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DIVISION - 5C OUTLINE SPECIFICATIONS

Highway illumination system, Electrical & HVAC

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TECHNICAL SPECIFICATIONS

CHAPTER -1

1. INTRODUCTION AND OBJECTIVE

1.1. GENERAL REQUIREMENT

The Contractor shall familiarize himself with all social, environmental, geological, climatic, and other prevailing conditions in the project area which in any way affect the performance of the Work. The Works shall include the design, manufacture, supply, delivery, construction. erection, installation, completion, testing, commissioning, defects rectification and maintenance.

The Contractor shall be responsible for the design, shipping to site, installation, setting into operation, testing and commissioning, training, documentation and warranty of complete MEP system for the MTHL project.

This Specification and the Drawings describe the minimum quality, quantity, performance parameters and workmanship to be provided. The Tenderer is invited to propose his most modern and reliable equipment and systems to achieve the same standards as the Drawings and Specifications.

The Contractor shall, however, undertake design, calculations, detailed engineering, schedules, construction reference drawings, shop drawings etc. and elaborate detail as required to meet adequately of design in an acceptable manner for approval.

The Contractor shall be responsible for obtaining all necessary approvals, operating licenses as may be required from statutory authorities and for the equipment supplies under this Contract. The costs of any tests associated with obtaining such approvals and licenses shall be deemed to be included.

The Contractor shall provide materials and equipment to recognized India and International standards. The equipment and components shall have CE and/or UL certification that the product complies with the essential requirements of the relevant health, safety and environmental protection legislation. Proof of standard shall be submitted to the Engineer.

The Project / Project Facilities under this contract shall conform to the minimum design requirements set out in this schedule. The Contractor shall carry out its own investigations and design the MEP system, in accordance with this Employer's Requirement.

This Technical Specification shall be read in conjunction with the General Specifications and the Drawings.

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1.2. DESIGN PROOF CHECK

The Contractor shall appoint Proof-Checking Agencies / Consultant(s) for Design Proof Check of the complete MEP system. The contractor shall submit the Credentials of Technical Expert(s) having Professional experience for approved by the Employer. This shall include deployment of Specialized Illumination expert who have complete acquaintance with design and evaluation of computer-based lighting design software and design parameter as require for outdoor and indoor lighting system.

The Proof-Checking Agencies /Consultant(s) as appointed by contractor shall validate Design parameters specified in the Employer requirement, issue certification Design and drawings as 'proof checked and validated' based on which the Engineer shall reviews and issue approvals. All designs should be checked and approved by the Proof Consultant as nominated by of contractors and further reviewed by the Engineer before execution.

The quality of various items shall be the responsibility of the Contractor. The Engineer shall, however, ensure and verify. On noticing any deficiency in the quality and or quantity, corrective measures as ordered by the Engineer shall be carried out by the Contractor at their own cost to the satisfaction of the Engineer.

The Contractor shall plan and implement the Quality Assurance Plan for the Project Road Bridge and associated buildings and finalize it in consultation with the Engineer at least one month prior to the commencement of the work.

1.3. DESIGN AND PERFORMANCE REQUIREMENTS

1.3.1. General

The design, manufacture, supply, installation, testing and commissioning of Electrical & Mechanical Works shall meet the design and performance requirements within the design environments specified in this Specification.

The Contractor shall execute the Works in two phases, the Design Phase and the Construction Phase. The Design Phase shall commence upon the date of issue of Letter of Acceptance. This phase shall include the preparation and submission of:

(a) the Preliminary Design

(b) the Definitive Design; and

(c) the Construction Reference Drawings.

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The Design Phase will be complete upon the issue of a Notice in respect of the comprehensive and complete Construction Reference Drawings Submission for the whole of the Permanent Works.

The Construction Phase for the whole or a part of the Permanent Works shall commence immediately upon the issue of a Notice by the Engineer/Employer in respect of the relevant Construction Reference Drawings Submission. Such Notice may be issued by the Engineer in respect of a Construction Reference Drawing Submission covering a major and distinctive part of the Permanent Works. However, construction shall not be commenced until the original negatives of the appropriate Working Drawings have been endorsed:

(a) by the Contractor as "Good for Construction"; and

(b) by the Engineer that he has no objections to the drawing.

The Construction Phase shall include the completion and submission of the Final Design and the preparation and submission of the As Built Drawings and other records as specified.

1.3.2. Design Environment

Mumbai experiences tropical wet and dry climate with high humidity and heavy rainfall during the monsoon season. The designs and plans for the works must take this into account. The Contractor shall obtain information on the climatic conditions in Mumbai, such as temperature, rain fall, wind, sunshine, relative humidity etc. from the Meteorological Department and/or other Authorities and shall make full provision for the effects of the local weather conditions in his planning, design programming and execution of the Works. An indicative data for reference as under:

Site Location	:	Mumbai /Navi Mumbai– Maharashtra
Geographic location	:	19 deg 7'. N; 72 deg 50'. E
Altitude	:	Mean sea level.
Seismic design	:	Seismic Zone III as per IS 1893
Relative Humidity	:	up to 95%
Summer Design Dry-Bulb	:	35.9 °C
Summer Coincident Wet-Bulb	:	22.7 °C
Winter Design Dry-Bulb	:	16.8 °C
Winter Design Wet-Bulb	:	10.9 °C
Maximum Ambient Temperature	:	50 deg.C

All the System, sub-system, equipment and materials shall be designed / provided to suit continuous operating conditions under ambient temperature of 50 degree Celsius and relative humidity up to 95% unless specified otherwise.

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1.3.3. Basic Design Philosophy and Requirements

Proven Design

a) The Contractor shall develop the design based on this specification and on proven and reliable Engineering Practices. The design details shall be submitted with technical data and calculations to the Engineer for review and approval.

b) The System, including all Sub-systems and Equipment shall be of proven design. The Sub-systems and Equipment proposed by the Contractor shall have been in use and have established their performance reliability on at least two projects under Service over a period of at least two years.

c) Where similar equipment or Sub-systems of a different rating are already proven in service, then the design shall be based on such equipment. In case these stipulations are not fulfilled, the Contractor shall furnish enough information to prove the basic soundness and reliability of the offered Sub-system. The design philosophy should meet the following criteria:

i. Application of state-of-the-art Technology
ii. Design life 30 years
iii. Minimum life cycle cost
iv. Low maintenance cost
v. Use of interchangeable, modular components
vi. Extensive and prominent labelling of parts, cables and wires
vii. High reliability,
viii. Low energy consumption
ix. System safety
x. Adequate redundancy and factor of safety as per standards.
xi. Use of fire-retardant materials,
xii. Environment friendly,
xiii. Adherence to operational performance requirements,
xiv. Specified values for reliability, availability, and maintainability (RAM) for equipment/Components etc.

1.4. DOCUMENTATION

The documentation during the detail design stages to be delivered by the Contractor shall include, but not be limited to, the following items:

1.4.1. Design Stage

a) Description of general design philosophy;

b) System reliability, availability, maintainability and safety evaluation reports;
c) Method of Statement of all system and Subsystems,
d) Automatic fault identification and isolation arrangement;
e) Determination of equipment ratings;
f) Determination of space requirement;
g) Design and proving protection devices / systems and its validation,
h) Type test reports for equipment selected;
i) Equipment Testing report of from accredited lab,
j) Detailed design drawings and reports;
k) Detailed interface reports and interfacing design drawings;
l) Hazard identification and control documentation.

1.4.2. Construction Stage

a) Construction and Installation Plan including site safety plan,
b) Factory Acceptance Test Plan for equipment;
c) Quality Plans.
d) Installation, operation and maintenance instruction of all equipment;
e) Operation and Maintenance Manuals;
f) Records and drawings of equipment installed;
g) All other records of construction, including hidden parts;
h) Site test report of equipment;
i) As built drawings including interface drawings; and
j) Other documentation as required, by the Employer's Representative.

1.5. STATUTORY REQUIREMENTS

a) The Contractor shall be fully responsible for obtaining relevant safety certificate or license or any other documents required from statutory authorities for commissioning the System. The renewal of the license/safety certificate during DLP will also be the responsibility of the contractor, if any.
b) The Contractor shall submit the relevant safety and clearance certificates obtained for each equipment from the statutory authorities to the Engineer.
c) The Contractor shall provide adequate signage and graphics as being statutory requirements, for the safe and proper utilization of each equipment, in adequate number exhibited at required locations.

1.6. CODE AND STANDARDS

All works related to the Project shall conform to the Indian Roads Congress (IRC) Standards, Codes, Guidelines and Special Publications as applicable to the latest Codes and Standards of the

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Bureau of Indian Standards (BIS), EUROCODES, AASHTO, ASTM, British Standards, National Highways and MoRT&H specifications, or any other international standards in that order of precedence. But where even these are silent, the construction and completion of the works shall conform to sound engineering practice with the approval of the Authority Engineer.

The codes, standards and specifications applicable for the design of the Project Bridge and Project Facilities shall be as under. The latest additions shall be adopted.

- NFPA 502: Standard for Road Tunnels, Bridges, and other limited access highways,
- European Directive 2004/EC/54 of the European Parliament and council Members,
- Indian Road Congress Code IRC 91,
- Ministry of Road Transport & Highways (MoRT&H) specifications.
- Central Electricity Authority Regulation 2010 with latest amendments.
- Indian Electricity Act 2003 with latest amendments.
- Standard and codes specified under subsequent section of these specification.

In case of any conflict between requirements, the more onerous one shall be followed, and other codes shall be referred in case, all the requirements are not covered in the first code. The relevant list of Indian standards and International standards are mentioned in the specifications shall always be considered first; in case the above standards are silent on the subject other standards shall be considered. Except where otherwise directed, all materials, workmanship, designs and assessments are to comply with standards mentioned above.

1.7. TESTING AND COMMISSIONING

1.7.1. Tests:

The Type Test, Factory Acceptance Test, Routine tests, any tests specifically demanded by the Purchaser and tests during manufacture shall be carried out on free of cost.

1.7.1.1 Type Test

The Tenderer shall provide details of any type and acceptance tests, which have been carried out on equipment offered, or any additional tests he recommends.

In general, certificates of previous type tests may be accepted at the discretion of the "Engineer/Engineer's Representative", if they are for identical equipment and conditions. Where appropriate, new and /or modified components to meet the requirements of this Specification shall be made available for type testing.

Type tests shall mean those tests, which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification and relevant Standards. These tests shall be carried out on samples prior to commencement of commercial production against the order. The Contractor shall indicate his schedule for carrying out these tests in the activity schedule. These tests shall have to be carried out at the Government Approved Testing Laboratory only in presence of the Purchaser's representative. Purchaser reserves the right to specify the name of the laboratory also, if any.

Contractor shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule. The Purchaser reserves the right to specify the name of the laboratory also, if any.

All applicable Type tests as per the relevant standards on equipment shall be carried out strictly as specified in the Specification and procedure of testing shall be submitted to "Engineer" for No Objection. Type Test should not be older than 5 years.

All the new suppliers, for the size offered or full lot, shall have to compulsorily carry out the Type Tests i.e. if the supplier has supplied one size of material to the Company in past and is having type test certificate.

In case of failure in any of the type test/s, the supplier is either required to modify the design of the material or repeat the type test three times successfully at his own expenses. The decision of the purchaser in this regard shall be final and binding. The Purchaser at its own desecration may also cancel the order at the risk and cost of the contractor, if the material fails twice successively in the Type Test.

1.7.1.2 Factory Acceptance Teat

Factory Acceptance Tests shall mean those tests, which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot. These tests shall be carried out at the manufacturer's works in presence of Purchaser's representative before the dispatch of the materials to the site.

1.7.1.3 Routine Test

Routine Tests shall mean those tests which are to be carried out on each material, equipment or assembly to check requirements which are likely to vary during production. These tests shall be carried out by the manufacturer on each material, equipment or assembly and shall have to furnish these reports to the Employers representative during his visit for acceptance.

Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the supplier to ensure the desired quality of the product to be supplied by him, including all Quality Control checks and Raw Materials testing.

All Routine & Acceptance tests and inspection of material shall be carried out at the place of manufacturer.

The manufacturer shall offer the Inspector (representing the purchaser) all reasonable facilities, free of charge at the time of Inspection.

The supplier shall prepare a prototype and offer the same for inspection of the material at his works and approval before taking up mass production and before dispatch.

The standards to which these tests will be performed including the procedures of the test are specified in subsequent chapter of this specification, or as mutually agreed to between the Contractor and the purchaser in the Quality Assurance Programmed.

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If required, the supplier shall also offer inspection of manufacturing painting and assembly processes and quality control system. If any material is not found in line with relevant specification the supplier shall carry out the modification and offer for re-inspection.

Inspection and acceptance shall not absolve the supplier of his responsibility to supply the material in accordance with the specifications.

For all Type and Acceptance tests, the acceptance values shall be the values guaranteed by the Contractor in the "Guaranteed Technical Particulars of his proposal or the acceptance value specified in this specification, whichever is more stringent for that particular test.

The Employer or Employer's Representative reserves the right to reject the material not confirming the relevant specifications.

1.7.2. Test Specification:

The Contractor shall submit for acceptance by the "Engineer/Engineer's Representative", test specifications for type tests, routine tests, tests on site, final acceptance tests and commissioning. The specifications shall detail the methods of conducting the tests, the tools and instruments used.

These test specifications shall include the design values of all quantities to be verified, with allowable tolerance or limits. Summary drawings or diagrams shall be included with the test specifications to show the dimensions and tolerances of all structural assemblies and sub-assemblies. In the case of welded fabrications, key diagrams giving all weld data shall be provided to enable systematic inspection to take place.

Verification of accuracy shall be required for all tools, apparatus, testing jigs, measuring instruments and "go" or "no go" gauges used for the purpose of routine tests.

All test instrument shall be calibrated not more than one year prior to their use. The Contractor shall submit calibration certificate or other documents for proof of Compliance.

All the Tests shall be carried out by the supplier at no extra cost to the Employer, (for any number of times, as may be required) at the Government Approved Laboratory or at the Laboratory specified by the Employer, at its own discretion.

The entire cost of testing for the type, acceptance routine tests and tests during manufacture, special tests etc. specified herein or in the relevant Standards shall be treated as included in the quoted unit price of equipment. The Tenderer shall bear cost on account of repeated tests, inclusive cost towards boarding, lodging and transportation for witnessing by the Employer Representative during witnessing tests.

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Supplier shall stand guarantee for five years from the date of supply towards design, materials, workmanship and quality of process / manufacturing of items under this contract.

Supplier shall provide Instruction Manuals covering erection & maintenance instruction and all relevant information & drawings with complete BOM pertaining to main equipment and list of complete set of accessories and tools required for erection and maintenance with each of the pillar boxes.

1.7.3. Test Report

Test reports shall be furnished in at least two (2) copies along with one original. One copy shall be returned duly certified by the Purchaser only after which the material already inspected i.e. the materials manufactured or selection of sample for type test, shall be dispatched on receipt of Dispatch Instructions from the Chief Residential Engineer for MTHL Project.

Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the purchaser's representative.

Test Certificates of test during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Purchaser.

1.8. SCOPE OF WORK

The following section establishes design criteria of mechanical & electrical systems for Roads, Bridges and associated buildings. The basis goal is to develop a safe, reliable, maintainable, energy efficient and economical Mechanical and Electrical system. The design of M&E services shall meet the following objectives:

- Provides the appropriate level of service and operation to contribute a safe environment for road users, local inhabitants, operators, maintenance staff, police and emergency services.
- Reduces Operational Risks, provide adequate visibility levels in all conditions always of the day and night and minimize whole life costs;
- Provide emergency response facilities in accordance with operational standards required by the authority; Incorporate mitigation measures from risk analysis as per EU directive.

The scope of Mechanical and Electrical system covers Design, Supply, installation/erection, testing and commissioning including operation, maintenance during defect liability period for a complete M&E System, but not limited to the following areas:

1.8.1. Electrical Works for Bridge

Table 0-1 Electrical Scope of Work for Bridge

Sr. No.	Description	Detailed Scope
	BEST Switching Station	

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Sr. No.	Description	Detailed Scope
1.	Power Supply Receiving source from BEST	Power demand application, Liasion with BEST for power Supply demand and associated work for Switching Station at Sewri including HT Metering Kiosk etc. The charges in terms Power demands, security deposit and fee as applicable including supervision charges etc. to be paid by the Employer to the BEST. The Employer shall, however, reimburse the amount to the contractor under Sub Head - Provisional Sum.
2.	Switching Station Design	Design, Seeking approval for Switching station building layout and associated equipment, HT Metering Kisok, SCADA system etc., procurement, supply, transportation, installation, testing & commissioning of Switching Station including all associated accessories in complete at Sewri in all respect with proper safety & security to meet the requirement stipulated by the BEST's Power Planning Team. The work to be supervised by BEST personnel on time to time basis. This shall also include supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra.
	MTHL Bridge and Buildings Substation	
3.	Compact Substations	Design, procurement, supply, transportation, installation, testing & commissioning of Compact Substations on the provided Substation platforms of various capacities across the Bridge. (location and Chainages are mentioned in the Employer's Requirement). This shall also include supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra.
4.	11kV HV Cables (E)	Design, procurement, supply, transportation, laying, installation, testing & commissioning of 11kV, 3 x 1Cx 240 Sqmm HV XLPE FR-LSH, Class-2 conductor Cu (E) Power Cable including associated Straight Through Joint and Termination to connect all the Compact substations on the bridge and buildings, as per the attached drawing. This shall include provision of Cable Tray / Ladder and Hangers etc. as required as per Employer's Requirement. All the fixtures and fittings should have seismic compliance. Note: This shall also include provision of Ladder and required support to lay 11 kV Cable along Box Girder from 11 kV Switching Station to the entry point of Box Girder at Sewri.
5.	1.1kV LV Cables	a. Design, procurement, supply, transportation, laying, installation, testing & commissioning of 1.1kV, 4x 1Cx 240/185/150/120/95 and 70 Sqmm Class-2 conductor, XLPE FR-LSH Al. Power Cable (as per the actual loads for feeder pillars and any other requirement). This shall include Straight Through Joint and Terminations and all associated etc. to feed LT Supply from the Compact substations all along the Bridge, as per the attached drawing. This shall include provision of Cable Tray / Ladder and Hangers etc. as required as per Employer's Requirement. All the fixtures and fittings should have seismic compliance.

Sr. No.	Description	Detailed Scope
		b. Design, procurement, supply, transportation, laying, installation, testing & commissioning of 1.1kV, 4Cx 25/35 Sqmm XLPE FR-LSH, Class-2 conductor, Cu Power Cable including associated terminations, joints and Junction Boxes etc. as required with each Light pole and ITS Pole to feed LT power for Lighting and power for ITS Equipment. This shall include provision of Cable Tray / Ladder suitable supports etc. as per Employer's Requirement and drawing. However, provision of 3 numbers 100 mm dia steel conduits in concrete of Crash barriers is being made by the respective Package contractor for Fibre cable and power Cables. c. Design, procurement, supply, transportation, laying, installation, testing & commissioning of 1.1kV, 4Cx 25/35/50/70 Sqmm, Class-2 conductor, XLPE FR-LSH Al. Power Cables as required as per design to meet load requirement from Substation / Feeder Pillar to feed various Distribution Boards like Girder lighting DB/ aesthetic lighting DB, event based lighting DB, Navigational, Vehicle charging, fire Fighting and ventilation fans etc. as applicable as per Employer's requirement and drawing. This shall include provision of Cable Tray / Ladder and Hangers etc. as required as per Employer's Requirement. All the fixtures and fittings should have seismic compliance.
6.	Earth Cables for Earthing & Lightning Protection	a. Design, procurement, supply, transportation, laying, installation, testing & commissioning of 1.1kV, 1Cx 240 Sqmm, flexible HR PVC insulated Al Class-2 conductor cable (for interconnection between Steel liner of the Pile Cap to Box Girder for body earthing & for interconnection between Steel liner of the Pile Cap to Crash Barrier cable tray for lightning Protection) with suitable clamps and support including termination, joints. The material, connections and joints etc. shall be rust proof. b. Design, procurement, supply, transportation, laying, installation, testing & commissioning of 1.1 kV, 1Cx 150/50/35/16 Sqmm, flexible bare Al Class-2 Conductor cables / wire (in Void of Box Girder and in Cable Tray along the Crash Barrier) with suitable clamps and support including termination, joints on existing Cable Tray / Ladder. The material, connections and joints etc. shall be rust proof. c. Design, procurement, supply, transportation, installation, testing & commissioning of 1.1 kV, 1Cx. 300 Sqmm, flexible HR PVC insulated Al Class-2 conductor cable for Lightning Protection Earthing between Pile steel liner and the bridge (Superstructure) including welded to liner by using additional steel plate as require as per Drawings. The provision shall be made at every 150mtr in marine area as well on the land portion.

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Sr. No.	Description	Detailed Scope
7.	Equipotential Earthing for all Poles, Panels, DBs and Junction Boxes etc. throughout the bridge	Supply, Installation, testing & commissioning of GI Strip of 32mmx6mm size / or equivalent conductor as require connecting Light / ITS Poles, Panels, DBs and Junction Boxes etc. for equipotential boding all along the bridge and Service Building. This shall include provision of redundant / duplicate earth connection as per standards.
6.	Fibre Cable	a. Design, procurement, supply, transportation, installation, testing & commissioning of 12 C Fibre Cable for SCADA/BMS Control and Monitoring System for HV Switching Station, Compact Substation, HV/LV Switchgears, RMU, etc. from Main Central Command Centre at Sewri and to make it operational etc. b. Design, procurement, supply, transportation, installation, testing & commissioning of 12 C Fibre Cable for SCADA/BMS for Lighting control and monitoring (ON/OFF/ FAILED status) across the Bridge. The OFC Cable shall be laid and running through the 100mm Steel conduit provided in crash barrier. Lighting Control from Main Central Command Centre at Sewri to make it operational, etc. as require as per specification.
7.	Cable trays	Design, procurement, supply, transportation, installation Galvanized, factory fabricated, Cable Tray / Ladder, Hangers etc. for supporting Cables / Wires / conduits etc. inside and outside the Box Girder as per Drawing and anchoring provisions made in box girder by Package-1, 2 & 3 Contractors for HV/ LV & Fibre Cables, etc. as per Employer's Requirement. The Cable Tray / Ladder, Hangers etc. shall be hot dip galvanized (IS- 4759/6745 latest) with PU painted (IS 13213), to suits saline environment of sea and provides corrosion resistance.
8.	Distribution Board / Feeder Pillars (on Bridge)	Design, procurement, supply, transportation, installation, testing & commissioning of Feeder Pillars with appropriate ratings of ACB / MCCB / MCB, Switchgears and associative wiring & indication in complete as require for façade lighting to view gallery on pier Top or at the location behind the crash barrier etc. as require as per specification. (The location and Chainages are attached with the Specification.
9.	Conical Poles for Lighting & CCTV/VIDS system	Design, procurement, supply, transportation, installation, testing & commissioning of 9/10 meter-high Conical Poles for Lighting & CCTV/VIDS. The poles shall be hot dip galvanized high tensile sheet steel of grade E350 (IS 2713 - Pt.-2) with PU painted (IS 13213), to suits saline environment of sea and provides corrosion resistance. This shall include Base Plate, 2 Nos 40 mm dia, 1,5 meter length GI Pipe, Junction Boxes inbuilt wiring and earthing etc. in complete as require as per Employer's Requirement and standards.
10.	Street Lighting Pole mounted	Design in accordance to IRC using proper software to meet Minimum 40 Lux, overall uniformity 0.4, and transvers uniformity 0.33 illumination on the surface of Road.

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Sr. No.	Description	Detailed Scope
		Procurement, supply, transportation, installation, testing & commissioning of 2x150 W LED Street Lighting fixtures. The provisions of mounting structure on crash barrier are being made by Package-1, 2 & 3 Contractors at every 26 meters interval to suit mounting arrangement for Light Pole. Necessary interface regarding mounting structure and fixing to be dealt by the Electrical Contractor. The Road and Bridge Lighting shall be based on Lighting control / dimming management system.
11.	High Mast Lighting	Design in accordance to IRC using proper software to meet Minimum 40 Lux, overall uniformity 0.4, and transvers uniformity 0.33 illumination on the surface of Road. Procurement, supply, transportation, installation, testing & commissioning of High mast (12.5mtr, 15 mtr & 25 mtr High for area Lighting at various ramp locations viz. Sewri, Sivaji Nagar, Gavan Toll Plaza, SH54 highway ramp and Chirle Interchange. (However, the location, numbers and height of High Masts shall be decided during detail design to achieve the require illumination level). The High Mast shaft shall be made of best steel grade in compliance with BS EN 10025 FE 510; minimum Yield strength of 355N/sqmm (min.) for thickness < 30mm, Tensile strength between 490 – 639/N/Sqmm, minimum, elongation for thickness 3 mm and 30 mm : 22%, and shall capable to withstand sustained basic wind of 180 KMPH with 3 sec. gust.
	Box Girder Lighting	Design, Procurement, supply, transportation, installation, testing & commissioning of Box Girder Lighting (Void) with average Illumination level of 10 Lux all along the length inside void of Box Girder. This shall include necessary wiring, cabling distribution Boards and all accessories as require meeting average illumination of 10 Lux all along the void.
12	Linear Heat Detection system in Box Girder	Design, procurement, supply, installation, testing & commissioning of Leaner heat Detection in the box girder including Fire alarm Panel ang all accessories in complete as require to be monitored from central command center at Gavan.
13.	Access Control System for Box Girder Entry point /Door, and Main Central Command Centre Buildings.	Electronic Security keypad provided by Package-1, 2 & 3 for limiting the access to the box girder on the preapproved basis and shall be relayed to the toll plaza monitoring station at Main Comment Centre at Gavan. This shall also include restricted area of Main Comment Centre at Gavan
14.	Substation Earthing	Design, procurement, supply, transportation, installation, testing & commissioning of 4 Nos. (2 for neutral & 2 for Body) Earth connection using 1cx 240Sqmm Cu, class-2,HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area as well on the land portion for approval of CEIG from the Bridge.
15.	Lightening protection for Substation	Design, procurement, supply, transportation, installation, testing & commissioning of 1 No. Earth connection for lightening protection using 1Cx 240Sqmm Cu, class-2 ,HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area as well on the land portion of bridge (Superstructure) as require for Substation Earthing.

Sr. No.	Description	Detailed Scope
17.	Earthing for Lightening Protection for electrical and electronic equipment on Bridge	Design, procurement, supply, transportation, installation, testing & commissioning of 1 No. Earth connection for lightening protection using 1Cx 300Sqmm Cu, class-2 ,HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area as well on the land portion of bridge (Superstructure) as require for Earthing.at every 150 mtrs / close to the ITS Equipment.
18.	60mtr x 7 mtr Layby / Rescue Bay along the main Bridge at every 7KM on North & South Road.	a. Design in accordance to IRC using proper software to meet Minimum 40 Lux, overall uniformity 0.4, and transvers uniformity 0.33 illumination on the surface of Road. Procurement, supply, transportation, installation, testing & commissioning of 2x150 W LED Street Light Fixture. b. Design, procurement, supply, transportation, installation, testing & commissioning of 9/10 meter-high Conical Poles for Lighting & CCTV/VIDS. The poles shall be hot dip galvanized high tensile sheet steel of grade E350 (IS 2713 - Pt.-2) with PU painted (IS 13213), to suits saline environment of sea and provides corrosion resistance. This shall include Base Plate, 2 Nos 40 mm dia, 1,5 meter length GI Pipe, Junction Boxes inbuilt wiring and earthing etc. in complete as require as per Employer's Requirement and standards. c. Provision for 1 nos. 20KW, 3 phase power supply points including Junction Box (IP:66 rated) and suitable provision of MCB as require for Electric vehicle charging in future at every rescue bay.
The work as above shall be complete in all respect but not limited to.		

