, Storage and Operator workstations.

The VMS shall support minimum 2500 cameras managed per Enterprise Database Server. Systems shall be scalable by adding additional Servers.

The VMS shall have Analytics Servers dedicated to analyse video streams. The Analytics Servers shall process the live video using preconfigured rules and Intelligent Video Analytics algorithms to determine events of interest.

Fault Tolerant Architecture and Redundancy

The database server shall provide a central fault tolerant repository for all configurations and run time information for the complete system.

The VMS must be capable of running a pair of similarly configured Database Servers in a hot backup configuration where at any point in time, one is the acting Primary and the other is acting as the Hot Backup. The backup Database Server shall be continuously synchronized with the master Database Server to ensure that it is always up-to-date and ready for a fail-over, when required. The failover for Database Server should be seamless and should not affect recording of cameras.

It must be possible to remove one of the redundant systems for maintenance without interrupting operation, and upon its reinstatement, automatically re-synchronize the databases, again without interruption to system operation.

The VMS shall support Primary and Backup Recording Servers allowing N: 1 to N: N redundancy as per BOQ. The failover and fail back mechanism between Preferred and Backup Camera Servers shall be configurable and support both automatic and manual operation. The failover process for Recording Server should not take more than 10 sec.

Concurrent Web Clients and Console Stations

The VMS shall provide Internet Explorer Clients for users other than Operators in Command & Control Room. These clients will be used for viewing of cameras by Security Officers and other authorized users other than in Command & Control Room. Incident and alarm responses are not required for these clients.

The VMS shall provide a professional level Surveillance Console interface for control room operators. Its primary role shall be to meet the operational requirements related to surveillance.

Operational Features of VMS

The VMS console shall have a Navigation Pane that include separate tabs to display available cameras, Views, groups and locations available to the operator based on their security settings. It shall include a Multi-level camera tree up to at least 5 layers deep with built-in filter search capability. It shall support

user defined logical groups.

The VMS shall have flexible workspace with simultaneous display of Live and Recorded video from the same or different cameras. Information describing the camera and associated video shall be shown in the tile including camera name, camera number, camera health status and whether the camera is currently recording, replaying video, paused or playing live video.

The VMS shall have Wild-Card search feature for cameras in Camera Tree and Groups.

The VMS console shall have a timeline control to display and play back recorded video for one or more cameras. Playback shall be possible on 1 or more cameras simultaneously for all cameras currently displayed in the Video Workspace.

The Timeline toolbar shall include Play, Pause, Snapshot, Fast Rewind (up to 1024x), Frame Rewind, Fast Forward (up to 1024x), Frame Forward, Jump Back, Motion Search and Calendar Control as standard features.

The timeline will also have zooming and scrubbing feature for easy analysis of recorded videos.

The VMS console shall have Motion Search feature that allows searching for areas of motion in recorded video. The Motion Search feature shall provide the ability to define a region of interest for each camera currently included in the timeline. The region of interest will be displayed on the camera image in the Video Workspace and each shall be separately configurable.

The VMS console shall provide a visual location for cameras that have recently been viewed by the operator. Cameras displayed in this location shall be represented by a live view image from the camera at reduced frame rate for easy reference.

It shall be possible to minimize each individual element of the Surveillance Console to maximize the use of the screen for video display.

The VMS shall support Snapshot feature, whereby on the click of a button operator shall captures the current frame of video and saves it as a bitmap image. This shall be available when viewing both live video and recorded video.

The VMS shall support Sequencing in Views, whereby the pre-sets of PTZ cameras as well as fixed cameras are cycled on a timed basis, within a single view or within the view port of a multiple camera view.

The VMS shall support Image Blocking preventing unauthorized operators from viewing live or recorded video when a specific class of operator takes control of a camera, thus helping to prevent potential collaboration between operators and suspects.

Mobile Client for Video

The VMS shall have integrated Mobile clients to view the cameras from the Smart mobile phones. The mobile application shall support iOS/ Android mobile OS.

Video shall be streamed at reduced frame rates and increased compression in case of insufficient network bandwidth. When sufficient network bandwidth becomes available video quality is automatically restored.

Mobile client shall have a navigation pane to select the cameras, locations and groups of cameras.

Mobile client shall support min concurrent camera views in Smartphone device and concurrent camera views in tablet devices.

PTZ function shall be available in mobile app for the PTZ cameras. Selection of pre-sets in PTZ camera

shall also be available in mobile client

Mobile client shall display real time frame delivery statistics for a video stream as an overlay on the video.

Bi-Directional Audio Support

The VMS shall support Bi-directional Audio providing a simple and inexpensive IP Intercom solution utilizing the existing network camera.

Edge Recording and Backfill

The VMS shall support edge recording of video on SD card inside the camera in case of network connectivity between camera and VMS is down. The VMS shall support restoration of edge recorded video in the VMS storage once the network connectivity between camera and VMS is up.

Digitally Signed Export of Camera Videos

The VMS shall support export of video for evidentiary purposes. It shall be possible to select the portion of video required and export only that portion in Windows Media Format and Native Format.

The VMS must support all exported recordings and exported audit logs to be digitally signed to prove authentication (origin of the recording and audit log) and integrity (exported recording and audit log have not been altered or tampered with).

The VMS system shall provide a default digital certificate for signing the exported recordings and audit logs. Customization shall also be provided to allow for the user to supply his/her own digital certificate.

Camera Temper Detection Feature

The VMS shall support temper detection for the connected cameras. Temper detection shall include changed field view, camera blurred and camera blinded.

PTZ Camera Control

The VMS shall support Area configuration to allow users to view specified cameras only.

The VMS shall support Control Level determining if a user is allowed to operate the PTZ controls for a camera.

The VMS shall support Control Reservation Period allowing if a particular user has controlled the camera no other user can control the camera until this reservation period has expired. Users with a higher security level shall be able to take control of the camera at any time.

Recording and Archiving of Camera Videos

The system has to provide sufficient storage to record all cameras for 30 days at 1080p, 25 fps, H.264 compression.

The VMS shall provide the ability to automatically archive all recordings. It shall be possible to automatically archive any type of recording at a preconfigured period after the recording has completed. It shall be possible to modify the automatic archive setting for each recording individually, as required.

The VMS shall support continuous background recording, scheduled recording, event activated recording and user activated recording for all connected cameras.

Search and Playback of recorded Videos

The VMS shall provide a simple search for all video recorded. The user selects the time indicator which shows a calendar and time line. The user selects the required search period. Once the time criterion is entered, the “search” is selected. Video recorded during the selected period will be returned by the

search.

The VMS shall provide an advanced search of recorded video. The search shall be based on recording time, camera and recording details. Wildcards shall be accepted for the Point ID, description, area, priority and value for alarm/event activated recordings.

Intelligent Video Analytics

The VMS shall have an integrated Intelligent Video Analytics system from same or other OEM.

Events from the Intelligent Video Analytics system shall be passed back to the VMS to start a recording and generate an alarm of configurable priority.

The Video Analytics System shall have following algorithms-

- person entered/exited restricted area
- person loitering in restricted area
- people converged or crowd gathering
- person trespassing - tripwire
- vehicle entered/exited restricted area
- vehicle parked in restricted area
- Video signal lost
- Camera defocused/ blurred
- Camera blinded
- Camera scene changed
- object left unattended
- object removed/ possible theft

Digital Zoom and Image Enhancement on live video

The VMS shall support the ability to digitally zoom into an area of the image as well as provide the ability to enhance the image viewed by adjusting the levels of brightness, contrast, noise levels and sharpness for both live and recorded video

Alarm Module

The VMS shall have integrated Alarm Module for video system and analytics alarms.

The Alarm module shall have Alarm and Event summary with Video Clip attached.

The Alarm module shall provide Audio Alert in different audio tones for Low, High and Urgent priority alarms

The Alarm module shall provide Alert in different colours for Low, High and Urgent priority alarms

The VMS shall have the feature to pop-up video from the camera on a dedicated alarm monitor in case of an alarm is generated in that camera. The cameras will be queued in sequence in case of multiple alarms till they are acknowledged by the operator.

The system shall have feature to send SMS alerts to predefined users in case of predefined priority alerts.

Diagnostic Module

The VMS shall provide diagnostic modules to assist with system health assessments and collection of diagnostic information.

The Diagnostics applications shall provide a unified user interface for running tests, recording system activity, collecting diagnostic information and viewing system log files.

It shall be possible to collect diagnostic information on all components of the VMS application including Database Servers, Recording Servers, Clients and network activities.

Enterprise Command Wall at Central Command Station:

The Video management System shall include an Enterprise Command Wall with touch interface at the Central Command Station. The Command Wall shall be a high definition multi touch screen with a minimum size of 60 inches.

The Enterprise Command Wall shall be used as a central resource for the review and discussion of operating activities and incident management.

The Enterprise Command Wall shall provide seamless integration with CCTV, Access Control, Fire

Alarm System and Perimeter Intrusion Detection System.

The Enterprise Command Wall shall have following features:

- Map navigation using multi-touch gestures - Pinch to zoom, Drag to pan
- Single touch navigation to area of interest
- Progressive Disclosure of map elements such as cameras, Access points and Sensor points.
- Contextual Incident notifications
- View incidents on map elements
- Contextual alarm notifications
- Alarms on map elements
- Enhanced Ontology to support Security and Fire
- Live video embedded in map, Camera Control (PTZ) using touch gestures, Video playback /Play/Pause /Fast forward/Rewind/Instant 30s rewind Controls

The Enterprise Command Wall shall be capable of all sub-systems at a single user interface to improve situational awareness and responsiveness particularly in abnormal situations.

Incident Management System:

The VMS shall have an integrated Alarms, Incident Management and Reporting module. The Incident Management System must have following features as minimum-

- Automatic creation of an incident based on a system detected condition
- Manual creation of incident
- Scheduled Incidents
- Customized Incident summary View
- Incident ownership and handover

- Execution of corresponding Standard Operating Procedures (SOPs)
- Authorized/Automated steps
- Import/Export of Standard Operating Procedures (SOPs)
- SOP Design User Interface
- Chronological comments
- Escalation- Manual/Time based
- Auto acknowledge of associated alarm
- Live video and Map orchestration
- Incident compliance Report
- Incident Summary Report

SPECIFICATION

1/2" colour camera of CMOS solid-state type

Resolution : at least 752 pixels (h) x 582 pixels (v)

Sensitivity : 0.5 lux for distinguishable picture, minimum

Geometric distortion: none (Lag and image distortion shall be minimised

Automatic white balance)

Signal to noise: 5 (6 dB minimum)

Light range : 1 min with auto-iris lenses, Auto black in reference to the darkest picture element Ten-digit insert text for camera recognition (minimum) 625 lines and 50 fields per second

SYNCHRONISATION:

- Line - Lock : Synchronises the camera to the power line zero crossing, for a roll-free vertical interval switching
- Genlock : Accepts composite video, composite sync, or H & V drivers for genlock operation
- Crystal – Lock : Internal crystal reference with full genlock capabilities to allow master synchronisation Lenses shall be with "C"-mounts.

VIDEO OUTPUT SIGNALS:

Standard video signal 1 Vpp at 75 Ohm asymmetrical

Two wires output 2 Vpp at 150 Ohm symmetrical

CAMERA LENSES

Lenses shall be with "C"-mounts.

Lenses for cameras mounted outside the tunnel : f/1.61 minimum range 11 - 100 mm or as approved

Lens for cameras inside the tunnel: f/1.4, 16 mm or as approved

The zoom shall be motor driven and remote-controlled. The lens shall have auto iris.

All other technical specifications as those of the camera are also valid for the lenses.

CAMERA HOUSING

The waterproof camera housing shall consist of highly corrosion resistant stainless steel material No.l.4404 .

System of protection : IP 67, IK 10

Input voltage: 240 V, 50 Hz

Window heater: 20 W, thermostat controlled, overheat limiting thermostat A sun shield for all cameras outside the tunnel shall be provided.

CAMERA MOUNTING BRACKET

The camera mounting brackets shall be used for mounting the cameras on the tunnel wall or on a column in the free field area. Also, the dome cameras shall be installed with this camera mounting bracket.

The material of the mounting bracket shall be of stainless steel with painting and shall be resistant against all environmental conditions. All fixing bolts shall be made of stainless steel No. 1.4404. Connection cables between each camera head assembly and the corresponding camera distribution box shall be fed down the pole internally.

3.14.9 Dome Camera

The dome cameras in the free field area shall monitor the portal areas of the Tunnel. The dome cameras shall be equipped with additional pan, tilt and zoom function (PTZ).

The electrical connection to the mounting shall be of waterproof fixed plug type.

The mechanism of the pan, tilt and zoom function shall not allow more than 1/3° free movement

(play) in any direction locked, a pan movement of 0° to 360° in horizontal plane and a tilt movement of +I- 90° minimum. Velocities of movement shall be approximately 6°/sec. for pan and approximately 3°/sec. for tilt.

The housing of the pan/tilt-system shall be waterproof; system of protection: IP 67, IK 10.

The exact location of the cameras, in the free field area shall be defined by the contractor in accordance with the Client on-site, depending on the landscape and the final prevailing conditions. It shall be guaranteed that, with the placement of the camera, the whole portal is visible.

The dome cameras shall be installed on therefore foreseen camera columns.

3.14.10 Optical Video and Date Transmission

The video signal of each camera shall be transmitted via an own fibre of a 9/125 µm single mode optical-fibre cable at the range of 1320 or 1550 nm from the camera to the Control Room.

The second fibre of this cable shall be used for data transmission (camera error, etc.). The third fibre shall be used for the control of the pan/tilt/zoom unit. The fourth fibre shall be spare.

Appropriate transmitters and receivers changing electrical video signals into optical signals and vice versa shall be provided.

Noise clearance: at least 50 dB

Video signal: FBAS 1 Vss at 75 Ohms (Functional behaviour assessment surveillance)

3.14.11 Optical Video Transmission Fixed Cameras

The video signal of each camera shall be transmitted via an own fibre of a 9/125 µm single mode

fibre-optic cable at the range of 1320 or 1550 nm from the camera to the multiplexer. A second fibre of this cable shall be used for data transmission (camera error/ etc.) Appropriate transmitters and receivers changing electrical video signals into optical signals and vice versa shall be provided.

Noise clearance: at least 50 dB

Video signal: FBAS 1 Vss at 75 Ohms

3.14.12 Camera Distribution Box

Each camera shall be connected with an own camera distribution box containing the necessary hardware to interface the power supply, control signals and the video signal as well as the electro-optical converter needed for transmission.

For dome cameras in the free field area, the distribution box also shall drive the pan/tilt facility and the motor zoom as ordered from the remote control.

Suitable terminations shall be provided for incoming and outgoing cables. The camera distribution boxes shall have a degree of protection of IP 67and all doors of the camera distribution boxes shall be protected by a suitable lock. Preferably all boxes shall be of identical size. If this is not possible due to physical constraint in the tunnel, not more than two standard box sizes shall be used, one for using inside the tunnel and one for the outside cameras. Construction details of the boxes and type of the lock shall be subject to the approval of the engineer. Details shall form part of this submission.

Protection devices of an approved design shall be connected to each signal line at each camera distribution box in such a way, that no damage occurs under fault conditions. The contractor shall state the surge protection capabilities of these limiting devices. These devices shall protect the equipment from main voltage (250 V) across a pair of signal lines or between a wire and ground and surges induced on the lines due to lightning etc.

Each outside camera distribution box shall be placed at a suitable point in that way, that the movements of the associated camera are clearly visible and can be easily checked. So the best mounting point would be the camera column / pole itself.

Camera distribution boxes for tunnel cameras shall be mounted near to the camera above the clear open space on the tunnel wall. The contractor shall state the maximum distance that is allowed between the camera and the camera distribution box.

Were column I pole-mounted camera distribution boxes are used, all cables to the cabinet shall be laid inside of the column I pole and further in conduits (in ground). The cables shall be easily maintain-able from ground.

3.14.13 Video Recording Unit

The Video Recording Unit shall be dimensioned for all cameras. The Video picture Recording Unit

consists of:

- Recording unit
- Storage
- Interface to Video-LAN

The analogue digital signal from the camera shall be transmitted to the camera distribution box / which shall convert the electrical signal into optical signal. Through optical fibre cable the video signal shall be transmitted to the multiplexer, which shall be situated in the Niches. From the Multiplexers, the video signals shall be sent via an optical fibre cable ring to the Control Room Building. In the Control Room

Building the signals shall be de-multiplexed and digitized by the Digital Video Codecs. After the video signals were digitized, they shall be stored on hard disks (RAID Units).

3.14.14 Video Detection Unit

The execution of the Video Detection Units shall be made with built in frames in the distribution cabinets.

The system must be able to detect pedestrians, and vehicles which are entering the tunnel.

The Video Detection Unit shall be able to evaluate the video images also in case of a reduced

illuminance and reduced contrast because of dust in the tunnel, etc.

DETECTING AT PORTALS

For detecting in the free field areas; one detection camera at each portal side shall be installed. With the Video Detection Unit it shall be possible to differentiate between pedestrians and vehicles. If a vehicle passes the tunnel, no alarm shall be triggered. If a human or a vehicle will enter the tunnel, an alarm shall be activated in the Control Centre and equipment Room . The CCTV images next to the alarm place shall be displayed on the CCTV alarm screens.

The detection of humans- never mind of standing or moving -shall be realized within 20 seconds.

DETECTING INSIDE TUNNEL:

For detecting purposes inside the tunnel tube, one camera each 150 m shall be installed (TV.D8, TV.D16, etc.). Those cameras shall have additionally to the common monitoring function, the functionality of detecting. If a vehicle passes the tunnel, no alarm shall be triggered.

The selected cameras inside the tunnel tube shall detect the velocity of the vehicles. The velocity measuring of the velocity shall be detected in a span between 5 and 100 km/h. Further if the velocity of the vehicle falls below an adjustable threshold value, information of the vehicle velocity must be handed over to SCADA and further to the Tunnel Ventilation System.

SOFTWARE & FUNCTIONS :-

- Suitable software for the control of the whole CCTV System, including picture switchboard and recording unit.
- Software to show every selected picture (Live pictures or pictures from the storage).
- Administration and configuration of the video network (Video-LAN)
- Tools for burning a CD and print the video pictures

INFRARED LED ILLUMINATORS SEMI-COVERT

Table 20: Electrical

Input Voltage	12 VDC ±10%; 24 VAC ±10%
Power Consumption	12 W maximum
Power Cord	2.5 m 12 or 24 VAC/DC

Table 21: General

Wavelength	850 nm/940 nm
Average Life (Lamp)	10 years
Construction	Aluminum body, stainless steel bracket, polycarbonate cover

Finish	Gray polyester powder coat
Operating Temperature	–40° to 50°C (–40° to 122°F)
Storage Temperature	–50° to 75°C (–58° to 167°F)
Weight	Unit Shipping 0.65 kg (1.40 lb) 0.80 kg (1.70 lb)

Table 22: Mechanical

Bracket Mounting	6.50 mm (0.25 in) hole diameter
Bracket Adjustment	2, 4 mm AF hex (M6 hex button head)

CERTIFICATIONS / PATENTS

• CE

• FCC, Class B

• UL/CUL Listed

• Meets IP66 / IP67 rating (environmental) and IK9 / IK10 (vandal resistant)

SUPPLIED ACCESSORIES

Units are factory-installed with a 35 x 10° Interchangeable Diffuser System (IDS); an additional 60 x 25° IDS is supplied.

Table 23: Recommended Accessories

RC - LED	Remote control for IR850, IR940, or WLED illuminators
LENSPKS - LED	Wide angle lens pack (80° and 120°) for IR850S-65, IR940S-30, or WLEDS-50
LBKT- LED	Mounting bracket for installing IR850, IR940, or WLED illuminators on walls or flat surfaces

Table 24: Integrated Command and Control

Standard	Built-in photocell for automatic on operation; LED Status Feedback System provides status on performance of the unit; photocell following output
Advanced	Accessed with remote control: – Power adjust from 20 to 100% – Photocell sensitivity adjust – Timer function (up to 30 minutes) – Telemetry control or remote dimming – LED Status Feedback System on/off – Restore factory default settings

3.14.15 Camera Column

The column shall be made of galvanized steel. Height above ground: 5 m

The exact location of the cameras, out of the tunnel, in the free field area shall be defined by the contractor in full accordance with the Client on-site, depending on the landscape and the final prevailing conditions. It shall be guaranteed, that with the placement of the camera, the whole portal is visible. The cabling shall run in the camera column. Furthermore, the columns shall have a lockable opening into the interior part of the column for cable installations. The opening shall be in a height, which is good reachable for the installation and maintenance people.

The column shall be fixed in foundations (the costs therefore shall be calculated into the price of the column). The column shall be connected to the earthing system by the contractor of Telecommunication.

Table 25: Technical Datasheet for CCTV Surveillance System (Bullet Camera)

Sr. No.	Parameters	Technical Specifications
3 MEGA PIXEL FIXED BOX CAMERA INSIDE THE TUNNEL		
1	Image Sensor	1/2.8" Progressive CMOS
2	Resolution	2048 x 1536
3	Minimum Illumination	Colour- 0.5 Lux @ 30IRE, Black & White- 0.05 Lux @ IRE
4	Lens	2.7mm to 12m Motorized Focus/Zoom Lens, F1.4
5	Back Light Compensation	BLC/ HLC
6	Motion Detection	On/ Off
7	Wide Dynamic Range	True WDR; 120 dB
8	Day/ Night	Auto/ Color/ BW, True Day/Night with ICR
9	Shutter Speed	1/10 to 1/10000 Sec
10	Noise Reduction	3D Noise Reduction (3DNR)
11	Signal to Noise Ratio	>=50dB, Back Light compensation ON/OFF selectable
12	IR Illumination	Built-in IR LEDs with up to 100m illumination
13	Privacy Mask	Mask up to 4 areas of a scene from view and record
14	Video Compression	H.264, MJPEG
15	Video Streams	Primary Stream: 1080p/ 720p/ D1 @ 25/30 fps Second Stream: D1/CIF @ 25/30 fps Third Stream: 720p/D1/CIF @ 25/30 fps
16	Network Protocols	IPv4/IPv6, HTTP, HTTPS, TCP/IP, UDP, UPnP, ICMP, IGMP, RTSP, RTP, SMTP, NTP, DHCP, DNS, PPPOE, DDNS, FTP, QOS, SNMP v2c/v3, LDAP (Client), NFS, RTCP, Bonjour
17	Security	User account and password protection
18	Supported open Protocol	ONVIF Profile S & G
19	Onboard Storage	Up to 128 GB Micro SD Card
20	Onboard Recording Type	Event trigger recording Continuous and scheduled recording Automatic recording when network fails
21	Event	Motion Detection, Video Tamper, Network Disconnection
22	Event Notification	Record in SD Card/ FTP, Relay Output, Snapshot
23	Alarm Input/ Output	2 Inputs, 1 Output
24	Power Source	12VDC ±10%, 24VAC ±10% 50Hz, PoE 1EEE 802.3af
25	Operating Temperature	-30°C to 60°C
26	Operating Humidity	20 to 80% RH (non-condensing)
27	Vandal Resistant	IK10
28	Ingress Protection	IP67
29	Regulatory	· CE – EN 55022 (Class A), EN 50130-4, EN 60950-1 · UL and cUL Listed – UL 60950-1, CAN/CSA – C22.2 No. 60950-1-07 · FCC (Class-A) – 47 CFR Part 15

Table 26: Technical Datasheet for Outdoor PTZ Camera at Tunnel Portals

Sr. No	Specification	Parameter
30X, 2Mpx High speed PTZ Dome Camera		
1	Image sensor	1/2.8-inch CMOS Sensor
2	Resolution	1920 X 1080 @ 60FPS
3	Dynamic Range	130db
4	White balance Range	2,500° to 8,000°K
5	Signal to Noise Ratio	50dB
6	Electronic Shutter Range	1 ~ 1/10,000 sec
7	Minimum Illumination	Color (200 ms) 0.08 lux ; Mono (200 ms) 0.015 lux
8	Imaging Technology	– Anti-Bloom Technology – 3D Noise Filtering – Enhanced Tone Mapping
9	Lens	4.3 mm (wide) ~ 129.0 mm (tele)
10	Optical Zoom	30X
11	Digital Zoom	12X
12	Horizontal Angle of View	55.4° (wide) ~ 2.9° (tele)
13	Iris Control	Auto iris
14	Active Noise Filtering	Yes
15	Presets	Min 256 preset
16	Tours	16
17	Preset Accuracy	Pan ±0.1°; Tilt ±0.05°
18	Auto flip feature	Yes
19	FPS	Camera should support 1920 X 1080 @ 60 fps
20	Video Streams	Both Primary and Secondary Stream at 1920 X 1080 @30FPS
21	Audio	Embedded with stream 1 and stream 2 G.711 A-law/G.711 U-law
22	Supported Protocols	TCP/IP, UDP/IP (Unicast, Multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4, IPv6, SNMP v2c/v3, QOS, HTTP, HTTPS, LDAP (client), SSH, SSL, SMTP, FTP, and 802.1x (EAP), GB28181
23	Built in Analytics	Object Counting , Abandoned object , Stopped Vehicle , Loitering Detection, Intrusion Detection , Wrong Direction , Camera sabotage .
24	Local Storage	Up to 32GB onboard Micro SD, SDHC Compatible
25	Analytics	Motion Detection and Camera Sabotage
26	Pan Movement	360° continuous pan rotation
27	Tilt Movement	+1° to –90°
28	Preset Speed	Pan 430°/sec; Tilt 200°/sec
29	Variable Manual Speed	Pan 0.1°/sec to 100°/sec Tilt 0.1°/sec to 50°/sec
30	Ports	RJ-45 connector for 100Base-TX; Auto MDI/MDI-X; Auto-negotiate/manual setting
31	Alarms	1 X inputs and 1 X output
32	Input Power	HPOE and 24 VAC and 24VDC; 50 VA
33	Operating Temperature	-40 to 50deg C
34	Operating Humidity	10% to 100% (noncondensing)
35	Housing	Aluminum Housing with Polycarbonate Bubble
36	Environmental Protection	Ingress for Water & Dust - IP66 / IP67 or higher
37	Vandal Proof Certification	IK10 or higher
38	Certificates	CE & FCC & UL CUL
39	ONVIF Compliant	ONVIF Profile S and Profile G conformant

3.15 Tunnel Radio

This covers the whole Tunnel Radio equipment of all the required equipment, material, accessories, and all labour.