1.8.2. Electrical Works for Buildings & Toll Plaza

Table 0-1 Electrical Scope of Work for Building & Toll Plaza

Sr. No.	Description	Detailed Scope
1.	BEST HV Switching Station, Sewri	BEST Switching Substation including Switchgear requirement in accordance with BEST Specifications and approval thereof from BEST including HT Metering Kiosk etc. as required to meet total Power Demand. Design, procurement, supply, transportation, installation, testing & commissioning of a. 11kV HV Switchgear for 11kV Ring Main Distribution b. HT Metering Kiosk for 1 Point meter Supply c. Scada Room d. Power system including all Panels as per SLD with all accessories, e. HT and LT Cables and Cable Trays f. Surge Arrestor, g. ELV/ Data/ telecom /FAS/ PAS as required

Sr. No.	Description	Detailed Scope
		h. UPS for Workstation including UPS Power Distribution Boards and Sockets, i. Lighting system as specified including emergency lighting j. Raw Power /General Power Distribution Boards and Sockets k. ELV/ Data/ telecom as required l. Neutral & Body Earthing m. Infra lighting including compound lighting & security n. 500kVA DG Set with acoustic Enclosure, AMF Panel, and fuel Tank as require. o. Access Control System in restricted area. p. supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra. q. Clean Gas based Fire Suppression System. The entire work shall be complete in all respect in accordance with NBC, IE Rules, Indian standards and local regulation of BEST Note: 3 phase 415 V LT Power Supply to be catered from the Nearest CSS of Sewri.
2.	Sub Command Centre, Sewri	Design, procurement, supply, transportation, installation, testing & commissioning of a. 11kV/433V, 500kVA Compact Substation to cater Sewri Area power demand b. Power Supply and Distribution System including Panels/ DBs/Switchboards per SLD with all accessories c. LV Cables and able Trays d. Surge Arrestor e. UPS for Workstation including UPS Power Distribution Boards and Sockets, f. Lighting system as specified including emergency lighting g. Raw Power /General Power Distribution Boards and Sockets h. ELV/ Data / telecom with EPABX and intercom as required i. Earthing j. Lightning protection k. Infra lighting including compound lighting & security, l. 500kVA DG Set with acoustic Enclosure, AMF Panel, and fuel Tank as require. m. Access Control System in restricted area. n. Lifts, o. BMS p. Solar Power System q. Fire Alarm and detection System r. Public Address System. s. Supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra t. Clean Gas based Fire Suppression System.
3.	Shivaji Nagar Command Centre.	Design, procurement, supply, transportation, installation, testing & commissioning of

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Sr. No.	Description	Detailed Scope
		a. 11kV/433V, 500kVA Compact Substation to cater Sewri Area power demand b. Power Supply and Distribution System including Panels/ DBs/Switchboards per SLD with all accessories c. surge arrestors d. LV Cables/ HV Cables and Cable Trays e. UPS for Workstation including UPS Power Distribution Boards and Sockets, f. Lighting system as specified including emergency lighting g. Raw Power /General Power Distribution Boards and Sockets h. ELV/ Data / telecom with EPABX and intercom as required i. Earthing j. Lightning protection k. Infra lighting including compound lighting & security, l. 500kVA DG Set with acoustic Enclosure, AMF Panel, and fuel Tank as require. m. Access Control System in restricted area. n. Lifts, o. BMS p. Solar Power System q. Fire Alarm and detection System r. Public Address System, s. Supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra t. Clean Gas based Fire Suppression System
4.	Porta Cabin	Design, procurement, supply, transportation, installation, testing & commissioning of a. Power Supply and Distribution System including DBs/Switchboards per SLD with all accessories b. surge arrestors c. LV Cables and Cable Trays u. UPS for Workstation including UPS Power Distribution Boards and Sockets, v. Lighting system as specified including emergency lighting w. Raw Power /General Power Distribution Boards and Sockets d. ELV/ Data/ telecom /FAS/ PAS as required e. Earthing
5	4 lane/ 6 lane Toll Plaza	Design, procurement, supply, transportation, installation, testing & commissioning of a. Power Supply and Distribution System including DBs/Switchboards per SLD with all accessories b. surge arrestors c. LV Cables and Cable Trays a. UPS for Workstation including UPS Power Distribution Boards and Sockets, b. Lighting system as specified including emergency lighting c. Raw Power /General Power Distribution Boards and Sockets d. ELV/ Data/ telecom /FAS/ PAS as required

Sr. No.	Description	Detailed Scope
		e. Earthing f. Area lighting & security
6.	Main Central Command Centre, Gavan	Design, procurement, supply, transportation, installation, testing & commissioning of a. 11kV/433V, 1000kVA Compact Substation to cater Gavan Area power demand b. Power system including all Panels as per SLD with suitable surge arrestors c. Cable Trays d. LV Cables/ HV Cables e. UPS for Workstation including UPS Power Distribution Boards and Sockets, f. Lighting system as specified including emergency lighting g. Raw Power /General Power Distribution Boards and Sockets h. ELV/ Data / telecom with EPABX and intercom as required i. Earthing j. Lightning protection k. Infra lighting including compound lighting & security, l. 500kVA DG Set with acoustic Enclosure, AMF Panel, and fuel Tank as require. m. Access Control System in restricted area. n. Lifts, o. BMS p. Solar Power System q. Fire Alarm and detection System r. Public Address System, x. Supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra s. Clean Gas based Fire Suppression System
7.	16 lane Toll Plaza including Tunnel	Design, procurement, supply, transportation, installation, testing & commissioning of a. Power system including all Panels as per SLD with suitable surge arrestors b. UPS for Workstation including UPS Power Distribution Boards and Sockets, c. Lighting system as specified including emergency lighting d. Raw Power /General Power Distribution Boards and Sockets e. ELV/ Data/ telecom /FAS/ PAS as required f. Earthing g. Area lighting & security

1.8.3. HVAC Works for Building & Toll Plaza

Table 0-1 HVAC Scope of Work for Building & Toll Plaza

Sr. No.	Description	Detailed Scope
1.	BEST HV Switching Station, Sewri	Design, procurement, supply, transportation, installation, testing & commissioning of Mechanical Ventilation System, as required as per standards and BEST Regulation.
2.	Sub Command Centre, Sewri	Design, procurement, supply, transportation, installation, testing & commissioning of 1. Air Conditioning System a. VRF System (Office Areas & Control Room) (1 Set working) Dx System (UPS RM, Battery RM, Electrical Room, Control Rooms) redundant System One Set Working and One Set Standby. [All monitoring room such as ITS, ATCC, HTMS room VRF as well as DX unit to maintain redundancy. DX unit will stand by units in case of failure of centralized VRF system] b. Precision Air Conditioners (Server Rooms) (One Set Working and One Set Standby) 2. Mechanical Ventilation a. Toilet exhaust, Pantry, Storerooms b. Battery Room Ventilation c. Emergency Ventilation (Staircase, Lift well, Lift Lobby Pressurization fire operations as per fire norms)
3.	Shivaji Nagar Command Centre.	Design, procurement, supply, transportation, installation, testing & commissioning of 1. Air Conditioning System a. VRF System (Office Areas & Control Room) (One Set Working) b. Dx System (UPS RM, Battery RM, Electrical Room, Control Rooms) (One Set Working and One Set Standby) [All monitoring room such as ITS, ATCC, HTMS room VRF as well as DX unit to maintain redundancy. DX unit will stand by units in case of failure of centralized VRF system] c. Precision Air Conditioners (Server Rooms) (One Set Working and One Set Standby) 2. Mechanical Ventilation a. Toilet exhaust, Pantry, Storerooms b. Battery Room Ventilation c. Emergency Ventilation (Staircase, Lift well, Lift Lobby Pressurization fire operations as per fire norms)
4.	Porta Cabin	Design, procurement, supply, transportation, installation, testing & commissioning of

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Sr. No.	Description	Detailed Scope
		1. Air Conditioning System a. VRF System (Office Areas & Control Room) b. Dx System (UPS RM, Battery RM, Control Rooms) c. Precision Air Conditioners (Server Rooms) 2. Mechanical Ventilation a. Toilet exhaust b. Battery Room Ventilation
6.	Main Central Command Centre, Gavan	Design, procurement, supply, transportation, installation, testing & commissioning of 1. Air Conditioning System a. VRF System (Office Areas & Control Room) (One Set Working) b. Dx System (UPS RM, Battery RM, Electrical Room, Control Rooms) (One Set Working and One Set Standby) [All monitoring room such as ITS, ATCC, HTMS room VRF as well as DX unit to maintain redundancy. DX unit will stand by units in case of failure of centralized VRF system] c. Precision Air Conditioners (Server Rooms) (One Set Working and One Set Standby) 2. Mechanical Ventilation a. Toilet exhaust, Pantry, Storerooms b. Battery Room Ventilation c. Emergency Ventilation (Staircase, Lift well, Lift Lobby Pressurization fire operations as per fire norms)
7.	16 lane Toll Plaza with Tunnel	Design, procurement, supply, transportation, installation, testing & commissioning of Mechanical Ventilation for Tunnel as require as per NBC and Indian Standards.

Note: The Scope of Work as above are indicative but not exhaustive, the Contractor shall, however, undertake design, detailed engineering, schedules, drawings etc. and elaborate detail as required to meet a complete Electrical & Mechanical work in an acceptable manner for approval by the Engineer.

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CHAPTER -2

2. DESIGN BASIS FOR ELECTRICAL WORKS FOR BRIDGE

2.1. General

Outline of Mumbai Trans Harbour Link (MTHL)

Mumbai Trans Harbour Link is a 21.800 km long expressway grade road bridge traversing Mumbai Bay connecting Mumbai with Navi Mumbai. Of the total length, 18.187 km is a bridge above the bay and the rest of the section is mostly viaduct.

Source: The preparatory survey on the project for Construction of Mumbai Trans Harbour Link

There are four interchanges along the road and only Sewri IC is located on Mumbai side, while three ICs will be constructed on Navi Mumbai side.

Construction of the road is divided into three packages as shown below.

Construction Package	Length (km)	Kilo Post	Type	Interchange
1	10.380	CH 0+000 – CH 10+380	Bridge	Sewri IC
2	7.807	CH 10+380 – CH 18+187	Bridge	Shivaji Nagar IC
3	3.613	CH 18+187 – CH 21+800	Viaduct	SH 54, Chirle IC
Total	21.800			

The intent of this design basis for electrical works is to list out the design philosophy considered to provide reliable power distribution to meet the electrical load of to ensure smooth, hassle free operation of the proposed MTHL Project (Ramps, Bridge on the Sea & Bridge on Land and Building Structures & Toll Plazas).

It should be noted that the roadway civil works & provision of the routes for Electrical, ITS & Communication Services along the roadway length shall be shared based on individual packages as stated above.

2.2. Source of Electrical Power

Electrical power supply at 11kV from BEST shall be obtained from Sewri - Switching / Receiving Station by fulfilling all necessary BEST requirements and standards.

2.3. Electrical Load Estimate for The Project

Electrical Load calculation on the Bridge includes following equipment & services which requires power supply from the planned substation.

- Street Lighting, Ramp Lighting, Area lighting near Ramps,
- Box Girder Lighting, Embedded lighting, substation platform lighting
- Navigational, Bridge Pier aesthetic Lighting in marine area
- Event based additional lighting: Beacon Lighting
- Fire Fighting of Bridge
- ITS System on Bridge (CCTV/ VIDS, MET, ATCC, VMS etc.)
- Vehicle charging Points provisions
- MEP Power requirement of Various Buildings, toll plaza's & tunnels.

ANNEXURE - A1, MTHL- SUBSTATIONWISE ELECTRICAL LOAD SUMMARY

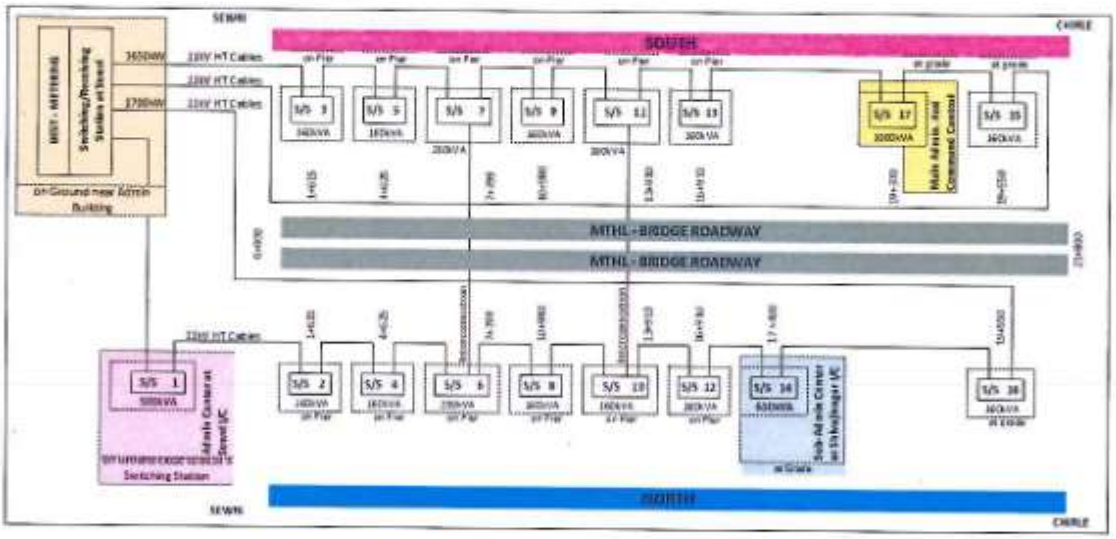
Sr. No.	Substation	Indicative Load (kW) **	CSS Transformer Capacity KVA	Level	Location / Chainage
1.	CSS-1	~375	500	At Grade	Sewri-Sub-Admin Building
2.	CSS-2	~110	160	On Pier(5Mx5M)	1+615 (MP20 North)
3.	CSS-3	~110	160	On Pier(5Mx5M)	1+615 (MP 20 South)
4.	CSS-4	~140	160	On Pier(**5Mx7M**)	4+625 (MP69 North)
5.	CSS-5	~140	160	On Pier(5Mx5M)	4+625 (MP 69 South)
6.	CSS-6	~160	250	On Pier(5Mx5M)	7+799 (MP110 North)
7.	CSS-7	~160	250	On Pier(5Mx5M)	7+799 (MP110 South)
8.	CSS-8	~120	160	On Pier(5Mx5M)	10+980 (MP156N North)
9.	CSS-9	~120	160	On Pier **(5Mx7M)**	10+980 (MP156N South)
10.	CSS-10	~115	160	On Pier(5Mx5M)	13+910 (MP191N North)

11.	CSS-11	~115	160	On Pier(5Mx5M)	13+910 (MP191N South)
12.	CSS-12	~88	160	On Pier **(5Mx7M)**	16+910 (MP240 North)
13.	CSS-13	~88	160	On Pier(5Mx5M)	16+910 (MP240 South)
14.	CSS-14	~515	630	At Grade	17 +400, Shivajinagar I/C - Sub-Admin Center
15.	CSS-15	~120	160	At Grade	19+550 (South)
16.	CSS-16	~120	160	At Grade	19+550 (North)
17.	CSS-17	~780	1000	At Grade	19+370, Main Admin. And Command Control Centre
	Total Load	**~3350kW**			

Note: **: The rating (Chainages) and numbers of CSS Transformers as above, are indicative but not exhaustive, the contractor shall however, undertake design, detailed engineering, schedules, drawings etc. and elaborate detail based on the actual loads and site condition as required to meet a complete Power Supply network in an acceptable manner for approval by the Engineer.

2.4. Electrical Ring Main Distribution from BEST, Sewri

Sketch 0-1 HV Ring Schematic 11 kV Ring Main Network



2.5. Electrical Distribution System Components for Bridge are as Listed Below

Sr. No.	Equipment	Description	Minimum Qtys
1.	HT Metering Kiosk, BEST		As per Design
2.	11kV Switchgear Panels, as per BEST' Specs.	11kV breakers Protection and Metering Panel. SCADA System for control and monitoring of Sewri Switching/Receiving Station.	As per Design
3.	11 KV HT Cables	11kV HT Cables One set each Cable Ring Mains to connect Switch Station Substations and MTHL's Substations (CSS) in Loop in Loop Out manner all along the Bridge and buildings as require as per the drawings. 2 Sets of 11 kV Cable Rings as spare with interconnection as per Drawing.	4 Sets of 11 kV Cable (Loop in Loop Out) to cover complete Bright, Building etc.
4.	11/0.433 kV Compact Secondary Substations (Type A)	11kV RMU with configuration of 2 No,s of 11kV 630A LBS & 1 No,s of 11kV 630A SF6 Circuit Breaker with all necessary protections. Transformer- 11kV/0.433kV, Dry type Distribution Transformer of 160/500/630/1000 KVA Rating (as listed under Para 3.3 Annexure -A) of the Specification) in compliance with ECBC for minimum losses. LT Compartment/ External LT Panel – Facilitating further LT Distribution with the ACBs & MCCBs with suitable ratings as per the load's requirements like Street Lighting loads, ITS loads, Space Heating loads and Various Building Services & associated loads in MTHL Project Buildings & Structures, shall be as per Drawing.	13 Locations. minimum and shall be decided during Design.
	11/0.433 kV Compact Secondary Substations (Type B)	11kV RMU with configuration of 3 No, s of 11kV 630A LBS & 1 No, s of 11kV 630A SF6 Circuit Breaker with all necessary protections. **Transformer**- 11kV/0.433kV, Dry type Distribution Transformer of 160/500/630/1000 KVA Rating (as listed under Para 3.3 Annexure -A) of the Specification) in compliance with ECBC for minimum losses. LT Compartment/ External LT Panel – Facilitating further LT Distribution with the ACBs & MCCBs with suitable ratings as per the load's requirements like Street Lighting loads, ITS loads, Space Heating loads and Various Building Services & associated loads in MTHL Project Buildings & Structures, shall be as per Drawing.	04 Locations. minimum and shall be decided during Design.
5.	Power Factor Correction Panels	Improvement of power factor to be targeted as 0.95 by using APFC panel with detuned harmonic filters.	17 Nos. as above with each Substations.
6.	Feeder Pillars	LT Sub-Distribution Panels for Various Services & associated loads for the Bridge, Toll plaza etc.	56 Locations. minimum and shall be decided during Design.
7.	LT Cables	LT Cables for Power distribution from LT Panel to various DBs of varying Loads (as per design) as required. The 3 phase 4 wire, 1.1 kV grade XLPE LT Cables between Panel and DBs shall be of aluminum. This shall include termination joints and all accessories in complete.	As require as per E&M Scope of Work in complete as specified under specification.

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2.6. Electrical Feeder Pillars locations:

List below showing tentative numbers of Feeder Pillars and Substation location / Chainages etc. for Bridges & Toll Plazas are as Listed Below:

Sr, No,	Feeder Pillars		Location / Chainage**	Sr. No	Feeder Pillars		Location / Chainage**
1	FP	1.1	Sewri- near Sewri I/C	29	FP	9.2	11+840 (MP171 South)
2	FP	1.2	Sewri- CSS	30	FP	9.3	≈ 13+038 (MP182 South)
3	FP	1.3	Sewri- near Sewri I/C	31	FP	10.1	≈ 13+910 (MP191 North)
4	FP	1.4	Sewri- near Sewri I/C	32	FP	10.2	14+810 (MP206 North)
5	FP	2.1	≈ 0+715 (MP5 North)	33	FP	10.3	≈ 16+010(MP226 North)
6	FP	2.2	1+615 (MP20 North)	34	FP	11.1	≈ 13+910 (MP191 South)
7	FP	2.3	≈ 2+455 (MP34 North)	35	FP	11.2	14+810 (MP206 South)
8	FP	3.1	≈ 0+715 (MP5 South)	36	FP	11.3	≈ 16+010(MP226 South)
9	FP	3.2	1+615 (MP20 South)	37	FP	12.1	≈ 16+910 (MP240 North)
10	FP	3.3	≈ 2+455 (MP34 South)	38	FP	12.2	17+902 (MP261 North)
11	FP	4.1	≈ 3+715 (MP53 North)	39	FP	13.1	≈ 16+910 (MP240 South)
12	FP	4.2	4+625 (MP69 North)	40	FP	13.2	17+902 (MP261 South)
13	FP	4.3	≈ 5+308 (MP75 North)	41	FP	14.1	17 +400, I/C (North)
14	FP	5.1	≈ 3+715 (MP53 South)	42	FP	14.2	17 +400, I/C (North)
15	FP	5.2	4+625 (MP 69 South)	43	FP	14.3	17 +400, I/C (North)
16	FP	5.3	≈ 5+308 (MP75 South)	44	FP	14.4	17 +400, I/C (North)
17	FP	6.1	≈ 6+539(MP89 North)	45	FP	14.5	17 +400, I/C (North)
18	FP	6.2	7+799 (MP110 North)	46	FP	14.6	17 +400, I/C (North)
19	FP	6.3	≈ 8+620 (MP124 North)	47	FP	14.7	17 +400, I/C (North)
20	FP	6.4	≈ 9+600 (MP135 North)	48	FP	15.1	≈ 18+500 (South)
21	FP	7.1	≈ 6+539(MP89 South)	49	FP	15.2	19+550 (South) Gavan S/S
22	FP	7.2	7+799 (MP110 South)	50	FP	15.3	≈20+500(South)
23	FP	7.3	≈ 8+620 (MP124 South)	51	FP	15.4	≈21+500(South)
24	FP	7.4	≈ 9+600 (MP135 South)	52	FP	16.1	≈ 18+500 (North)
25	FP	8.1	≈ 10+980 (MP156 North)	53	FP	16.2	19+550 (North) Gavan S/S
26	FP	8.2	11+840 (MP171 North)	54	FP	16.3	≈20+500(North)
27	FP	8.3	≈ 13+038(MP182 North)	55	FP	16.4	≈21+500(North)
28	FP	9.1	≈ 10+980 (MP156 South)	56	FP	17.1	≈19+370 (South)Chirle I/C

Note: **: The rating, Chainages and numbers of Feeder Pillars as above, are indicative but not exhaustive, the contractor shall however, undertake design, detailed engineering, schedules, drawings etc. and elaborate detail based on the actual loads and site condition as required to meet a complete Power Supply network in an acceptable manner for approval by the Engineer.

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2.7. Power Factor Correction Panels

Automatic power factor compensating system with contactor control switching arrangement, detuned harmonic filters and capacitor units shall be provided to maintain of average power factor between 0.95 to unity and to have effective savings in energy cost. Thyristor control switching arrangement with detuned filters for reducing harmonics shall be provided. This shall automatically switch ON/OFF the capacitor units to achieve the pre-set power factor. Detuned harmonic filters harmonic filters shall be used with harmonic-filter-duty power capacitors to mitigate harmonics, improve power factor and avoid electrical resonance in electrical network.

2.8. Lighting System - Street Lighting

The Contractor shall develop design to meet Minimum Level of Illumination (in Lux) and shall validate the design through computerized Simulation Study by using AGi32 & DIALUX software (latest version). The Level of Illumination shall be of 40 Lux (Minimum), overall uniformity 0.4, and transvers uniformity 0.33 illumination on the surface of Road all along the section.
This include Procurement and installation of Circular / Conical Smart Light Poles for Street Lighting applicable for CCTV Installations as well.

The provisions of mounting structure on crash barrier are being made by Package-1, 2 & 3 Contractors at every 26 meters interval (indicative) to suit mounting arrangement for Light Pole. The Contractor shall actively involve necessary interface regarding mounting structure and fixing arrangement etc.

The Contractor shall provide lighting at locations of the Project Bridge Specified in Schedule-B, using appropriate system and source of electric power as per the requirement of this section.

Unless stated otherwise stated elsewhere, the minimum level of illumination on the stretches of the project Bridge including toll plaza's truck lay-byes, interchanges etc. shall design to meet Illumination levels as specified under Chapter – 4.

2.9. Lighting Control and Monitoring

The contractor shall design and implement Centralized Control & Monitoring System for Road/Street lighting for the entire stretch of Road and Bridge. The Centralized control and monitoring system (CCMS) is envisaged to achieve the lighting control for Road lighting and building etc. shall be located in Control Room of Administration Buildings. Specification in detail is specified under Chapter – 4.

2.10. Earthing System

Earthing system shall be provided to give safety to the equipment as well as to the human beings. The system shall provide earth bonding of all electrical equipment, panel boards and other metallic parts like building structural work, metallic cable trays, bus ducts, piping, metal sinks etc.

As part of Bridge, 3 Nos of earth pits (2 No. for Body earthing & 1 no for Lightning Protection) shall be provided at every pier at an interval of 150mtr and terminated to the steel liner which forms part of pile work and touching the actual ground under the soil.

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As part of Compact Substation, 5 Nos earth pits (2 No. for Body earthing & 2 Nos for Neutral Earthing & 1 no for Lightning Protection) shall be at every substation provided at every 3k M spacing and shall be terminated to the steel liner which forms part of pile work and touching the actual ground under the sea.

Sr No.	Earth Pits	Purpose	Requirement	Method
1.	Substation Earthing (Body)	Equipment Body Earthing	At every 3KM Substation platform has piles which are provided with Steel Liners for Bridge.	2Nos. for Body Earthing and earth connection using 1cx 240Sqmm Cu, class-2, HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area as well on the land portion for approval of CEIG from the Bridge.
2.	Substation Earthing Neutral	Neutral Earthing Transformer / Compact Substation	At every 3KM Substation platform has piles which are provided with Steel Liners for Bridge	2Nos. for Transformer Neutral Earthing and earth connection using 1cx 240Sqmm Cu, class-2, HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area as well on the land portion for approval of CEIG from the Bridge.
3.	Substation Lighting Protection	Lighting Protection	At every 3KM Substation platform has piles which are provided with Steel Liners for Bridge	1 No. Earthing and Earth connection for lightening protection using 1Cx 240Sqmm Cu, class-2, HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area as well on the land portion of bridge (Superstructure) as require for Substation Earthing.
4.	Equipment Body earthing across the Bridge	Body earthing	At every 150Mtrs for Bridge aligned Equipment like, Poles, structural framework, Metallic framework, Feeder pillars, panels etc.,	1 No. Earth connection for lightening protection using 1Cx 300Sqmm Cu, class-2, HR PVC insulated cable bonded to pile steel liner and welded to liner by using another steel plate in marine area of bridge (Superstructure) as require for Earthing. Measures to avoid close contact with saline water to be ensured and shall be provided with test link at appropriate location for earth resistance testing.
5	Equipotential Earthing & Bonding All along the Road/Bridge	Equipotential Earthing	Continuous GI Earth strip of 32mmx6mm or equivalent conductor section shall be provided on Road Bridge across the entire length of the Project.	The Insulated cable shall be connected to this GI Strip which will run across the Bridge Length connecting all the ITS Equipment & Lighting Pole, Metal structure, Cable Trays, Panels etc. for proper body earthing.

The combined earthing resistance shall not exceed more than 1 Ohm under all the cases. The Copper strip type earthing with no risk of fire and maximum conductor temperature of 500°C shall be considered.

The complete earthing system shall be mechanically and electrically bonded to provide an independent return path to the earth source.

All the non-current carrying metal parts of the electrical installation and mechanical equipment's shall be earthed properly. The cables armour and sheath, electric panel boards, lighting fixtures, ceiling and exhaust fan and all other parts made of metal shall be bonded together and connected by means of specified earthing system. An earth continuity conductor shall be installed with all the feeders and circuits and shall be connected from the earth bar of the panel boards to the conduit system, earth stud of the switch box, lighting fixture, earth pin of the socket outlets and to any metallic wall plates used. All the enclosures of motors shall be also connected to the earthing system.

Contractor shall develop design for validating earth conductor sizing as require for Switching-Receiving Station HV Equipment's, HV equipment in CSS– (RMU, Transformer), LV Panels, Feeder Pillars, HVAC Equipment's & Panels, Fire Fighting System Panels, Plumbing & Water Supply System Panels etc. The design shall be supported with calculation based on actual fault current of BEST. The design shall be accepted and consented by the Engineer.

2.11. Lightening Protection

The Contractor shall develop design for Lightning Protection System as per IS/IEC 62305 and additional requirements of local authority for safety of MTHL equipment / Bridge and Buildings.

The risk assessment shall be carried out for shall be based on the risk assessment level the system shall be capable for protecting the equipment / Road and Building against sever lightning strike.

Conductors used under the lightning protection system shall be suitable against sever environment pollution and shall be connected safety with earthing system dedicated to Lightning Earthing.

All metallic structures within a vicinity of 2000 mm in air shall be bonded to the conductors of lightning protection system.

All exterior metallic conductor shall be connected to the lightning protection system

The system for the MTHL Roadway Bridge shall comprise of following elements:

- Vertical Air Termination Rod, (on the top of the street lighting pole, located at 30m interval as per risk calculation)
- Copper Conductor Cable

Sr No.	Earth Pits	Purpose	Requirement	Method
1	Lightening protection of ITS Equipment & Metal	Lightening Protection	At every 150Mtrs for Bridge aligned Equipment like, Poles, structural	External Connection (1Cx 300Sqmm Cu, class-2, HR PVC insulated cable to the Steel Liner and welded and

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Sr No.	Earth Pits	Purpose	Requirement	Method
	frameworks of the Bridge		framework, Metallic framework, Feeder pillars, panels etc.,	covered with Steel plate and welded to avoid further contact with saline water at the bonding and shall be provided with test link at appropriate location for earth resistance testing.
2	ITS Equipment, Metal structure, all metallic barriers shall be inter-connected across the Bridge	Equipotential Bonding for Lightening Protection	Continuous GI Earth strip of 25mmx3mm shall be provided across the entire length of the Project.	The Insulated cable shall be connected to this GI Strip which will run across the Bridge Length connecting all the lightening arrestors provided on top of ITS Equipment & Lighting Pole, all view barriers for proper earthing the electric charge.
3	Electrical Equipment Lightening Protection	Lightening Protection	At every 3KM Substation platform has piles which are provided with Steel Liners for Bridge.	External Connection (separate) by insulated 1Cx 240 Sqmm Cu, class-2 ,HR PVC insulated cable to the Steel Liner and welded and covered with Steel plate and welded to avoid further contact with saline water at the bonding and shall be provided with test link at appropriate location for earth resistance testing.

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CHAPTER -3

3. DESIGN BASIS FOR ELECTRICAL WORKS: BUILDINGS & TOLL PLAZA

3.1. Electrical System for Building Listed Below but not limited to:

Sr. No.	Equipment	Description	Qty
1.	MLTP's, PDB's, LDB's	Factory Fabricated as applicable for Indoor & Outdoor application as per relevant standard.	As per requirement
2.	Cable Tray	Power Cable Containment	As per requirement
3.	Trunking	ELV, Tele/Data, ITS Systems	As per requirement
4.	Conduits	FRLS PVC conduits, Rigid & Flexible, Junction Boxes	As per requirement
5.	Sockets,	ELV DATA/ telecom Sockets, Power sockets, industrial Sockets etc.	As per requirement
6.	UPS's	Power supply for Workstations, IT Equipment, DB Boards and Sockets for IT equipment etc. a require.	Suitable Capacity at: BEST Switching Station, Sub-command Center Sewri Command Cenre Shivaji Nagar, Main Command Cenre Gavan, Porta Cabin, Toll Plaza and Tunnel.
7.	Invertor	For minimum illumination under outage of power. Level of illumination shall be NBC compliant.	Suitable Capacity at: BEST Switching Station, Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan, Porta Cabin, Toll Plaza and Tunnel.
8.	LT Diesel Generator Set	with Acoustic Enclosure, to provide 100% power backup at 3 locations -Sewri, Shivajinagar & Gavan	3 Nos of 100% backup Capacity
9	Solar System	Grid connected roof top Solar System as per regulation laid down by Power supply authority	Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan
10	Fire Detection System	Addressable Intelligent Fire Detection and Alarm System	Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan
11	Lift (Elevator)	Buildings shall be provided with 8 Passenger Lifts	Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan
12	Linear Heat Sensing Cable	Void of Girder Bridge shall be provided with Linear Heat Sensing Cable for Fire Detection	Void of Girder Bridge
13	Clean Agent Gas Flooding System	TO provide Electrical Switch Room / Substations and IT Rooms	Void of Girder Bridge
14	Access Control System	to restrict entry in Void of Girder Bridge	Entry door Void of Girder Bridge and Admin Building Command Centre Shivaji Nagar, Main Command Centre Gavan

15	BMS System	Control and Monitoring of Equipment and lifesaving items.	Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan
16	SCADA System	Control and Monitoring of HV & LV Equipment including Street Lighting management	All Substations, Street Lights Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan
17	DG Set	Emergency supply for Building Services	Sub-command Center Sewri Command Centre Shivaji Nagar, Main Command Centre Gavan

3.2. Require Illumination Level for Buildings & Toll Plaza

The proposed Illumination Level (Lux) in the rooms and other building areas is mentioned hereunder for refences, however, the contractor shall develop design to comply the following requirement as minimum.

The Illumination Level Minimum Lux of lighting shall be validated through computerized Simulation Study by using AGi32 & DIALUX software (latest version)

Area/ Room	Average Lux Level	Area/ Room	Average Lux Level
Toll Booth Cabin	300	HTMS Control Room	300
Toll Collection Bay & Canopy	200	Toll Control Room (Manager + Staff W/S Room)	300
Cash Tunnel	200	HTMS Control Room	300
Toilets	200	VMSS Room	300
Showers	200	Emergency Call Box	300
Stilt Parking/ Covered Parking/ Secured Parking	150	CCTV Room	300
Ticket Cabin	300	HTMS Room	300
Kitchen/ Pantry	300	ATCC Room	300
Cashier	300	Audit Room	300
Staircase/ Corridors/ Lift Lobbies	150	Network Equipment Room	300
OPD Area & First Aid	300	CITY ITS UPS Room	300
Nursing Staff Room	300	Meteorological OBS Room	300
Server Room	300	Stores	200
UPS Room	200	Documents Room	300
Generator Room/Mechanical Room/Electrical Room/ MV Switchgear Room/ Metering Room	200	Staff Workstation Room	300
Staff Rooms/ Offices/ Manager Cabins	300	Rest Room	200
Reception/Pre-Conference	300	Sales Room	300
Conference Rooms	300	Staff Room	300
Control Room	300	Terrace - Open/ Covered	150

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Area/ Room	Average Lux Level	Area/ Room	Average Lux Level
ITS Control Room	300	Ramp	150

Note: Uniformity of illumination level shall not be less than 0.4 in any case.

3.3. Emergency Lighting for Buildings

The Project Buildings shall have independent inverter with Battery System to feed the emergency lights and exit signages in the Project Buildings. The battery back-up time shall be minimum 90minutes as per NBC2016. I The level of Illumination provided with the emergency lighting shall not be less than 10 in room / escape root of the building.

Following are the minimum requirements associated with emergency lighting inverters.

- BEST Switching Station,
- Sub-command Center Sewri,
- Command Centre Shivaji Nagar,
- Main Command Centre Gavan, and
- Porta Cabin, Toll Plaza and Tunnel.