The contractor shall provide a Tunnel Radio System, which guarantees a complete radio capability in the whole tunnel (even in the Accesses if any). Transmitter and receiver frequencies are required for road and emergency staff.

The realization of those shall be calculated into the prices of the Tunnel Radio System.

If any coordination is necessary, all coordination (even with the local fire brigade, rescue service, police, military, etc.) shall be included in the prices of the Tunnel Radio System.

Connection to control centre shall be (made by contractor of E & M).

The Signals of the Tunnel Radio System shall be transmitted from the LF-connecting network to the telecontrol system with TCP / IP cabling.

The whole Tunnel Radio System shall be as uniform as possible. Further on devices, which are easily to expand, and change shall be used.

The different parts of the Tunnels Radio System shall be arranged by easy changeable, pluggable units with very accessible operator's controls. Also, those parts of the radio system, which shall be maintained, shall be very accessible.

The required values of the tunnel radio system shall be kept, even by these environmental conditions:

- Relative air humidity 100 % till -20°C
- Ambient temperature by parts of the plant in heated rooms of 0°C - + 40°C
- Ambient temperature by parts of the plant, which are located elsewhere from -20°C -+50°C.
- Power supply voltage with a range of -15% - +10%.
- System frequency of 50 Hz ± 2 %

3.15.1 Scope Of Work

- Radio Service And Channels
- Amplifier
- Tunnel Antenna – Leaky Feeder Cable
- Antenna Column
- Free Field Antennas
- Cabling
- Desktop Station

3.15.2 Technical Specifications

Functionality of Tunnel Radio System

The operation stations of the Tunnel Radio System shall be provided in the control centre and in the equipment room buildings. The Tunnel Radio System also shall be integrated in the telecontrol system (SCADA).

The Tunnel Radio System shall provide an uninterruptable radio connection to the headquarters and operation centres for all vehicles and handheld device of the tunnel operator's staff, emergency staff

and vehicles, which passes the tunnel.

The communication of all channels in the tunnel shall be independently, simultaneous and failure free.

No disturbing interferences shall occur at the tunnel portals; there are crossovers from the free field radio area to the tunnel radio area.

The radio signals of the free field area shall be handed over with the free field antennas and shall be transferred to the radio central unit at the equipment Room control room.

The contractor shall measure the best location for the antenna column. The measurement protocol shall be handed over to the client. In accordance with the client, and the measurement, the exact location of the radio column shall be determined.

In case of breakage, malfunction information shall be indicated for every channel. This malfunction information shall be available in the tunnel radio cabinets as potential free two way contacts. Also malfunction information of the tunnel antenna monitoring, and the malfunctions of their power supply units shall be indicated at SCADA.

The Tunnel antenna system shall be wide band system; for the frequencies between 68 MHz and 470 MHz. The channels may have any frequencies, which are in this frequency band.

An enlarging of additional channels in the Tunnel Radio System shall be easily, and without any adjusting operations to do. Also, a changing of frequencies, at already existing channels in the system, may be done as easily as the enlargement. The changing shall be done without intervention of installed transmitting system in the tunnel. Only in the Equipment Room / control room the equipment shall be adjustable. The changing of frequencies shall be able with common maintenance tools and measuring devices.

The transmitting of the individual channels must not be influenced by each other.

The antennas in the free field area shall be situated on the column. It shall be a tubular column and situated in location, depending on the best receiving frequencies. These antennas shall be directional antennas, which shall be directed to the respective bases and relay stations.

To avoid a coupling between the free field antennas and the tunnel antenna, a decoupling, which is as high as possible (about 140db), shall be realized. if the decoupling of the individual channels is not enough, additional methods shall take place, to guarantee a fully functional Radio System. By the overtaking of the radio system by the client, the definitely decoupling of the radio system shall be verified metrological.

The Tunnel Radio System shall work automatically and without external support.

The contractor shall calculate the values of the system.

In the tunnel the transmitting probability of the radio signals shall be 98%.

The radio devices of the system shall have transmitting power between 1 W and 10 W. The mobile radio devices shall have the small transmitting power, as well, as a mini flexible antenna with a negative antenna gain.

All parts of the radio system shall be supplied redundantly. The power supply units shall be supplied by two separated voltages (Normal supply and UPS), and separately protected be miniature circuit breakers. A malfunction of a power supply shall be indicated.

Not even parts of radio system shall be supplied via HF – cables.

All housing of devices and distributors shall be connected to the earthing system (by the contractor of

tele communication).

3.15.3 Radio Service and Channels

The number of channels is determined, and their frequencies shall be determined in accordance with the Indian standards, client and the local requirements.

The equipment of the tunnel Radio System in the tunnel tube shall be placed in the (control) cabinets of the EM niches. The contractor shall avoid a collision with other equipment, placed in the EM niches.

IMPEDANCE OF TUNNEL RADIO SYSTEM

All components of the radio system in the free field area shall be executed 50 Ohm technology.

SURVEILLANCE OF CABLING

An appropriate surveillance system shall be erected (e.g. (audible) pilot signal). The signals shall be transferred as potential free contacts to tunnels control system.

The surveillance system shall contain at least following components:

- HF components for transmitting and receiving equipment, pilot signals, monitoring of cabling, inclusive all evaluation units
- Filter, equalizer, pre-amplifier, overvoltage protectors, test sockets, etc.
- Cable joints, system switches, inclusive cabling and terminals to the HF-connecting networks, and transferring of the message

Desktop stations shall be erected in the Control Centre and in the equipment Room. They are for enabling the tunnel operators speaking into the Tunnel Radio System. Also, the possibility to play messages shall be given at the desktop stations.

The beginning and ending of a message shall be indicated.

MEASUREMENT OF TUNNEL RADIO SYSTEM

- Design – Measurement:

Before the beginning of installing the tunnel radio system, the receiving relations at the tunnel portal / control room

- Takeover – measurement:

After finishing of installation work of the Tunnel Radio System, measurements shall be taken to guarantee the functionality on one hand, and the compliance of all standards on the other hand.

The contractor shall hand over a paper original as well as an electronic copy of the measurements.

3.15.4 Details Of Tunnel Radio System

a) **MALFUNCTION INFORMATION**

The malfunction information shall be potential free contacts and shall be available directly at the distributors. This malfunction information is necessary:

- General malfunction radio
- Malfunction optical transducer
- Malfunction for each channel
- Malfunction for each part of the leaky feeder cable

- Malfunction of every wide band amplifier (ON / OFF)
- Malfunction of connection to control centre
- Malfunction of complete tunnel radio system

If more malfunction information is required for full operation, they shall be calculated in the price of the Tunnel Radio System.

A monitoring of HF free field transmitters shall be provided. If one transmitter occupies a frequency for a long time, the connection will be disconnected automatically after 10 min.

b) **TECHNICAL REQUIREMENTS**

The devices of radio system shall not cause a sound pressure level in the working rooms, which is more than 50db(A).

All equipment of the Tunnel Radio System shall guarantee a simultaneous and disturbing free operation. It shall be verified, if the foreseen frequencies are free of intermodulation among themselves. If they are not free of it, corresponding actions shall take place.

In case of power loss, the device of the radio system shall not be damaged. If the power supply returns, the radio plant shall start and work automatically and self- acting again.

c) **OTHER REQUIREMENTS**

Measuring Sockets:

Measuring sockets with defined coupling shall be installed at the terminals of the tunnel antennas. Although a damping of the out-coupling is required, so that all in and output signals can be monitored by common measurement devices.

Measurement Technique:

The contractor shall deliver interface adapters and interface cables as well as according maintenance software inclusive manuals.

Coaxial Interconnection:

The HF-**C**oaxial interconnections shall correspond internally to the IEC-Standard types BNC,N and SMA.

Externally they shall correspond to IEC- Standard types BNC, N.3.5/9.5 and 4.1/9.5 and 7/16 and 3.5/12.

If the contractor uses other types, corresponding measuring tools shall be delivered.

Additionally, the HF-interconnections of the leaky feeder and coaxial transport cables shall be extensively silvered inside(at the contact areas) and have a protection against oxidation outside.

All coaxial interconnections which are stressed by weather or washing solutions, shall be protected against these influences by shrinkable tubes or else.

if there are shared connections, multi- terminals shall be used. if litz- wires shall be connected, wire end ferrules shall be used.

d) **CONTROLLING**

The UPS- supplied parts of the tunnels radio equipment shall work with zero-signal current principal. Other controlling equipment shall only work with this principle, if no substantiated reasons are against it. Controlling equipment, which may cause a transition-signal, shall work with the principle of

operating current.

potential free contacts are necessary for controlling. They shall be dimensioned for a capability of at least 0.2 A and 50 VDC.

The tunnel antenna shall not be used for transmitting of controlling signals.

e) **LOW FREQUENCY SIGNALS**

Standard level : 6 dBm at 600 ohm (±0.5dB)

(A) Output signals of radio receivers:

The standard level shall be reached at every interface with a modular frequency of 1 kHz and this hub:

- 1.62 kHz with phase modulation (PM)
- 3.0 kHz with frequency modulation (FM)

(B) INPUT SIGNALS at every interface:

With a frequency of 1 kHz and the defined standard level of the frequency hub at each transmitter:

- 1.62 kHz with phase modulation (PM)
- 3.0 kHz with frequency modulation (FM)

(C) The type of modulation shall be the same at all devices of the radio service. The input signals at every interface are:

- **Frequency response for outgoing signals**: The tolerance scheme according to CCITT / 5 shall be used.
- **Noise Voltage**: if there are no. LF - signals on the cable, the noise voltage shall be less than 46 dBm.
- **Equalization of wiring**: The plant shall be able to equalize wirings up to a 10km, so that a tolerance according to CCITT / 5 at the frequency response may be kept.
- **Feedback at 4 wire wiring:** An incoming signal with a level of 6 dBm and a frequency of 1 kHz shall not cause a signal in the outgoing wiring with a level higher than 46 dBm.

f) **PRECAUTIONS FOR FUNCTIONAL TEST**

For measurements of frequency and levelling at the high and low frequency parts of the radio devices, the contractor shall provide measuring and control sockets. It shall be possible, to take the measurements during operation.

At the control outputs, the values of the corresponding equalizations shall be indicated.

g) **GENERAL MECHANIC STRUCTURE**

All switches, pilot lamps, control sockets and other operator's controls shall be very accessible after opening of the distributor's door (and) the swing frame in the distributors.

The lettering of the radio plant shall be undetachable and unmistakable. The indication also shall be in accordance with the documentations.

The equipment, which is necessary for signal conditioning, shall be situated in the maintenance Niches and Cabinets in the tunnel tube and in the equipment room. They shall be located in cabinets.

3.15.5 Details And Specifications of Devices

FREE FIELD RADIO SYSTEM

The complete transmitting and receiving devices of the free field area radio system shall have an adjustable output power (1W -10 W). The minimum responsivity shall be 0.4µV for 20 dB S+N / N and measured with CCITT filter.

The free field area radio shall be designed in that way, that no disturbance may occur between the tunnel radio system and the free field area radio system.

The transmitting and receiving device shall be delivered with all cable coupling and connectors.

The device shall be situated in distributors in the equipment room building.

TUNNEL RADIO TRANSMITTER

The complete transmitting device shall have an output power, which guarantees the required minimum responsivity in the tunnel.

The contractor shall deliver the transmitting device shall including all cable couplings and connectors.

TUNNEL RADIO RECEIVER

The exact size of the frequency band depends on the used system (which shall be defined in accordance with the client). The radio receiving device shall support the services for those frequency bands.

The receiving device shall be delivered with all cable couplings and connectors.

COMBINER / DIVIDER

The interconnection of all signals to and from the tunnel antenna system shall occur in a corresponding connecting network with filters, directional couplers, isolators, separating filters, etc.

The changes of the frequencies at the connecting network shall be easily to do.

COMBINER TUNNEL TRANSMITTING PLANT

All Tunnel transmitters shall be interconnected by a combiner, so that the occurring intermodulation products are at least 60dB beneath the amplitude of the smallest useful-carrier. If the intermodulation signal meets a fundamental frequency of a tunnel receiver, this signal even not shall make the tunnel receivers operating.

Simultaneous operation of all radio service shall occur without influencing of each other.

The combiner shall be modular and easy to maintain and service. All tunnel radio transmitters of the radio plant shall be able to be combined and supplied into the radio transmitting system. This shall be able for all channels.

COMBINER / DIVIDER TUNNEL RECEIVING PLANT

The signals, which were received by the tunnel antennas, shall be divided by suitable actions to the responding receivers.

Intermodulation problems and disturbing interferences shall be avoided.

The divider shall be modular and easy to maintain. All HF-signals of the radio transmitting system plant shall be able for spreading them to the tunnel radio transmitters.

All necessary equipment and material for installing the combiners and dividers shall be included in the price of the tunnel radio system.