3.4. Lighting Control System for The Project Buildings

The contractor shall design and implement Centralized Control & Monitoring System for Building and area lighting. The MTHL Project Buildings shall be planned to implement a Centralized Control system shall be monitored through BMS.

The detail specification including functional and technical requirement Lighting control System is specified under Chapter – 8.

3.5. System of Wiring & Power Socket Points

The wiring system shall consist of PVC insulated multi stranded copper stranded conductor flexible LSZH (Low smoke zero halogen) / ZHFR (Zero Halogen Fire Retardant) / FRLS wires in metallic / non-metallic (Rigid heavy Duty ISI -marked Low smoke fire retarded PVC Conduits of minimum 2mm Wall thickness and Sizes starting from 20 mm diameter) conduits and shall be concealed or surface mounted above false ceiling as called for.

The following shall be used for carrying wires/ cables from the electrical distribution boards to loads:

1. PVC conduit wherever the conduit is buried in slab at the time of casting.
2. PVC FRLS conduits wherever the conduit runs exposed in ceiling space or chased in wall.
3. GI cable trays or cable ladders and GI raceways for carrying multi-conductor cables to workstations.

The fire partitions penetrations by raceways/ cable trays shall be protected by approved sealing methods, maintaining the same fire resistance rating as the partition.

Following are the minimum provision to be ensured for Power Point Socket and Wiring.

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Application/ Service	UPS Power			Raw Power		
	UPS Power Modular Socket & Switch Outlet	Single Phase Industrial Socket with ELMCB	Power Distribution Unit	Raw Power Modular Socket & Switch Outlet	Single Phase Industrial Socket with ELMCB	Three Phase Industrial Socket with ELMCB
Workstations in - Offices/ Staff Areas/ Manager Cabins/ Reception/ Ticketing Cabins/ Control Rooms - ITS, CCTV, HTMS, ATCC etc.)/ Toll Booth	2No, s of 6/16A (in group) per W/S			1No, s of 16A per W/S		
Server Room/ Network Equipment Room	2No, s of 6/16A (in group) per W/S	1 No, s 25A per IT Rack/ Server (as kW Rating)	As Per IT & ITS equipment power requirements	2No, s of 6/16A per Room		
Electrical Room/ MV Switchgear Room/ Generator Room/ Mechanical Room/ Metering Room				2No, s of 6/16A per Room		
Conference Room	6No, s of 6/16A per Conference Room			4No, s of 16A per Conference Room		
Kitchen /Pantry				4 No, s of 16A		
DX Split AC Units					25A or 32A per DX Split AC Unit (as kW Rating)	
VRF Indoor Units (IDU)				1No, s of 6/16A per IDU		
Water Cooler / RO Unit				1No, s of 16A per Unit		
Exhaust Fan in Toilets				1No, s of 16A per Unit		
Hand Dryers in Toilets				1No, s of 16A per Unit		
Electrical Vehicle Charging Units (Only for MAIN ADMINISTRATION AND COMMAND CONTROL CENTER at GAVAN)						4 No, s of 32A

Note: The above the proposed provisions i.e. numbers and ratings for Power Sockets are minimum and indicative for refences, the contractor, however, shall be worked out details to meet performance and operational needs.

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3.6. Power Factor Improvement for MTHL Project Buildings

Automatic power factor compensating system with contactor control switching arrangement, detuned harmonic filters and capacitor units shall be provided to maintain of average power factor between 0.95 to unity and to have effective savings in energy cost. Thyristor control switching arrangement with detuned filters for reducing harmonics shall be provided. This shall automatically switch ON/OFF the capacitor units to achieve the pre-set power factor. Detuned harmonic filters harmonic filters shall be used with harmonic-filter-duty power capacitors to mitigate harmonics, improve power factor and avoid electrical resonance in electrical network.

3.7. UPS System & Batteries

The provisions of critical power through UPS Set is mentioned hereunder for a refences, however, the contractor shall develop design and assessed capacities of UPS Set in coordination with actual load requirement as require for MTHL roadway equipment, traffic Management Systems and Service Building with un-interrupter power back-up.
The critical loads to be fed from UPS is summered hereunder, as minimum:

1) Life safety, security and communication systems all along the MTHL roadway including monitoring / Control of equipment of Substation Platform.

2) Life safety items, Security & Communication systems, IT & ITS Server including Traffic control system for Service Buildings and Control Centre.

3) The UPS for ITSs Systems, , IT & ITS Server Loads Traffic Management Systems shall be in the UPS Rooms in the respective MTHL Project Buildings.

The UPS shall be with IGBT technology, Low harmonic distortion (THD<3%) & High input and output power factor, hence separate filters are not considered. The UPS proposed are modular type, hence N+1 parallel redundancy configuration with a minimum back-up time of 30 min is considered.

The UPS and battery back-up for the Project Buildings shall be housed in AC environment for better battery life.

The detail specification including functional and technical requirement for UPS System is specified under Chapter - 5.

3.8. 415V Diesel Generator Set for Buildings & Toll Plaza's

The provisions of Emergency Power through D.G. Set is mentioned hereunder for a refences, however, the contractor shall develop these requirement and prepare detail design and assessed capacities of D.G. Set in coordination with actual load values as require for Illumination, Ventilation, HVAC, Fire Fighting, water supply, Power Sockets, UPS, IT Equipment and other lifesaving equipment to fulfill the Employer's Requirements.

100% Diesel Generator Backup shall be provided for the Buildings as listed below.

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Sr, No,	Building	Indicative Connected Load (kW)	Indicative DG Set Rating kVA
1	SUB- ADMINISTRATION AND COMMAND CONTROL CENTER AT SEWRI	304.15	
	Sub-Total	**351.67**	**500 KVA**
3	SUB- ADMINISTRATION CENTER AT SHIVAJINAGAR INTERCHANGE	52.43	
	Sub-Total for Sr, No, 3 to 9	**404.45**	**630 KVA**
10	MAIN ADMINISTRATION AND COMMAND CONTROL CENTER AT GAWAN	733.07	
	Sub-Total for Sr, No, 10 & 11	**782**	**1000 KVA**

Note - (1) : The above the proposed requirements and ratings are minimum and indicative for refences, UPS Sizing, however, shall be worked out to meet performance and operational features.

Note - (2) : Diesel Generator Backup is not considered for street lighting loads.

Note – (3) : The rating and locations of D.G. Set as above, are indicative but not exhaustive, the contractor shall however, undertake design, detailed engineering, schedules, drawings etc. and elaborate detail based on the actual loads and site condition as required to meet a complete Power Supply network in an acceptable manner for approval by the Engineer.

The detail specification including functional and technical requirement for D.G. Set is specified under Chapter - 5.

3.9. Earthing System

Earthing system shall be provided to give safety to the equipment as well as to the human beings. The system shall provide earth bonding of all electrical equipment, panel boards and other metallic parts like building structural work, metallic cable trays, bus ducts, piping, metal sinks etc.

Clean earthing shall be designed for UPS system, communication systems and generally as per IS 3043.

The combined earthing resistance shall not exceed than 1 Ohm. The Copper strip type earthing with no risk of fire and maximum conductor temperature of 500 °C shall be considered.

The complete earthing system shall be mechanically and electrically bonded to provide an independent return path to the earth source.

All the non-current carrying metal parts of the electrical installation and mechanical equipment's shall be earthed properly. The cables armour and sheath, electric panel boards, lighting fixtures, ceiling and exhaust fan and all other parts made of metal shall be bonded together and connected by means of specified earthing system. An earth continuity conductor shall be installed with all the feeders and circuits and shall be connected from the earth bar of the panel boards to the conduit system, earth stud of the switch box, lighting

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fixture, earth pin of the socket outlets and to any metallic wall plates used. All the enclosures of motors shall be also connected to the earthing system.

Sizing of earth conductor for Switching-Receiving Station HV Equipment's, HV equipment in CSS– (RMU, Transformer), LV Panels, Feeder Pillars, HVAC Equipment's & Panels, Fire Fighting System Panels, Plumbing & Water Supply System Panels etc. shall be based on actual fault current calculated.

Earthing network/ connections of UPS/electronic/ IT equipment shall be separate & shall not be connected to general earthing grids.

In marine portions of the MTHL Bridge, earthing connections at required locations, shall be taken from the foundation earth pile with the help of Earth Pile Electrode. This shall facilitate the earthing for the Substations and Downstream LT Panels & equipment's located along the bridge roadway length.

Components of Earthing System

Earth Electrodes

- Conventional Earth Pits (Plate or Pipe)
- Maintenance free Earthing Electrode System/ Chemical Earthing

Earth Conductor

- Strip/Tape
- Wire
- Earthing Cable (Insulated)

3.10. Lightning Protection

The Contractor shall develop design for Lightning Protection System as per IS/IEC 62305 and additional requirements of local authority for safety It Equipment and MTHL Buildings.

The risk assessment shall be carried out for shall be based on the risk assessment level the system shall be capable for protecting the equipment and Building against sever lightning strike.

The lightning protection system shall be installed in accordance with IEC standard and additional requirements of local authority.

The risk assessment shall be carried out for the MTHL Roadway Bridge & Individual Project Building. Based on the risk assessment level the system shall be capable of protecting the building against a lightning strike.

Conductors of the lightning protection system shall not be connected to the conductors of the safety earthing system above ground level.

All metallic structures within a vicinity of 2000 mm in air shall be bonded to the conductors of lightning protection system.

All exterior metallic conductor shall be connected to the lightning protection system

The system for the Project Buildings shall comprise of following elements:

- Air Termination network
- Structural columns
- Structural slabs

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- Façade
- Roof steelwork and other equipment.
- Down conductors
- Pile Caps
- Earth Pits
- Bi metallic test clamps
- Electronic Surge Suppression Devices.
- External Metal structure
- All architectural metallic extensions from building façade

3.11. Solar PV (Photovoltaic) System for MTHL Buildings

In order to promote renewable and green energy sources, the available space on roof top of service buildings will be utilized by use of roof mounted Solar Panels on the MTHL Project

The contractor shall develop feasible study for optimum use of solar energy and design, procure, install - Grid tied SPV system (without battery) along with necessary features to supplement the grid power during daytime.

A Grid Tied Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables and switches. PV Array will be mounted on a suitable structure over roof of building.

The detail specification including functional and technical requirement for Solar System is specified under Chapter – 5 of this document.

CHAPTER – 4

4. Outline Electrical Specifications - Bridge

4.1. General

This Specification describe the minimum quality, performance parameters and workmanship to be complied with. The contractor shall develop and propose most modern and reliable equipment and systems to achieve the standards as laid down in the specifications. The Contractor shall, however, undertake design, calculations, detailed engineering, schedules, and drawings etc. as require for design, Supply, installation Testing & commissioning specifications for Electrical Works to meet adequately of design in an acceptable manner for approval.

4.2. Design Standards

In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However, the Engineer's decision in this regard will be final and binding.

Priorities in case of conflicts:

In case of any conflict between various referred documents following order of priority shall govern.

- Statutory regulations
- Referred codes and standards
- This Specification/Material Requisition
- Data sheets / reference Single line diagram

Sr. No.	Description	Standards Code
1.0	Complete Electrical System	
	National Electrical Code	NEC
	National Lighting Code	NLC
	Indian Electricity Rules	IE Rules
	1910, Updated as on Date	Electricity Act
	Indian Road Code for Lux Level	IRC – SP87-2013
	National Building Code of India	NBC
	NOC from Chief Fire Officer	CFO-NOC
	Approval from Ministry of Environment & Forest	MOEF- Approval
	Approval from Chief Fire Officer	CFO-NOC
	CPWD Specifications	Latest
	CPWD BOQ	Latest
2.0	Compact Substations	
	High Voltage Low Voltage Prefabricated Substation Type tested for internal arc for IAC-AB for 20KA for 1 Sec	IEC:62271-202
	High Voltage Switches	IEC 60265
	Metal Enclosed High Voltage Switchgear	IEC 60298/ IEC62271-200

Sr. No.	Description	Standards Code
	High Voltage Switchgear	IEC 60694
	Low Voltage Switchgear and Control gear	IEC 60439
	Power Transformers	IEC 60076
3.0	HV Cables	
	XLPE Cables	IS: 7098
	Insulation Sheath	IS: 5831
	Copper and Aluminum	IS: 8130
	Wooden Drums	IS: 10418
	Armoring	IS: 3975
	Current Rating	IS: 3961
4.0	Dry Type Transformers	
	Classification of Insulating Material	IS 1271
	Power Transformers (Part I -V)	IS 2026
	Bushing for Alternating currents above 1000V	IS 2099
	Current Transformers	IS 2705
	Code of Practice for Climate Proofing	IS 3202
	Power Transformer Fittings and accessories	IS 3639
	Porcelain Bushings for Transformers	IS 4257
	Dry Type Transformer	IS 11171
	Application guide for Tap Changers	IS 8478
	Code of Practice for Selection, Installation and maintenance of transformers	IS 10028
5.0	Switchboards	
	Low voltage Switch gear and Control gear assemblies Part-I, type tested and partially type tested assemblies.	IEC 439-1 1992
	Low voltage Switch gear and Control gear Part-I general rules.	IEC-947-1, 1998
	High voltage test techniques for low voltage equipment Part–I definition test and Procedure requirement	IEC-1180-1, 1992
	Low voltage switchgear and control gear.	IS: 13947
	General requirements for switchgear and control gear for voltages not exceeding 1000 V a.c. or 1200 V d.c...	IS : 4237
	Terminal marking for electrical measuring instrument and their accessories.	IS : 8197
	Danger notice plates	IS : 2551
	Specification for factory-built assemblies of switchgear and control gear for voltage up to and including 1000 V A.C. and 1200 V D.C.	IS: 8623
	Current transformer	IS: 2705
	Voltage transformer	IS: 3156
	Electrical relay for protection	IS: 3231
	Indicating instrument	IS: 1248
	Integrating instrument	IS: 722
	Control switches and push buttons	IS: 6875

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Sr. No.	Description	Standards Code
	Switchgear bus bars, main connection and auxiliary wiring, marking and arrangement.	IS: 375
	Degree of protection provided by enclosures for low voltage switchgear and control gear	IS: 2147
	Busbar Connections and Accessories	IS: 5578, 11353
	Code of Practice for Phosphating Iron & Steel	IS: 6005
	LSZH Wires	IS 694
6.0	LT Switchgear	
	Specifications for A.C. circuit breaker	IS: 2516
	Specifications for A.C. isolator and earthing switch	IS: 9921
	Code of Practice for installation and maintenance of switchgear.	IS: 10118
	Specification for factory-built assemblies of switchgear and control gear for voltage up to and including 1000 V A.C. and 1200 V D.C.	IS: 8623
	Miniature circuit breakers.	IS: 8828
	Air circuit breaker	IS: 2516
	Fuse switch and switch fuse unit.	IS: 4064
	HRC fuse links	IS: 9224
	Auxiliary contactor	IS: 2959
	A.C. motor starters of voltage not exceeding 1000 V	IS: 1822
	Metal enclosed Switchgear and Control gear for voltages above 1000V but not exceeding 11000V.	IS 3427
	Switches and Switch Isolators for voltages above 1000V, Ring main unit 11 kV grade	IS 9920 Part 1,3 & 4, IEC:60265
	Voltage Transformers	IS 3156
	Electrical Relays for power system protection.	IS 3231
	Danger notice plates	IS: 2551
	Specification for factory-built assemblies of switchgear and control gear for voltage up to and including 1000 V A.C. and 1200 V D.C.	IS: 8623
	Current transformer	IS: 2705
7.0	LT Cables	
	XLPE insulated electric cables (heavy duty).	IS: 7098 Part I
	Recommended current ratings for cables.	IS: 3961
	Aluminum conductors for insulated cables Indian Electricity Act and Rules.	IS: 8130
	Guide for marking of insulated conductors.	IS 732 / IS 12307 / IS 12349 / NBC, IS 5578
	Standard for Testing of Fire Survival for Category C, W, Z.	BS 6387
	Standard for Testing of Flame Retardant	IEC 60332-1
	Standard for Testing of Low Smoke	IEC 601034-3
	Fire Retardant Low Smoke (FRLS) / Flame Retardant Low Smoke Zero Halogen (FRLSZH) compound	IS: 7098 (Part I)
8.0	Cable Trays & Trunking	

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Sr. No.	Description	Standards Code
	National Electric Code 2011	NEC 2011
	NEMA Standards for Manufacturing of Cable Trays	NEMA VE1, FG1,VE2
	Steel Conduit and Fitting Accessories LSZH Conduit and Fitting Accessories	IS:9537 (Part-II)/ CEE 23 & IEC 60695-2-1:1991
	Cable Tray	ISO 9000, ISO 9001, ISO 9002 or Equivalent IS Standard.
	Cable Ladder	ISO 9000, ISO 9001, ISO 9002 or Equivalent IS Standard.
	Cable Trunking	IS 14927, IEC 1084.
	Guide for uniform system of marking and identification of conductors and apparatus terminals.	IS 11353
9.0	Lighting	
	1960 Code of practice for interior illuminator.	IS: 3646
	1969 General and Safety requirements for electric lighting fittings	IS :1913
	National Electric Code	
	National Lighting Code-2010	NLC-2010
	AASTHO an information guide for Roadway Lighting Latest Edition	
	Smart Lighting- comply to IoT System	
	Lighting of Public Thoroughfare	IS:1944
	Decorative Lighting	IS:5077
	Luminaire Series	IS:10322
	Methods of photometry of Luminaire	IS: 13383
	Ballast for Fluorescent Lamp	IS:1534
	Electronic Ballast	IS:13021
	Compact Fluorescent Lamp	IS:15111
	Tubular Fluorescent Lamp	IS:2418
	International Civil Aviation Organization	ICAO-Annex 14
	General Lighting - LEDs and LED modules – Terms and Definitions	IS 16101 : 2012
	Self- Ballasted LED Lamps for General Lighting Services Part 1 Safety Requirements	IS 16102(Part 1) : 2012
	Self-Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements	IS 16102(Part 2) : 2012
	Led Modules for General Lighting Part 1Safety Requirements	IS 16103(Part 1) : 2012
	Led Modules for General Lighting Part 2 Performance Requirements	IS 16103(Part 2) : 2012
	Safety of Lamp Control Gear Part 2 Particular Requirements Section 13 d.c. or a.c. Supplied Electronic Control gear for Led Modules	IS 15885(Part2/Sec13):2012
	D.C. or A.C. Supplied Electronic Control Gear for LED Modules - Performance Requirements	IS 16104 : 2012
	Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources	IS 16105 : 2012

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Sr. No.	Description	Standards Code
	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products	IS 16106 : 2012
	Luminaires Performance Part 1 General Requirements	IS 16107(Part 1):2012
	Luminaires Performance Part 2 Particular Requirements Section 1 LED Luminaire	IS 16107(Part 2):2012
	Photobiological Safety of Lamps and Lamp Systems	IS 16108 : 2012
10.0	Earthing, Bonding & Lightning Protection	
	Earthing Code of Practice	IS 3043
	Lightning Protection System	IS 2309
	Lightning Protection System	IEC 61024-1-2
	Lightning Protection System	BS EN 62305 (1 to 4)
	Accessories for Lightning Protection Systems	EN 50164
	Code and practices for design loads for structures	IS 875 (Part III)
	Hot rolled low, medium and high Tensile structural steel	IS 2062
	Grades of MS plates	BSEN 10025/DIN 17100
	Degree of provided by Enclosures- IP code	BSEN 60529
	Welding	BS 5135 / AWS
	Galvanizing	BS EN ISO 1461
	Lighting columns, Recommendations for surface protection of metal lighting columns	BS EN 5649-4
	Specifications of Masts and foundations	TR No. 7 ILE, UK

4.2.1. Design & Drawing Software

The contractor shall prepare and submit the following design report document and drawings:

- The Drawings Shall be prepared in latest version of Autocad,
- Lighting Design, Simulations, 3D rendering & walkthroughs,
- Dialux Latest Version (for interior illumination design),
- AGI 32 Latest Version (for Street/Roads & Exterior Area illumination design);
- Conductor Signing and voltage dop calculation,
- Earthing and Bonding design including Calculation,
- Lightning Dsign and Calculation,
- Revit, Navisworks, 3D Max & other relevant required software tools (3D rendering & walkthroughs)

4.3. 11KV Receiving Station - BEST

BEST is Power Supplying Authority finalized for MTHL Project and supply is made available at11kV from Sewri and it shall be metered at 11kV. This supply shall have dual source with dual ring for entire length of the project till Chirle to have uninterrupted power supply.

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The Contractor shall comply the requirement of design and installation of 11KV receiving Station of BEST. The liasoning with Utility shall be carried out by Contractor to get the necessary approvals. The Equipment and the layout shall be approved by BEST within the receiving station.

4.3.1. Design Approval:

Schematic arrangement with Equipment capacity shall be got approved from the EIC and Electrical Inspector

4.3.2. Layout Approval:

Switching station layout shall be approved by BEST Execution Team. The Contractor shall have license to carry out HV Works.

4.3.3. Equipment Selection Approval :

Equipment Selection shall be from the given List of Approved makes in the Tender and same shall be acceptable to BEST's and EIC.

Supply, Installation, Testing & Commissioning of the HV Panels, SCADA System, and other Equipment shall be complete in all respect. The entire switching station equipment, Power & Control cabling shall be carried out in close co-ordination with BEST's Power Supply & planning Team along with SCADA System shall be implemented as per latest & best practice to meet the requirement of operation and Control of Power Supply at all the connected compact substations for the Project.

4.3.4. Reference Drawings :

Reference Design Drawings are attached for your further Design and detailing of the system at the time of Execution of the Electrical Works.

4.4. 11KV/415V Compact Substation & SCADA System

4.4.1. General

The 11 KV packaged distribution substation shall be completed with all components and accessories, which are necessary or usual for their efficient performance and trouble-free operation under the various operating and atmospheric conditions. The handling equipment's required for operation & maintenance shall be in the scope of supply.
Package Sub-station - 11KV SF6 Insulated Ring Main Unit consisting of

- 11KV Load break switch - Isolators / interrupter incoming-outgoing feeder cables
- 11KV protection circuit breaker for transformer protection,
- 11/0.433 kV Dry Type Transformer
- Low Voltage Switchgear Panel including all accessories, fitting & auxiliary equipment
- 415 V, 3 Phase LT power distribution system as per details specified in this specification.

This specification may have not covered complete parts and accessories etc., but otherwise form part of the 11 KV packaged distribution substation necessarily be required being part of standard trade and/ or professional practice and/ for proper operation, shall also included in the specification. The Contractor shall not be eligible for any extra charges for such accessories etc.

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The manufacturer of CSS shall supply RMU as a part of CSS. The Vacuum Interrupter (VI) used in RMU shall be of same make as that of RMU.

The CSS shall also be provided with one set of coupling Interrupter as require to couple the Cable Ring Main at the strategic locations to maintain reliability under exigencies. Therefore, one set Interrupter (Breaker) shall also be housed in CSS to facilitate Cable Ring Main Interconnections at the strategic locations (three locations have been identified between Sewri to Gavan along the route) as per the detail mention in the specification and drawing for reference.

4.4.2. Compact Substation Design Requirement

The Ring Main Unit (RMU) shall be designed to operate at rated voltage of 12kV and shall consist of two numbers of load break switches and one number of circuit breaker for transformer protection shall be enclosed in the main tank using SF6 gas as insulating and vacuum as arc quenching medium or SF6 gas as both insulating and arc quenching medium for control of 11/0.433kV transformers up to 1000 kVA.

4.4.3. Basic Constructional Aspects

The equipment offered shall be metal enclosed free standing with transformer mounted type. The free standing RMU shall be stable and rigid on its own support. The unit shall be provided with lifting facilities of proven design for easy handling.
The equipment shall be complete with necessary cable termination boxes, earth fault indicating device with current transformers, vacuum circuit breaker and disconnect or earthing switch with necessary safety interlocks and designed for minimum maintenance.

The mechanical design and strength of the compact substation unit and components shall be able to bear the mechanical stresses on the switch terminals when installed and in operation, The equipment shall withstand the electro-dynamic forces without reduction of the switches reliability or current carrying capacity.
The main tank (Inner enclosure of circuit breaker and ring main switches assembly) and Transformer including all switchboard assembly and LT Panel / distribution Boards shall be housed in a single compact metal clad suitable for outdoor application.

Inner Enclosure (Main Tank)

Main tank which will use for SF6 as insulation and quenching medium (vacuum is however preferred for quenching in CB's) shall be welded stainless steel / Aluzinc etc. The pressure system shall be defined as a sealed for life system with an operating lifetime exceeding 30 years. The leakage rate of SF6 gas shall maintain less than 0.1 % per year. In order to guarantee a reliable and tight welding, manufacturer shall make sure all welding work is carried out by computer-controlled robots. An absorption material such as activated alumina in the tank shall be provided to absorb the moisture from the SF6 gas to regenerate the SF6 gas following arc interruption.

A temperature compensating gas pressure indicator offering a simple indication shall constantly monitor the SF6 insulating medium. The degree of protection of the inner enclosure shall be rated IP 65, IP 67 is preferred.

4.4.4. Vacuum Circuit Breaker

The 3 pole circuit breaker for the protection of distribution transformers shall be enclosed in the main tank. The rated breaking and making current at rated voltage shall be as follows.

- 1kV system : Rated breaking capacity shall be 21kA for 3 second

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- Rated making capacity shall be 52.5kA for 3 second.

The manual operation of the circuit breaker shall not have an effect on the spring harging mechanism.

4.4.5. Cable Boxes

All cable boxes shall be air insulated suitable for dry type cable terminations. The cable boxes at each of the two load break switches suitable for HV cables up to 300mm² and circuit breaker cable suitable up to 300mm². The cable box shall be arc resistant as per IEC 62271- 200. The internal arc fault test on cable box shall be carried out for 11kV system for 21kV for 1 second.

The clearance between phase to phase and phase to earth shall be as per IEC 61243-5. The cable termination and gland arrangements shall be appropriate for the type and style of cables used at the time. Deration and increased clearances due to altitude will be detailed by the Contractor

4.4.6. Operational Switches

The load break switches (isolator) for incoming and outgoing supply must be provided and must fully insulate by SF6 gas. The operating mechanism shall be spring assisted mechanism with operating handle for ON/OFF. Earth positions with arrangement for padlocking in each position. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched ON 'at the same time. The selection of the main and earth switch is made by a lever on the facia, which can move only if the main or earth switch is in the off position. The load break switches should have the facility for future remote operation. Each load break switch shall be of the triple pole, simultaneously operated, non-automatic type with quick break contacts and with integral earthing arrangement. The rates current of isolator shall be 630A continuous at maximum ambient temperatures.

4.4.7. Earth Fault Indicators / Fault Passage Indicators (EFI/FPI)

These 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 unit should be self-contained requiring no auxiliary power supply. The EFI shall be integral part of RMU.

4.4.8. Anti-Corrosive Prevention

The housing chamber interiors shall be cleaned of all scaled rust by shot blasting or any other approved chemical method and shall be coated with paint/enamel or suitable medium resistive to the electrical insulating medium adopted.

The exterior of the unit cleaned of all scale and rust by shot blasting or any other approved chemical method and shall be treated with zinc spray. Every precautionary method should be taken to design and construct the unit for weatherproof against the service conditions indicated.

4.4.9. Outdoor enclosure:

The outdoor enclosure shall be type tested made of galvanized Sheet Steel of thickness 2 mm and having 4 mm base frame tropicalized to local weather conditions. The metal base shall ensure rigidity for easy transport & installation. Substation will be used in outdoor application hence to prevent enclosure from rusting/corrosion. The enclosure shall have IP 54 degree of protection for HT & LT switchgear compartment & IP 23 degree of protection for transformer compartment.

The Enclosure exterior shall be Powder coated (Colour Light Gray & D.A.Gray). Each compartment will be provided with the door and pad locking arrangement. The

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Compartment illumination lamp with door operated switch shall be provided for each compartment. Roof of CSS should be slant to avoid water logging.

4.4.10. Foundations

The floor fixing of the equipment shall allow for mounting on a simple rectangular plinth with a flat surface.

4.4.11. Basic Operational Aspects

The operating mechanisms shall be of independent manual type and shall be integral with switches and interlocks. The movement of any operating handle against an interlock shall not by any means originate, store or activate the energy mechanism.
Padlocking Arrangements
The circuit breakers and switches can be locked in the open/closed or earth on position by 1 to 3 padlocks ESI size.

4.4.12. Testing Facilities

Remote Control of the RMUs : Remote operation of the RMU's 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. RMU shall fully energized when install on site and manufacturer should provide detailed instructions for installation to the control mechanism. The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches or circuit breaker.

4.4.13. Earthing

There shall be continuity between the cast resin earth screen and metallic parts of the switchboard and cables so that there is no electric field pattern in the surrounding air.

4.4.14. Main circuit

The cables shall be earthed by an integral earthing switch with short-circuit making capacity, in compliance with IEC 60129. The earthing can only be operated when the switch is open. The earthing switch shall be operated through the main circuit mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

4.4.15. Tools

Any form of special tools or devices necessary for routine operation and maintenance of the unit shall be incorporated and supplied with the unit. The recommendation of the tools shall be for a period of five years operation.

4.4.16. Ratings:

Description	Unit	Value
Rated Voltage / Operating Voltage	kV rms	11
Rated frequency & Number of phases	Hz & nos.	50 & 3

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Description	Unit	Value
Rated maximum power of substations	kVA	160kVA/500kVA/630kVA/1000kVA
Rated Ingress protection class of Enclosure		IP-23 -Transformer Compartment and IP-54 : RMU Compartment. IP 65 : RMU (Inner Tank)
HV Insulation Level		
Rated withstand voltage at power frequency of 50 Hz	kV rms	28
Rated Impulse withstand Voltage	kV peak	75
HV Network & Busbar		
Rated current	Amp	630A
Rated short time withstand current	kA rms /	21KA
Duration of short circuit	3 sec	
Making capacity for switch-disconnector & earthing switches	kA peak	50kA
Breaking capacity of Isolators (rated full load)	A	630A
LV Network		
(as per CSS technical particulars)	Incomer from Transformer: 50KA, 50Hz, 4P, Fixed type Microprocessor based Air Circuit Breaker (ACB).	
	Outgoings: 4P, 50kA Microprocessor based Air Circuit Breaker (ACB) with O/c, E/f & S/c OR 36kA Microprocessor based motorized Moulded Case Circuit Breaker (motorized MCCB) with O/c, E/f & S/c protection. (as per CSS technical particulars)	

4.4.17. Salient Technical feature of "SF-6 Insulated RMU."

Ring Main Unit (RMU), comprising of combination of Load break Switches and Vacuum "T" OFF Circuit Breaker with (3 O/C & 1E/F) Relays, each consists of:

- Load Break Switch (LBS) (630A)
- Vacuum Circuit Breaker (CB 630 A) and Earthing Switch

- Auxiliary contacts 1NO and 1NC
- Anti-reflex operating handle
- LED Indicators thru Capacitor Voltage Dividers mounted on the bushings.
- Operating handle
- 3O/C + 1E/F self-powered relay with Low and High set for Over current and Earth Fault with RS485 port for MODBUS communication.
- Relay should have facility to trip the breaker from remote without shunt trip coil.
- Mechanical ON/OFF/EARTH Indication Loose Material,
- Battery and charging circuit of be 24V DC and 26 amp-hours (min) for motorized operation for 4 minimum hour of operations.