LOW FREQUENCY PREPARATION

The equipment for low Frequency Preparation shall be equipped as approved.

These preparations includes all necessary functions and equipment, which are required for faultless operation / combining and dividing of LF- signals, as eg combination, dividing, amplifier, mixing amplifiers, distribution amplifier, frequency response equalization, galvanic separation , overvoltage protection, etc.

Interfaces shall be foreseen for to:

- Transmitting and receiving devices
- Talk function at the desktop station in the equipment Room and the Control Centre

All equipment, which is necessary for those functions, shall be suitable equipped for the required channels.

WIDE BAND AMPLIFIER CONFIGURATIONS

The amplifiers are for terminal the leaky feeder cable and transmitting the transmitting and receiving signals. The amplifiers shall be made with the latest wide band technology (band width 68 MHz – 470 MHz) / as applicable.

The amplifier shall not cause disturbing signals by intermodulation, combination, etc. which:

- fall below a span of 8 dB in the connection of stationary station to mobile stations (span of usable carrier to unwanted noise signal in the suable wide band of as channel).
- fall below a safe clearance of 23 dB in the connection of mobile station to stationary stations (span between usable carrier to unwanted noise signal in the usable wide band of a channel).
- are less than 20 dB smaller than the smallest usable carrier in direction of stationary mobile station and an unusable signal.

The noise factor of the amplifier shall be not more than 8 dB.

The power supply occurs with 250V / 50Hz. An energy supply via the leaky feeder cable is not allowed.

The degree of protection of the amplifier shall be IP 54. The amplifiers shall be situated in the cabinets.

COUPLING UNIT

The coupling units are for electrical disconnection of the signals of the leaky feeder cable, which were supplied from both ends of the cable. But only in case of breakage, the coupling units shall be activated.

They shall be mounted directly on the ceiling of the tunnel between the both parts of the leaky feeder cable. The coupling units shall be covered with shrinking tubes, for protecting them against the tunnel atmosphere.

A low frequency sound signal, which is produced by a cable monitoring unit, shall be injected into the leaky feeder cable.

The telecontrol system uses this sound signal as indicator for the monitored parts of the leaky feeder cable. It indicates disconnections of the parts of the leaky feeder cable.

In case of a fracture (open circuit) or short circuit of one section of the leaky feeder cable, both parts of the leaky feeder cable shall be interconnected via the coupling unit.

In the coupling units are two coaxial relays, which couples the two sections of the leaky feeder cable. With this method also in the immediate area of the location of breakage, a radio operation shall be

possible. The cable monitoring unit generates the malfunction information of the corresponding segment.

HIGH FREQUENCY OPTOELECTRIC CONVERTER

HF opto electric converter, depending on the requirements, are used as transmitter or receiver. All equipment which is necessary for transmitting / receiving shall be included in the price of the Tunnel Radio System.

The HF optoelectric converters are necessary for the low noise transferring of HF signals over single mode fibres.

The converters shall be connected by SC terminals at patch field. The converters shall be able for installing in cabinets.

Technical requirements:

- Frequency Band: 50MHz -1GHz
- Optical Fibres: E9 /125
- Potential Free Malfunction Contact

DISTORTION FACTOR

The distortion factor over each feasible connection in the system shall be maximum 10%, if the HF level is high enough.

SYSTEM VALUES

The contractor shall calculate and measure all values of the radio system. Thereby also those frequencies, which are announced by the client, shall be proofed, if they are free of intermodulation.

If they are not free of intermodulation, the contractor shall arrange corresponding actions, to guarantee an operation, free of disturbing.

If, because of physical reasons, a mixed product may not be avoided, the contractor shall already point at it in the offer!

LOW FREQUENCY INTERFACES

For avoiding crosstalk on the LF cables, the cables of the radio plant shall be supplied with

-6 dBm maximum.

If there is no other prescription , the value of -6 dBm shall be a specified value for the handover of LF levels to foreign of feeders.

- **The output level of the radio plant shall be**: -6dBm at 600 Ohm (±0.5 dB)
- **If Speaking into the microphone**: At 1.07-1.1 Pa sound pressure and frequency of 1 kHz
- **Noise Voltage:** The noise voltage shall be less than -46dBm, if there are no LF signals on the cable.
- **Line Attenuation**: The radio plant shall be able to equalize cable lengths up to 10km, so that a frequency response with its tolerance after 1 / 5 CCITT may be kept.

Equipment For Plant- Inspection

Channel processing test sockets shall be foreseen at the LF interfaces of each channel processing unit. At these sockets, the actual levels can be measured. These measurements shall be made during operation

without disturbing the radio plant. For testing purpose, the ability to disconnect the LF course at the test sockets shall be given. So it is possible, to substitute the input signal of the plant with the test signal.

At the location of the handover from the radio central unit to the tunnel antenna system, test sockets are also necessary and shall be provided by the contractor. The signals from and to the tunnel antenna shall be decoupled by directional couplers. Therewith it shall be avoided, that the levels at the tunnel antenna are influenced , at the test sockets in case of a level measurement.

At the test outputs the corresponding operation levels shall be described.

The power supply of the whole radio plant shall occur with 250V, 50Hz by UPS.

For supplying the distributors of the Tunnel Radio System in the equipment Room, these voltages shall be provided: 1 x UPS and 1 x Normal supply for the test sockets.

The number of plug sockets depends on the number of devices, which shall be plugged in. These plug sockets shall be fused with own circuit breakers.

The power shall be controlled by these criteria:

- Triggering of main fuse in tunnel radio system distributor
- Loss of internal power supply (each voltage shall get an own information signal)
- The circuit breaker of the plug sockets shall not be controlled.

All signals shall be transmitted as potential free two way contacts to the tunnel control system.

For all parts of the radio plants (radio central unit and tunnel antenna system) which are situated at the equipment Room or EM niches / cabinets shall not be supplied by coaxial cables. Not even parts of the radio system shall be supplied by coaxial cables!

OVERVOLTAGE PROTECTION

Cables, which are coming from the free field area and run into the radio system into the tunnel or into the equipment room, shall be protected against overvoltage.

Low frequency cables shall be equipped with isolating transformers which have a voltage endurance up to 2.5 kV. This protection consists of a combined protection against longitudinal and transverse dimensioned in accordance with the respective operating voltage.

Overvoltage protection devices shall be installed by using plug connectors with suitable terminals at antenna cables in the free field area.

3.15.6 Tunnel Antenna - Leaky Feeder Cable

In the main tunnel tube a leaky feeder cable shall be used as antenna.

It consists of a coaxial structure with gaps or slots in it, with a regular span in its outer conductor for radiating or receiving signals along its entire length. Those gaps / slots ensure repeating coupling and decoupling of the energy. Furthermore, the leaky feeder cable shall have a flame retardant sheath as per IEC 332-1, 332-3/C, 754-2 and 1034.

The leaky feeder cable shall be executed for 50 ohm and a frequency band of 60 – 500 MHz.

The section of the leaky feeder cable shall be supplied with a wide band amplifier in a T- system (in the tunnel tube to the accesses) and in a L- system (from the equipment room to the tunnel portals).

For transmitting and receiving of the frequencies in the tunnel tube two leaky feeder cables shall be foreseen . One is for TX- signal and other one for RX -signal.

A disconnection of the leaky feeder cable shall not stop or interfere the operation of radio. Each amplifier of the Tunnel Radio System shall supply leaky feeders with a length of maximum 625 m to the left and right side. If the leaky feeder cables will be squeezed or pinched off, the radio connection from the amplifier to the sectioning point shall be sustained.

Depending on the installation site, the cable shall be mounted with cable holder, spacer, cable clamps. plain washers, and so on. The span between the fixings shall be 1.0m. Additionally to the common fixings, fire proofed cable clamps, made of stainless, shall be installed in an irregularly span (between 8 m and max.12 m).

The course of the leaky feeder cable shall be straight.

In those areas, where shotcrete is used in the tunnel, first a steel wire rope shall be fixed on the ceiling. Onto this steel wire rope the leaky feeder cables shall be fixed. Therewith the unevenness of the tunnel ceiling shall be levelled by using corresponding spacers, so that the steel wire rope runs straight. If required, the steel wire rope shall be included in the price of the leaky cable.

The instructions of the cable producer and the Indian standards, which accord to the installation of the leaky feeder cable shall be considered. Furthermore, actions for mechanical protection (e.g. guide roller) shall be used. It is not allowed, that the cable were pulled on the blank concrete, edges, etc.

The leaky feeder cable shall be mounted on the roof of the tunnel tube.

The leaky feeder cable, which will be used , shall be appropriate for using in tunnels and it shall operate independently of environment influences. it shall be resistant against the tunnel atmosphere (salt, temperature change and humidity), as well as mechanically and chemically stresses insensitive.

Terminal resistors, which are situated in the tunnel tube or accesses, shall be made moisture proof with shrink tubes. Those shrink tubes shall be coated with adhesive inside.

For transmitting of control signals, the leaky feeder cable shall not be used. The power supply must not run through via the leaky feeder cable.

The values of the cable , as line and coupling attenuation, shall be coordinated to the whole system. The functionality of the whole system shall be verified with calculations. These calculations shall be handed over to the client.

3.15.7 Antenna Column

All free field area antennas shall be situated on the antenna column. The height of this column shall be 25 m The column shall be fixed on a foundation and the material shall be made of galvanized steel tube. Further the antenna column shall include a safe climbing system with fall protection ladders.

Safe Climbing System

The safe climbing system with fall protection ladders (Y-spar ladders), made of light metal which suits to the antenna column. Also a leading system for the cabling along the column shall be covered at the lower part (the first 3 m on the column from the bottom) by a lockable covering, so that a climbing or damaging of unauthorized people will be avoided. The keys for the lockable covering shall be handed over to the client. The span between the footsteps shall be 500mm. The rung spacing shall be approx. 300 mm.

The safe climbing system also shall have a top and bottom end stop.

The safe climbing system shall be erected from the foundation of column up to masthead.

Additionally, to the safe climbing system with fall protection ladders a staff protective equipment shall be delivered. This staff protective equipment shall fit to the safe climbing system. it shall include at

least a safety harness and a quick adjusting manual rope grab with shock absorber. A vertical lifeline shall be connected to an anchor point.

The antenna column shall have a protection against lighting. Therefore, a lightning rod shall be provided, and the contractor shall connect all metallic parts with the earthing system.

All cables along the column shall be installed by C –section rails, which are separately fixed with cable clamps. The C – section rails shall be fixed permanently with spacer in a span of 50 cm.

The location of the antenna column shall be near the equipment room / control room. The exact location depends on the results of the measurement. The contractor shall deliver static calculations for the foundation, the column and the mounting structures of the column. The calculations shall be handed out to the client.

All costs , which are combined with the delivering and mounting (also for the foundation) of the column, shall be calculated into the price of the tunnel radio system. Also the total erection and the static calculations of the foundation and the antenna column shall be included in the price of the Tunnel Radio System.

3.15.8 Free Field Antennas

Directional antennas for the corresponding frequency band shall be provided and installed. The antennas shall be designed as a professional type inclusive of protection against icing.

- Frequency Band : 68 - 470 MHz
- Polarization : Vertical
- Antenna Gain : Approx.. 15 dBi

The mounting, alignment and installing shall be included in the price of the tunnel radio system.

3.15.9 Desktop Station

In the control rooms desks in the equipment Room and Control Centre Desktop Stations for the Tunnel Radio System shall be installed. The functionality consists of listening and talk function for the individual channels.

The Tunnel Radio Desktop Station shall be modular and for all Channels. It shall be easy to operate and maintain. It shall consist of a handset, “gooseneck microphone”, a loudspeaker and push button key pad with a control display. This display shall indicate the status of the various channels. The transmitting shall talk with the desktop station into the Tunnel Radio System. Also, the possibility to play text conserves shall be given. Different pre-recorded messages (amount and text message shall be defined in accordance with the client) shall be stored.

The Desktop Station for Tunnel Radio System also can be used for the public address system, if required.

All necessary equipment shall be included in the price of The Tunnel Radio System.

3.16 Emergency Call and Service Telephone System

3.16.1 General

According to IRC SP99 an emergency telephone system shall be installed for dispatching information regarding the occurrence of an accident to the Central Control and the Authorities, by person involved in or discovered the accident. Telephones shall be installed at intervals of 150 m, and in every relevant area of the tunnel (cross passages, Layby etc.). Emergency Pushbuttons to be activated by person involved in or discovered the accident shall be provided along the tunnel at intervals of 50 m.

An emergency telephone is a phone specifically provided for making calls to emergency services and is most often found in a place of special danger or where it is likely that there will only be a need to make emergency calls.

Whenever road user needs to contact control room in case of an accident or emergency, he will just lift the handset and call will be get connected to control room. Location from which user is dialling will also be indicated in control room. Voice over IP emergency telephone shall be used to communicate with the operation and maintenance centre. In these devices, a location identifier is also transmitted. The signalling and voice transmission is handled with the VoIP standard protocols, SIP / SDP (Session Initiation Protocol) and RTP (Realtime Transport Protocol). The driver initiates a call by lifting the receiver. Until the operator in the OMC answers the call, a message to wait and keep calm is being presented to the driver. Once the call is established, the driver and the operator can speak to each other. The call can be ended by the operator or the driver, who has to put down the receiver.

3.16.2 Scope of Work

The emergency and service telephone system includes:

- Intercom-Stations
- Telephone Central Unit
- Desktop station
- Emergency call stations
- Service telephone stations
- Cabling

All equipment shall be designed and manufactured for an operation 24 h each day.

3.16.3 Technical Specification-Emergency Call and Service Telephone System

The hardware of emergency call system shall be situated inside distribution panels.

The EPC / EM contractor shall guarantee that functionality for emergency system shall be sustained over the whole tunnel length. The emergency telephones shall provide a reliable voice connection to the control system in case of an incident. The emergency call stations shall be built up very user friendly. On one hand, the emergency telephones are needed to grant persons in the tunnel an immediate connection to the Control Centre in case of emergency. On the other hand, along the whole tunnel as well as in the equipment rooms are also service telephones situated. These telephones are required for maintenance staff. The emergency and service telephones shall be combined in one system. They use the same transmission cable, but for the emergency system an immediate connection to the Control Centre must be given. The emergency call has a higher priority than a service call! The optical fibre ring shall run over switches.

In these switches optical fibre electrical converters shall be included. All telephones, that means the emergency and the service telephones shall be connected directly to those switches via RJ 45 plug-in connections. The intercom stations (emergency call central unit master and slave) at the equipment Room / Control Centre shall manage the telephone calls of the whole tunnel. So, the intercom station at the Equipment Room / Control Centre also shall initiate the distribution of the calls. That means, if an emergency call arrives, the information shall be prepared for transferring it to the control system via TCP / IP, because the main operation and receipt of the emergency call Shall be at the Control Centre. But also, in the Equipment Room desktop call stations, visualization and operations shall be possible. The intercom station shall be the interface to the contractor of E&M. The contractor of E & M shall

take the information from the intercom station and shall transfer it to SCADA.

Furthermore, the tele control system shall enable the operation of these calls. That means, the emergency call's information shall be shown at the operator's screen and different functional processes shall be activated as described in Tunnel Control and Instrumentation System"

If a service telephone call arrives, the system shall check if this call is determined for the external (public) or internal telephone system. A distribution to the external (public) telephone system occurs via a Telephone Central Unit.

Generally the transmission of the whole emergency and service telephone system shall occur via intercom station at the Equipment Room / Control Centre. But if an optic fibre ring is interrupted, or a failure at any device is detected the system shall find an alternative route via the intercom station at the equipment Room / Control Centre. The required reaction and information transmission although shall be kept in permitted time. The operator in the Control Centre must be able to communicate with the person at the emergency telephone within a time of 3 sec. after the set of the emergency' call.

The contractor shall guarantee, that even after a long break down of the power supply / the IP addresses of the telephone call system are not gone lost (whether emergency call nor service telephone system).

The telephone system shall be free structure- programme- and scale-able.

If somebody presses the push buttons at the hands-free speaking device at the emergency callstation, immediately a visual and audible alarm shall be initiated at the equipment room and Control Room, and automatically all predefined functional processes shall be executed.

Apart from the information of speed also the information of failures shall be transmitted during an

emergency call. If a failure is detected (short circuit, interference voltage, etc.) the other parts of the system shall be untainted.

When the push button at the emergency call station is pressed, the voice connection -shall be initiated automatically to the tunnel operator at the Control Centre. As long as the emergency call is not answered by the operator, a pre-recorded text conserves shall be played (e.g. "your call is being answered soon, please stay calm" or similar). The exact messages shall be defined in accordance with the Client's instruction & requirement. Even the language (Hindi and or eventually English) shall be defined in accordance with the Client.

The voice communication between the operator and the fugitive shall be ended only if the operator disconnects.

Since the emergency call stations do not have a handset and that the tunnel is also used by maintenance personnel & others, it is necessary to ensure a good understand ability ("audio quality") although a hands-free speaking system is used. Also the volume shall be adjusted to the environment manually during initial operation.

The expandability for data transmitting shall be given. All push buttons and cabling shall be cyclic monitored. The zero-signal current also shall be monitored. If any failure is detected, fault signals shall be transmitted.

With the signals of emergency system no activation of any fire-programmes are allowed.

The maximum time, which may pass from the moment when an emergency call is set up till the operator answers the call, is 5 seconds.

The complete emergency and service call system shall be supplied by the UPS-System, so also in case of main power break-down the call system (especially emergency call system) keeps functioning.

The whole cabling from the distributor to the consumer shall be installed by the EPC contractor (Telecommunication).

3.16.4 Emergency Call Station (Voip)

Emergency telephones shall be a single-line set, mounted in the emergency call cabinet of the Niches (with E&M equipment's), Maintenance room panels and in the Emergency Call Cabinets at the portals and Accesses.

Emergency telephones shall have a hands-free-speaking system. The emergency call will be activated by the fugitives with a push button. The push button shall be integrated in the front panel of the hands-free speaking system, so that they are very easy to press in case of emergency.

Only speaker, microphone and the push button of the emergency call system shall be mounted in the front panel of the emergency cabinet, so in case of communication, it shall not be necessary to open the cabinet. The rest of the emergency equipment shall be situated inside of the cabinet.

A two-way voice communication is necessary, so that the people can tell the operators about their situation in the tunnel, as well as the operator can calm the fugitives down and give them important instructions. The emergency call stations shall be resistant against the tunnel pollution (exhaust gases, smoke, etc.) as well as against the humidity ("weather proof type", IP 65) inside the tunnel tubes.

3.16.5 Emergency Telephones (Ip-Telephones)

IP-telephones shall include a microphone, a loudspeaker, a push button, etc. The protection shall be at least IP 65, the power supply 24 V-42 V AC. Further they shall contain 2 potential outputs and 2 inputs for potential free contacts.

The values are valid for emergency and service telephones. Hands-free speaking system shall be connected directly with the switches, by a suitable device. Emergency call stations throughout the whole tunnel shall be indicated via illuminated signs, mounted on the tunnel wall above the emergency call station. Size of these signs shall be 470 mm x 470 mm. The symbols of the illuminated signs shall be visible in both tunnel directions. These signs also shall be supplied by the UPS. But the signs and their cabling will be erected by the contractor of E&M.

3.16.6 Intercom Stations

In the Control Room, master and slave intercom stations shall be placed. These stations execute the same function as a "Telephone System Server". On one hand these stations shall screen all calls of complete telephone system and on the other hand they are the interface to the transmission of the emergency calls to the tele control system and further on to the Control Centre. This transmission shall occur via TCP/IP. The service telephone calls shall be transmitted to the Telephone Central Unit.

The intercom stations shall be equipped with an interface to the tele control-system, so that automatic programmes can be initiated- for example, if an emergency call is initiated activated / the nearest camera will be connected / switched to the emergency video screen at the operators place automatically.

The intercom station shall be equipped with different modules. The modules are for preparing an interface to the SCADA, to the external (public) telephone system, desktop call station. Each module can operate no. of telephones.

The operating system of the emergency call system shall be realized with high-level language, but it also shall be object orientated. The operating system shall be stored in a Flash prom, so that a changing of e.g. EProms is not necessary for updating the operating system.

The following cards are required for the Intercom Station at the equipment Room / Control Room:

- Participant-cards TCP/IP for no. of participants
- Participant-card for connecting the desktop call station
- Network card ISDN with one basic terminal
- Network interfaces
- Digital audible coupling- and recording-card

The following cards are required for the Intercom Station at the equipment Room:

- Participant-cards 2-wired for no. of participants
- Participant-card for connecting the desktop call station
- Output card for relays, potential free
- Network card
- Network interfaces

Following features are required at the intercom stations:

- System Functions: 1-8 digit telephone numbers (also mixed), Frequency 300 Hz -16 kHz (analogue), feedback-protection, selective locking of features
- Voice Control: conversations in Open Duplex, Duplex or Simplex/ Volume separated adjustable for different functions
- General Conversation Functions: automatic conversation set-off for each participant; different pre-recorded messages (number and text shall be defined in accordance with the Client); discreet-function; locking of microphone function; "occupied"-function; priority call function; call-back-request; connecting with other participants; retrieving of last call; speed dial for all participants, or separated for each participant; priority function.
- Functions with additional Interfaces: adapting with telephone-dial-devices/ output contact for system functions
- Group-calls
- Teleconferences with any participants, and predefined participants
- Audible transmitting of alarm inclusive an alpha numeric display
- Desktop call station: selecting of a set-up between service- and emergency-calls; displaying wait-information after set-up of a call, wire-detection for telephone stations, output-contacts for service- and emergency calls/ group-contacts for calls, manual calls - switching, automatic call-switching of calls depending on time (night I day), texts for display, changing to communicate via more desktop call stations at same time
- Bidirectional communication to control system
- Tests of functionality: periodic tests by testing loudspeaker and microphones / monitoring of wiring of call stations and their inputs, monitoring of network

SCADA generally shall process all emergency calls.

In the Control Centre also a desktop call station shall be situated. Therewith the operator can communicate per voice with the people at the emergency call stations very easily. Also, a communication with the service telephones shall be possible with this desktop call stations. Those

desktop call stations shall be connected to the Intercom Stations in the Equipment Room and Control Centre.

Each emergency call causes a visible and an audible alarm in the Control Centre, so the operator is immediately warned. Furthermore, the exact location of the incoming emergency call shall be Visualized on the operator's screen (tele control screen).

The operator may switch between different calls and sets up a connection from the Control Centre to any emergency station.

The complete emergency call system also surveillances itself, so malfunctions shall be kept to a minimum. The system shall also check itself for interruptions of connections due to wire breakage or open circuits. If such a failure is detected, the failure shall automatically be notified & sent to the tele control-system, where maintenance messages for the operator will be generated. So, failures will instantly be detected and can be repaired rapidly.

A further function of the Intercom Station regarding to the Service Telephone System, is to provide a connection from the internal service telephone system to the external (public) telecom system with the Telephone Central Unit. The intercom station transmits the calls to the Telephone Central Unit. There it will be prepared and transmitted to the external (public) telecom system.

3.16.7 Voice Recorder

A voice recording system shall be linked with the Intercom Station in the Control Room Building. There all emergency calls (not the service telephone calls) shall be recorded and stored automatically. Since ·it is required to store the emergency conversations this digital voice recorder shall be able to record all emergency calls simultaneous. Also, the possibility to hear the calls to a later time again must be given.

Table 27: Technical Datasheet of Voice Recorder

Frequency	20-6800 Hz
Distortion factor	0.2 %
Interference voltage span	-70 dB
Maximum possible storage time	360 seconds for each emergency
Call Hard disc storage for voice recording	80MB
Resolution	12 Bit linear
Recess frequency	16kHz
Output	0.2-2V/200 Ohm

3.16.8 Desktop Call Stations

The handling of emergency and service telephone calls by the operator shall occur via a desktop call station. With this station, the conversations shall be administrated, the inputs displayed and the outputs shall be controlled. The system of the desktop call station has to build up fully VoIP-digital and connected with corresponding interfaces to the intercom station.

This desktop station shall include a loudspeaker, a "gooseneck-microphone" and a keyboard with functional keys for talking, clearing, volume, etc. The possibility for digital monitoring of loudspeaker and microphone of the desktop call station shall be given. The display shall have a suitable resolution and number of rows and signs.

The individual desktop call stations shall have the possibility to operate parallel. The individual functions of the desktop call stations shall be able to be combined with each other. Also, the sequences of the incidents shall be displayed. The incidents have to cause an audible signal at the desktop station. A failure-key shall check all functions of the desktop call station. The individual function keys shall have status. LEDs.

All executed control functions of the desktop stations shall be transferred to the intercom station. The Desktop station shall be supplied by intercom station-with signals.

3.16.9 Service Telephone System

The Service Telephone System shall include telephones at the equipment room/ Substation/ control room. These telephones shall provide a possibility for voice communication for the maintenance staff. Because the service telephone and the emergency call system are combined, it shall be guaranteed, that the priority always shall be by the emergency call.

The service calls do not have to be recorded and stored like the emergency calls.

The Service Telephone System also shall have an outline to the external (public) telecom system (this outline will be erected by others, but the module therefore shall be provided by the EPC /EM contractor of Telecommunication System) .

The system shall guarantee that calls from the substations can communicate directly together without exchanging through the central unit. This means the possibility of direct connection among each other shall be given. The transmitting of the service telephone calls to the external outline shall occur by a "Telephone Central Unit". This connecting equipment shall distribute the telephone calls.

Additionally, the possibility to dial from the substations through the outline to external telecom system is required. But for every substation this function shall be separately adjustable (locked I unblocked).

The functions are also required:

- Pick up of an internal or external call from every substation
- Call diversion to every substation
- Conference call
- Call diversion in the night to a certain telephone, or a certain outline.
- Blocking of out callings
- Creation of authorization levels (max. 3) for different kinds of callings (only internal callings, all callings, etc.)

3.16.10 Main Telephone Apparatus (Ip Telephones)

This telephone shall be positioned at the operator's desk. The handset shall be impact-resistant, made of plastic, coloured as required by the Client. Further it shall consist of a rectifier for hearing protection and a cord. But the operator even may communicate by the desktop call stations.