4.4.18. Indoor RMU for CSS

- Modular design, type tested,
- RMU must be made of robotically welded non-magnetic and non-ferrite grade stainless steel with all live parts inside stainless steel tank Non extensible.
- Maximum Modules can be accommodated in a single Stainless-steel Tank to make it more compact and reliable.
- Cable covers must be interlocked with Earth switch to have complete safety of operating person. Battery and charging circuit of be 24V DC and 26 amp-hours (min) for motorized operation for 4 minimum hour of operations.

4.4.19. Service conditions

The switchgear and control gear should be suitable for continuous operation under the following service conditions:
Ambient temperature – 50deg.C
Relative humidity up to 95%
Altitude of installation up to 1000m,
The switchgear should have the minimum degree of protection (in accordance with IEC 60529)
IP 65 for the tank with high voltage components,
IP 54 for Front Cover
IP 3X for the cable connection covers

4.4.20. Technical Data

Guaranteed Technical data - Ring Main Unit,

Electrical data and service conditions		
Rated voltage	KV	12KV
Power frequency withstand voltage	KV	38
Impulse withstand voltage	KV	95
Rated frequency	Hz	50
Rated current busbars	A	630
Rated current (cable switch)	A	630
Rated current (T-off)	A	630
Breaking capacities:		
active load	A	630
closed loop (cable switch)	A	630

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off load cable charging (cable		
Switch)	A	135
earth fault (cable switch)	A	200
earth fault cable charging (cable switch)	A	115
short circuit breaking current		
(T-off circuit breaker)	kA	21
Rated making capacity	kA	50
Rated short time current 3 sec.	kA	
21KA (Outdoor)/ 21kA (Indoor)		
Ambient temperature:		
Maximum value	°C	+ 50
Altitude for erection above sea level 4m ...1000		
Relative humidity Max		95%

4.4.21. General data, enclosure and dimensions

Standard to which Switchgear complies	IEC
Type of Ring Main Unit Metal Enclosed,	
Panel type, Compact Module.	
Number of phases	3
Whether RMU is type tested	Yes
Whether facility is provided with pressure	
Relief	Yes
Insulating gas	SF6
Nominal operating gas pressure as per IEC	
Gas leakage rate / annum %	0.1% per annum
Expected operating lifetime	30 years
Whether facilities provided for gas	Yes, temperature

Compensated manometer monitoring can be delivered

Material used in tank construction Non - Magnetic and Non ferrite grade Stainless steel sheet

4.4.22. Operations, degree of protection and colours

Means of switch operation	separate handle
Means circuit breaker operation separate handle and push buttons	
Rated operating sequence of Circuit Breaker O	–3min-CO-3min-CO
Total opening time of Circuit Breaker	approx. 40-50ms
Closing time of Circuit Breaker	approx. 30-45ms
Mechanical operations of switch	CO 1000
Mechanical operations of CO earthing switch	1000
Mechanical operations of circuit breaker	CO 2000
Principle switch / earth switch	3position combined switch

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4.4.23. Other Main Features

a. Bus bars

Comprising the 3 single phases electrolytic grade copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

b. The mechanisms

All mechanisms should be situated in the mechanism compartment behind the front covers outside the SF6-tank. The mechanism for the switch and the earthing switch is operating both switches via one common shaft. The mechanism provides independent manual operation for closing and opening of the switch, independent closing of the earthing switch and dependent opening of the earthing switch.

The mechanism for the T-off switch and earthing switch is operating both switches via one common shaft. The mechanism has stored spring energy and provide independent manual operation for closing and opening of the switch, independent closing of the ear thing switch and dependent opening of the earthing switch. The mechanism for the vacuum circuit breaker (VCB) and disconnector- earthing switch is operating the VCB and the disconnector earthing switch via to separate shafts. The mechanism for the VCB has stored spring energy and provides independent manual operation for closing and opening of the VCB. The mechanism has a relay with related CT's and/or remote tripping device. The mechanism for the disconnector earthing switch provide independent manual operation for closing and opening of the disconnector, independent closing of the earthing switch and dependent opening of the earthing switch.

c. Front covers

The front operating cover contains the mimic diagram of the main circuit with the position indicators for the switching devices. The voltage indicators are situated on the front panels. Access to the cable bushings is in the lower part of each module.

d. Position indicators

The position indicators are visible through the front cover and are directly linked to the operating shaft of the switching devices.

e. Voltage indicator

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.

f. Cable Compartment:

It should be possible to terminate up to a 1x 3c x300sqmm core HV cables in each cable compartment. The access to the compartment will be possible by removing the cable cover OR Hinged to the main frame only when earth switch is ON. Cable Compartments of RMU should be Arc Proof and interlocked with respective Earth Switches. Each module has a separate cable compartment that is segregated from each other by means of a partition wall. A partition wall should be fitted to divide the cable compartment from the rear side of the switchgear. In case of an arc inside the tank, followed by the opening of the pressure

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relief, the partition wall prevents the hot gases flowing out from the pressure relief to enter the cable compartments. All covers are removable. The ground continuity is achieved when the covers are in place by means of Hinged connections. Interconnection between HT switchgear and transformer shall be using 1Cx3x95 sq.mm Al. unarmoured XLPE Cable.

g. Interlocking.

The mechanism for the cable switch should be provide a built-in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position.

The mechanism for the T-off switch should be provide a built-in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position. The mechanism for the VCB and the disconnector-earthing switch should be having a built in interlocking system to prevent operation of the disconnector-earthing switch when the VCB is in the closed position.

Further is should not be possible to Open the Cable doors unless the Earthing Switch is Turned ON. In case the Cable door is accidentally left open a positive interlock shall prevent operation of Load Break Switch and Isolators / Breaker from any operation.

h. Fault Passage Indicators.

These shall facilitate quick detection of faulty section of line. The fault indication may be based on monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU to avoid thefts. The FPI shall have clear display, automatic reset facility and shall be SCADA compatible. 1 No FPI shall be provided in each Isolator.

4.4.24. Type & Routine Test on Package Substation:

Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298,60420,60529 and 60694. The Package Substations offered must be type tested as per IEC 62271-202 in the last 5 years. CSS manufactured at in JV consortium shall not be accepted. The copy of type test summary should be submitted along with the tender.

Routine Tests: Routine tests should be carried out in accordance with IEC 60298 standards. These tests should be ensuring the reliability of the unit.
The routine tests shall be made on each complete prefabricated substation.

Test Witness: Routine test shall be performed in presence of Owner's representative if so desired by the Owner. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

Test Certificates:

Certified reports of all the tests carried out at the works shall be furnished in three (3) copies for approval of the Owner.

4.5. Dry Type Distribution Transformer in CSS

4.5.1. General

This specification covers distribution transformers to step down the 11 kV BEST supply, the dry type 11/0.433 kV transformers as required to supply loads in the bridges and roads, service buildings, control rooms and other auxiliary loads.

All transformers must be appropriate for the seaside environment and temperature range stated under the specification. Nevertheless, the dielectric strength of the air in such a high altitude is less than sea level. Such effect needs to be taken in to account when external insulation is designed and tested. De-rating calculation needs to be carried out by manufacturer and approved by the Engineer.
The manufacturer shall make recommendations for surge arrestors, suitable for the lightning incidence of the area.

The load capacity of transformers is indicative, however, shall be dependent upon the final lighting and power loads and other system design solutions. Each transformer will be sized to accept 100% of the relevant substation load. Under normal operating conditions.

4.5.2. Codes & Standards

The equipment covered by this specification shall, unless Otherwise stated to be designed, constructed and tested in accordance with latest revisions of relevant Indian standards / IEC publications stated above.

4.5.3. General Design Features

All transformers shall be of the latest design, dry type Cast Resin only.

The type of cooling shall be Natural Air cooled (AN) and the corresponding ratings for each transformer shall be as indicated in the specific requirements.

Each transformer shall be suitable for operation at full rated power on all tapings without exceeding the applicable temperature rise.

It shall be possible to operate the transformer satisfactorily, with the loading guide specified in IS-6600. There shall be no limitations imposed by bushings, tap changers, auxiliary equipment to meet this requirement.

The transformer shall be design to to operate safely for 30 seconds with a voltage of 1.3 times rated voltage imposed to the feeder winding. Further they shall be able to operate continuously at their nominal ratings within the limits of temperature rises, at voltage variations of ±10% at their feeder windings, at any frequency variation between -5% and +5% and at any combination of voltage and frequency variation together with any voltage ratio to be adjusted by the tap changer.

4.5.4. Construction

The transformer shall be dry type, AN cooled suitable for Compact substation application. The core-clamping frame shall be provided with lifting eyes having ample strength to lift the complete core and winding assembly. Off circuit tapings shall be provided on the HV windings. Tap changing is done by means of off-circuit links accessible through openings provided. The lifting lugs and rollers shall be provided. A winding temp. Scanner shall be provided and is actuated by means of resistance temperature detectors embedded in the windings of all three phases. It should have alarm and trip contacts at a specified temperature. The enclosures shall effectively enclose the live parts. Access to the

transformer be permitted by means of hinged doors or other approved methods the enclosure shall provide protection of IP 23 protection class. The wall thickness of doors and other metal enclosure shall not be less than 1.8 mm..

a. Windings

The winding insulation shall be Class 'H' and temperature rise limit to Class H i.e. 180 deg.C as required. Windings shall be of high conductivity Copper conductors Windings shall be designed to withstand the specified thermal and dynamic short circuit stresses. The windings shall be duly sectionalized. Accessible joints brazed or welded and finished smooth shall connect similar sections. No corona discharge shall result on the winding upon testing the transformer for induced voltage test as specified in IS. The end turns of the high voltage windings shall have reinforced insulation to take care of the voltage surges likely to occur during switching or any other abnormal condition. The high voltage and low voltage winding are shall be made of copper Conductors. HV winding will be always be resin casted under vacuum while LV winding can either be casted or pre-impregnated with resin.

b. Core

The double wound Core shall be constructed from non-ageing Cold Rolled Grain oriented steel sheets. The built core shall be painted with high temperature resistant paint to prevent corrosion at the edges of core plates and to withstand high temperatures. By using different core material optimization of core losses shall be achieved. The yokes shall be firmly clamped between yoke channels or plates. The top & bottom yoke frames shall be secured to each other by means of tie-rods, which help in securing the winding in place. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and the production of flux component at right angles to the planes of laminations which may cause local heating.

c. Off-Circuit Tap Changing Links

Off circuit tapings are provided on HV windings. Tap changing is done by means off circuit links. Use of tap changing links eliminates any moving parts as against a manually operated tap changer.

d. Terminal Arrangement

HV side and LV side of transformer will have the top busbar arrangement for connection of HT side by means of cable and LT side by means of busbar.

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4.5.5. Technical particulars of dry type transformer

DESCRIPTION	PARTICULARS
Type	Three Phase, 50 Hz, Core type, two winding, Cast Resin Dry Type Transformer
Ratings (KVA)**	160kVA/ 500kVA/ 630kVA/ 1000kVA
Winding material	Copper
No load voltage ratio	11 / 0.433
Connection HV LV	 Delta Star with neutral
Vector group	Dyn 11
Insulation level (KVp/ KVrms) HV b) LV	 75 / 28 -/ 03

DESCRIPTION	PARTICULARS
Type of Tap Changer for giving voltage variation to HV	Off circuit tap links
Tapping range	+5 % to –5 % in step of 2.5%
Temperature rise winding over ambient temperature	130 °C
Class of Insulation	Class 'H'
Enclosure	IP 23 (Without Enclosure)
Method of Cooling	AN (Air Natural)
No load losses (IS Tol.)	As per ECBC 2017 (with IS Tolerance)
Full load loss (IS Tol.)	As per ECBC 2017 (with IS Tolerance)
Termination HV LV	 Busbar Busbar
Fittings for Dry type	2 Numbers Earthing Terminals, Rating and Diagram Plate, Lifting Lugs, Winding Temp Scanner.
Paint	Enamel-RAL 7032 (Siemens Grey) (as per manufacturers standard)

Note** : The KVA rating transformer (s) as above, are indicative but not exhaustive, the contractor shall however, undertake design, detailed engineering, schedules, drawings etc. and elaborate detail based on the site condition and actual parameters as required to meet a complete Power Supply System in an acceptable manner for approval by the Engineer.

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4.5.6. Painting

All steel surfaces shall be thoroughly cleaned by sand blasting or chemical agents as required to produce a smooth surface free of scale, grease and rust the external surface, after cleaning, shall be given a cost of high-quality red oxide or yellow quoted primer, followed by filler coats.

4.5.7. Routine Test

All Routine Tests in accordance with IEC 60076 / IS 2026 shall be carried out on each transformer.

4.6. LT DISTRIBUTION PANELS AND SWITCHBOARDS

The scope of work shall cover design, manufacture, supply, installation, testing and commissioning of all LT Distribution Panels, Switchboards, and Distribution Boards suitable for 415 volts, 3-phase, 50 Hz, 4-wire system, comprising of circuit breakers, bus bars, wires interconnections, metering, protection, earthing and SCADA / BMS Compatibility etc., meeting the requirements shown in schematic diagrams, and as specified in this specification.
The Distribution Panels and Switchboards shall be design and procured for 415 volts, 3-phase, 50 Hz, 4-wire power distribution for Bridges & Roads lighting, building for illumination (internal / external), Ventilation,& HVAC, lifesaving services, small power, control and monitoring equipment including emergency power for essential services.

The Contractor shall undertake and to provide discrimination study for the complete LT distribution system from the source to downstream to the final circuit for application of protective device. The study shall be provided in paper and electronic format for approval by the Engineer in Charge.
If discrimination is not achieved between any adjacent pairs of protective devices this shall be identified to the Employer or Employer's Representative and if this is not carried out it shall be deemed that full discrimination has been achieved. This shall ensure discrimination on overload and short circuit applications is achieved by using the appropriate switchgear components and rating.

All switchgear shall be sourced from the same manufacturer (i.e. ACBs/MCCBs/MCBs / MPCB/SFU'S etc., mixing of switchgear manufacture shall not be permitted on this project.

The control scheme shall provide for automatic load transfer if the normal incoming supply to a bus is lost, and permit manual switching to remove second incoming line from service or to return an incoming line to service after a transfer, with no break in the power supply.

All components of the switchboard shall be rated for the electrical system characteristics shown on the single-line diagram(s). The rating of equipment / component shall take full account of all heat sources and other de-rating factors, non-linear loads within the enclosures. Special reference is made in respect of enhanced circuit making requirements and the DC component of fault current at breaking.

Unless otherwise stated only electronic releases (LSI) will be equipped with **all the** ACBs and MCCBs above 200A. However, MCCBs up to 200 A shall be equipped with Thermal-magnetic trip units. These releases shall be integral to the protective device.

4.6.1. STANDARDS

All equipment, components, materials and entire work shall be carried out in conformity with applicable and relevant IS/BS/IEC Standards and Codes of Practice. In addition relevant clause of Indian electricity act 2003 and Indian electricity rule 1956 amended up to date shall apply.
It is to be noted that updated and current standards shall be applicable irrespective of dates mentioned with references/ standards in the tender documents.

In case of any conflict between specifications & the standards, the instructions/decision of 'the Engineer' or Employer's authorized representative shall be binding. It is responsibility of contractor to take entire switchboard on communication to SCADA/BMS with widely acceptable open protocol Modbus/ BACnet TCP/IP so that all electrical parameters on the switchgear can be control and monitored from Centralized Control Centre.

4.6.2. AIR CIRCUIT BREAKER (ACB)

Air Circuit breakers shall be air break, horizontal electrical draw-out type fully interlocked and meeting the requirements of Indian /IEC standards. Breakers shall be rated for operating voltage Ue of 415/690 V & insulation voltage Ui: 1000 V, rated Impulse – 12kV for main feeders. Breaker shall be capable of making and breaking system short circuits as specified. Total discrimination should be available among the breaker upto the extent of specified capacity of downstream breakers at the point of fault.

Breakers shall be electrically operated with remote operation facility, complete with front-of-the-panel operating handle, isolating plug with safety shutters, mechanical ON/OFF indicator, silver plated arching and main contacts, arc chutes suitably designed to provide larger arc elongation, trip free operation. Breakers shall be capable of being racked out into 'Testing', 'Isolated', and 'Service' and Maintenance position and kept locked in any position. Breakers for remote operation shall be 240 volt ac motor operated spring charged accessory fitted in it. All the poles shall have completely insulated from each other internally and double insulation as standard feature.
All 4 Pole ACB shall have 100% Neutral rating and capable of setting Neutral protection to N or N/2 to ensure precise neutral protection. All ACB's shall be of single frame size upto 2000A to optimize requirement for spares management.

4.6.2.1 Technical parameters

The Circuit Breaker shall be of air break type of robust and compact moulded case design, with class 2 front facia, suitable for indoor mounting and conforming to IS: 60947 with symmetrical rupturing capacity at 415 Volts as specification and drawings. All circuit breakers shall be provided with over current/ short circuit and earth fault releases. The ACBs should have a short time withstand capacity of not less than 50 kA for 1 second. Shunt trip and closing coil of Suitable rating, suitable for 240 volt ac as per drawing shall be provided. The ACBs shall have Ics = Icu = Icw for 1 second. The circuit shall comply with the isolating function requirements of IEC 60947-2 section to facilitate the safety of person.

4.6.2.2 Constructional features

Each Circuit Breaker shall be housed in a separate compartment enclosed on all sides. 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.
Air Circuit Breakers shall be provided in fully draw out cubicles. These cubicles shall be such that draw out is possible without disconnection of the wires and cables. The power and control circuits shall have self-aligning and self-isolating contacts. The fixed and moving contacts shall be easily accessible for operation and maintenance. Mechanical door interlocks shall be provided on the draw out cubicles to ensure safety and compliance to relevant Standards. Door interlock shall be true door interlock as per relevant standards.

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Self-aligning cluster type isolating contacts shall be provided for the Circuit Breaker with automatically operated shutters to screen live cluster contacts when the Breaker is withdrawn from the cubicle. Sliding connections including those for the auxiliary contacts and control wiring shall also be of the self-aligning type. The fixed portion of the sliding connections shall have easy access for maintenance purposes.
The automatic shutters should be integral part of breaker & locking arrangement should be provided as per standards Contacts should be self aligning type requiring no special effort to align them.
The ACBs shall be fitted with arc chutes on each pole designed to permit rapid dispersion, cooling and extinction of the arc.
ACBs shall have separate main and arcing contacts. Arcing contacts shall be hard wearing material of copper or silver Main contacts shall be of Silver nickel graphite.
The insulation material shall confirm to Glow wire test as per IEC 60695.
ACBs shall be CE marked. The shunt trip and closing coil of ACB shall be continuous rated.
ACB shall have minimum watt losses in order to restrict temperature rise inside the breaker.

4.6.2.3 **Operating Mechanism**

The Circuit Breaker shall be trip free with stored energy type operating mechanism, closing spring shall be able to manually charged by operating the front lever with mechanical ON/OFF indication. Breaker shall be convertible from manual to Electrical at site. The operating mechanism shall be such that the circuit breaker is at all times free to open immediately the trip coil is energized. The operating handle and mechanical trip push button shall be at the front of and integral with the Circuit Breaker.
The Circuit Breaker shall have the following three distinct and separate positions, which shall be indicated on the face of the panel. Service/Test/Isolated position shall be positively achieved only through the racking motion of draw out mechanism and not by trial & error.

"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.

4.6.2.4 **Circuit breaker interlocking**

Sequence type strain free interlocks shall be provided to ensure the following:

a) It shall not be possible for the Breaker to be withdrawn from the cubicle when in the "ON" position. To achieve this, suitable mechanism shall be provided to lock the Breaker in the tripped position before the Breaker is isolated. The racking shutter should open only when ACB is off Condition.
b) 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.
c) It shall not be possible for the Circuit Breaker to be plugged in unless it is in the OFF position.
d) A safety latch shall be provided to ensure that the movement of the breaker, as it is withdrawn, is checked before it is completely out of the cubicle, thus preventing its accidental fall due to its weight.

4.6.2.5 **Circuit Breaker auxiliary contacts**

The Circuit Breaker shall have minimum 4 changeover auxiliary contacts rated at 10 A 220 volts 50 Hz. The auxiliary contacts could be used as NO or NC as per requirement & there should be provision to add minimum 6 aux. contacts, if required for future use. 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. The changeover contact should be replaceable without disturbing any critical parts like trip unit/mechanism of breaker.

4.6.2.6 **Anti-pumping.**

Mechanical and electrical anti-pumping devices shall be incorporated in the circuit breakers as required.

4.6.2.7 **Mechanical & Electrical life.**

The mechanical life must be at least 25000 operations, with regular ordinary maintenance. The electrical life must be at least 10,000 operations, with regular ordinary maintenance. These values are intended to be valid only for CAT B circuit-breakers. The ACB shall have 8 trip history records for faults and 20 trip history of events. Releases shall be upgradable to power measurement at a later stage. All ACBs shall be provided with mechanical operation counter.

4.6.2.8 **Type Test Certificates**

The ACBs shall be type tested and certified for compliance to IS: 60947/Equivalent IEC from Indian/International Testing Authorities. Supplier should submit combined sequence test certificates for the same. All ACB shall confirm to EMI / EMC Standard & shall be immune to harmonics to avoid nuisance tripping. All incomer & outgoing ACBs shall be provided with RS 485 / ethernet ports for SCADA & BMS connectivity through MODBUS/Backnet, TCP/IP protocol.

4.6.2.9 **Protection**

The true RMS sensing microprocessor based communication inbuilt numerical release with intrinsic RS 485 port for communication by open protocol shall be provided on circuit breaker for offering protection against overload (long time) with adjustable time delay, short circuit (short time) with intentional delay, earth fault protections with intentional time delay& instantaneous protection all with adjustable settings. There shall be LCD /LED display for actual value display for showing the percentage loading in each phase built in the trip unit. The release shall have an LED/LCD display to show RMS current in all three phases, neutral (4 pole). The release should have individual fault detection by LEDs for faster fault diagnosis and reduce down time. The release shall also offer additional protections like under & over voltage, current & voltage unbalanced, phase sequence etc. The release shall be self-diagnostic with indication. All the adjustment should be on line and the circuit breaker need not be switched of while adjusting the setting. The control unit shall have thermal memory throughout the range to store temperature rise data in case of repetitive overload or earth fault for protecting the cables and loads. The Release shall provide zone selective interlocking for short circuit and earth fault protection zones between ACBs to reduce thermal stress on the system. The release should provide last 5 trips fault history including cause of fault as well level of fault current. Acknowledgement of settings should be visible on the screen of release. Communication feature should be independent of trip unit i.e. any outside disturbances should not affect the trip unit of circuit breaker. The trip unit should be self-powered.

All incomer ACBs shall have following additional protections other than mentioned above.

- Under and over voltage
- Under and over frequency
- Restricted Earth Fault protection
- Trip Circuit supervision with PS class CT's
- Release should display the Contact wear indication.

The Parameters of the Protection Release should be changeable from Release as well as thru communication network. Release should have graphical LCD for display of power parameters.

- Phase currents (running, average & max) – All parameters in single window.
- Release should be able to capture short circuit current on which ACB has tripped. The last ten trips and alarms shall be stored in memory with the date & time stamping along with type of fault and alarm. The sensing CT Should be Rogowski type with measurement precision of 1%.
- Release should be self-powered.

- Release should have facility to select different type of IDMTL protection (DT, SIT, VIT, EIT, HVF) for better co-ordination with HT Breaker/Fuse.
- Phase voltages (running, average & max)
- Energy & power parameters (active, reactive and apparent) and PF
- Frequency
- Maximum Demand (KVA & KW)
- Total Harmonics distortion

All O/G ACBs shall have following functions.

i. **Protection**

- The ACB control unit shall offer the following protection functions as standard: Long-time (LT) protection with an adjustable current setting and time delay;
- Short-time (ST) protection with an adjustable pick-up and time delay;
- instantaneous (INST) protection with an adjustable pick-up and an OFF Position.
- Current and time delay setting shall be indicated in amperes and seconds respectively On a digital display.
- Earth-fault protection with an adjustable pick-up and time delay shall be provided if indicated on the appended single-line diagram.

ii. **Measurements**

- An ammeter with a digital display shall indicate the true rms values of the currents for each phase. Release shall acknowledge the current & time delay settings done by user on the LCD display.
- A LED bar graph shall simultaneously display the load level on the three phases.
- A maxi meter shall store in memory and display the maximum current value observed since the last reset. The data shall continue to be stored and displayed even after opening of the circuit breaker.

4.6.3. MOULDED CASE CIRCUIT BREAKER (MCCB)

Moulded Case Circuit Breakers shall be standard products of established manufacturers as indicated in list of approved makes best suited to the application duty and shall conform to IEC 60947-2./ IS 60947-2, MCCBs shall be suitable for fault levels as specified in the specification / drawings or higher. Upstream breakers shall be of higher kA rating compared to downstream breakers, if required to ensure total discrimination, coordinated protection of the distribution system. MCCB's shall be provided in fixed type cubicles.

MCCBs shall be current limiting type with trip time of less than 10 millisecond suitable for 3 phase 415 Volts AC 50 HZ supply with neutral 4P/3P/2P as required and rated for insulation voltage 690- 750 V, Rated operating voltage of 415V for 3 Phase, Rated impulse withstand voltage -8kV, Service short circuit breaking capacity (Ics) as specified and required as per relevant standards. All Breakers/MCCBs shall incorporate front adjustable interchangeable trip units with adjustable overload and adjustable short circuit faults.

MCCB of 250A and above rating shall be Microprocessor based Type with OL, SC & EF protection, whereas the MCCB below 250A shall be Thermal Magnetic type. All MCCB's offered shall have double insulation feature as standard. MCCB's offered shall be from the same series to have a commonality of appearance and spares management. No mixing of series is allowed within a manufacturer's range of MCCBs. Four pole MCCBs shall have flexibility of setting neutral current N or N/2. The mechanical operations MCCBs shall be > 15000 operations.

MCCB cover and case shall be made of high strength heat resisting and flame retardant thermosetting insulating material. Operating handle shall be quick make/break, trip-free type having suitable ON, OFF and TRIPPED indicators and a common handle for simultaneous operation of all the phases. Suitable arc extinguishing device shall be provided for each contact. Tripping unit shall be connected by a common trip bar such that

tripping of any one pole causes three poles to open simultaneously. Contact tips shall be made of suitable arc resistant alloy. Terminals shall be with adequate clearances.
MCCBs shall be provided with Suitable rated releases accessories to avoid the burning due to sustained command. In addition, MCCBs shall be provided with interlocking devices with the compartment door. Door interlock to prevent door being opened when the breaker is in ON position (extendable rotary handle to be invariable provided). Interlock to prevent the breaker being switch ON with the door open.
All MCCBs shall have suitably rated minimum 2 changeover auxiliary contacts unless specified otherwise. All Models 3&4 Poles versions shall be of same type, design and make and utilization category 'A'.
MCCBs shall have trip free mechanism such that tripping command always overrides the closing command. MCCBs shall have disconnection capability to ensure that handle does not return to off position in case of contacts getting welded. Compartment doors shall clearly indicate the state of MCCB i.e. ON/OFF/TRIP MCCBs shall be provided with test function (push button or equivalent) to check the correct functionality of the MCCBs.

- Each MCCB shall have a facility for padlocking in the off position.
- MCCBs shall have Copper spreader links with phase barriers as feature.
- MCCBs protection releases should be shrouded to avoid unauthorized tampering.
- In-built RMS sensing
- Central front from O/L S/C adjustments.
- MCCBs shall be CE marked.
- MCCBs shall not have any load line biasing.

MCCBs shall have cross bolted/shrouded terminals to withstand thermodynamic stress at higher short circuit current. MCCBs shall be type tested and certified from local/International testing authorities for conformance to IEC/IS standards. Switchboard shall be fully type tested as per IEC61439-1&2 guidelines.
All releases shall be tamper proof and should be total discrimination between ACBs and MCCBs upto the design fault level of the downstream devices.

All incomer and outgoing MCCB's shall be provided with RS485 port to enable it to communicate with BMS on Modbus/Bacnet, TCP/IP open protocol.

Earth fault protection shall be inbuilt feature of MCCB.

MCCB shall be motorized. if require, for control operation and switching from remote control center. The Contractor shall identify and design the power supply scheme and distribution system to full fill the Employer's Requirement.

4.6.3.1 Current Limiting & Coordination

The MCCB shall employ maintenance free minimum let-through energies and capable of achieving discrimination up to the full short circuit capacity of the downstream MCCB. The manufacturer shall provide both the discrimination tables and let-through energy curves for all.

4.6.3.1 Protection Functions

MCCBs with ratings up to 200 A shall be equipped with Thermal-magnetic (adjustable thermal for overload and fixed magnetic for short-circuit protection) trip units and MCCBs with 250A and above ratings shall be equipped with microprocessor-based (adjustable) trip units.
Microprocessor and thermal-magnetic trip units shall be adjustable, and it shall be possible to fit lead seals to prevent unauthorized access to the settings.
Microprocessor trip units shall comply with appendix F of IEC 60947-2 standard (measurement of rms current values, electromagnetic compatibility, etc.) Protection settings shall apply to all poles of circuit breaker.

4.6.3.1 Testing

Original test certificate of the MCCB as per IEC 60947-1 &2 or IS13947 shall be furnished.

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Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.

4.6.3.1 Interlocking

MCCBs shall be provided with the following interlocking devices for interlocking the door of a switch board.

a) Handle interlock to prevent unnecessary manipulations of the breaker.
b) Door interlock to prevent the door being opened when the breaker is in ON position.
c) Defeat-interlocking device to open the door even if the breaker is in ON position.

4.6.4. Motor Protection Circuit Breaker (MPCB)

Motor circuit breakers shall conform to the general recommendations of standard IEC 947 -1,2 and 4 (VDE 660, 0113 NF EN 60 947-1-2-4, BS 4752) and to standards UL 508 and CSA C22-2 N°14.
The devices shall be in utilization category A, conforming to IEC 947-2 and AC3 conforming to IEC 947-4.MPCB shall have a rated operational and insulation voltage of 690V AC (50 Hz) and MPCB shall be suitable for isolation conforming to standard IEC 60947-2 and shall have a rated impulse withstand voltage (Uimp) of 6 kV. The motor circuit breakers shall be designed to be mounted vertically or horizontally without derating. Power supply shall be from the top or from the bottom. In order to ensure maximum safety, the contacts shall be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc., by high performance thermoplastic chambers. The operating mechanism of the motor circuit breakers must have snap action opening and closing with free tripping of the control devices. All the poles shall close, open, and trip simultaneously. The motor circuit breakers shall accept a padlocking device in the "isolated" position.
The motor circuit breakers shall be equipped with a "PUSH TO TRIP" device on the front enabling the correct operation of the mechanism and poles opening to be checked. The auxiliary contacts shall be front or side mounting, and both arrangements shall be possible. The front-mounting attachments shall not change the breaker surface area. Depending on its mounting direction the single pole contact block could be NO or NC. All the electrical auxiliaries and accessories shall be equipped with terminal blocks and shall be plug-in type. The motor circuit breakers shall have a combination with the downstream contactor enabling the provision of a perfectly coordinated motor-starter. This combination shall enable type 1 or type 2 co-ordination of the protective devices conforming to IEC 60947-4-1.Type 2 co-ordination shall be guaranteed by tables tested and certified by an official laboratory: LOVAG (or other official laboratory).The motor circuit breakers, depending on the type, could be equipped with a door-mounted operator which shall allow the device setting. The motor circuit breakers shall be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection. In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) shall be factory set to an average value of 12 Ir.
All the elements of the motor circuit breakers shall be designated to enable operation at an ambient temperature of 60°C without derating. The thermal trips shall be adjustable on the front by a rotary selector. The adjustment of the protection shall be simultaneous for all poles. Phase unbalance and phase loss detection shall be available. Temperature compensation (-20°C to +60°C)

4.6.5. MINIATURE CIRCUIT BREAKERS (MCB)

The MCBs shall be of the completely moulded design suitable for operation at 240/415 Volts 50 Hz, single phase/3-phase and neutral system. MCBs shall be quick make and break type conforming to relevant standards. Housing shall be heat resistant and have high impact strength. MCBs shall be flush mounting type and shall be provided with trip free manual operating liver with ON/OFF indications.