The telephone keyboard shall consist of phone buttons, speed dial keys, a display with at least 4 rows (as required to suit site requirements) and status LED next to the function keys.

This apparatus shall ring with a volume of at least 65 dB.

3.16.11 Telephone Sockets

The telephone sockets shall be mounted on walls or in distribution panels. The sockets shall be RJ45 type. The housing shall be impact resistant, made of suitable material and the colour as required of the Client.

3.17 Public Address System

3.17.1 Design Requirements

SYSTEM DESIGN

The design for the Digital Public Address/Voice Alarm System should meet the user and system requirements below.

USER REQUIREMENTS

The broadcasting system uses the same device to play the emergency broadcast. It has an emergency call microphone in the fire control centre for evacuating the crowds in specific zones when accidence happens and a paging microphone in the broadcasting centre to broadcast announcements and search notices.

The broadcasting devices located in the broadcasting centre or the specified location according to the user's requirement. The placement of the devices should meet the operating environment requirement and save up floor space. The amplifier capacity should comply with national standards and be with redundancy. Meanwhile, the emergency broadcast can achieve the linkage of the adjacent layers. Users can select the layers to be linked.

SYSTEM DESIGN REQUIREMENTS

The global mature and advanced technologies are critical for designing the public address system and only the broadcasting system incorporating mature and industry-leading technology and high-technology products can ensure the intelligence for buildings.

In the system design, advanced concepts, technologies and methods need to be adopted; system structure, product designs and wiring easiness also need to be considered.

FUNCTIONALITY AND RELIABILITY

Besides the technical advancement mentioned above, functional design, system structure, system performance, manufacturing process and after-sales support are also important as to ensure the reliability and stability of the system operation, maximizing the mean error-free time.

A mature technical platform and the rigorous manufacturing process are the bases of functions' realization. During the runtime, system should be able to discover and eliminate all the functional faults in time. The core components can achieve auto backup. System administrators can easily access the failures and work logs.

SYSTEM FUNCTION

SYSTEM DESIGN COMPOSITION AND PRINCIPLE

The system has placed broadcasting devices in Tunnel. The distributed control device (DCS) is integrated with many functions and supports the connection via Ethernet. It has loudspeakers output circuits to connect the loudspeaker in zones and network connection interfaces to connect to network paging control panel via Ethernet. Each DCS can connect up to 4 amplifier channels. The device has integrated amplifier switching matrix to support the redundancy switching and the general dry contact input/output interface to connect the external audio sources and dry contact interface of the linkage fire system. It has a built-in 1G memory to store the audios such as digital voice messages and the alarm tone of the emergency broadcast. This device can operate independently without the PC. It encompasses the functions like the audio playing, zone control, fault monitoring, log recording, volume control and amplifier switchover.

The control device for the system is customized. It has the LCD touch screen for operations, like zone

selecting, calling, audio sourcing selecting, and emergency broadcast, monitoring and internal communication. The functions of the Programmable network paging console NPM can be configured using the configuration software.

KEY FEATURES

DISTRIBUTED CONTROL

This distributed design for the system is based on the tunnel profile to facilitate the connection of the loudspeakers in several nearby zones, which will make the control of the loudspeakers easier. The selected system devices should use the TCP/IP technologies and build on the standard network platform to ensure the extensibility, compatibility for multiple technology platforms and advancement of the system.

FAULTS DETECTION AND ISOLATION

The Faults detection function for the broadcasting system can automatically examine the host system, power amplifier, power source, communication, and detect the open circuit, short circuit and grounding fault to generate the fault alarm and log.

When the grounding fault or short circuit occurs, the amplifier or the main controller of the system should isolate the circuit to ensure the operation of the main devices and normal circuits.

SERVICE BROADCASTING

The paging microphone allows users to make paging and broadcast search notices by zone. The paging microphone has a colour LCD touch screen. Users can configure the functions directly on the screen. Users can select the zone and audio source, adjust the volume, and enable the emergency broadcast by pressing the button on it. Paging microphones can intercommunicate. 255 broadcast priorities levels available. When the connected distributed control unit is out of order, a paging microphone can continue the intercommunication with other microphones in the network and precede the remote broadcasting configuration on other control units.

TIME SYNCHRONIZATION

Within the system, the controller can specify any main device as the main time source or choose a third party system to be the time source. Other devices synchronize their time with the main time source to make sure the time is consistent in the system.

EMERGENCY BROADCAST

The broadcasting system can be linkage of the fire system to achieve the alarm function in the adjacent layers. The layers for linkage can be configured with the software as the requirements. Users can record the voice message for the emergency broadcast and save it in the host system. The emergency broadcast can start automatically (when linkage of the fire system) and manually. The broadcasting system has its own emergency microphone, which could be used to play emergency broadcasts and evacuate the crowds in specific zones.

AUTOMATIC AMPLIFIER SHIFT

The system has standby amplifiers. When a main amplifier fails to function, the standby amplifier replaces it automatically. After the main amplifier recovers, the system will use it instead of the standby amplifier in an automatic way.

BROADCAST RECORD

The DCS can record sufficient voice message (up to 1GB), and its contents can be customized. The voice message contains the emergency broadcasts for fires, such as evacuation and all-clear information,

which are played by the digital speech synthesis system automatically (linkage of the fire alarm system) or manually. Four languages for the voice message are available. Users can select one of the languages to record the information.

LOG

The system can record the device fault log and operation log. Users can search information in the logs using time, devices, operators and log types as search criteria.

POWER SOURCE FORCED SWITCHOVER

The key devices, like DCS and amplifiers, have main power source and 24V standby power source. When the main power source fails to function, the standby power source is responsible for the power supply.

DISTRIBUTED CALL STATION

The distributed call station can call the specified zones. The call station has remote control function, which can control emergency broadcast, zone audio sources and external devices.

AUTOMATIC VOLUME CONTROL

The volume of the system can adjust automatically responding to different levels of environment noise in the crowded areas.

LOCAL & REMOTE MONITORING

Users can monitor audio sources status via local distributed control units and remote call stations.

EMERGENCY BROADCAST - Emergency broadcast Requirement:

i. Forced Switchover (Auto/Manual): Once the emergency broadcast is triggered by a remote control microphone or other external devices (fire alarm system) the system will play the recorded voice message (alarm and evacuation information) for fire emergency or the information from the emergency microphone until the all-clear.

ii. The system will switch to emergency broadcast in 3 seconds.

iii. The signal tones and voice messages (alarm and evacuation information) of the Emergency broadcast system are stored on the voice storage flash or SD card, which will not be ageing or lost. Users can play them in all zones.

iv. Emergency broadcast system should have system testing function as a standard configuration. The testing for the system can enable the operator to ensure the normal operation for the system all the time. The testing of emergency broadcast should be enabled via the software instead of playing the actual emergency broadcasts and causing public's panic.

v. Emergency broadcast system should achieve the automatic amplifier shift. Once an amplifier fails to function, the standby amplifier replaces the breakdown amplifier automatically without changing the input and output circuits of the amplifier manually.

vi. Emergency broadcast system should have pre-recorded emergency broadcast messages. The system should be able to edit and record the alarm and evacuation message. The priorities of the emergency broadcast can be programmed. DCS should be with a PTT emergency microphone, with which operators can announce real-time evacuation notices when emergency happens.

vii. Users can listen to stored or audios about to play to avoid playback error message which may lead to crowd panic.

viii. Language kinds should meet the user's requirements. There should be spaces left for the tags to facilitate users to stick related prompts for management.

ix. System can automatically record voice messages sent by emergency microphone. Users can listen to and broadcast the voice message.

x. The linkage signals of the emergency broadcast uses the volt-free contact. All signals are from the fire control centre. The number of the cables is the same as the fire control centre number.

xi. Can achieve the linkage of the adjacent layers. Users can select the layers to be linked via software configuration.

xii. When system switches to fire alarm mode, fire floor plan will pop up in the operating interface, directly showing where the fire happens. Operators can select specific zones and activate the warning and evacuation broadcast on the operating panel.

xiii. The loudspeakers allow the 3-wire forced volume control switchover.

CIRCUIT DETECTION

It is able to detect every zone's status to ensure the working order of the circuits and report faults in time. When a short-circuit error takes place, the device isolates the zone where error happens to protect the amplifiers and to cut off its impact on other zones.

3.17.2 Functional Requirements

DEVICE SELECTION

The system should be based on the TCP/IP network technologies with high level of integration and flexible configuration to meet various requirements. It is designed for the emergency broadcast enabling fire emergency broadcast functions like automatic fire warning, voice message pre-setting, emergency calling, emergency call recording and circuit monitoring. The device is accordance with the Automatic Control System for Fire Protection (GB16806) and Standard EN 54-16, IS-11360

With public address and voice alarm system integrated into one, the system should solve the duplication of investment and security risks and other problems caused by two individual systems. The distributed intelligent systems should be capable of accessing the 10/100M Ethernet network and multiple audio sources from the network. It supports connections in the Ethernet and the networking for several other control systems to perform centralized and distributed management via software. This product should be suitable for medium-scale and large-scale requirements

TECHNICAL CHARACTERISTICS

HIGH INTEGRATION

The controller should be able to integrate audio source storage, network audio reception, voice broadcasting, audio matrix, volume control, and monitoring, troubleshooting and main/standby amplifier switch functions together.

SAFETY

The system should be GB16806/EN54-16 compliant and can work in severe environment. It can be used to broadcast in case of emergency to disperse and evacuate people. It is a great guarantee for people's life security

ETHERNET BASED EXTENSION

The central controller should be able to connect over the Ethernet without any external device. The configurable Network Paging Microphone could be placed anywhere in the Ethernet, which will enable

the following:

- The method of distributed installation can save the cost of wiring.
- If the band width is sufficient, it can use current internal network.
- Provide plentiful network audio sources.
- Centralized management of the system via system software.
- Control the local or global broadcasting by the manner of permissions.
- Easy to upgrade

MULTIPLE AUDIO SOURCES SUPPORT

The system supports the audio sources from emergency microphone, network audio, ancillary line input, build-in audio/music files and web microphones.

PRIORITIZED CONTROL

The system supports 255 priorities. Users can configure it in any way they want and realize all kinds of prioritized broadcasting controlling.

AUTOMATIC VOLUME CONTROL FUNCTION

In places of crowded people and loud noises, users can install a noise detector, which can help control the broadcasting volume automatically to ensure sound's intelligibility.

LOCAL AND NETWORK MONITORING FUNCTION

With the built-in loudspeaker of controller or Configurable Network Paging Console, users can monitor each zone's broadcasting. The monitoring volume can be adjusted.

TOUCH SCREEN

Programmable network paging console (NPM) is equipped with a touch screen. Users can operate on the touch screen to configure multi-zones settings without the need to extend hardware key modules, saving floor space on the desktop.

TROUBLE SHOOTING FEATURE

The ASD troubleshooting technology can support the system to automatically detect the failure of the main power, standby power, amplifier circuit, amplifier protection/power, software, communications and loudspeakers etc. It can also locate the failure for maintainers to repair or replace the fault units.

LOUDSPEAKER CIRCUIT DETECTION

The SIM loudspeaker circuit detecting technology helps monitor loudspeaker circuits' statuses. When short-circuit or open-circuit faults are found, the device will send a warning automatically. The software can display all the circuit faults for maintenance's convenience. Usually a loudspeaker's short-circuit fault will activate the amplifier protection, affecting the working order in other zones. SIM solves this problem by automatically isolate the short-circuited zone where fault is found.

AUTO-BACKUP

Risk Free auto-backup technology focuses on realizing the main units', including servers' and amplifiers', backup and switchover functions. A server machine is paired up with a standby one, while a standby amplifier can serve as the backup machine of one, two or three main amplifiers. When faults are detected on the main machines, the system will switch over to the standby one.

INPUT/OUTPUT TRIGGERING

This system has input/output interfaces which can be triggered by dry contacts. Engineer staffs can configure the contact input to achieve the broadcasting control by the external device (linkage of the fire system). The contact output can be used to control the external devices for the volume, forced switchover and so on. The contact output interface can be linked of the broadcasting operations.

VOICE RECORDING

Besides in the system server, the controller should have 1GB solid-state storage to store the alarm voice, service voice and other audio files. Users need to upload the audio files to the device using the specified configuration software.

VOICE ALARM

This system is designed in accordance with the EN54-16 Standard and national standard GB16806. It is full featured for the fire alarm. When the fire occurs, the system will play the pre-set voice information. Then it can play the evacuation information for the zones with fires and the fire alarms for the nearby zones. The system can set several kinds of language for voice information, which can be played using the operation panel.

ONE CLICK TECHNOLOGY

To increase operation's convenience, One Click technology is developed with which broadcasting can be started by clicking only one key. The operation shortcut can be configured with system management software and network paging console.

MULTICHANNEL DIGITAL POWER AMPLIFIER

Multi-channel digital power amplifiers with CLASS-D technology design should be used in the system. Its output efficiency is more than 80%, which can reduce the power costs. Besides low power consumption, it is small in size. In this case, several amplifiers can be put in the same chassis to save the space. This kind of power amplifier has the features as below:

i. CLASS-D Amplifier saves the energy with high efficiency.
ii. Channel number can be 1, 2 or 4
iii. 100V or 70V output is used for each channel.
iv. Support balanced input or unbalanced audio input mode.
v. Cooling mode is forced air-cooling mode.
vi. Able to limit output voltage automatically.

FLEXIBLE CONFIGURATION

This system allows users to customize the configurations flexibly using the specific software. The engineering technicians and maintainers can configure the built-in audio sources, keys' functions, troubleshooting, audio source play modes, broadcasting priorities and contact input/output and other customized operations the One Click functions. The configuration software for this system is used to configure the hardware. The default configuration for the device contains only the basic functions. Users need to work on each setting, including basic parameters, troubleshooting, broadcast pre-set and key events and so forth.

SYSTEM MANAGEMENT SOFTWARE

The system management software can run on the Windows XP/Windows Vista/ Windows 10 or latest operation system. It can communicate with the system via the Ethernet. The operation is as simple as

below:

SYSTEM CONFIGURATION

- Configure the components and functions of the system management software.
- Configure the devices for the server.
- Configure the electronic map or operation interface.
- Configure audio sources and pre-set broadcasting operations.
- Drag the maps, icons and buttons to modify the layout on the server operation interface.
- Configure the managing scope and authorities for software on the client end.

USER MANAGEMENT

It can add, edit and delete users and manage access control of the users.

BROADCASTING CONTROL

The broadcasting control function allows users to manage all the broadcasting businesses and to manage the broadcasting management client ends.

SYSTEM STATE MANAGEMENT

The software can obtain broadcasting states of each device in the system. The buttons and icons representing devices or zones will be green when all functions are normal, and will turn red when fire occurs.

SYSTEM WARNING

System Warning Function allows for centralized management of device failure states in the system and recording the fault log automatically in the log module. When the system detects failure, the interface of the system management software will give out audible & visual alarm. Failed device unit is yellow. Users can accurately locate the failure unit using the interface of the system management software.

LOG MANAGEMENT

System can record and store all system operations histories and failure events for future analysis. Work log and failure log will be stored in separate memories and cannot be deleted manually. Only the logs of the latest one year will be stored. Users can query the logs according to time, workgroup, device, etc. and export the result logs.

VOICE SYNTHESIS

The system management software provides the interfaces for the third party voice synthesis software. It can convert the text words into voice for playing.

AUDIO MANAGEMENT

It allows users to perform centralized management of the audio files on the server, and to play them on the network. The audio management function can convert the audio source files in different format into the specified formats of the system. It can put the audio files to the specified broadcasting zones by configuring the pre-set broadcasting operation.

DEVICE DESCRIPTION

DIGITAL INTEGRATED SYSTEM MANAGER / CONTROLLER

The Digital Integrated System Manager is hereinafter referred to as the DCS.

The DCS is the control equipment in the system designed for extending the number of loudspeaker zones, and can support multiple sound source files for broadcasting. The system integrates with functions such as the sound source file storage system, the network audio broadcasting system, the loudspeaker zone control system, and the system for monitoring and diagnosing faults.

The DCS offers various features, which are listed below:

- Supports the manual selection of sound source files, zone buttons, and can be directly operated.
- Supports emergency microphone input for emergency broadcast in the event of, for example, a fire evacuation.
- Includes different indicator lights that identify system running states.
- Performs remote paging and broadcasting operation through the Configurable Network Paging Console (NPC).
- Includes 8 zone outputs. The number of zones can be configured through the software.
- 4 auxiliary inputs that can connect to external sound source equipment such as a CD player or tuner
- 4 auto volume control input ports that can set the phantom power supply and gain of each input.
- Auto loudspeaker circuits' short-circuit and open-circuit detection.
- A fuse protects the main power supply. In the case of a power supply short circuit within the DCS, the system automatically disconnects the main power supply.
- Built-in loudspeaker that can monitor the zones and sound sources, as well as monitor the network audio through the NPM / NPC.
- Contains 1GB of built-in flash memory that can store recorded voice files so as to full fill functions such as voice information broadcasting and voice synthesis
- Can simultaneously broadcast four types of sound sources, such as voice audio sources and external input or network audio sources.
- Can automatically record operation and fault logs, and can store up to 10,000 logs of each log type (operation and fault log types).
- Supports switching between the main and backup power amplifiers, and is capable of configuring the standby mode.
- Contains a self-test function.
- Supports automatic fault diagnosis.
- Supports broadcasting volume adjustment.
- Can define the zone and sound source functions. Button function description labels are also easy to install.
- An audio matrix enables broadcasting any audio source in any zone.
- Supports fire emergency broadcast mode so as to improve personnel evacuation efficiency in case of an emergency.
- Supports broadcasting designated recorded voice audio at a designated time so as to allow for unattended broadcasting.
- Capable of system extension through an Ethernet network.

600W HIGH EFFICIENCY POWER AMPLIFIER

The DA has the following main characteristics:

i. Energy-efficient CLASS-D power amplifier
ii. Contains 1/2/4 independent channels
iii. Each channel has 100V or 70V of output
iv. Supports balanced or unbalanced audio input
v. The DA is cooled through forced air-cooling
vi. Provide automatic re-settable over current, overload, overheating, overvoltage, under-voltage and DC protection

CONFIGURABLE NETWORK PAGING CONSOLE

The Configurable Network Paging Console is hereinafter referred to as the "NPM"

The network paging microphone (NPM) connects to the system and related devices to transmit audio and control information through the Ethernet network. The NPM is used for paging, controlling broadcasts, monitoring zones, and for using the bidirectional intercom function.

The NPM has the following characteristics:

i. Lightweight and innovative patent outward design. Support embedded desktop installation
ii. 4.3-inch colour LCD touch screen. Can display system status and be operated for zones and groups' division or global paging and broadcast control
iii. Simple and intuitive user interface
iv. Can connect with up to 20 units. Button numbers can be added via software configuration
v. Built-in monitor loudspeakers. Can utilize functions like zone monitoring and two-way intercom between stations.
vi. Digital audio processing to avoid acoustic fidelity distortion
vii. Can intercommunicate with other paging microphones and DCS in the network even when the connected DCS is not running
viii. 3 shortcut buttons: microphone talk mode switch, select all function and emergency broadcast
ix. Has one audio input and output port for playing BGM from a CD source or for recording an output.

VOLUME CONTROLLERS

Volume Controllers have the following four types: 6W, 30W, 60W and 120W respectively. The features are as follows:

i. Build-in 24V DC forced cut-off relay;
ii. 5 volume levels control;
iii. Applicable to 3-wire, 4-wire and 6-wire systems;
iv. Standard 86X86 installation base-shell.

LOUDSPEAKERS

Horn Loudspeaker

- 15W Horn Loudspeaker with IP66 protection

3.17.3 Emergency Voice/ Alarm Communication

The EVAC system shall contain all equipment required for audio, communication, signalling and supervisory functions. This shall include speaker zone indication, digital voice units, and microphone.

- Function: The EVAC system equipment shall perform following functions:
  - Operate as a supervised dual channel emergency voice communication system.
  - Operate as a two-way emergency communication system control centre.
  - Supervise condition of every connection circuit.
  - Audibly and visually annunciate any trouble condition of tone generators and digital voice units required for normal operation of the system.
  - Provide all-call activities through activation of a single control switch. Provide selectable zone calling.
  - Provide automatic, digitally recorded voice messages or field-programmed through the microphone.
- The system shall be modular in construction and shall be capable of being field programmable without requiring the return of any components to the manufacturer.
- The system and associated equipment shall be protected against unusually high voltage surges or line transients.

GENERAL

A Public Address System shall be provided to inform / warn maintenance and service staff and give instructions to people in abnormal conditions during incident. Therefore loudspeakers shall be installed every 60 m or as per drawing in the main tunnel tube. Operator terminals shall be in the Control Room Buildings at the portals or in the Control Centre.

SCOPE OF WORK

- Loudspeakers
- Amplifiers (wide-band amplifiers)
- Digital Sound Processing Unit
- E/O and O/E Converter
- Public Address Central Unit
- Cabling

TECHNICAL SPECIFICATION

The loudspeakers shall be fed by multi-range amplifiers, which shall be supplied with audio-data via electric loudspeaker cables from the Control Room Buildings and Niches. At the Control Room Building the central unit for the Public Address System shall be situated. This central unit shall be connected to the Control Centre by use of the tele control system. The central unit shall be used as interface to the tele control system. The contractor of E&M shall take the signals from there. At the Control Room Buildings / at the Control Centre, a control unit with a microphone for the announcements shall be situated. With these control units different circuits of loudspeakers can be switched on (e.g. all loudspeakers ON; only the loudspeakers near the accident ON; etc.) and the operator may control which

way of voice communication via the loudspeaker shall be (if the operator speaks directly into the loudspeakers, or if predefined text conserves shall be played).

The loudspeakers itself shall work with supply-voltage (from the amplifiers).

With the loudspeaker arrangement of 60 m distance between each other as per final design compliance, to design system and best acoustic shall be provided. But nevertheless, it is very critical to operate a Public Address System in a tunnel. So, the contractor has to guarantee a good understand ability and test the loud speaker system on a certain level of 'get the spoken words:

- even if no vehicle is in tunnel
- a vehicle runs into a tunnel (maybe 2 km away)
- a vehicle runs out of a tunnel
- a vehicle stands close/next to the passengers on the walkway

The dimension of the facility shall be determined in the way that one loudspeaker device, in a range of 1 to 4 kHz1 can reach a minimum sound pressure level of 110 dB(A) in a distance of 3 m / as approved.

LOUDSPEAKERS

Loudspeaker inclusive associated equipment as well as construction.

Technical Data:

Material: Aluminium

Degree of protection: IP 65

Nominal Power: 15 W

Nominal Voltage: 100 V

Frequency range: 200- 5000Hz

Sound pressure level: min. 114 dB(A)

AMPLIFIER

The amplifiers shall be solid state amplifiers in cabinet of industrial design. The amplifiers shall be installed in the cabinets to provide good access to the control elements, control lamps, test and monitoring sockets and cables. The amplifiers shall be marked clearly readable and permanent at the front side.

CHARACTERISTICS

Remote control with inrush current limiting

Wear-free digital level control

Switch-On-noise suppression

Status signals for operation, standby, test

LED control display

TECHNICAL DATA

Construction type: Cabinet / by EPC Contractor / as approved

Inputs: 4xAudio-Lf-IN

Power: 4x 100 W

Distortion factor: 0 / less than 1 %

Frequency range: 60-15000 Hz

Output: 70V/SO Ohm- 100 V/100 Ohm, with overload and short circuit

protection Overheat protection

DIGITAL SOUND PROCESSING UNIT

The signal preparation shall be realized with a 24 bit AID-converter and the internal signal preparation with 32 bit floating point signal processor, which can control each output channel, and as well as the total signals independently in gain and delay guides.

The digital sound processing unit shall be installed in the cabinets to provide good access to the control elements, control lamps, test and monitoring sockets and cables. The digital sound processing unit shall be marked clearly readable and permanent at the front side.

CHARACTERISTICS

Input with 1 x high-pass· and 1 x low-pass

Output with l x high-pass and 1 x low-pass

Status LEDs

Remote power on

Self-Monitoring

TECHNICAL DATA

Construction type: Cabinet

AID-Converting: minimum 16 bit

Sampling rate: 48 kHz

Inputs: 1 x Audio-LF-Input (XLR)

Input impedance: 10 k Ohm

Outputs: 4 x Audio-NF-Outputs (XLR)

Output impedance: 50 Ohm

Distortion factor: less than or equal 0.01 %

Frequency range:50 - 20000 Hz

E/O- O/E CONVERTER

The transmission of the low frequency signals from the loudspeaker central unit in the Control Room Building South to the optic fibre patch panels and further to the DSP units and amplifiers in the Niches and E & M niches shall be realized with Electrical/ Optical or Optical/ Electrical Converters.

TECHNICAL DATA E/O

Type: Cabinet / as approved

Input LF: LF signal

Output optical: 2x ST or SC for Multimode-optical fibre cable

Transmitted: up to 2000 m

Power supply:24VDC

TECHNICAL DATA O/E

Type: Cabinet

Output optical: 2x ST or SC for Multimode-optical fibre cable

Output LF: LF signal

Power supply:24VDC

PUBLIC ADDRESS CENTRAL UNIT

The Public Address Central Unit shall be installed with all necessary units (input modules, relay modules, control unit, etc.).

The necessary equipment shall be installed in the distribution cabinets to provide good access to the control elements, control lamps, test and monitoring sockets and cables. The equipment shall be marked clearly readable and permanent at the front side.

THE PUBLIC ADDRESS CENTRAL UNIT SHALL CONSIST OF FOLLOWING MODULES I EQUIPMENT

1x basis equipment with central control and operation unit

1x extension rack

1x digital voice recording unit

1x microphone I Line-In input module

1x communication terminal

1x relay module (blocking, error massages)

1x Line module (8x group lines, 1x connection to LAN)

INTERFACE TO TUNNEL RADIO SYSTEM

Low frequency range: 300 - 3400 Hz

Output level:6 dBm ± 2 dB

Input level: between:6 dBm and - 20 dBm

Impedance: 600 Ohm

Noise level: < - 46 dBm

Distortion factor: < 10 %

Furthermore a voice recording system shall be linked with the Public Address System. There predefined text conserves shall be stored. The different text contents of those conserves shall be in accordance with the Client.