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MCBs shall be provided with magnetic thermal releases for over current and short circuit protection with separate indications for short circuit.
MCBs shall have quick make and break non-welding self wiping silver alloy contacts rated for 10 kA or 15 kA (as applicable) short circuit at 230/415 volts in accordance with IEC 60898 and IS : 8828 - 1996 as per the deign both on the manual and automatic operation. The MCB shall confirm to Class 3 Energy Limitation. The MCB shall be confirm to Class 3 Energy Limitation. Each pole on the breaker shall be provided with inverse time thermal over load and instantaneous over current tripping elements, with trip-free mechanism. In case of multi-pole breakers, the tripping must be on all the poles and operating handle shall be common.
Breakers must conform to IEC 60898 with facility for locking using padlock with hasp in OFF position. Copper Pressure clamp terminals for stranded/solid conductor insertion are acceptable up to 10-sqmm size and for higher ratings, the terminals shall be suitably shrouded.
MCB shall have a minimum life expectancy of 20,000 operations.

4.6.6. RESIDUAL CURRENT CIRCUIT BREAKER

RCCBs shall be double pole or four-pole current-operated, housed in a totally enclosed moulded case, manufactured and tested in compliance with IEC 61008 or EN 61008.
RCCBs shall meet the following requirements:

- Number of poles: double-pole or four-pole as specified on the Drawings,
- Rated current (In): as shown on the Drawings,
- Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on the drawings or as per approval of the Engineer.
- Rated voltage: 240 / 415 V AC, Rated frequency: 50 Hz,
- Rated short-circuit capacity: not less than 1.5 kA unless otherwise specified,
- Operating characteristics in case of residual currents with DC components: as specified,
- Method of mounting: distribution board type,
- Method of connection: connection shall be made with proper size of thimbles and number ferruring for circuit identification,
- I2t characteristic: suitable for equipment and circuit being protected,
- Degree of protection: IP 2X to IEC 60529 or EN 60529,

The tripping mechanism shall be of trip-free so that the unit cannot be held closed against an earth fault. Tripping devices utilizing electronic amplifiers or rectifiers are not acceptable. Provision shall be made for testing the automatic earth - leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage. There shall be separate indication on RCCB for earth leakage faults.

4.6.7. LV PANEL SWITCH BOARD CONSTRUCTION

4.6.7.1 General

The LV switch boards shall comply with type tested assembly as per latest IEC 61439 – 1&2. All test shall have been carried out as defined in the standard. The panel manufacturer should have ISO 9001/9002 – 2000 certification having adequate manufacturing & testing facilities.
All medium voltage switchboards shall be suitable for operation at three phase/three phase 4 wire, 415 volt, 50 Hz, neutral grounded system with a symmetrical short circuit level.
The Switch Boards, shall comply with the latest edition with upto date amendments of relevant Indian Standards and Indian Electricity Rules and Regulations and IEC.

Main switch board and Panel (inclining MLP and Emergency Panels) shall confirm to Form 4B and rest of Panel of Form 3b Type 2 to be used as per IEC.

Switch board shall also pass the internal arc containment test for 50KA for 0.1 sec in accordance with IEC61641 without compromising the IP level as required. Internal arc type

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test must have been done in various locations in the panel as stated in standard implies as on busbar compartment both vertical and horizontal feeder, functional unit compartment, cable alley compartment etc., to prove the safety requirement.
The type tested design of the switchboard shall be proven design from the main switchgear manufacturer (OEM). Tenderer shall submit type test certificated for totally type tested and verified assemblies.

4.6.7.2 **Switch Board Configuration**

The Switch Board shall be configured with Air Circuit Breakers, MCCB's, Switch Fuse units and other equipment & material etc.
The MCCB's and Switch Fuse units shall be arranged in multi-tier formation whereas the Air Circuit Breakers shall be arranged in Single tier formation only to facilitate operation and maintenance.

Constructional features

All the electrical distribution and sub distribution boards / panel / Feeder Pillars etc. shall be sturdy and robust, modular, extendable, metal enclosed, moisture, dust, termite & vermin proof rigid, free standing or wall mounting dead front welded structure of sheet steel cubicle pattern, single front, and suitable for indoor mounting to accommodate and support all equipment mounted on them without vibration or movement. Structural members shall not obstruct access to equipment, units nor sub-assemblies. Checking and removal of components shall be possible without disturbing adjacent equipment.

Enclosure: - Dead Front type of enclosure shall be able to provide the degree of Protection. Each LT incomer/ outgoing switchgear should be mounted in separate compartment to ensure added safety.
Enclosure shall comply with IS: 60947 Part-I 1993 & IEC 61439. All adjoining units, doors and covers shall be fully Neoprene gasketted unless specified/approved otherwise and equipped with integral lock.
The enclosure protection shall be not less than the following:

Indoor Installation : IP 54

Outdoor Installation : IP 65

All panels/boards shall be dead front, front operated, dust, vermin proof, extensible, top/bottom cable entry, compartmentalized made of CRCA sheet steel of thickness 1.6mm non-load bearing & 2.0mm load bearing members & rigid supports for components and with lockable hinged doors. Joints of any kind in sheet metal shall be seam welded and all welding slag ground off and welding pits wiped smooth with plumber metal. All holes in metalwork shall be protected by substantial grommets or bushes to protect wiring passing through them. The maximum overall height of panels and the maximum/minimum height of the operating handles from floor level shall be as per standard norms.
The frame work shall be finished with standard two coats of final paint of approved colour shade after necessary chemical degreasing and primer coating as per standard practice as per 9 tank process.
All panels and covers shall be properly fitted and secured with the frame. Fixing screws shall enter holes tapped into an adequate thickness of metal or provided with hank nuts. Self threading screws shall not be used in the construction of the Switch Boards.
The switchboard shall be designed for the incoming and Outgoing LV feeders as per the provisions of IS: 8623 (Part I)–1993, IS 60947:1993 and IEC Pub 947-5-1 to latest version.
Generous space shall be provided for vertical rising cables, their bending and termination.
The switchboard panel shall have provision for top / bottom in coming and bottom / top out going to suit site conditions of cable entries.
The switch board / panel shall be divided into cubicles and all front doors of cubicles containing MCCBs shall be inter-locked so that the doors cannot be opened unless the MCCB is off. Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of live parts.

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The layout of the equipment and the components shall be such as to ensure creepage distances and isolating distances specified in the latest version of (IEC 61439-1). The sub-assemblies of similar equipment shall be interchangeable.
All connections shall normally be accessible from the front side of the panel. Where connections are not accessible from the front, the back side shall be provided with doors with handles and panel type locks. Required number of lifting lugs fixed on separate sections of the framework shall be provided. Two earthing studs shall be provided on the framework.
All panels shall have digital meters connected through RS 485 port to SCADA / BMS. All other BMS connections, unless specified otherwise, shall be through potential free contacts and it should be ensured that all such connection points are brought to one place at a suitable terminal strip duly numbered, easily accessible for the purpose. SCADA / BMS wiring shall start from this designated terminal strip.

4.6.7.3 **Switchboard dimensional limitations**

A base channel of minimum size 75 mm x 40 mm x 3 mm thick shall be provided at the bottom. A minimum of 200 mm blank space between the floor of switch board and bottom most units shall be provided. The overall height of the Switch Board shall not exceed to 2400 mm from finish floor level. The height of the operating handle, push buttons etc shall be restricted between 300 mm and 1800 mm from finished floor level.
The Switch Board shall be divided into distinct separate compartments comprising:

- A completely enclosed ventilated dust and vermin proof bus bar compartment for the horizontal and vertical busbars.
- Each circuit breaker, switch fuse units and MCCB housed in separate compartments enclosed on all sides.
- Sheet steel hinged lockable doors for each separate compartment provided and duly interlocked with the breaker/switch fuse unit in "on" and "off" position.
- Separate and adequate compartments for all Circuit Breakers provided for accommodating instruments, indicating lamps, control contactors and control fuses etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, busbars and connections.
- A horizontal wire way with screwed cover provided at the top to take interconnecting control wiring between vertical sections.
- Separate cable compartments running the height of the Switch Board in the case of front access Boards provided for incoming and outgoing cables.
- Inter-changeable feeder compartments for all identical feeders of same rating.

Cable compartments of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top. Adequate and proper support provided in cable compartments to support cables.

4.6.7.4 **Bus Bars**

The bus bar and interconnections shall be of electrolytic **tinned copper** and of rectangular cross sections suitable for full load current for phase bus bars and half/full rated current for neutral bus bar as per load requirement, and rated for a temperature rise over the ambient temperature specified as per IS/IEC standards, based on insulated conductor rating (IS:8084-1976) and the maximum current density for copper shall be 1.4 amp per Sq.mm for ratings up to 500 Amp and beyond 500 amp maximum current density shall be 1.2 amp per Sq.mm & bus bar design shall be as per OEM (switchgear) validated design and in accordance with IEC 61439. Bus bar supporting system shall be suitable suitable design to withstand the stresses of a symmetrical fault level MVA (as per power Authority BEST) at 415 volts for 1 second.
The bus bars shall be insulated with coloured, heat shrinkable PVC Sleeves. Accessible bus bar joints shall be shrouded in an approved manner. Minimum clearances between phase to phase and between phases and neutral (including protruding nuts and bolts if any) shall be 25 mm. Minimum clearance between phases and earth (including protruding nuts and bolts if any) shall be 20 mm.

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While providing the bus-bar section, the total load with 25% over load margin may be considered which may be transferred to an individual panel through the inter-connection between panels in the event of failure of incoming supply to the other panels. The diversity factor of various loads shall be taken as 1 for design purposes. The bus bar shall be designed for easy extension in future at either end.
An earthing bus made of Copper as approved shall be provided throughout the switchboard/panel with securely connected earthing terminals at both ends.
All internal wiring, busbar metering etc. shall conform to IS: 5578 – 1984 with all amendments.
All bus bar connections in Switch Boards shall be bolted with high tensile strength steel bolts and nuts. Additional cross section of bus bars shall be provided wherever holes are drilled in the bus bars. No insulation tape shall be used in the busbars / interconnections.
Feeder connections shall be solid copper bars duly insulated with bimetallic clamps wherever required.
Shrouds for bus bar joints /tapping points shall be FRP only. Bus insulators shall be flame retardant, track resistant type with high creapage surface and non-hygroscopic material such as epoxy/SMC/ Busbars shall be supported and braced to withstand the stress due to max. short circuit current and also the thermal expansion.

4.6.7.5 **Components installed in the assembly**

All components shall conform to respective Indian Standards or IEC specifications and shall be suitable for the particular requirements of rated current, voltage, service life, making and breaking capacity and short-circuit withstand strength. Co-ordination of component matching shall be observed.
The Employer's Representative shall be empowered to choose compact component/ accessories as deemed fit out of the list of the approved makes.
Separate current transformers shall be provided for each protection device and for instrumentation.
All assemblies of switchgear and control gear shall comply with IEC 61439 – 1&2 The clearance in front, back and side of all assemblies of switchgear and control gear shall be not less than 1.2 metres or minimum specified in standards, while switchgear considered in the fully drawn out condition.
Auxiliary contacts including push button contacts – All main as well as auxiliary contacts should be rated for 10A minimum.
All push buttons shall be of the push to actuate type and provided with number of contacts as required.
Control & selector switch - Control & selector switches shall be rotary type having enclosed (in removable cover) contacts, stay put maintenance type, provided with escutchean plates clearly marked to show the position.

4.6.7.6 **Instrument accommodation**

Instruments and indicating lamps shall not be mounted on the Circuit Breaker Compartment door. The current transformers for metering and for protection shall be mounted on the solid copper busbars with proper supports.
For MCCB's/SFU's, instrument, handles and indicating lamps can be provided on the compartment doors.

4.6.7.7 **Terminal arrangement**

Both incoming and outgoing cables shall have top / bottom entry depending on site requirement.
The marking and arranging of switchgear, bus bars, connections and small wiring shall be clear and comply with an approved international standard. Terminal blocks for low voltage wiring shall be of the rail mounted type moulded from high-grade non-hygroscopic melamine having all live parts fully shrouded and assembled in banks with marking tags to fit into moulded tag slots.
Terminals for final connections for indication, instrumentation and metering circuitry shall have test probe facilities.

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4.6.7.8 **Contactors**

Contactors shall comply with IEC 60947-4-1 and shall be of the break type having an uninterrupted rated duty, and utilization category AC 3. The contractors shall be capable of frequent switching & shall operate at 55 deg for AC3 applications
Contactor operating coils shall be AC suitable for the phase to neutral voltage of the supply and shall be protected by means of a low current MCB/cartridge fuse. Main contactors shall be silver faced.
The rated voltage of the contactors shall be equal or superior at 415 V and rated insulation voltage shall be 690/1000 V. The rated impulse voltage of the contractor shall be 8 kV.
Contactors shall not dropout at voltage at 70% of rated voltage and minimum pickup voltage shall be 85% or as specified.
The contactor should be modular in design and should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors. The contactors from 4 kW to 400 kW will be associated with the same auxiliary contact block range.

4.6.7.9 **Wiring**

All wiring for relays and meters and other associated equipment shall be with FRLSZH PVC insulated, stranded copper conductor wires.
The wiring shall be colour coded and labeled with approved ferrules for identification. PVC ferrules yellow in colour, locked to avoid movement & with black engraved letters shall be provided at each end of all wires marked to correspond with equipment/circuit designation & termination numbers as specified / approved or as required.
A separate bunching & separate route shall be followed for AC& DC wiring.
The minimum size of copper conductor control wires for switch-boards shall be 1.5 Sq.mm.
Wiring shall be terminated through cage clamps or using crimping lugs where former not feasible, without joints or Tee on their run. Wiring shall be run on sides of panels, neatly bunched, secured without affecting equipment mounting.

4.6.7.10 **Cable terminations**

The Switch Boards shall be complete with supporting clamps and brackets etc for termination of 1100 volt grade aluminium/copper conductor cables, Knockout holes of appropriate size and number shall be provided in the Switch Board in conformity with the location of incoming and outgoing conduits/cables. Gland plates, gland-brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated.
The cable terminations for the MCCB's shall be brought out to the rear in the case of rear access switchboards or in the cable compartment in the case of front access Switch-Boards. The Contractor shall design and co-ordinate the cable sizes and corresponding crimping type copper lugs for each Incomer and Outgoing feeders and correct size lugs shall be provided bolted up in the switchboard.

4.6.7.11 **Space heaters**

The Switch Board shall have in each panel thermostatically controlled space heaters adjustable in the range of 30° C to 100° C with a controlling 15 amp 230 volt switch socket outlet to eliminate condensation.

4.6.7.12 **Earthing**

All switch panels shall be provided with protective earthing.
A main earth bar of GI or aluminium as required shall be provided throughout the full length of the Switch Board to earth all switchgears with a provision to make connections to the sub-station earth's on both sides.
The frame of the Circuit Breaker shall be positively earthed when racked into the cubicle.
Protective earthing of the switch-boards shall be connected to the building earth.

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4.6.7.13 **Sheet Steel treatment and painting**

Sheet Steel materials used in the construction of these units should have undergone a rigorous rust proofing process comprising of alkaline degreasing, descaling in dilute sulfuric acid and a recognized phosphating process. The steel work shall then receive two dip-coats of oxide filler/ primer before final painting. Castings shall be scrupulously cleaned and fettled before receiving a similar oxide primer coat. The manufacturer is required to have 9 tank treatment facility.

All sheet steel shall after metal treatment be powder coated with two coats of shade 692 or as approved to IS Code No. 5 on the outside and white on the inside. Each coat of paint shall be properly stoved and the paint thickness shall not be less than 80 microns. The panel manufacturer should have in-house power coating facility.

Name plates and labels - Suitable computerized laminated powder coated name-plates and identification labels of metal for all Switch Boards and Circuits shall be provided. These shall indicate the feeder number and feeder designation.

4.6.7.14 **Labels**

Engraved Aluminums labels shall be provided on all incoming and outgoing feeder. Each panel shall have label indicating Switchboard Tag Number

- System voltage, phases, wires and frequency
- Rated fault current and duration
- Busbar rating
- Year of manufacture
- Purchaser's name
- Order item no.
- Characters shall be 12 mm high

Circuit diagram showing the arrangements of the circuit inside the control panel shall be pasted on inside of the panel door and covered with transparent plastic sheet. Each circuit shall be fitted with a label giving the following information: -

- Equipment tag number and equipment designation
- Equipment rating

Characters shall be 5 mm high Labels shall be fitted on front and back of cubicles. When operating sequence of equipment is not evident e.g. mechanical / key interlocking features, instruction labels shall be provided and fixed near the point of operation.

Labels shall have black characters on a white background and be made of a non – corrodible material. Warning / danger labels shall have white lettering on a red background. Labels shall be affixed by means of screws or rivets. Use of adhesives shall not be accepted.

Each circuit shall be provided with durable one-line synoptic diagram, clearly indicating the specific function of the different compartment when this would not be clear from general layout.

Description	Requirement
Material	Anodized Aluminium
Engraving	Black engraving on white background
Size of label	To suite application / importance
Fixing	With self-tapping screws
Use	Main panel, feeders and individual devices

4.6.7.15 **Meters**

a) All voltmeters and indicating lamps shall be through MCB's
b) Meters and indicating instruments shall be digital electronic type.
c) All CT's connection for meters shall be through Test Terminal Block (TTB)
d) CT ratio and burdens shall be as specified on the Single line diagram.

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4.6.7.16 **Instrument Transformers**

Current transformers shall be provided for Distribution panels carrying current in excess of 60 amps unless otherwise specified. All phase shall be provided with current transformers of suitable VA burden with 5 amps secondary for operation of associated metering.
The CTs shall confirm to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast/ Flame Retardant resin filled Nylon type robust to withstand thermal and dynamic stresses during short circuits. Metering CTs, shall have inbuilt bus bar mounting arrangement. Secondary terminals of CTs shall be brought out suitable to a terminal block which shall be easily accessible for testing and terminal connections. The secondary terminal should be covered with insulation cap/cover so that there should not be any possibility of touching the live terminal. The protection CTs shall be of accuracy class 5P10 and measurement CTs shall be of accuracy class 1.
Secondary terminals of CTs shall be brought out suitable to a terminal block which shall be easily accessible for testing and terminal connections. Secondary terminal should be covered with insulation cap / cover so that there should not be any possibility of touching the live terminal.
The secondary windings of instrument transformers shall be earthed at one point through a removable link, with provision for attaching test links.
Current transformers shall be rated to withstand the thermal and magnetic stresses resulting from through fault currents equal to switchgear fault rating.
Voltage transformer primary winding shall be protected by High Rupturing Capacity cartridge fuses and secondary winding shall be protected by MCB. Voltage transformers shall have provisions for safely disconnecting the fuses and transformers from energized busbars.
Instrument transformer nameplate shall be fixed in a position so that details can easily be read when fitted in cubicle.
The design and construction shall be dry type, epoxy resin cast / Flame retardant resin filled nylon type robust to withstand thermal and dynamic stresses during short circuits.

4.6.7.17 **Selector Switch**

Where called for selector switches of rated capacity shall be provided in control panels, to give the choice of operating equipment in selective mode.

4.6.7.18 **Thermal Overload Relay**

Thermal overload relay shall have built in phase failure sensitive tripping mechanism to prevent against single phasing. The relay shall operate on the differential system of protection to safeguard against three phase overload, single phasing and unbalanced voltage conditions.
Auto-manual conversion facility shall be provided to convert from auto-reset mode to manual reset mode and vice-versa at site. Ambient temperature compensation shall be provided for variation in ambient temperature from –5deg C + 55 deg C.
All overload relays shall be of three element, positive acting ambient temperature compensated time logged thermal overload relays with adjustable setting. Relays shall be directly connected for motors up to 35 HP capacity. C.T. operated relays shall be provided for motors above 35 HP capacity.

4.6.7.19 **Time Delay Relays**

Time delay relays shall be adjustable type with time delay adjustment from 0-180 seconds and shall have one set of auxiliary contacts for indicating lamp connection.

4.6.7.20 **Toggle Switch**

Toggle switches, where called for in Schedule of Quantities, shall be in conformity with relevant IS codes an shall be of 5 amps rating.

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4.6.7.21 **Push Button Stations**

Push button shall be provided for manual starting and stopping of motors / equipment "Green" and "Red" colour push buttons shall be provided for 'Starting' and 'Stopping' operations. 'Start' or 'Stop' indicating flaps shall be provided for push buttons. Push buttons shall be suitable for panel mounting and accessible from front without opening door, Lock lever shall be provided for 'Stop' push buttons. The push button contacts shall be suitable for 6 amps current capacity.

4.6.7.22 **Indicating Panel**

All meters and indicating instruments shall be in accordance with relevant Indian Standards. The meters shall be flush mounted type. Indicating lamps shall be of low burden and shall be backed up with 2 amps MCB.

4.6.7.23 **Testing**

Testing of panels shall be as per following codes:

a) IS: 8623 (Part -I) 1993 for factory-built assemblies of switch gear for voltages up to and including 1000 VAC.
b) IS: 13947: 1993 Degree of protection
c) IS: 5578 & 11353:1985 Arrangement of bus bars.

4.6.8. Lighting DB and Feeder Pillars

The Lighting Distribution Board / Power Feeder Pillars etc. shall comply with the latest versions of the relevant requirements of the Indian Standards, British Standards, and International Electro technical Commission (IEC) standards, European and other International Standards specified in the section of specifications or approved equivalent International
standards. In case of any contradiction between various standards mentioned in the clause 2.0, the latest and /or most stringent standard will apply.

All panels should be OEM design verified and Authorized Channel factory built. The complete units shall be suitable for service on a 415 V, 3 phase 4 wires, 50 Hz supply.

The contractor shall develop design of the switchboard shall be proven design of the main switchgear manufacturer. The design and layout of pillar box shall be compact and convenient to provide ease of termination of cables and operation of MCB's/MCCB's. It shall be designed for termination of cables and operation of MCB's shall be from the front end.
The Feeder Pillar enclosure shall be provided with appropriate degree of protection shall not be less than IP-55 (indoor) and IP-65 (outdoor) in accordance with IS-2147.

The lighting distribution switchboards and the associated equipment, including switchgear, control gear and busbar assemblies shall be certified for the category of duty specified. All lighting distribution switchboards shall be of same type and fully identical in mechanical construction to the lighting distribution switchboard which had been type-tested by an acceptable, accredited and Independent testing laboratory for the fault conditions, temperature rise limits etc. Any manufacturer not having the above will not be considered for supply. The main circuits of the lighting distribution switchboards shall have an insulation voltage of 1000 V AC or higher. For incoming feeders irrespective of the ratings MCCB will be deployed in all Lighting Distribution Board.

The enclosure shall be suitable for Outdoor installation. The enclosure shall be Compartmentalized made of CRCA sheet steel of thickness 1.6mm non-load bearing & 2.0 mm load bearing members & rigid supports for components and with lockable hinged doors

to withstand rough usage and weather. Panels shall be rigid free standing & floor mounting type and comprise of structural frames enclosed completely with specially selected smooth finished cold rolled sheet steel of thickness not less than 2.0 mm for load bearing members of the panels such as front sheet and door frames, sides, door top and bottom portions.

The switchgear assembly/sub-assemblies or panels shall be termite and rodent proof. The sub-assemblies of similar equipment shall be interchangeable.

All the lighting distribution switchboards as a minimum shall have the following but not limited to:

- Provision to have Smart tariff meter in Future if require.
- A Load break switch (Isolator) at the incomer.
- A TPN incomer essentially a MCCB (63A to 250A) with three lamps (over 3 nos. of DP-MCBs one phase + neutral) to indicate incoming supply of each phase is on. MCCB outgoing end should have indicating lamps for ON, SHUNT TRIP, OVERLOAD, EARTH LEAKAGE etc. as minimum and all the lamps should be flush on the panel door. An emergency push button shall be provided flush to panel to trip incomer in case of emergency.
- Enough No of outgoing feeders shall be provided per lighting distribution board and each outgoing feeder will have one TPN RCBO with ON indication lamp flush on panel door.
- Each outgoing feeder will have rating between 16 to 160 Amps and outgoing feeder's respective ratings will be decided,
- Enough no. of auxiliary contactors, push buttons and other hardware shall be provided to device balanced segment switching schemes per lighting distribution switchboard including for remote switching. Such schemes will be informed by the Engineer later
- Over and above aforementioned outgoing feeders, 20% fully loaded / populated and wired spare feeders (all the highest capacity of outgoing) shall be provided. Spare feeders will no way be different from outgoing feeders assigned for services already.
- Surge Protective Devices to divert transient over voltages to ground to protect Wifi, CCTV, Ethernet switches and other resistive electronic components. Quantity will be decided during detailed Engineering by contractor and approved by the Engineer.
- Band Pass Filters should be provided within the LDB before the street lighting gateway and the lights so that all potential electromagnetic interferences and high frequency harmonics in the network caused by external factors are blocked out from the grid before they reach the street lighting gateway or the street lighting controllers.
- All items shall be tropicalized to suit the conditions prevailing in MTHL in general and within the substations / Service Area. In particular, the following points for topicalization of electrical components shall apply.

The requirement, as above are indictive, however, the lighting distribution board's GA / wiring schemes etc. will be design by the contractor and submit for approved by the Engineer. This shall include switching, control/diming, monitoring, etc. as per light control requirement. The contractor should provide all accessories required to complete the scheme, including interconnecting multicore control cables along with necessary gear etc.

5.6.12.1 **Bus Bar**

The current rating of the neutral busbar shall be 100% of the phase busbars. Maximum current density for the busbars shall be 0.8 A/sq.mm for aluminium and 1.4 A/sq.mm for copper busbars Cable termination arrangement shall be from bottom and suitable for external cables of type and sizes as mentioned in the specification.

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5.6.12.2 **Other requirement**

The Retro reflective paint strip shall be provided on the four faces of the pillar box which shall withstand the temperature conditions and reflect vehicular light at night-time providing safety to traffic.
All sheet steelwork shall be phosphate in accordance with IS: 6005 "Code of practice for phosphating iron and steel".

The pillar box shall be provided with durable and legible Aluminium nameplates containing all technical parameters and manufacturing details. A plate of statutory instruction like 'stick no bill' shall be provided on all four side of the pillar box. The pillar box shall be provided with a plate 'Danger' mark for 430V AC as per IS 2551-1982. Property plate mentioning the name of the Employer and project name if any shall also be provided.

The enclosure shall be sized to facilitate easy maintenance at minimum height of 300 mm above FFL. Air ventilation arrangement shall be provided at top and all sides of the enclosure to facilitate air circulation.

The door shall have three-point locking arrangement. Special type tamperproof heavy duty built-in inter-lock with appropriate key shall be provided. Locking system with handle up & down arrangement shall be provided on front side of the doors. The door shall be provided with pad-locking facility also.

The Pillar shall be provided with removable split type base plate fitted with rubber grommets for cable entry to facilitate cable jointing. Proper support shall be provided for holding I/C& O/G cables. These, cable support arrangement shall be provided to take the load of the cable.

Busbars including branch connections shall be fully insulated except in cable/busduct compartment(s). FRP shrouds shall be provided at joints and tapoffs. Busbars exposed to air shall be tin plated. Main busbar shall be of the same cross-sectional area throughout the length of the switchgear. And Shall be Made up conducting material and breaking capacity as per the design.

4.6.9. Testing and Inspection

All Panel/ Switchboards and DBs shall be factory inspected by Employers' representative before finishing and dispatch.
Certificate for all routine and type tests for circuit breakers in accordance with the IS:13118-1991 shall be furnished.
Equipment shall be subject to pre-dispatch inspection by a duly authorized representative of the Engineer. Inspection may be made at any stage of manufacture at discretion of the Employer or Employer's Representative and the equipment, if found unsatisfactory as to workmanship or material, the same is liable to rejection.

5.6.9.1 **Type Tests**

The equipment offered should have been successfully type tested at NABL laboratories in India or equivalent international laboratories in line with the relevant standard and technical specification, within the last 5 (five) years from the date of offer. The Contractor shall be required to submit complete set of the type test reports along with the offer.

Type test certificates from the manufacturers for the switch board / lighting panel & components viz. ACBs, MCCBs, MCBs, change-over switches shall be furnished. These shall include following but not limited to,

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- Degree of protection on complete Panel/Switch Board / Feeder Pillar shall be carried out as per IS: 13947/1993 or
- Clearances and creepage distances,
- Effectiveness of assembly (protective circuit) for external faults,
- Incorporation of switching devices and components,
- Internal electrical circuits and connections,
- Terminals for external conductors,
- Impulse withstand voltage,
- Temperature rise test: -The temperature rise test should be carried out as per IS: 8623 –1993.
- Short Time Withstand Current Test shall be carried out as per IS 8623: or latest version.
- Electromagnetic compatibility (EMC),
- Effective continuity between the exposed conductive parts of the assembly and the protective circuit,
- Power frequency withstand voltage,
- Mechanical operation,
- Resistance to corrosion
- Thermal stability of enclosure,
- Resistance of insulating material to heat
- Mechanical impact test (IK)
- High voltage test shall be carried out as per IS: 8623/ 1993 amended up to date.

5.6.9.2 **Acceptance Test**

Following tests shall be carried out as per acceptance tests in addition to routine tests on one random sample of each rating out of the lot offered for inspection. Routine and acceptance tests as per relevant IS shall be carried out at the manufacturers' works.

- Temperature rise test on one sample of each rating.
- Overall Dimensions Checking.
- Insulation Resistance Tests.
- High Voltage Test at 2500 V, 50 Hz AC for one minute.
- Manual and electrical operation of circuit breakers etc. and electrical operation of contactors/automatic change-over switches.
- Dry insulation test with power frequency voltage.
- Insulation resistance of circuits.

The following critical status and alarms for each Switchboards, Lighting DBs and Feeder Pillar etc. shall be sent for remote monitoring via volt-free contacts to be ensured with the Lighting Distribution Board /Power Feeder Pillars etc.

- Individual /MCCB/MCB open/close status.
- Status for MCCB/MCB trip on fault (Earth fault, Overload and short circuit)/ earth leakage and trip locally.
- Control supply failure.
- MCCB/MCB ready to close indication.
- Under voltage alarms for under voltage release.

4.6.10. Design Submission and Approvals

The Contractor shall submit detail design and calculation for approval and before ordering for procurement shall include following guaranteed performance particulars:

- Switch boards/panels' Name & Make
- Bus Bar: i) Size, ii) Material, iii) Rated capacity, iv) Busbar supporting system and the Short circuit with-stand capacity
- ACBs and MCCBs: Rated capacity, Rupturing capacity, Make, No. of NO/NC contacts, Conformity to Standards.

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- Miniature circuit breakers: Rated capacity, Rupturing capacity, Conformity to Standards
- Voltmeter & Ammeter: Make, size, Range, accuracy class, Indication type
- Residual current devices: Name, Make, rated capacity, Range, sensitivity,
- Air Circuit Breakers: capacity, rupturing capacity, Protections, Auxiliary contacts & accessories, Conformity to specifications

List of Switch Boards - Switch boards and panels as per following list need be provided. The incoming
& outgoing feeders, indications, metering and protection details are shown on various drawings.
The Panel / Distribution Board / Switch Board as identified shall be provided on the following locations:
BEST HV Switching Station, Sub-command Centre Sewari, Shivaji Nagar Command Centre, Main Control Centre Gavan, Compact Substations CSSs), Porta Cabin, Toll Plaza and Feeder Pillar for Street Lighting.
The locations, however, as proposed are indicative only, the contractor shall design the LT distribution network for the complete section consented by Employer / Engineer.

4.6.11. Insulating Mat

Insulating mat shall be provided in front to cover the full length of all panels. Where back space is provided for working, operations or maintenance, from the rear of the panel, mat shall also be provided at the back of the panel also to cover the full length of panel on the rear also.
Insulating Mats shall follow IS-15652-2006.
The insulating mats shall be made of Elastomer (a generic term that includes rubber, latex and elastomer compounds that may be natural or synthetic or a mixture of both) for use as floor covering for the protection of workers on AC and DC installation with the system voltage up to 66 KV AC and 240 volts DC.
Mats shall be resistant to acid and oil and low temperatures and shall be identified by the respective class symbol.
Thickness of mats, physical properties, dielectric properties and all other specification shall be as per IS:15652-2006.be free from blisters, pin holes, cracks, embedded foreign matters and other defects

4.6.12. Installation & Foundation (if required)

The location of each foundation shall be correctly set out in accordance with the approved foundation layout drawing. Base channels shall be grouted, leveled in cement concrete pad for switchgear and other cubicle panels, etc. with reference to a bench mark in the building. Pedestal type panels and superstructures shall be erected by grouting foundation bolts into the foundation in cured holes left in foundation blocks. For concreting on existing floors, a proper bonding surface shall be made by chipping the floor. The final finish to the surface of the floor shall be given after all equipment has been installed. If floor is broken for installation of equipment, it shall be restored to original finish after completion of installation.
The concreting shall be done in accordance with the provision of Indian Standard Code of Practice for Plain and Reinforced Concrete, IS: 456-2000.
Suitable grooves or niches shall be provided in the foundation block at the time of casting to enable embodiment of earth strips without calling for chipping of the blocks. Subsequently conduits of appropriate size shall be embedded in the foundation blocks for cabling, in the first instance, wherever required.
All foundations shall be cast in the presence of the Employer's representatives. All foundation and grouted bolts shall be cured for a minimum period of 48 hrs.
Foundations shall be prepared as per manufacturers drawing, shall be levelled, checked for accuracy and the switchboards installed. Busbar connections shall be checked with a feeler gauge after installation. Tightness of accessible bolted bus joints shall be checked

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using calibrated torque wrench. Sealing of cable and boxes to prevent moisture entry shall be checked. Switchboard earth bars shall be connected to the earth grid.
Fabrication drawings of all panels shall be approved by the Employer's representative before fabrication.

4.6.13. Details of Compact Substations

Following are an indicative detail of Compact Substation for Road Lighting an Power supply:

HT Switchgear						
11kV, 630A, 21kA SF6 RMU as stated above						
11/0.433kV Dry Type Transformer						
11/0.433kV, Dyn11, Cast Resin, Dry Type Transformer with Impedance shall be 4% for the ratings up to 630kVA & 5% for the ratings 800kVA,1000kVA (As per IS tolerances).						
Transformer Ratings in kVA	160			500	630	1000
LT Compartment						
433V LT Indoor panel with Aluminium Bus bars of suitable size & current rating, Fabrication using 1.5/2 MM CRCA sheet steel, Ingress protection IP65, complete with internal wiring. (provision to mount TVM Meter as per CPWD specifications & BEST Requirements)						
kVA Rating of CSS Transformer (11/0.433kV)	100	160	250	500	630	1000
Current Rating of Main LT Incomer breaker from Transformer: (in A)	160	250	400	800	1000	1600
1 No, of 4P, 50kA MP based ACB with O/c, E/f & S/c protection	Yes			yes	yes	yes
1 No, of 4P, 36kA MP based MCCB with O/c, E/f & S/c protection.	Yes					
Enclosure as specified above						
Interconnection & Earthing						
Interconnection Between HT switchgear & Transformer using suitable rating of HV Cable with respective fault current and interconnection between Transformer & LT switchgear, Internal earthing connections by using 50x6 mm GI strips (minimum).						
LT Switchgear Panel /DB/Circuit Ways in LT Compartment						
Note: The contractor must check the feasibility to house the LT Switchgear Panel / DB Mentioned in LT Compartment of the CSS for ratings up to 400kVA. For CSS Ratings above 400kVA, separate outdoor type LT Panel shall be considered as per the site conditions & place of installation of LT Panel.						
Main Incomer for LT Panel	160	250	400	800	1000	1600
1 No, of 4P, 50kA MP based ACB with O/c, E/f & S/c protection	Yes			yes	yes	yes
1 No, of 4P, 36kA MP based Motorized MCCB with O/c, E/f & S/c protection.	Yes					
Monitoring & Control through SCADA/BMS	yes			yes	yes	yes
LT Sub-Outgoings (No, of Outgoing feeders)						
4P, 36kA MP based MCCB with O/c, E/f & S/c protection.	63A			Nos. as specified in SLD's, However, contractor shall prepare during design stage.		
	100A					
	125A					
	160A					
	400A					
4P, 50kA MP based ACB Breaker (ACB) with O/c, E/f & S/c protection	500A					
	630A					

Note: The rating and numbers of switchgears as above, are indicative but not exhaustive, the contractor shall however, undertake design, detailed engineering, schedules,

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drawings etc. and elaborate detail based on the site condition and actual parameters as required to meet a complete Power Supply System in an acceptable manner for approval by the Engineer.

4.6.14. SCADA System for Substation Equipment

The SCADA system is intended for centralized monitoring and control operation of CSS equipment remotely from Sub-station (BEST) as well equally from in Command Center on the workstation and on large screen as require. This shall include automatic acquisition of energy parameters and preparation of customized reports and monitoring / control of the Circuit Breakers / Switches/ Isolator etc. The objective shall be achieved with the help of SCADA software and substation RTUs. Integration of rooftop/over ground solar through net meter,

4.6.14.1 Communication Protocol

The communication protocol for SCADA system and RTUs must be open standard protocol and shall involve / support IEC 60870-5-104 and IEC 61850 for all levels of communication.

The SCADA system shall be designed, developed, tested, installed, and commissioned at the substation/ plant as per IEC Standards for protective relays and energy meters. The SCADA system shall contain the following main functional parts:

- SCADA application and station Human Machine Interface (HMI).
- Ethernet Local Area Network communication infrastructure for remote monitoring (to be supplied by the institute).
- Remote Terminal Unit (RTU)
  - Act as Gateway as each Meter / Transducer shall communicate data to the RTU through a serial or Ethernet network connection using a selected protocol.
  - Additionally, the RTU should have the capability to communicate with SCADA System over IEC 60870-5-104 & IEC 61850 Protocols.
- RTU shall have hard wired interface with local control panels for status monitoring and control of the electrical switchgear.
- SCADA system shall be realized via a redundant set of servers and by means of human machine interface (HMI) and software package, which shall contain an extensive range of data acquisition and control functions.

4.6.14.2 Scope

Design, Supply, installation, testing and commissioning of RTU's at 18 11/0.433kV substations of Mumbai Trans-Harbor Link Project.

Design, Supply of SCADA system software should have scalable for future requirements or additions without any cost implication.

Design, Supply of Wiring from RTU to relays / meters for monitoring and control including any associated hardware required for the communication between relays/meters to RTUs.

Design, Supply and Configuration of SCADA system software and connection with RTUs and other communication devices.

Design, Supply of SCADA system software as detailed in the following section.

Design, Supply of 2 number of hardware servers and 4 number of hardware workstations.

The server should be configured in high availability (HA) cluster mode.

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Training and demonstration on SCADA, RTU and associated communication network.

Support the System Integrator (SI) in integrating the SCADA system.

Supply of DMS applications that include, but not limited to the distribution system state estimation application, fault management, load-shed application, and feeder reconfiguration application.

4.6.14.3 RTU – Hardware capability

It shall have a flexible high-performance expandable disc less and fan less platform.
Specifications

- 64-bit processor.
- 2 or more LAN ports
- 4 or more serial ports / USB
- Digital inputs as per requirements (minimum support for 100 DIs)
- Digital outputs as per requirements (minimum support for 100 DOs)
- Analog inputs as per requirements (minimum support for 24 AIs)

It shall have network time protocol (NTP) format time protocol support.

The communication protocol for RTU must support IEC 60870-5-104 and IEC 61850 and all other standard protocols required (MODBUS and IEC 60870-5-103) for all levels of communication such energy metering, relays, etc.

The primary function of the RTU shall be to concentrate metering data by polling and receiving information from connected meter / transducer. Each meter / transducer shall communicate data to the RTU through a serial or Ethernet network connection using a selected protocol.

The RTU shall be hard wired to Local Control Panel (LCP) for Monitoring and Control of the Circuit Breakers / Switches / Isolators etc. and other available signals at LCP.

The RTU shall be able to accomplish these tasks using embedded software applications.

RTU source code and complete development environment shall be provided including training also. Alternately, the SCADA application software, including its development environment, shall have the facility to seamlessly host / integrate to any custom developed software / algorithm on top of it.

These software applications shall be configurable to set up the RTU to operate as per the requirement of the system.

4.6.14.4 Salient features of RTU

- Data concentration for all types of Meter
- Hard wired interface with local control panel for monitoring and control
- Ease of use /configuration
- Support for network time protocol (NTP)
- Support for multiple SCADA protocols for communication to multiple masters

4.6.14.5 SCADA Server: Hardware (minimum 2. Nos.)

Rack mounted blade servers with minimum configuration given below.

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2 * Intel Xeon Silver 4208 2.1G, 8C/16T, 9.6GT/s, 11M Cache, Turbo, HT (85W) DDR4-2400 Processor / 128 GB (4*32GB) RDIMM 2666MT/s Dual Rank RAM / 3 *12TB 7K SAS 12Gbps 512e 3.5in Hot-Plug Hard Drive / PERC H330 RAID Controller / Dual, Hot-plug, Redundant Power Supply (1+1), 750W / Dual-Port 1GbE On-Board LOM / Broadcom 57416 Dual Port 10GbE BASE-T Adapter, PCIe Full Height / Ready Rails Sliding Rails With Cable Management Arm / 5 Years Next Business Day On-Site Service Warranty Windows Server 2016 or latest is to be provided by the bidder for both the servers

4.6.14.6 **SCADA Workstation / operator console: Hardware (5 Nos.)**

- Computer System Configuration:
- Industrial Grade
- 64 Bit Architecture
- Intel i9-7940 or Higher
- 16 GB RAM
- 2TB HDD 7200 RPM
- Drive-52X
- Ethernet Card x 2 (1gbps×2)
- Color 32" Full HD Monitor×2
- Operating System — Windows 10 Professional 64 bit ,
- Nvidia Quadro P200 5GB Card (1 No.)

4.6.14.7 **Group Definition**

The software shall provide facility for grouping of meters to define virtual meters.
This feature shall be used for calculation of total energy loss and consumption of a location.

4.6.14.8 **Alarm Management**

It shall provide user definable alarms for different parameters.
These alarms shall be available for system monitoring on real time basis.

4.6.14.9 **Reports**

- The software shall provide various types of reports like min-max, energy consumption data, alarm data, interruption data, meter replacement, demand data, energy loss data etc.
- The reports shall provide time-related follow-ups of measured and calculated values.
- The data displayed shall comprise:
- Trend reports: Hourly (mean, peak), Day (mean, peak), Month (mean, peak), Year (mean, peak)
- Historical reports of selected analog values:
  - Day (at 15 minutes' interval and Hour interval)
  - Week
  - Month
  - Year

There shall be a facility to develop new reports for the analysis of any electrical parameter/s or trends. It shall be possible to select displayed values from the database in the process display on-line.

Scrolling between days shall be possible. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

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- Daily voltage, load and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
- Weekly trend curves for real and derived analog values.

Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analog parameter for each circuit in 24 hr period.
Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer
Printout on adjustable time period as well as on demand system frequency and average frequency.
Reports in specified formats which shall be handed over to contractor.

4.6.14.10 **Trend display (historical data)**

It shall be possible to illustrate all types of process data as trends — input and output data, binary and analog data. The trends shall be displayed in graphical form as column or curve diagrams. Adjustable time span and scaling ranges must be provided.
It shall be possible to change the type of value logging (direct, mean, sum, or difference) online in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.
There shall be an export facility to export required reporting data to the excel sheet. Ø Data Import and Export - The software shall have facility to import CSV files from a third-party application. User should export the meter data to CSV format.
SCADA Source code and Development Environment shall be provided. Vendor will also provide training to work on SCADA Source code and Development Environment.

4.6.14.11 **For RTUs**

Graphical user interface (GUI) based software on Windows platform.
Online views

- Tabular and Graphical.
- The Substation SLD mimic shall be realized on computer screen.
- One screen of SLD mimic shall be populated by data from RTU.

4.6.14.12 **RTU Communication Support**

The software shall acquire data from IEC Protocols such as IEC 60870-5-104 / IEC 61850 compliant RTUs.

4.6.14.13 **Viewing Online Data**

The software shall provide facility to monitor instantaneous electrical parameters on real time basis.
Online data can be viewed in graphical /tabular formats/substation SLD mimic.
Control of the Circuit Breakers
The software shall provide facility to control Circuit Breakers as per user requirements.
Commands shall be performed from SLD / Detail views mimics and shall be user configurable.
System should support direct and select before executing commands as per IEC standards.
Commands shall be linked with the Input Status of the breaker so that Alarms / Events can be managed for Operator Actions and differentiated from tripping signals.

4.6.14.14 **User-authority levels**

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It shall be possible to restrict activation of the process within a certain user authorization group.

Each user shall then be given access rights to each group of process, e.g.:

- Display only
- Operator
- System administrator
- Developer

The access rights shall be defined by passwords assigned during the log-in procedure.

Only the system administrator shall be able to add/remove users and change access rights.

Role based user authentication is possible. New roles and their assignments can be configured for access control.

4.6.14.15 **For monitoring and control**

- SCADA system shall be able to monitor critical electrical parameters based on certain rules and shall be able to take actions automatically in case of rule violations.
- SCADA display shall allow operator to control the substation devices remotely on click of button.
- The SCADA system shall have the option to operate it in an auto or manual mode with manual override facility.
- System shall allow user defined alarms and events for both analog and digital values.
- User shall be able to define the severity level of alarms and associated color codes for easy identification of the alarms.
- User shall be able to send alerts for the alarms / events through SMS / EMAIL.

4.6.14.16 **For customization activity**

The SCADA system application shall be based on open source / developed source codes. The source code of SCADA system shall be provided along with the development environment for the future customization. Alternately, the SCADA application software, including its development environment, shall have the facility to seamlessly host / integrate to any custom developed software / algorithm on top of it. The SCADA software should be flexible enough to support any future enhancements in the application. It should also have flexibility to add/delete/modify data points, connections of communicable devices such as RTUs, PMUs etc. The SCADA database should be accessible and customizable to support and configure data exchange between core SCADA and the custom build applications. The training for development environment shall be provided to the Employer's Representatives / Engineers.

5.6.15.1 **Applications of SCADA system**

The following applications / features shall be provided in the SCADA system.

- SLD with paging and zooming facility.
- Remote monitoring and control.
- Data acquisition and management.
- Device configuration for data acquisition. Alarm and event management.
- Bad data detection and its replacement with the calculated / manually entered value.

- 2D/3D Graphical and tabular display.
- Reporting

4.7. MV LV Cables

General

The cabling reticulation system in the bridges, roads and buildings MV, comprises LV and sub-main power cables, final LV sub-circuit cables, fire detection and activation cables, CCTV cables, equipment cables, SCSDA cables and, and other communication cables.

All cables shall be Low smoke halogen free to prevent the release of toxic or corrosive fumes under fire conditions.

Generally, all essential services cables including cable for lifesaving system for sub-circuits, fire detection, activation/systems, communication and all other essential light and power distribution shall be halogen free insulated and 2-hour fire rated.

The requirements for power cables shall apply to all cables for 11 kV, 400 V and 230 V ac service, as well as cables for 110 V, 48 V, 24V dc service which are frequently or continuously loaded to more than 70 per cent of the rated capacity of the cable.

The size of cable conductors for power cables shall be determined in accordance with IEC 60364, Electrical Installations of Buildings, except that the minimum conductor size shall be 4 Sqmm.

4.7.1. HV Cables

General

Cables shall be of Copper conductor, cross linked polyurethane (XLPE) insulated, earthed and shall be supplied, inspected, laid, tested and commissioned in accordance with drawings, specifications, relevant Standard Specifications and cable manufacturer's instructions. XLPE insulated cables shall be rated for continuous operation at a maximum conductor temperature of 90 °C & for a maximum short circuit temperature of 250 °C.

The cables shall be suitable for laying in trays, trenches, ducts, and conduits and for underground buried installation with uncontrolled backfill and possibility of flooding by water and chemicals.

All Electrical Panels, Feeder Pillars shall be suitably mounted on Suitable Galvanized Iron (GI) Channel Frame Foundation secured properly using Anchor Fasteners with the Floor.

Material

a. Conductor

The cable conductor shall be made of high conductivity and stranded high-density Copper to form compacted circular shaped conductor having resistance within limits specified in IEC-8130.

Conductors shall be smooth, uniform in quality, free from scale, spills, splits and any other defects. There shall be no joints in individual strands except those made in the base rod or wire before final drawing.

b. Insulation (XLPE)

High quality unfilled insulating compound of natural colour shall be used for insulation and shall be suitable for system voltage.

Insulation shall be applied by extrusion process and shall be chemically cross linked in continuous vulcanization process.

The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi conducting screen and insulation. The insulation of the cable shall be high quality generally confirming to IS-7098-II and relevant IEC.

c. Shielding

All cables rated 11 kV and above shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi-conducting shielding.

The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by "Triple Extrusion "process to ensure perfect bonding between the layers. The core identification shall be by coloured stripes or by printed numerals.

The insulating shielding shall consist of non-metallic extruded semi-conducting compound in combination with a nonmagnetic metallic screening of copper. The copper screen shall be capable of carrying the single line to ground fault current.

d. Armouring

Armouring shall be applied over the inner sheath. Armouring for multi-core cables shall be by single round galvanized steel wires where the calculated diameter below armoring does not exceed 13 mm and by galvanized steel strips where the dimension greater than 13 mm.

Requirement and methods of tests for armour material and uniformity of galvanized and dimensions shall be as per IEC. Armouring for single core cable shall be with round wire of 2.5 Sq.mm diameters and shall be of non-magnetic material. The dimensions of steel strips shall be as per latest edition of IEC-3875.the direction of the lay of the armour shall be opposite to that of the cable cores.

e. Inner Sheath

The cable core shall be supplied with bedding of PVC in the form of extruded type ST-2 PVC inner sheath, conforming to IEC-583, suitable to withstand the site conditions and desired temperature. The inner sheath shall be compatible with the temperature ratings of the cable and shall have no effect on any other components of cable. Single core cable shall not be provided with inner sheaths.

f. Outer Sheath

Extruded type ST-2 PVC outer sheath, conforming to IEC-5831 over the armoring in case of armored cables or over inner sheath in the case of un-armored cables.

The colour of outer sheath of all XLPE cables shall be as per Specific requirement and pigment added shall be such that they don't fade even when exposed to direct sunlight. In addition, suitable chemicals shall be added into the FRLSH compound of the outer sheath to protect the cable against rodent and termite attack.

The outer sheath shall be applied by extrusion over the armoring with compound meeting FRLSH properties mixed with chemicals for protection against rodent and termite attack.

Tests

Cables shall be type tested and routine tested in accordance with IEC:7098 (Part II).

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a. Conductor resistance test.
b. Partial discharge test.
c. High Voltage test.

The following tests shall be carried out at site for insulation between phases and between phase and earth before and after cable laying:

a. Insulation Resistance Test.
b. Continuity test.
c. Sheathing continuity test.
d. Earth test.
e. High Voltage test.

Cables shall be laid with a clearance of at least 75 mm between two cables.

End Termination of HT Cable

Pre-moulded cable terminations (Touch Proof) for XLPE cable shall be used as per manufacturer's instructions. The steel cone of M-seal Push-On shall consist of highly track resistant insulating section vulcanized to a semi-conducting section. The pad material shall have cold-flow properties and shall be flame retardant.

Each end terminal shall undergo Hi Pot Test.

Jointing Kits:

The straight through jointing kits shall be suitable for installation on overhead trays, concrete lined trenches, and ducts and for underground burial with uncontrolled backfill and possibility of flooding by water and chemicals. These shall have protection against any mechanical damage and suitably designed to be protected against rodent and termite attack.

Laying of HT Cables

Cables shall be installed in accordance with IEE Regulations 17Th edition and in accordance with the following additional requirements.
Cables shall be installed in a neat and workmanlike manner free from kinks and unnecessary bends. The Contractor shall provide all necessary terminals, cable glands, ties, cleats, cable boxes and terminating facilities for the plant to which cables are to be connected and shall supply and install all facilities for the purpose of supporting cables.
Particular care shall be taken that the cable sheath is not damaged during installation. Any cable damaged during installation shall be replaced by the Contractor.
All cables shall generally be installed on cable ladders except where preformed cable trenches or ducts have been provided or cables are buried direct in the ground.

4.7.2. LV Cables

1100 Volts Grade LV cables with stranded H2/H4 grade Copper/aluminium conductor, FRLSH, XLPE insulated, colour coded, laid up with fillers and/or binder tape wherever necessary provided with extruded PVC inner sheath, single galvanized round steel wire or galvanized strip armored and provided with PVC outersheath. Both, inner and outer sheaths shall be of Type ST-2 as per IS:5831 (latest amendment). The cable shall conform to IS: 7098 (Part 1) (amended upto date) and must bear ISI mark.

Continuous AC Current Capacity: The continuous ac current capacity shall be as per IS:7098.

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Conductor:

The conductors shall be solid for conductor of nominal area up to and including 6 Sqmm and stranded beyond 6 Sqmm. Conductors of nominal area less than 16 mm2 shall be circular only. Conductors of nominal area 16 mm2 and above may be circular or shaped as per IS 8130. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS 1554 (Part-1). All conductors shall be of Class-2 type.

The core insulation shall be with cross linked polyethylene insulating compound dry cured, applied by extrusion. It shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. It shall conform to the properties given in Table-1 of IS: 7098 (Part -2).

The insulation screen and conductor screen shall be of non-metallic semi conducting compound.

The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.

All cables shall be provided with armour except those specifically specified as unarmoured. Requirement and methods of tests for armour material and uniformity of galvanization shall be as per IS - 3975 and IS -10810 (Part 41). The dimensions of armour shall be as per method (b) of IS - 7098 (Part -2).

The minimum and average thickness of outer sheath for unarmored cables and minimum thickness of outer sheath for armored cables shall be as per IS: 7098 (Part-2).

The thickness of the insulation, inner sheath shall be governed by values given in Table-4 and Table-5 of IS: 7098 (Part -2).

All flexible cables as per requirement of the project shall be in conformance to IS-8130.

If heat resisting PVC cables are specified as per requirement, it shall be possible to continuously operate the cable at a maximum conductor temperature of 85°C under full load condition and 160°C under short-circuit condition. For XLPE insulated cables, it shall be possible to continuously operate the cable at a maximum conductor temperature of 90°C under full load condition and 250°C under short-circuit condition.

4.7.3. Control Cables

Conductor: The wires in the conductor shall have the same nominal diameter before stranding. The number of wires in the conductor shall be not less than 3 and the maximum resistance of conductor at 20 deg. C shall be as per Table 2 of IS:8130.

Insulation: The insulation shall be FRLSH PVC Compound applied by extrusion (conforming to the requirements of IS-5831) suitable for a maximum rated conductor temperature of 70 deg C intended for cables with rated voltages up to and including 3.3 kV.

Core Identification:

Cores: Cores shall be identified by different coloring of PVC insulation by adopting the following scheme:

2 cores: Red and Black

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2 cores + Earth: Red, Black, Green/Yellow
3 cores: Red, Yellow, Blue
4 cores: Red, Yellow, Blue & Black
10 cores or more: As per IS:1554 (Part-1)-1988

Inner & Outer Sheath:

Materials: For cables with general purpose insulation, the inner & outer sheath shall be of Type ST-1 PVC compound conforming to the requirements of IS:5831 as recommended for general purpose sheath intended for use in cables operating at a maximum rated conductor temperature 70 deg C.

Construction: The outer sheath shall be applied by extrusion over the inner sheath as applicable for un-armored twin and multi core cables. It shall be so applied that it fits closely over inner sheath and it shall also be possible to remove it without damaging the inner sheath. The color of the outer sheath shall be black.

Thickness: The average and minimum thickness of the PVC Inner & outer sheath shall be not less than the values specified hereunder as per Table 7 of IS:1554

4.7.4. Cable Accessories: Cable Jointing, Glanding & Termination

The termination and straight through jointing kits for use on the systems shall be suitable for the type of cables offered as per this specification and shall meet requirements of IS 13573.

The accessories shall be supplied in kit form. Each component of the kit shall carry the manufacturer's mark of origin.

The kit shall include all stress grading, insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.

The contents of the accessories kit including all consumable shall be suitable for storage without deterioration at a temperature of 50° C, with shelf life extending to more than 5 years.

a. Jointing Kits

The straight through jointing kits shall be suitable for installation on cable trays concrete lined trenches, and ducts and for underground burial with uncontrolled backfill and possibility of flooding by water and chemicals. These shall have protection against any mechanical damage and suitably designed to be protected against rodent and termite attack. The inner sheath like that provided for cables shall be provided as part of straight through joint. The jointing kits shall be from one of the makes/ types mentioned in the data sheet.
Cable Glands

Cable glands shall be of nickel-plated brass unless otherwise specified. The single compression type cable glands shall be used for indoor panels/equipment (e.g. substation, control room, etc.). The cable glands for outdoor terminations shall be weather protected, double compression type. Cable glands forming a part of relevant FLP enclosure shall be FLP type, tested by CIMFR or any other recognized independent testing laboratory and approved by NABL or any other statutory authority as applicable. Indigenous FLP glands shall have valid BIS license as per the requirements of statutory authorities. All cable glands shall comply with the requirements given in IS/IEC-60079.

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Entry thread of cable gland shall be compatible to the entry thread provided in the equipment. If required, suitable reducers/adopters shall be used.

b. Connectors

Terminations of cables with stranded conductor shall be made with crimped type tinned copper solder less lugs which shall be suitable for the cable size mentioned in cable schedule.

Ferrules

Ferrules shall be of approved type and of size to suit core size mentioned and shall be employed to designate the various cores of control/signal cable by the terminal numbers to which the cores are connected, for ease of identification. Ferrule shall be printed type. Cross-ferruling shall be done. Ferrules shall be used at both ends of terminations

c. Terminations

All cables up to 1100V grade and higher levels shall be terminated at the equipment by means of double compression type cable glands suitable for the cable size. They shall have a screwed nipple with electrical threads and check nut. The cables shall be identified close to their termination points at both the ends of cable (cable numbers shall be punched on stainless steel straps 2mm thick and securely fastened to the cable, wrapped around it) and along the route at regular intervals, by cable tag numbers.

All cable entries for outdoor termination shall be through bottom/side. Outdoor cable termination through top of equipment shall not be permitted.

Power cables cores wherever color coding is not available shall be identified with red, yellow and blue PVC tapes. Where copper to aluminium connections are made, necessary bimetallic washers shall be used. All unused spare cores shall be either earthed or properly insulated with insulation tape.

In case of control cables, all cores shall be identified at both ends by their terminal numbers by means of PVC ferrules suitable for core size. Wire numbers shall be as per schematic/ wiring/inter-connection diagram. All unused spare cores of control cables shall be neatly bunched and ferruled with cable tag at both ends, for future use.

Contractor shall drill holes for fixing glands wherever necessary. Gland plate shall be of non- magnetic material/ aluminium sheet in case of single core cables. All unused cable entries on equipment/panels shall be plugged/sealed.

The cable shall be terminated at electrical equipment/switchboards through glands of proper size. The individual cores shall then be dressed and taken along the cables ways or shall be fixed to the angles with polyethylene straps. The cable glanding shall be done as per manufacturer's instructions. Cable armour shall not be exposed after termination is complete.

In case of termination of cables at the bottom of a panel over a cable trench having no access from the bottom close fit holes shall be drilled in the gland plate for all the cables in one line, then gland plate shall be split in two parts along the centre line of holes. After fixing bottom plate, uncovered cable holes/gaps shall be sealed with cold setting compound.

Crimping of lugs to cable leads shall be done by hand crimping / hydraulically operated tool as per requirement. Insulation of the leads shall be removed before crimping. Conductor surface shall be cleaned and shall not be left open. Suitable conducting jelly shall be applied on the conductor lead. Lugs shall enclose all strands of cable core. Cutting of strands shall not be allowed.

The contractor shall bring to the notice of Engineer-in-charge any mismatch in cable glands, lugs provided with the equipment vis-à-vis to the cable size indicated in cable schedule for taking corrective action.

The cable joints shall be avoided as far as possible. In case a joint is unavoidable, the following shall be insured:

The number of joints shall be restricted to minimum as far as possible.

The location of joints shall be identified with permanent markers.

No joints shall be allowed in incomer cables & cables laid in hazardous areas without the approval of the Engineer.

The jointing and termination of medium voltage power cables shall be carried out by trained personnel only. Jointing and termination of high voltage cables shall be done by skilled and experienced jointer duly approved by the Enigneer. Only type tested jointing and termination kits of approved make shall be used.

Non authorized repairs, modifications shall not be carried out on the hazardous area equipment terminal boxes and junction boxes. Damaged enclosures of hazardous area equipment shall be brought to the notice of the Engineer by contractor. After termination is complete, all the bolts, nuts, hard wares of terminal box shall be properly placed in its position and tightened.

All cables glands installed outdoor shall be provided with suitable sized shrouds and rates for the same shall be included in the scope of the termination of the cable glands. No separate payment is envisaged for the same.

4.7.5. TEST & INSPECTION

The cables shall be tested and inspected at the manufacturer's works. Manufacturer shall furnish all necessary information concerning the raw material supply to the Engineer. The representative shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality. For HV cables, the vendor shall give at least 2 weeks advance notice to the purchaser, regarding the date of testing to enable purchaser's representative to witness the tests

After completion of manufacture of cables and prior to dispatch, the cables shall be subjected to type, routine, acceptance and special tests as detailed below. The test reports for all cables shall be got approved from the Engineer before dispatch of the cables.

All routine tests, acceptance tests, type tests and additional type tests for improved fire performance shall be carried out as listed in IS: 1554 (Part-1) and IS: 7098 (Part-2) on PVC and XLPE insulated cables respectively.

The test requirements for PVC insulation and sheath of cables shall be as per latest revision of IS: 5831.

All Type tests as per IS 7098 to be carried out as per latest revision. The basic minimum requirement shall be carried out as per below list.

- Insulation Resistance Test.
- Continuity test.