The text conserves (messages) shall be retrieved by the tele control system or even by the Tunnel Radio System, so that it is possible to reach the voice messages even through the Tunnel Radio System.

DESKTOP STATION

The Desktop Station of the Tunnel Radio System also shall be used for the Public Address System.

LOUDSPEAKER CABLE

3 core 2.5 sqmm FRLS copper cable, as per Technical Data Sheet shall be used for connecting the loudspeakers. Depending on the used loudspeaker types by the customer, shall provide fitting system-cabling. The predefined values of the loudspeaker manufacturer shall be kept as per approved make.

OPTICAL FIBRE CABLE

The optical fibre cabling, which transfers the information from the Control Room Buildings to the EM-Niches shall be A-DF(ZN)2Y 12x12 E9/125 or as specified. This cable will be installed by the contractor of E&M.

The required fibres shall be used by the contractor of Telecommunication for the Public Address System (plug-in system - E2000 / as specified and approved).

Table 28: Technical Data Sheet for Digital Integrated System Manager / Controller

Parameter	Value
Power Supply	
Main power supply	~100-240V, 50/60Hz
Backup power supply	DC 21.5V-28.5V
Main power fuse	T2AL 250V
Max. input power	120 W
Rated power	50 W
Audio Input	
Auxiliary input	0dB
Input impedance	20 kΩ
Frequency response	60Hz-16KHz
PTT microphone input	-51dB
SNR	>85dB
Audio Output	
Audio output channels	4个
Output signal	0dB
Record output	0dB
AVC Input	
Channels	4个
Input signal	-50dB/0dB, configured by switch
Input impedance	20KΩ
Phantom power	DC 24V, configured by switch
Frequency response	60Hz-16KHz
SNR	>65dB
Loudspeaker Circuit	
Output channels	8, with circuit fault detection function
Max. output load power	250W
Trigger Input / Output	
Trigger input ports	8
Trigger output ports	8 (NO, NC and COM)
Max. working voltage	AC 250V/DC 30V
Max. working current	2.5A
Others	
Monitoring loudspeaker	10W/8W
Ethernet speed	10M/100M
Ethernet interface number	4
Storage space	1GB
Work Condition	

Parameter	Value
Humidity	< 95%, without condensing
Working temperature	-10°C~+55°C
Storage temperature	-40°C~+70°C
Specification	
Dimension (W×H×D)	482 mm×88 mm ×420mm
Mount dimension (W×H×D)	580mm×235mm ×552mm
Net weight	9.3Kg
Gross Weight	12.5 Kg

Table 29: Technical Datasheet for Power Amplifier

600W HIGH EFFICIENCY POWER AMPLIFIER	
Rated output power	Max. 600W
Main power supply voltage	AC 220V -15% - +10%50-60Hz
Backup power supply voltage	AC 220V -15% - +10%50-60Hz
Main power supply fuse	T10AL 250V
Loudspeaker output	100V / 70V
Frequency response	70-15KHz (+1dBto -3dB)
Input sensitivity and impedance	1.414VRMS& 20K ohm
Output voltage/impedance	100V/40ohms, 70V/19.6ohms
Signal-to-noise ratio (SNR)	>90dB
Nonlinear distortion	<0.1% (1KHz,1/3 rated output power)
Number of channels	2
Environment humidity	< 95%, without condensing
Working temperature	0 to +40°C
Storage temperature	-10°C to +55°C
Product dimensions (width × height × depth)	88mm × 440mm × 440mm

Table 30: Technical Datasheet for Paging Console

CONFIGURABLE NETWORK PAGING CONSOLE	
Power supply voltage	DC 24 V
AUX input	0 dB
AUX input impedance	10 KΩ
Frequency response	60 Hz – 16 KHz (local input signal)
Microphone input	-51 dB
Audio output	0 dB
Monitoring loudspeaker	2 W/8 Ω
Monitoring sound pressure level	Higher than 65 dB and lower than 115 dB (1 m in front of where the audio is being output)
Operating temperature	-10 °C to +55 °C
Storage temperature	-40 °C to +70 °C
Humidity	<95%, without condensation
VOLUME CONTROLLERS	
Rated power	6W/30W/60W/120W
Supply voltage	100V
Frequency response	50Hz~20KHz
Attenuation	5X2dB + off
Current consumption	20mA, 24V DC

Table 31: Technical Datasheet For Loudspeakers

HORN LOUDSPEAKERS	
Max Power	25 W
Rated Power	15 W
Power taps @ 100 V	15 W / 7.5 W
Sound Pressure Level at 6W/1W (1kHz, 1m)	110.3 dB / 98.5 dB
Frequency range (-10 dB)	500 Hz – 5 kHz
Dispersion Angle (1kHz / -6dB)	140°
Protection	IP 66
Rated Input Voltage	100 V / 70 V
Rated Impedance	500 Ω / 1 kΩ
Connection	Cable
Dimensions (diameter x height)	225 x 165 x 240 mm
Weight	1.38 kg
Color	White (RAL 9010)
Case Material	ABS

Table 32: List of Approved / Likely Sources

S. No.	Description of Items	Manufacturer's Name
	Electrical System	
1	Diesel operated Power Generating Engine	Cummins India Caterpillar Koel Green (IEC) Sterling & Wilson Sudhir Power Jackson Kirloskar
2	Power Transformer Oil filled (33kV / 11kV)	ABB BHEL Schneider Siemens Crompton Greaves Alstom (Areva) Voltamp Tesla Transformers Ltd. Sudhir Power
3	Distribution Transformer Dry Type (11kV / 433V)	ABB BHEL Schneider Siemens Crompton Greaves Kirloskar Alstom(Areva) Voltamp Tesla Transformers Ltd. Sudhir Power Legrand
4	Synchronizing Panel, Auxiliary Panel and Motor Control Centre	Tricolite Electrical Industries Jackson Engineers Limited Adlec Control System Schneider Sudhir Power Legrand L&T

S. No.	Description of Items	Manufacturer's Name
5	Power Distribution Panels and Distribution Boards	Schneider Siemens ABB Legrand Adlec L&T Tricolite
6	Automatic Transfer Switch	ASCO Cummins GE Power Control Socomec L&T
7	Air Circuit Breaker (3/4 Pole), MCCB, MCB, Switch Fuse Unit, HRC Fuse, RCCB, Aux. Contactor, Changeover Switch	Schneider Larsen & Toubro Siemens ABB Legrand
8	Potential Transformer, Current Transformer	AE L&T Siemens Schneider Crompton Greaves Kappa Matrix Pragati
9	Instrument Transformer	Precise G&M Matrix Legrand Schneider AE Kappa Pragati
10	Numeric type Protection Relay, Generator Protection Relay, Automatic Power Factor Correction Relay	L&T Siemens Schneider ABB Alstom GE
11	Indicating Lamps LED Type, Push Buttons	L&T Siemens Schneider ABB Legrand Rishabh
12	Overload Relays with built in Single Phase preventer	Schneider Larsen & Toubro Siemens Alstom Legrand ABB
13	Capacitor Control Relay, Power Capacitor Panel	EPCOS Legrand Schneider ABB

S. No.	Description of Items	Manufacturer's Name
		L&T Siemens Neptune
14	Electronic Digital Meters, Electro-Magnetic Meters	Trinity Conzerv system Pvt. Ltd. Automatic Electric ABB Siemens Schneider HPL Socomec L&T
15	Static Power Meter and Logger	Conzerv System Pvt. Ltd. Ducatti Neptune L&T
16	33kV, 11kV XLPE copper conductor armoured Cables	Universal Cables Havells KEI Polycab RPG Finolex Gloster
17	433V XLPE insulated e-beam FRLSLH Cables	RR Kabel Universal Cables KEI Havells Finolex Polycab
18	33kV, 11kV Cables with Fire Protection Cover as per specifications	KBS Cable Eastern Copperfields Trading Inc. Legrand MEM Schneider Havells Finolex Polycab
19	LT Joining / Tremination Kit, Cable Glands double Compression, Cable lugs	Raychem Brass Copper & Alloy Ltd Dowell's 3M SV Systems Xicon Comet M-Seal HMI Trinity Touch
20	PVC insulated copper conductor stranded flexible wires	Finolex R.R.Kabel KEI Havells RPG Polycab Grandley

S. No.	Description of Items	Manufacturer's Name
		Rallison CMI Delton
21	SS Conduit, PVC Conduits, Accessories for SS Conduit	BEC Polycab RMG Steels Pvt. Ltd. Vimco Steelkraft JPC Flexicon Plica India Pvt. Ltd. Trinity Touch
22	Timer	L&T Siemens Schneider Minilec
23	Emergency Power Supply-UPS	Schneider Eaton Numeric Emerson Delta
24	Ni-Cd batteries	Exide Standard Hitachi Amaron Amara Raja AMCO Quanta HBL Statcon Panasonic
25	Battery Charger	Volstat Caldyne Amco Hitachi Exide Panasonic
26	Cable Trays, Cable Ladders	Rico Steel Cablofil Legrand Obo-Bettermann SV Systems MEM Schneider
27	Bus Duct	Schneider Electric Legrand Siemens L&T C&S
28	MS Pipes, GI Pipes	Tata Steel Jindal APL Apollo Jindal Star
29	MS Pipe / GI Pipe Fittings	Jainsons Industries

S. No.	Description of Items	Manufacturer's Name
		Bharat Forge Pipeline Products Easyflex Unik Jindal Steel C-Brand
30	33 kV / 11 kV Insulating Mats	DL Miller & Co. Ltd Premiere Polyfilm Ltd. RMG Polyvinyl India Ltd. Duratuff AM Vinyl Jyoti Electromat Padmini Trinity Touch
FIRE DETECTION & FIRE FIGHTING SYSTEM		
31	Fire Alarm System	Futech Multisystems Samay Project Services Firepro Vimal Fire Groups
32	Soft Fire Wall, Fire Barrier	Siemens Listec Cushion S90 Hilti 3M
33	Linear Heat Sensor, Smoke Detector, Fire Detection Unit, Control & Monitor Modules, Main Control Panel, Manual Call Stations	Siemens Listec LST Safeguard Edwards Techfab System AP Sensing Samay Project Services Honeywell Vimal Fire Group
34	Split A.C., Air supply unit, Ventilation Ducts, Control Panels for Room Ventilation	Blue Box Daikin Blue Star Voltas Hitachi Stulz LG Mitsubishi Toshiba Samsung
TUNNEL AUTOMATION & SCADA SYSTEM		
35	PLC and SCADA System, FO cables and accessories, Cabinets, Cat-6 Armoured FTP, Cat-6 Patch Cord, Fiber Terminations	ABB Schneider Siemens L&T Rockwell Panduit Pyrotech

S. No.	Description of Items	Manufacturer's Name
		Siemens Honeywell Legrand Finolex Lapp Polycab Molex Aksh Cisco TC communications Tyco
36	Lighting Sensors, Control & Automation	Schneider Helver Lutron Honeywell Bajaj Siemens
LIGHTING, PA, CCTV SYSTEM		
37	Video Management Software, CCTV Camera,	PELCO BOSCH AXIS Philips Siemens Schneider
38	Workstation and Monitor	HP DELL HCL Siemens Honeywell Schneider
39	Speaker, Radio system, Voice Alarm controller, Amplifier, IP phones	Bosch Ateis SystemSensor Motorola Zenitel Commend Schneider
40	High pressure Sodium Lamp, Fluorescent Lamps	Philips Osram Bajaj
41	LED Lighting Fixtures	Philips Wipro Osram Bajaj Thorn Surya Syska
42	Door contact, Plug Socket, Telephone Socket, Switches	EAZ Legrand Havels Crabtree Hensel Schneider L&T

S. No.	Description of Items	Manufacturer's Name
		Spelsberg Cap electric BCH Clipsal Panasonic Hager ABB
Miscellaneous		
43	Junction Box	Hensel Legrand
44	Potential Equalization Connections, Galvanized Steel & Copper, Galvanized Steel Ropes	Pipe Life Meinhart Obo-Bettermann SY Systems Erico Easyflex JMV Indelec
45	Earthing System	JMV LPS Ltd Erico Furse(ABB) Indelec Obo-Bettermann Macronite
46	Industrial Switches, Routers, Media Converters, Uplink Modules & Modems	Cisco Schneider Siemens TCCommunications Tyco D-link HP Alcatel Allied Telesis
47	Enclosure, Rack & Patch Panels, Containment	Netgear Schneider APC Korenix Globe Indiana Profab Engineer Rittal Valrack
48	Paints	AsianPaints Berger ICI ShalimarPaints Johnson & Nicolas Nerolac
49	Mannhole Covers and frames, CILA Fittings	Raj Iron Foundry Kartar Valves and Fittings Neco Electrosteel
50	Lightning Protection System	JMV LPS Ltd

S. No.	Description of Items	Manufacturer's Name
		Furse Erico Indelec OBO-Bettermann
51	Signages	Illumination Enterprise 3M Local & Approved

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