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- Sheathing continuity test.
- Earth test (in armoured cables).
- Hi-Pot Test.
- Cold Bend Test
- Cold Impact Test

Test for Resistance to Ultraviolet Radiation: This test shall be carried out as per ASTM-G-154 on outer sheath. The retention value of tensile strength and ultimate elongation after the test shall be minimum 60 % of tensile strength and ultimate elongation before the test. Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by the Engineer before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in-house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided outer sheath remains same.

Acceptance tests as per IS-1554 (Part-1) and IS-7098 (Part-2) and the following special tests to be performed on the cables as per sampling plan for all cables. However, these tests are required to be witnessed by the Engineer representative for HV cables.

Accelerated water absorption test for insulation as per NEMA-WC-70. (For PVC insulated cables) and as per NEMA-WC-53 (for XLPE). Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by the Engineer before dispatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in-house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided type of insulation remains same.

Dielectric Retention Test: The dielectric strength of the cable insulation tested in accordance with NEMA-WC-70 at 75 ± 1° C shall not be less than 50 % of the original dielectric strength. (For PVC insulated cables). Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by the Engineer before dispatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in-house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly and once for each order.

Oxygen Index Test: The test shall be carried out as per IS-10810 (Part 58). Sampling to be done for every offered lot/size as per sampling plan.

Flammability Test: The test shall be carried out on finished cable as per IS-10810 (Part 61 & 62). Sampling for these tests is to be done randomly once for each order, provided outer sheath remains same. The acceptance criteria for tests conducted shall be as under:

Part-61-The cable meets the requirement if there is no visible damage on the test specimen within 300 mm from its upper end

Pan-62-The maximum extent of the charred portion measured on the test ample should not have reached a height exceeding 2.5 m above the bottom edge of the burner at the front of the ladder.

Test for rodent and termite repulsion property shall be done by analyzing the property by chemical method.

Following tests shall be carried out to prove FRLS property of the cable.

Critical oxygen index as per ASTM-D-2863 i.e. Determination of % of oxygen required for combustion at room temperature of FRLS sheath which shall remain as 29%(min.).

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Temperature index as per ASTM-D-2863 i.e. to determine at what temperature normal oxygen content of 29% in air will support combustion of FRLS sheath which shall remain as 250°C.

Halogen acid gas emission as per IEC-60754 Part 1 i.e. to determine the % of release of hydrochloric acid gas from the FRLS sheath under fire which shall be 20% (max.)

Smoke Density Test shall be as per ASTM D - 2843 and Smoke Density Rating of FRLS Sheath shall be 60%.

Detailed Data Sheets & Catalogue of cables.

Test certificates from the manufacturer for having successfully conducted all the prescribed tests at the manufacturer's works as per IS/IEC standards.

Inspection & Test Plan for all cables.

FAT reports

Any other relevant documents/references required for the material.

List of Deviation from Technical Specification, if any.

4.7.6. Tests:

The type, acceptance, routine tests, any tests specifically demanded by the Purchaser and tests during manufacture shall be carried out on the cables free of cost.

Type tests shall mean those tests, which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification and relevant Standards. These tests shall be carried out on samples prior to commencement of commercial production against the order. The Contractor shall indicate his schedule for carrying out these tests in the activity schedule. These tests shall have to be carried out at the Government Approved Testing Laboratory only in presence of the Purchaser's representative. Purchaser reserves the right to specify the name of the laboratory also, if so felt.

Acceptance Tests shall mean those tests, which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot. These tests shall be carried out at the manufacturer's works in presence of Purchaser's representative before the dispatch of the materials to the site.

Routine Tests shall mean those tests which are to be carried out on each strand / spool / length of the cable to check requirements which are likely to vary during production. These tests shall be carried out by the manufacturer on each drum and shall have to furnish these reports to the Employers representative during his visit for acceptance tests.

Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the supplier to ensure the desired quality of the product to be supplied by him, including all Quality Control checks and Raw Materials testing.

Samples for individual wires for tests shall be taken before stranding from not less than ten percent of the spools in the case of copper and aluminium wires and ten percent of the coils in the case of steel wires. If samples are taken after stranding, they shall be obtained

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by cutting 1.2 meters from the outer end or inner end of the finished cable from at least ten percent of the finished reels.

The standards to which these tests will be carried out are listed against them. Where a test is a specific requirement of this specification, the norms and procedures of the test shall be as specified in this Specification or as mutually agreed to between the Contractor and the purchaser in the Quality Assurance Programmed.

For all type and acceptance tests, the acceptance values shall be the values guaranteed by the Contractor in the "Guaranteed Technical Particulars of his proposal or the acceptance value specified in this specification, whichever is more stringent for that particular test.

4.7.7. Type Tests:

All the type tests as per relevant Standards (IS 1554-Part-I, IS 7098-Part-II and IS 9968) and this Specification shall be conducted once on each sample /samples of cables for every 50 KMs or less of production from each manufacturing facility. However, if the Supplier has carried out the Type Tests within 5 years of opening of this Tender, the same will be considered acceptable, subject to submission of the same in original. However, Employer may ask any of the suppliers to carry out the Type Test at its own discretion, even if the same are not older than 5 years, but the same will be subject to allotment of minimum 15% of the total quantity indicated in this Specification. Some tests are listed below:

All the Type Tests shall be carried out by the supplier at no extra cost to the Employer, (for any number of times, as may be required) at the Government Approved Laboratory or at the Laboratory specified by the Employer, at its own discretion.

All the new suppliers, for the size offered or full lot, shall have to compulsorily carry out the Type Tests i.e. if the supplier has supplied one size of cable to the Company in past and is having type test certificate.

In case of failure in any of the type test/s, the supplier is either required to modify the design of the material or repeat the type test three times successfully at his own expenses. The decision of the purchaser in this regard shall be final and binding. The Purchaser at its own desecration may also cancel the order at the risk and cost of the contractor, if the material fails twice successively in the Type Test.

Contractor shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule. The Purchaser reserves the right to specify the name of the laboratory also, if so felt.

The entire cost of testing for the type, acceptance routine tests and tests during manufacture, special tests etc. specified herein or in the relevant Standards shall be treated as included in the quoted unit price of cable.

4.7.8. Sample Batch for Type Testing:

The Contractor shall offer minimum five (5) drums or the full quantity, whichever is less, for selection of samples required for conducting all the type tests.

The Contractor is required to carry out all the acceptance tests successfully in the presence of Purchaser's representative before dispatch of the selected sample to the testing laboratory for type test.

However, the new supplier will have to offer the first lot for selection of sample for type test, after successfully carrying out the acceptance tests on it, in presence of the Employers Representative. The first lot shall be minimum of 5 drums or full allotted quantity.

4.7.9. Test Reports:

Test reports shall be furnished in at least two (2) copies along with one original. One copy shall be returned duly certified by the Purchaser only after which the material already inspected i.e. the materials manufactured or selection of sample for type test, shall be dispatched on receipt of Dispatch Instructions from the Chief Residential Engineer for MTHL Project.

Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the purchaser's representative.

Test Certificates of test during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Purchaser.

4.7.10. Drawings:

The Contractors must submit the drawings for the cables and drums to be utilized for packing of the control and power cables, for the lengths specified in this Tender Specification. The cable drawing shall be enclosed with the calculations of current rating, dimensions etc. and drum drawings with calculations in support of the size of the drum to accommodate the required length of cable.

- Cable Route & Elevations
- Critical care for installation
- Cables buried in Ground
- Cable carried through Concrete Segment of the Bridge on Cable Tray
- Cable carried through Steel Segment of the Bridge on Cable Tray
- Cable installed in pipes within Crash Barriers
- Expansion Joints locations
- Reference Drawings

4.7.11. Fire retardant Cable Paint & Fire Barrier

The fire-retardant paint / barrier shall be taken 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.

4.7.12. Fire retardant cable Paint

The Fire-retardant cable coating / painting shall be intumescent / ablative, water based compound and 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-

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toxic, asbestos free, & halogen free and shall have good mechanical strength. The colour of paint shall be white in color and density of coating shall be 1.3kg/ltr, coating shall have a snap time of 30 minutes, the expansion shall begin at 230 □C and it shall have an 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.

4.8. Fibre Cable

Fibre Optic Cable Specification as specified in ITS Specifications for separate Lighting & separate Scada system

4.9. Cable Trays and containments

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.
Cable trays, wire-way and trucking shall be purpose made and incorporating factory made fittings (on-site cutting and f o r m i n g not allowed) made from sheet steel and all trays, wire-way, trunking, supports and clamps shall be hot dipped galvanized after manufacture. Lengths of trays, wire-way and trunking shall be bolted together with approved fishplates and webs. Power cable and communication / data cables shall be segregated by running in different containment.
The Contractor shall develop design and drawing to accommodate power and control cables of adequate size. The cable tray shall be fabricated from minimum 2 mm thick perforated hot dip galvanized (as per IS 3769/6745) sheet steel and shall be in complete with tees, elbow, risers and necessary hardware.

4.9.1. 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).

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 relate to the trays by using fasteners. Typical details of trays, fittings and accessories etc. are shown in the enclosed drawings.

4.9.2. Cable Ladder:

The cable Ladder and all accessories shall be fabricated from sheet steel and must be hot dip galvanized against corrosion confirming to IECO 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 rungs 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 overs 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 relate to the ladder by using fasteners.

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 meters.

4.9.3. Hangers & Support for Electrical System.

Scope:

The specifications given below relates to the design, procurement, installation, testing & supplying support system for busducts, busbars, conduits, cable trays, cable ladders:

Support, Anchorage & Attachment Components:

Steel Slotted Support Systems: Factory-fabricated components for field assembly.

Metallic Coatings: Hot-dip galvanized after fabrication and applied according to IS Standards.

Non-metallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied.

Painted Coatings: Manufacturer's standard painted coating applied.

Channel Dimensions: Selected for applicable load criteria.

Non-metallic Slotted Support Systems: Structural-grade, factory-formed, glass-fibre-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches.

Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.

Rated Strength: Selected to suit applicable load criteria.

Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armoured electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported.

Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

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Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened cement concrete, steel, or wood, with tension, shear, and pull-out capacities appropriate for supported loads and building materials where used.

Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened cement concrete with tension, shear, and pull-out capacities appropriate for supported loads and building materials in which used.

Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18

Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

Toggle Bolts: All-steel springhead type.

Hanger Rods: Threaded steel.

4.10. Hot Dip Galvanizing Process

The purpose of this specification is to identify by the contractor towards hot dip galvanize process and therefore, is applicable for the Mild Steel used For Earthing, Cable Trays, Ladders, switchboards/ DBs and Junction Boxes as specified under Electrical Installation.

The Contractor shall take into consideration, the corrosive effect of the atmosphere in the items Mild Steel used For Earthing, Cable Trays, Ladders, switchboards/ DBs and Junction Boxes as specified under Electrical Installation.

- All steel components shall be hot dipped galvanized in accordance with BS 729, with minimum thickness of 85µm or as specifed.
- All mechanical and cast-iron assemblies shall be cleaned and painted. The running surfaces of car guides shall be treated with an accepted rust preventive compound.
- All parts constructed in sheet steel shall be either galvanized by the hot dipped process or fabricated from hot dipped galvanized sheet steel.
- All hardware, fastenings, screws and shims shall be hot-dipped galvanized. However, all visible screws and fastenings shall be of stainless steel. Epoxy painting will be permitted only on-site damage repairs.
- Wherever galvanization on ferrous components has been damaged in handling the same shall be given two coats of zinc chromate primer and two coats of aluminum paints conforming to IS 2339.

4.10.1. Galvanization shall comply with the standard mentioned below:

- ISO 1459 - Metallic Coatings – Protection against corrosion by hot dip galvanizing – Guiding Principles.
- ISO 1460 - Metallic Coatings – Hot dip galvanized coatings of ferrous materials – Gravimetric determination of the mass per unit area.
- ISO 1461 - Hot dip galvanized coating on fabricated ferrous products – Specification
- ISO 2064 - Metallic and other non-organic coatings – Definitions and conventions concerning the measurement of thickness.
- ISO 2177 - Metallic Coatings measurements of coating thickness – coulometric method by anodic dissolution.

- ISO 2178 - Non-magnetic on magnetic substrates – measurements of coating thickness – magnetic method.
- ISO 2859 - Sampling procedures and tables for inspection by attributes.

4.10.2. Mounting Accessories (Supports & Brackets)

The mounting accessories shall be fabricated from steel and must be hot dip galvanized against corrosion confirming to IECO 1461-1999 for installations in both indoor and outdoor applications and should be of completely modular type.

All support 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 hardware etc. to form various arrangements required to support the cable trays. Welding of the components at the site shall not be allowed.

4.10.3. 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 rubberized 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 center 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.

4.11. Corrosion Protection:

Mild Steel used For Earthing, Cable Trays, Ladders, switchboards/ DBs and Junction Boxes as specified under Electrical Installation shall be provided with PU paint as per Indian Standard 13213 (latest revision), to suits saline environment of sea and provides corrosion resistance.

4.11.1. Testing & Certification of 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.

4.11.2. Marking, Documentation, Compliance and Inspection

Each system component shall be durably and legibly marked with:

- the manufacturer's or responsible vendor's name or trademark 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 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 checked by inspection.

The manufacturer or responsible vendor shall provide all necessary information 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.

4.12. STREET LIGHTING & CCTV

4.12.1. General

Scope of under the section shall include design, supply, installation, testing at site, commissioning, Operation and maintenance of Street Lighting, Aesthetic Lighting Navigational, Bridge and Pier Lighting in the marine area.

The Light design shall also be acceptable to Bombay Natural History Society (BNHS) and therefore, judiciously design to meet the following aspects:

i) The Artificial light lights should be installed in a way so that migratory birds are neither disrupted nor displaced from feeding or roosting areas, and should able to undertake normal behaviour such as foraging, pruning and maintenance.
ii) In case of mudflat area, where, large number of flamingos feed on the mudflats around the **Sewri** and **Nhava** ends of MTHL during the low tide. As such, special precautions must be taken at the Sewri and Nhava area so that the lighting should not spill into the mudflats as this may discourage birds from feeding zones.
iii) The glow in the sky resulting due to artificial lights often results in photo-pollution that disrupts the circadian rhythm of various wildlife species.
iv) The height of the lamp posts should be kept at minimum so that they adequately illuminate
v) The light fixtures should be effectively projecting light downward thereby minimizing the glow in the sky. the road while taking care of photo pollution.

vi) Optimum use of light dimming/ light switching device and encourage the use of adaptive light controls to manage light timings, intensity and colour.

Based on the above assumptions, the contractor shall deploy experienced light experts, while design and enhance use of best practice and mitigate measures against the effect of artificial light by reducing photo pollution and minimize its effect on wildlife.

The contractor is liable to undertaking an Environmental Impact Assessment for effects of artificial light on behaviour and survivorship of migratory bird species.

The Contractor shall appoint an experienced Lighting Consultant to prepare, develop design and execute the world class lighting theme across the Bridge to enhance its visibility over and under the Bridge and aesthetic aspect with environmental safety and pollution control.

The Contractor appointed an experience and proven Lighting Consultant shall develop design world class lighting theme as require for Street Light, Aesthetic Lighting all along the Bridge. This will enhance its visibility over and under the Bridge.

The Contractor shall bear all costs of design, procurement, installation, testing & commissioning cost of all lighting, including the cost of energy consumption up to the date of handing over / completion Certificate as earlier, to be borne by the Contractor".

4.12.2. General Requirement

The Contractor shall develop design in accordance to IRC using proper software to meet Minimum 40 Lux, overall uniformity 0.4, and transvers uniformity 0.33 illumination on the surface of Road.
The Contractor shall Procure, supply, transportation, installation, testing & commissioning of Circular / Conical Smart Poles for Street Lighting Applications & CCTV Installations. This includes 2x150 W LED Street Lighting fixtures.
However, the provisions of mounting structure on crash barrier are being made by Package-1, 2 & 3 Contractors at every 26 meters interval (indicative) to suit mounting arrangement for Light Pole. The Contractor shall actively involve necessary interface regarding mounting structure and fixing to be dealt by the Electrical Contractor.

The Contractor shall develop design to meet Minimum 40 Lux, overall uniformity 0.4, and transvers uniformity 0.33 illumination on the surface of Road. This include Procurement and installation of Circular / Conical Smart Poles for Street Lighting Applications & CCTV Installations.
The provisions of mounting structure on crash barrier are being made by Package-1, 2 & 3 Contractors at every 26 meters interval (indicative) to suit mounting arrangement for Light Pole. The Contractor shall actively involve necessary interface regarding mounting structure and fixing arrangement etc.
The Contractor shall provide lighting at locations of the Project Bridge Specified in Schedule-B, using appropriate system and source of electric power as per the requirement of this section.

The contractor shall make the suitable arrangements for procuring power supply to ensure uninterrupted lighting during night and when visibility is low, including provision of redundant power supply.

4.12.3. Functional Requirement

Unless stated otherwise stated elsewhere, the minimum level of illumination on the stretches of the project Bridge including toll plaza's truck lay-byes, interchanges etc. shall design to meet Minimum 40 Lux, overall uniformity 0.4, and transvers uniformity 0.33 as per table given below:

Area and purpose	Lux Level (Minimum)	Overall Uniformity	Transvers Uniformity
Bridge Roadway – 9 / 10 m high Pole (above Road level) with 2x150 W LED Lights @26m interval), mounted on crash barrier of roadway, shall be as per design and indicative drawings.	40lux	0.4	0.33
Ramp / Interchange - 9 / 10 m high Pole (above Road level) with 2x150 W LED Lights @26m interval), / or High Mast with LED Street Lights) with suitable height,	40lux	0.4	0.33
Toll Plaza - Roadway Lanes 30m High Masts with Suitable No, of 250W/ 400W LED Flood Light Fittings as per the Lighting Design Calculations as per design and indicative drawings.	40lux	0.4	0.33
Girder Box (Void)	10lux	To be design inside void of Girder Box.	
Aesthetic Light	As per aesthetic report generated by the Package 1,2 & 3 Contractor. Specified in this Employer Requirement.		
Power Supply for Event based light	Spare provision for power supply for meeting additional 40 Lux (Min) or 80 Lux Min. fin totality on the entire stretch of Road.		
Built up sections on the Project Bridges	As per Standard and Specification		

Light parameters as above are indicative but not exhaustive, the contractors, however, shall develop layout for lighting system together with type of luminaires at various locations in such a manner that the minimum illumination level prescribed above should be achieved. All the design / drawing shall be submitted to the Engineer for review and comments, if any, for approval.

4.12.4. Construction Work

The contractor shall perform the construction work according to Contract specification and in compliance with following:

- National Electric Code
- AASTHO an information guide for Roadway lighting Latest Edition
- Manual on Uniform Traffic Control Devices for Street & Highways and
- Smart Lighting shall be compliant to IoT System

Materials: Obtain approval on the design and selection of luminaire based on the Lux level required for the Bridge as per IRC by GC/ Engineer in Charge before installation.

All the information shall be available at the Central Control Centre for its quick maintenance Before ordering materials, confirm the type and location of service available from the Utility Company - BEST.

After completing the installation and before the electrical services in connected, obtain a certificate of compliance from the Kentucky Department of Housing, Building, BNHS for marine lives and construction, Electrical Inspection Division .

The Plans indicate the extent ad general arrangement of the lighting circuits and equipment and are for general guidance. Advice the Engineer in Charge in writing and obtain written approval for any necessary modifications.

Stake pole locations and obtain the Engineer's approval.

4.12.5. Luminaire Description

The Luminaires shall work on single phase three wire system (phase, neutral & earth). The luminaire light output (lumen) shall be constant and shall be able to withstand allowable supply source voltage variations within 120-270V AC.

The streetlight luminaire should be capable of withstanding voltage stress of 440V. The Luminaires shall be suitable for operation within the input supply voltage range specified. The driver of the light should be able to sense and cut-off power to the light in case of phase-to-phase/ 440 V fault. No claim in this regard shall be considered.

The Luminaries shall have a sturdy and corrosion resistant high pressure Die cast Aluminium alloy housing with weatherproof gasket for lamp and control gear accessories.

The housing shall be top openable powder coated, without any cracks or thorough holes, made in a single piece of diecast LM6 Aluminium alloy. The luminaries shall be totally enclosed, dust tight and waterproof.

The dimensions of luminaries shall be optimum and adequate to permit enough heat dissipation, through the body itself, to prevent abnormal temperature rise inside the lantern and consequential damage to the cover and gasket materials, LEDs, lenses and electronic drivers. Heat sink must be thermally connected to MCPCB/ LED light source.

The optical system shall consist of Poly Carbonate lenses on high power LEDs designed & tested to achieve typical street lighting distribution from the LED Luminaire. These lenses provided for individual LEDs are to be fixed on lens plate to have consistent light distribution from luminaries. Luminaries should conform to the Photometric Distribution / requirements of Cut-Off / Semi Cut – off light distribution and optics as classified in IS 1944 and NLC 2010.

Suitable number of LED lamps/array shall be used in the luminaries. The wattage of each LED should be greater than 1 watt.

The Luminaries shall be provided with distortion free, clear, high tensile, heat resistant, toughened glass of minimum 0.8mm thickness or UV resistant polycarbonate cover fixed or with Integrated optics with corrosion free/ stainless Steel screws.

All Luminaires shall conform to RoHS/CE/ERTL/ERDI requirements.

A heat proof silicon loop gasket shall be provided in the lantern body to ensure a weatherproof seal between the cover and the metal housing to exclude the entry of dust, water, insects, etc. Luminaries should conform to degree of protection of IP 66 or above. Felt gasket will not be accepted. The test report from NABL accredited laboratory shall be submitted along with the technical proposal/ Bid.

Luminaire shall be enclosed in an aesthetically designed housing with corrosion resistant polyester powder Coating after phosphor-chromate treatment.

Both Luminaries and Driver should be BIS approved and both driver and luminaries along with BIS certificate should be submitted. Luminaire and driver preferably should be from same make.

Name of the Employer, Year of Manufacture, Batch No., Serial Number or Identification No. Luminaries, Wattage and Frequency should be mentioned on the housing. Manufacturer's name or logo should be embossed on the housing.

LED luminaries should conform to the various National / International standards for safety & performance. Manufacturer should provide test reports as per LM 79 & LM80. The test report from NABL accredited laboratory shall be submitted along with the technical proposal/ Bid for LED as well as Luminaires. Driver should be EMC/EMI compliant and test report must be submitted.

Luminaries should conform to the National / International standards for Safety & Performance and test certificates as per IS 16103/ IS 16107 should be provided by the manufacturer.

The electrical component of the LED and LED driver must be suitably enclosed in separate sealed unit to function in environment conditions mentioned above.
All the connecting wires inside the Luminaries shall be Low Smoke Halogen Free, fire retardant cable.

All the material used in the luminaries shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant confirming to relevant standards.

The Manufacturer shall have all the relevant testing facilities certified by an accredited laboratory and shall be offered for inspection to the Employer for verification of the required parameters and tests. contractor shall confirm the same in the BID.

The control gear shall comply with the provisions of IEC 61347-2-13, IEC 62031 and IEC 62384. Appropriate in-built surge protection of 4KV with provision of additional 10KV surge protection bolted within the luminaire shall be provided in all the Luminaires. No claim for failure of Luminaires, on account of voltage surges other than Lightning surges, will be considered.

In case of voltage surges due to lightning, it is expected that lights, in the affected circuit, will fail in a group and not in an isolated manner. Hence, any such failure of lights in a group on account of Lightning surges, may be reported to the Employer, along with circumstantial evidence preferably within 48 hours of such occurrence. The responsibility for submission of supporting documentation rests with the successful contractor.

The Luminaires shall be suitable for operation within the input supply voltage range specified. The driver of the light should be able to sense and cut-off power to the light in case of phase-to-phase/ 440 V fault. No claim in this regard shall be considered.

The lighting fixtures offered shall comply with the data sheet attached below. The complete luminaire assembly shall have a warranty period of 5 years as decided. Protection against any type of mischief should be made.

4.12.6. Pole Mounted LED Street Lights & LED Flood Lights: Technical Particulars

S..No.	Criteria	Specification for Street/ Flood LED Light
1	Luminaire configuration	Side entry type for roads (exceptions being top for pedestrian crossing luminaire and high mast luminaire

S..No.	Criteria	Specification for Street/ Flood LED Light
		will have mounting brackets at rear). Shall consist of separate optical and control gear compartment. Both LED & Driver should be easily replaceable in the field condition.
2	Technical requirement	Shall consist of separate optical and control gear compartment. Inclination adjustable at 0 / 5 / 10 / 15 degrees for streetlight luminaire as per design.
3	Housing / Body of fitting Finish	Pressure Die cast housing with powder coated surface. Aesthetically designed housing with Black / Grey / Cream color/ Silver/ Red corrosion resistant polyester powder coating.
4	Cover / glass	All luminaries - Fixture cover - UV stabilized Polycarbonate. Shield in extra-clear (transitivity more than 91%) temperature glass with impact resistance IK08(EN62262). Test certificate for the material of the fixture cover should be submitted to the Employer / Employer's representative for their approval.
5	Product qualities	Energy efficient, high quality consistency, glare control, lumen maintenance. LM 80 report to be submitted to the Employer / Employer's representative for their approval for LEDs to be used in each type of Luminaire.
6	Protection – IP	Minimum IP65 protection. IP 66 is desirable. (as per IS/IEC60529-2001, to be confirmed with test certificate)
7	Impact resistance	Impact resistance should be greater than or equal to IK 08.
8	Total system wattage of Fixture including Driver	Total system power consumption should be within +/- 5% of rated wattage.
9	LED Chip efficacy	Efficacy of bare LED should be greater than 120-132 Luminous/watt.
10	LED Luminaire efficacy	The system lumen output of the Luminaire should be more than 100 Lumens/Watt supported with LM79 report at the time of installation. Toli power consumption should be inclusive of driver wattage loss.
11	Lux level for the given parameters	Lighting design shall conform to IS: 1944 (Part I & II). The recommended illumination level and uniformity for roads shall be as per IUT (Institute of Urban Transport) (Ministry of Urban Development, Govt. of India) and IRC. The street lighting should be designed with 0.75 maintenance factor or the factor applicable after 5-year operation (whichever is lower should be considered). Average Lux level on the sea level below the bridge including below the sea should be minimum and not more than 1lux
12	Optical assembly	Structured LED array for optimized roadway photometric distribution with photometric lenses designed to optimize application efficiency and minimize glare also to have optimized independent assembled LED modules for easy replacement at site. Excellent uniformity and glare reduction be ensured. Must have constant luminous flux control for exact and high energy efficient lighting throughout life.
13	Operating voltage	150-277-volt AC electronic driver.
14	Frequency	50 Hz (with 2 % variation on both sides).
15	Power factor	> 0.95.

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S..No.	Criteria	Specification for Street/ Flood LED Light
16	Fixture Ambient Temperature	0°C to + 50°C (Must withstand Sun radiation continuous temperature of 84 degC) (Certification in this respect from an independent lab is needed).
17	Working Humidity	10% to 90% RH.
18	Driver Temperature	ta=65°C; tc=90°C.
19	Storage Temperature	Range -30°C to +80°C
20	Total Current Harmonic Distortion	< 15% (to be confirmed with test certificate)
21	Total system wattage of Fixture including Driver	Rated power consumption should be
		For LED Street Lights 1)150W 2)180W 3)220W
		For High Masts - LED Flood Lights - 1)100W 2)120W 3)150W 4)200W 5)400W
		Total system power consumption should be within +/- 5% of rated wattage. Total power consumption should be inclusive of driver wattage loss.
24	Power efficiency / LED driver efficiency	The efficiency shall be more than 90 % in all the types of luminaires.
25	Calculated Lifetime	50,000 hr. @ Ta=35°C at (L70, F50) as per IS16107 Part 1):2012
26	Correlated Colour temperature	3000K (or as applicable for marine lives)
27	CRI	The value of CRI shall be more than 70.
28	Light distribution	Optimized roadway photometric distribution
29	Lux level for the given parameters	Lighting design shall conform to IS: 1944 (Part I & II). The recommended illumination level and uniformity for roads shall be as per the minimum average lux levels specified in the technical specification, designed with 0.75 MF. Specified illumination levels shall be maintained for minimum 3 years.
30	Make of LED Lamps	Osram /CREE /Philips/ Lumileds / Nichia
31	Lens	Lens should be provided for so as achieve optimum optical efficiency & Light Output
32	LED Drive Current	>=700 mA to <=1200 mA. 150-277 Volt AC electronic driver with
33	Driver Specification	150-277 Volt AC electronic driver with Internal surge protection of at least 10kV. Wide range of voltage to withstand the fluctuation.
34	Heat dissipation / heat sink	Heat sink must be of aluminum extrusion with proper Thermal management system.
35	Heat Proof Internal Wiring	Should be able to withstand heat up to 105°C
36	Electrical safety Luminaire Standards / Test Reports	As per IEC safety standards. The luminaire should meet IEC 60598-1, 60598-2-3, EN 55015 EMC radio disturbance, EN 61000-3-2 Harmonics and flickers, EN61547 EMC immunity requirements, EN62471 eyes safety requirements, JESD22 Reliability standard, Environment: ROHS, EN 61000-4-2, EN61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-8 (All test reports and as asked by Employer OR Employer's representative will be submitted before dispatch).
37	Standard Compliance	CE / BIS Conformity.
38	Driver Standards	IEC 61347-2-13, IEC 61000-3-2, CISPR 15, IEC 61547.

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S..No.	Criteria	Specification for Street/ Flood LED Light
39	Mounting	The LED streetlight fittings should be suitable for fixing to conical /octagonal smart street lighting pole. The LED flood light fittings should be suitable for fixing to brackets on High-Masts.
40	Controlling	LED Driver power source should be controlled by Astrological timer/Photocell/ Toggle Switch located in feeder pillar through the Street/Area Lighting Management System. The luminaires will be controlled by means of CCMS panel and Remote Management, Switching, Dimming and Monitoring of Streetlights using group control systems to be supplied with 5 year Software as a Service and Data Hosting Charges considering feeder pillar cabinet for 40 Nos of LED streetlight poles. Feeder pillar should have Multi step dimming option for suitable fixture.
41	Marking	LED street/ flood light fitting should be supplied with company name engraved on the fitting. The product label should mention: Name of Purchaser, Manufacturer, Street light fitting model name, Wattage of fitting and other relevant details.
42	Light distribution requirement	As per Deign.
		As per Deign.

4.12.7. Drawings:

Before final inspection of the roadway lighting system, provide a complete set of reproducible as-built drawings that show the arrangement and locations of all equipment and circuits. Include each duct or conduit pavement crossing with distances to permanent markers, such as structured and curb lines. Keep a daily record of all conduit placed in trenches, showing the distance from the pavement edge, the depth, and the length of runs and indicate there on the as-built drawings.

4.12.8. Testing of Luminaire

The Routine test on each of the offered Luminaries shall be carried out by the contractor before dispatch.

Following tests shall be carried out as Routine tests by the contractor for the offered Luminaries;

- Visual and Dimensional check
- Checking of documents of purchase of LED

Insulation resistance test

- HV test
- Reverse polarity

The Acceptance test shall be carried out by the employer or employer's Representative on a sample of the lot offered for Acceptance. The Lot shall be different from the lot from which the Type test samples have been drawn.

The cost of the testing shall be borne by the CONTRACTOR.

Following tests shall be carried out as Acceptance tests by the CONTRACTOR for the offered Luminaries;

- Visual and Dimensional check
- Checking of documents of purchase of LED
- Insulation resistance test
- HV test
- Over voltage protection
- Surge protection
- Reverse polarity
- Lux measurement
- Test for IP protection

4.13. Poles for Street Lighting & CCTV

4.13.1. General

The scope of work shall cover design, manufacture, supply, installation, testing and commissioning of Circular / Conical Pole structure for Street Light, advertising signage & CCTV.

4.13.2. Design:

Circular / Conical poles shall be designed as per ILE TR7 & BS5649 for structural design & as per IS875 (Part III), 1987 for dynamic loading.

The poles shall be hot dip galvanized high tensile sheet steel of grade E350 (IS 2713 - Pt.-2, 2629 / IS 2633 / IS 4759) as per BS 729 / IS 2629, with PU painted (IS 13213), to suits saline environment of sea and provides corrosion resistance. This shall include Base Plate, 2 Nos 40 mm dia, 1,5 meter length GI Pipe, Junction Boxes inbuilt wiring and earthing etc. in complete as require as per Employer's Requirement and standards.

4.13.3. Pole Shaft

The pole shaft shall be made single piece MS structure continuously tapered having circular cross section and a single longitudinal welding. The welding will be done as per BS 5135 / IS 9595. No circumferential welding shall be allowed in the pole shaft. The MS shall conform to BSEN 100025/100027.
All circular poles shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

Door opening: The Poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be having hinges with good strength and shall be vandal resistance and shall be weatherproof to ensure safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing. The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

Material: The Poles HT Steel Conforming to grade S355JO. Base Plate Fe 410 conforming to IS 226 / IS 2062 Foundation Bolts EN.8 grade

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Welding: The welding shall be carried out confirming to approved procedures duly qualified by third party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

4.13.4. Galvanization:

The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 standards with average coating thickness of 70 micron. The galvanizing shall be done in single dipping. This shall include minimum two coats of PU painting as per IS 13213 (latest revision), to suits saline environment of sea and provides corrosion resistance.

4.13.5. Fixing Type:

The Circular / Conical Poles shall be bolted on a foundation with a set of four foundation bolts for greater rigidity

Pole Testing Facility: The manufacturing unit shall have in-house pole testing facility for validation of structural design data. The pole testing facility shall conform to BS EN 40-3-2-2000 part 3-2.

Manufacturing Unit: The pole / bracket manufacturing & galvanizing unit shall be preferably ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

On completion identification marking for each pole shall be done with PU painting as per the instructions.

4.13.6. Special Fittings & Considerations:

The street Lighting pole shall have the arrangements to install advertising signage & CCTV Cameras.

The street Lighting pole shall have the arrangement to install the Lightning Protection System Components – Vertical Air Termination Rod, on the top of the street lighting pole, as per Lightning Protection System Design.

4.13.7. Galvanized Circular / Conical Poles Dimensions

HEIGHT	TOP DIA (A/F)	BOTTOM DIA (A/F)	SHEET THICKNESS	BASE PLATE DIMENSION (LxBxT)	FOUNDATION BOLT			
					BOLT SIZE (NO. x DIA)	PITCH CIRCLE DIA (PCD)	BOLT LENGTH (MM)	PROJECTED "J" BOLT LENGTH
(mtr)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
9/10 m as per design	90	210	3	300 x 300 x 20	4 x 24 Dia	300	750	125

4.14. Wiring

Where installation more than one circuit within the same conduit, affix permanent circuit identification numbers to the wires/ cables wherever the wiring emerges, including junction boxes, transformer bases, and control cabinets.

4.14.1. Conduit Installation

Provide rigid steel conduit encasement for all conductors except as specified in the plans. The department will allow bonded slip joints for joining rigid conduits to junction boxes. When a standard coupling cannot be used, use an approved threaded union coupling. Ream all conduit ends to remove burrs and sharp edges. Paint damage portion of galvanized surfaces and untreated threads resulting from field cuts with an Engineer approved rust prohibitive paint. Ensure that conduit bends have a radius of not less than 12 times the nominal diameter of the conduit.

Lay conduit not subjected to traffic to a depth of no less than 18 inches. Lay ducted cables to a depth of 2 feet. On transverse crossings under roadway surfaces and shoulders, place the conduit at a depth of no less than 2 feet below grade. Likewise, run ducted cables inside rigid steel conduits, or other Engineer approved methods, when crossing roadways. Make all pavement crossings by placing conduit in the subgrade before paving or by boring and jacking under existing pavements. When it is necessary to bore under roadways and ramps, obtain the Engineer's approval of the boring procedure. Do not cut any pavement without obtaining the Engineers prior approval. Before starting backfilling, all the Engineer to inspect the conduit installation. Place and compact the backfill materials in lifts of 9 inches or less. Restore all disturbed areas as result of the Contractor's operations to the Engineers satisfaction. Bond together conduits, junction boxes, metal poles and control boxes throughout the lighting system to the ground rods by using grounding bushing on the conduit ends. Bond these conduits to the electrical system ground.

Install underground utility warning tape immediately above the circuit cables. Bury the tape at a depth of 6 to 10 inches. Use a durable and colorfast tape confirming with the APWA-ULCC National colour Code with black lettering on Red that continuously reads "CAUTION: ELECTRIC LINE BURRIED BELOW": alternating with a no digging symbol.

4.14.2. Splicing

When the Engineer allows splicing, splice only in junction boxes, in transformer bases, or in pole bases when no transformer bases is provided. Make butt splices, soldered and encased in waterproof resin filled splicing kits. Use copper of the correct wire range, 3M scotch cast splicing kits or approved equal, and Scotchcast#4 resin or approved equal. Encase each conductor, including the ground, in a separate splice kit. Make splices for connecting leads from multiple circuits conductors to ballast terminals with approved filed applied connector Kits.

4.14.3. Painting

Clan un-galvanized or damaged surfaces of exposed junction boxes, pull boxes, control panels, poles and similar equipment, and apply on coat of an inhibiting paint and two coats of P.U. paint, inside and out, after completing installation. For items fabricated from galvanized or nonferrous alloys, which hare inherently rust resistant, paint only on damaged surfaces with an application of inorganic zinc rich primer as applicable.

Lighting Standard Installation: Ensure that concrete bases for lighting standards up to 50 feet high, have minimum depth of 6 ½ feet and a minimum diameter of 2 feet. Construct a level base and the transformer base when the pole is plumbed. The department will allow steel plates or washers between the nuts and the transformer base or pole for stabilization and shims to plumb the pole for gaps up to 1/4 inch. For breakaway supports, conform to section 7 of the standards specifications for structural supports of highway signs, luminaires, and traffic signals. Grade the surrounding surface appropriately to meet the 4-inch breakaway support stub height.

4.14.4. Marker Installation:

When specified in the plans, mark the position of buried circuits with concrete slab markers. Install cable markers immediately above the cable. Place the markers with the top exposed appropriately 2 inches above ground. Mark each cable run at approximately 100-yard increments between junction boxes and/or light poles, with additional markers at each charge of direction. Install concrete slab markers at the end of the conduits crossing a roadway if a junction box is not present.

Impress the world "LIGHTING", appropriate directional arrows, and appropriate circuit identification number on each marking slab. Use letters that are approximately 3 inches high and 2 inches wide. Ensure that the stroke is ½ inch wide and ¼ inch deep.

4.14.5. Testing

After completing the service and equipment installations, conduct and operating test. Demonstrate that the system operates according to the Contract. Ensure that circuits test free of shorts and unauthorized grounds and have an insulating resistance of no less that 10megohms when tested with 500-volt direct current potential in a reasonably dry atmosphere between conductors and ground. The department will also conduct its own tests with its own equipment before final acceptance.

4.15. Ramp Lighting - High Mast Lighting

4.15.1. Scope

The scope of this specification includes design, engineering, manufacture, transport, Supply, commissioning & testing of complete high-mast lighting system, with raising & Lowering mechanism, power tool, Feeder-pillar, Push-button station, luminaries & lamps with all accessories. Civil foundation work, supply of all other accessories required for safe Operation & maintenance of the lighting system, whether explicitly stated or not shall be Within the scope of work. Applicable standards:

The equipment covered by this specification shall unless otherwise stated, be designed, manufactured and tested in accordance with the latest editions of the following Indian, International standards and shall confirm to the regulations of the local authorities.

4.15.2. Structure

The High mast shall be of continuously tapered, polygonal cross section, at least 20 sided, presenting a good and pleasing appearance and shall be based on proven In-Tension design conforming to the standards referred to above, to give an assured performance, and reliable service. The structure shall be suitable for wind loadings as per IS 875 part3 1987.

4.15.3. Construction

The mast shall be manufactured using special steel plates, conforming to BS-EN10-025 and shall be delivered in multiple sections of minimum effective length 10 meters. Thus, a 30 Mtr mast shall be delivered in three sections to site. Each section shall be fabricated out of single plate duly folded and welded. There shall be only one longitudinal seam weld per section. Sections with more than one weld, circumferential or longitudinal, shall not be accepted. At site the sections shall be joined together by slip-stressed-fit method. No site welding or bolted joint shall be done on the mast. The minimum overlap distance shall be 1.5 times the diameter at penetration. The minimum top diameter shall be 150 mm. Bottom diameters and plate thickness shall be as per the structural requirements. Detailed design calculation of the mast shall be submitted for verification. Manufacturer of the mast must have conducted Wind Tunnel testing on their mast sample. Parameters considered for design shall be taken from the Wind Tunnel testing. Wind Tunnel test report shall be submitted along with offer.

The mast shall be provided with fully penetrated flange, which shall be free from any lamination or incursion. The welded connection of the base flange shall be fully developed to the strength of the entire section. The base flange shall be provided with supplementary gussets between the bolt & holes to ensure elimination of helical stress concentration. For the environmental protection of the mast, the entire fabricated mast shall be hot dip galvanized, internally and externally, having a uniform average thickness of 85 microns for plates with more than 5 mm thickness and 70 microns for 5 mm or less. Galvanizing shall be done in single dipping method for better adhesion and life. All the Hardware shall be stainless steel AISI 304 grade.

4.15.4. Door Opening

An adequate door opening shall be provided at the base of the mast and the opening shall be such that it permits clear access to equipment like winches, cables, plug and socket, etc. and facilitate easy removal of the winch. The door opening shall be complete with a close fitting, vandal resistant, weatherproof door, provided with a heavy-duty double internal lock with special paddle key. The door opening shall be carefully designed and reinforced with welded steel section, so that the mast section at the base shall be unaffected and undue buckling of the cut portion is prevented. Size of door opening shall not be more than 1200 x 250 mm to avoid buckling of the mast section under heavy wind conditions.

4.15.5. Dynamic Loading for the Mast

The mast structure shall be suitable to sustain an assumed maximum reaction arising from a wind speed as per IS 875 (three second gust) and shall be measured at a height of 10 metres above ground level. The design life of the mast shall be 25 years

4.15.6. Lantern Carriage

The Lantern Carriage shall be fabricated in two halves and joined by bolted flanges with stainless steel bolts and nylon type stainless steel nuts to enable easy installation or removal from the erected mast. The inner lining of the carriage shall be provided with protective PVC arrangement, so that no damage is caused to the surface of the mast during the raising and lowering operation of the carriage. The entire Lantern Carriage shall be hot dip galvanized after fabrication.

4.15.7. Fabrication

A fabricated Lantern Carriage shall be provided for fixing and holding the flood light fittings and control gear boxes. The Lantern Carriage shall be of special design and shall be of

steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grommets. The Lantern Carriage shall be so designed and fabricated to hold the required number of flood light fittings and the control gear boxes and have a perfect self-balance.

4.15.8. Raising & Lowering Mechanism

For the installation and maintenance of the luminaires and lamps, it will be necessary to lower and raise the Lantern Carriage Assembly. To enable this, a suitable Winch Arrangement shall be provided, with the winch fixed at the base of the mast and the specially designed head frame assembly at the top.

Winch:

The winch shall be double drum & double gear type with a provision to operate individual drum for fine adjustment of the rope. The winch shall be of completely self-sustaining type, without the need for brake shoe, springs or clutches. Each driving spindle of the winch shall be positively locked when not in use, through gravity activated PAWLS. The capacity, operating speed, safe working load, recommended lubrication and serial number of the winch shall be clearly marked on each winch.

The gear ratio of the winch shall be 53: 1. However, the minimum working load shall be not less than 750 kg. The winch shall be self-lubricating type by means of an oil bath and the oil shall be readily available grades of reputed producers.

The winch drums shall be grooved to ensure perfect seat for stable and tidy rope lay, with no chances of rope slippage. The rope termination in the winch shall be such that distortion or twisting is eliminated and at least 5 to 6 turns of rope remains on the drum even when the lantern carriage is fully lowered and rested on the rest pads. It should be possible to operate the winch manually by a suitable handle or by an integral power tool. It shall be possible to remove the double drum after dismantling, through the door opening provided at the base of the mast. A test certificate shall be furnished by the Contractor from the original equipment manufacturer, for each winch in support of the maximum load operated by the winch. The winch shall be type tested in presence of Institutions like IIT and the type test report shall be submitted along with offer.

Head Frame:

The head frame which is to be designed as a capping unit of the mast, shall be of welded steel construction, galvanized both internally and externally after assembly. The top pulley shall be of appropriate diameter, large enough to accommodate the stainless-steel wire ropes and the multi-core electric cable. The pulley block shall be made of non-corrodible material and shall be of die cast Aluminium Alloy (LM-6). Pulley made of synthetic materials such as Plastic or PVC are not acceptable. Self-lubricating bush bearings and stainless-steel shaft shall be provided to facilitate smooth and maintenance free operation for a long period. The pulley assembly shall be fully protected by a canopy galvanized internally and externally.
Close fitting guides and sleeves shall be provided to ensure that the ropes and cables do not dislodge from their respective positions in the grooves. The head frame shall be provided with guides and stops with PVC buffer for docking the lantern carriage.

Stainless Steel Wire Ropes:

The suspension system shall essentially be without any intermediate joint and shall consist of only non-corrodible stainless steel of AISI 316 grade.

The stainless-steel wire ropes shall be of 7/19 construction, the central core being of the same material. The overall diameter of the rope shall not be less than 6 mm. The breaking

load of each rope shall not be less than 2350 kg. giving a factor of safety of over 5 for the system at full load as per the TR-7 referred to in the beginning of this specification. The end construction of ropes to the winch drum shall be fitted with talurit. The thimbles shall be secured on ropes by compression splices. Two continuous lengths of stainless-steel wire ropes shall be used in the system and no intermediate joints are acceptable in view of the required safety. No intermediate joints/terminations, either bolted or else, shall be provided on the wire ropes between winch and lantern carriage.

Electrical System, Cable and Cable Connections:

A suitable terminal box shall be provided as part of the contract at the base compartment of the high mast for terminating the incoming cable. The electrical connections from the bottom to the top shall be made by special trailing cable. The cable shall be EPR insulated, PCP sheathed, and metal braided to get flexibility and endurance. Size of the cable shall be 2.5 sq mm copper conductor. The No of cores to be designed to suit the high mast ON/OFF logic specified in the control panel. Separate cable for essential & non-essential supplies to be provided.

The exposed potion of the cable is to be covered with PVC reinforced metallic conduit. The cable shall be of reputed make. At the top there shall be weatherproof junction box to terminate the trailing cable. Connections from the top junction box to the individual luminaries shall be made by using 3 core 2.5 sq. mm flexible FRLS PVC insulated, PVC sheathed & metal braided cables of reputed make. Also, suitable provision shall be made at the base compartment of the mast to facilitate the operation of internally mounted, electrically operated power tool for raising and lowering of the lantern carriage assembly. The trailing cables of the lantern carriage rings shall be terminated by means of specially designed, metal clad, multi pin plug and socket provided in the base compartment to enable easy disconnection when required. Provision is to be made to test the luminaries in the lowered condition without disturbing the wiring.

4.15.9. Power Tool for the Winch:

A suitable, high-powered, electrically driven, internally mounted power tool with manual override shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The speed of the power tool shall be to suit the system. The power tool shall be single speed, provided with a motor of the required rating. The power tool shall be supplied complete with suitable control. The capacity and speed of the electric motor used in the power tool shall be suitable for the lifting of the design load installed on the lantern carriage.

The power tool mounting shall be so designed that it will be not only self-supporting but also aligns the power tool perfectly with respect to the winch spindle during the operations. Also, a handle for the manual operation of the winches in case of problems with the electrically operated tool, shall be provided and shall incorporate a torque limiting device. The power tool operation shall always be through a separate torque-limiting device to protect the wire ropes from over stretching. It shall be mechanical with suitable load adjusting device. The torque limiter shall trip the load when it exceeds the adjusted limits. There shall be suitable provision for warning the operator once the load is tripped off. The torque limiter is a requirement as per the relevant standards in view of the overall safety of the system. Each mast shall have its own power tool motor.

4.15.10. Lightning Finial:

One number heavy duty hot dip galvanized lighting finial shall be provided for each mast. The lightning finial shall be minimum 1.2 M in length and shall be provided at the centre of the head frame. It shall be bolted solidly to the head frame to get a direct conducting path to the earth through the mast. The lightning finial shall not be provided on the lantern carriage under any circumstances in view of safety of the system.

Aviation Obstruction Lights:

Suitable Aviation Obstruction LED Lights of reliable design and reputed manufacturer shall be provided on top of each mast.

Earthing Terminals:

Suitable earth terminal using 12 mm diameter HDG bolts shall be provided at a convenient location on the base of the Mast, for lightning and electrical earthing of the mast.

High Mast Control Panel

Each mast shall be provided with a High Mast control panel fabricated out of 14 SWG CRCA sheet and finished with two coats of red oxide primer and gravy enamel paint of shade 631 of IS-5. The High Mast Control Panel shall comprise of incoming 40 Amp TPN MCB, suitable TPN contactors for lighting control, Copper wiring, outgoing terminals and contactors for reversing the motor.

There shall be Essential / Non-essential compartment in the High Mast Control Panel. Each High mast control panel shall also be equipped with suitable day light sensor, timer controller and toggle switch (for bypass & testing purposes). These day light sensors and timers shall also have suitable MODBUS output port for monitoring of their conditions and information on BMS system.

High mast control panel should be suitable for mounting of the Emergency Stop Push Button (ESB) of fuel hydrant system in a separate compartment.

High mast control panel shall also have suitable number of potential free interlocks for BMS monitoring and control of high mast lights. The minimum number of potential free contacts required to be provided for control and monitor of high mast lighting are as follows:

High Mast ON/OFF Status control and monitor.

100% lights ON/OFF control and monitor.
50% lights ON/OFF control and monitor.

High mast trip indication for monitoring.

High mast panel on LOCAL or REMOTE mode condition monitoring.

Day Light Sensor and Timer Controller monitoring.

4.15.11. High Mast Foundation

The scope of work under this specification also includes design & construction of the civil foundations for High Mast System & associated High Mast Control Panel.

Design details considering the soil test report for site, along with drawing of foundation is required to be submitted to the Employer.

Design and drawing shall be prepared by the contractor, on standard size sheets and submitted for approval prior to execution of works.

The execution of the high mast system & required foundation works shall be carried out only after the Employer's approvals to the foundation shop drawings & mast system shop drawings.

4.15.12. High Mast System Technical Particulars

Site Conditions & Electrical Supply Particulars	
Ambient Temperature	50°C
Relative Humidity	95%
Altitude	Around 1000 M above MSL.
Design Wind Speed	250 KMPH (To be confirmed at site conditions from Meteorological Data)
System Voltage (Normal)	415V
No. of Phases	3
Frequency	50Hz
Fault level	10 KA at 415V
Neutral Earthing	Solidly earthed
Details of High Mast System	
Height of mast	30 Mtr.
No. of Sections	3
Material construction	S 355 grade as per BS-EN10 025
Cross section of Mast	20-sided polygon.
Base dia. and top diameter (A/F)	Top diameter 150 mm(minimum) & Bottom diameter 630 mm (min)
Plate Thickness	Top: 5 mm, Middle: 6 mm, Bottom: 8 mm.
Type of joints	Stress fit at site
Length of overlap	Min overlap shall be 1.5 times the dia at penetration
Provision for cable termination	MCB Isolator
Diameter of base plate:	840 mm (minimum)
Thickness of base plate:	40 mm (minimum)
Lightning protection finial:	G.I single spike of length 1200 mm
Size of Opening & door at base	1200 X 350 mm (minimum)
Number of foundation bolts:	16 nos or more (per mast) as per design
PCD of foundation bolts:	750 mm (min)
Type / diameter / length of foundation bolts	: TS 600 / 30 mm dia / 850 mm long (min)
Details of Trailing Cable	
Conductor:	Copper 5 core, 6 sq. mm
Insulation:	EPR insulated PCP sheathed
No. of circuits per mast:	One
Details of Winch / Power Tool	
Type / SWL of winch:	Double drum, double gear, SWL 750 Kg
Method of operation:	Motorized
Motor capacity:	2 HP (minimum)
Torque limiter:	With mechanical tripping facility
Details of Stainless-Steel Wire Rope	

Grade / construction:	AISI 316, 7/19 construction
Number of ropes:	Two continuous
Diameter (mm):	6 mm
Braking load capacity:	2350 kg x 2
Details of Luminaires Carriage	
Material of construction:	50 NB ERW Class B - M. S. Pipe
Diameter of carriage ring (mm):	710 mm (ID)
Construction:	12 Arm, Welded, 2 sections
Load carrying capacity:	12 Luminaries (Weight of Luminaries - as per selection of Light Fitting as per lighting design)

4.16. Aesthetic Lighting & Event base Lighting

4.16.1. General

The Contractor shall appoint an experienced and proven Lighting Consultant to prepare, develop design and execute the world class lighting theme across the Bridge to enhance its visibility over and under the Bridge and aesthetic aspect with environmental safety and pollution control.

Aesthetic report generated by the Contractors of Packages 1,2 & 3, is providing the guidelines for the aesthetic lighting aspect. It shall be detail designed with best perception and experience and 3D & Walkthroughs rendering shall be presented to the Employer' for their approval prior to execution.

Aesthetic Lighting Design Requirements for the project shall be presented & submitted for the approval of the Employer or Employer's representative The Contractor shall bear all costs of design, procurement, installation, testing & commissioning cost of all lighting, including cost of energy consumption specified in this Section.

The Contractor shall bear all costs of design, procurement, installation, testing & commissioning cost of all lighting, including the cost of energy consumption up to the date of handing over / completion Certificate as earlier, to be borne by the Contractor.

4.16.2. Objectives

Following are the key objectives, for which the Employer's or Employer's representative's approval shall be taken in context of Aesthetic Lighting Design & Planning before the Execution of Aesthetic Lighting Package.

- The Design shall adhere to AASTHO Guidelines for selection of luminaire and light source Design Basis Report on Aesthetic Lighting,
- Light Fitting Selection along with Technical Datasheets for Aesthetic Lighting,
- Lighting Control System Architecture & Schematic,
- Drawings and Technical Datasheets,
- 3D Renderings & Walkthroughs,
- Good for Construction Drawings,
- Installation Details for Aesthetic Lighting,
- Light pollution Report in compliance to the BNHS directives.

All necessary Lighting & Control System Components to achieve the functionality as per the Design Basis and as per the Employer's Expectations.

The contractor shall make provision in Lighting / Power Feeder Pillars, of the Power Requirements of the Aesthetic Lighting Requirements in coordination with the Aesthetic Lighting Consultant.

4.16.3. Luminaire Specification

Below are the indicative reference of specifications of the different type of façade /Aesthetic lighting and controllers, which needs to be followed during facade design of the bridge.

S.No.	Description (Facade / Astatic Light)
1	Exterior rated 4 feet LED Linear 60W luminaire with beam angles of 10x50 and 50 degrees dedicated optics for architectural lighting including LED Channels of RGB and DMX 512 based controller. Powder coated die cast AL housing and tempered glass lens, IP 66 and IK 06 type, lumen output more than 1900 lm on all colours full light Operating voltage range is 100-277V AC, 50Hz. Luminaire dimension (HxWxL) of 102 x 1210 x 73.3 mm including mounting hinge. Luminaire should be UL/cUL, FCC Class A, CE, CQC, PSE, RCM certified.
2	Exterior rated LED floodlighting luminaire of 72W with dedicated optics for architectural lighting, able to produce light by LED Channels of RGB and DMX 512 based controller. Powder coated die cast AL housing and tempered glass lens, IP 66 and IK 07 type, lumen output more than 2350 lm on all colours full light The operating voltage range is 100-277V AC, 50Hz Luminaire dimension(HxWxL) of 275x353x91mm including mounting hinge. Luminaire should be UL/cUL, FCC Class A, CE, CQC, PSE, RCM certified.
3	White LED strip light IP66- 10m for straight or curved coves and recessed applications with housing of Extruded silicone, 75W with lumen output of not less than 7500, IP66 protection Luminaire has a choice of beam angles of 120° degree. Fixture should run on input voltage of 24VDC and Controlled through DMX/Ethernet protocol. Certification of luminaire UL/cUL, FCC Class A, CE, PSE, C-Tick and must be BIS certified.
4	Exterior rated LED Direct view luminaires with dedicated optics for architectural lighting. Beam angles of (165°-175°) x (110°-120°) .UV Stabilized extruded polycarbonate housing and Translucent cover lens, 14W for 4 ft and 300 lumen with three LED Channel (Red/Green/Blue). IP66 IK09. Option of end to end connection. Luminaire lifetime of more than 60,000 hours @L70 Certifications of UL/cUL, FCC Class A, CE, CQC, RCM are required.

The Lighting luminaires as above, are indicative for a reference and understanding only. The Contractor shall develop design with careful study, based on the site condition and at the feasible location as applicable and acceptable to the Engineer.

4.17. Beacon Lighting System

4.17.1. General

The specifications given below relates to the testing and supplying of beacon lighting System at the strategic place of Bright and Building to enhance architecture.

Codes & Standards: ICAO (Annex 14):Aviation Lighting - Beacon Lighting System

Technical Details:

The Contractor shall Design, Procure, install, Testing & Commissioning the complete Obstruction Beacon Lighting System. Obstruction Beacon Lighting System for the building shall comply with local civil aviation requirements.

The system shall comprise Low and Dual Medium intensity obstacle lights, external photocell, gps unit, wiring system and power supply units serving the obstacle lights. All obstruction lights shall be provided with an interface point to allow a central controller to monitor the status of each light fitting. This shall be provided at a single point on the floor where the lights are located to allow connection into the interface by the contractor.

Fittings to incorporate an intensity step changer including all accessories, lighting to be at 20,000cd during daylight hours automatically step changed down (by the control panel to 2,000cd during dusk till dawn. Fittings to be at levels as per drawings and specification.

Louvers to be provide to all lights to avoid dazzle to aircraft and residents.

Panel to incorporate GPS Synchronization function allowing fitting in site owner to flash in synchronization.

Panel to FAA and FCC tower light monitoring requirements.

Control panel to operate at 240V, 50Hz and include interlocked safety switch. Cable entry shall be through double compression plated brass glands.

The Control panel shall provide for 24h/365d automatic monitoring of all fittings. The system shall be designed to register the malfunction of any light on the tower regardless of its position.
The system should automatically change intensity steps when the northern sky illumination in the Northern Hemisphere on a vertical surface is as follows:

Day-to-Twilight. This should not occur before the illumination drops to 60 foot-candles (645.8 lux) but should occur before it drops below 35 foot-candles (376.7 lux). The luminance-sensing device should, if practical, face the northern sky in the Northern Hemisphere.

Twilight-to-Night. This should not occur before the illumination drops below 5 foot-candles (53.8 lux) but should occur before it drops below 2 foot-candles (21.5lux).
Night-to-Day. The intensity changes listed above should be reversed when changing from the night to day mode.

Fittings to come complete with light, controllers, photocell, mounting brackets and all equipment to provide for a fully functional system.

The supplied shall provide for a MTBF of 100,000h and shall be maintenance-free.

Fittings to be shock and vibration proof

Mechanical parts shall be marine grade aluminum, acid proof steel or glass and suitable for the Mumbai environment

Units to come with built in photocell/flasher @ 25FPM.

Each fitting shall be protected via A Class-I surge arrester.

MMRDA

4.18. Street Lighting Control & Monitoring System

Scope of Works for Smart Street Lighting shall include design, supply, installation, testing at site, commissioning, Operation and maintenance of lighting controls through Centralized Control & Monitoring System – (CCMS) for LED streetlights installed under the scope of this package. Operation and Maintenance of CCMS shall be as per the terms and conditions of the contract & specifications.

The CCMS system shall be provided for the complete installed streetlights that is offered based on the design by the contractor.

4.18.1. System Component

The CCMS System shall consist of the following components;

A. In the Field enclosed within the Feeder Pillar (FP)
- Controller
- Communication Module/ Gateway
- Antenna
- Battery Bank for 12 Hrs. Back up

B. Server for storage of data

preferably dedicated server set-up or cloud-based arrangement to ensure 100% guarantee of the data transmission, and real time data storage and archived data for the contract period.

Web Based Application Software Concept of Smart Street Lighting to be implemented for Street Lighting.

CCMS shall consist of Street Light Controllers and its accessories installed within each Feeder Pillar with a gateway to communicate with Server.

The Maximum quantity of luminaries controlled by each Controller shall be decided by the contractor, however, it shall not be less than 100 light fixtures per Controller.

All the LED Luminaires shall be Remotely/ Automatically/ Manually Switched ON-OFF in GROUP through Web Based Applications based on Sunrise/ sunset timing depending on geographical locations of the Switching Point / Feeder Pillar Based on pre-programmed/ Scheduled timings

All the LED Luminaires which are rated equal to and above 60W shall be Dimmable whereas the rest of the lights shall be non-Dimmable. Moreover, the dimmable Luminaires shall be switched ON and switched Off in steps and in synch with the natural light during Sun rise and Sun Set time.
The setting shall be adjustable / programmable at site as per the Sun rise time & seasons.

C. Feature

The CCMS shall provide the following features;

Offer Web-based solution for Remote management on Real Time basis of the Outdoor Lighting System through wired or wireless GPRS/ 3G/ 4G/ Fibre/ LAN/ WIFI communication networks securely.

Capturing and monitoring the all the data from the Smart Energy meter to check the status of all the electrical parameters available at the FP Monitoring of ON and OFF period; Provide On/Off control based on Sunrise and Sunset timings for burn hour optimization, Energy optimization and simplify maintenance.

MMRDA

Shall facilitate easy and remote configuration/ programming of the system from a web-based interface that can be changed as per requirement.

Shall facilitate Fault Monitoring and Automatic Fault detection; Event Logging and Report generation, Alarm Generation and Alert Notifications through emails & SMSs to desired number of users.

The system shall be modular and easily scalable.

Battery Backup for Minimum 12 Hrs. shall be provided for the controller to store the data in case of power failure

Emergency Override - Locally & Remotely.

Facilitate Asset mapping through GPS coordinates of each Feeder Pillar on existing maps

The controller shall have inbuilt memory storage in each controller to store data in case of Communication network failure and transfer it as soon as the link is resumed

Shall have protection logic to operate the hardware to automatically isolate the system during abnormal conditions and restart the system as soon as the system normalizes

Server uptime should be minimum 99.99% with disaster backup and enough storage capacity and processing power to ensure stable operation of CCMS throughout the contract period Minimum 60 Days data shall be stored in the CLOUD. Data Older than 60 days shall be backed up on Editable tapes/ Discs

Should be easy to integrate with Central Control Room of the MTHL Project.

CCMS shall ensure Data authenticity, Cyber security, safe database management, data retrieval and trouble-free operation of software and allied systems. It shall have a self-diagnostic and self-healing feature to identify fault and resume the system by isolating it within shortest possible time.

4.18.2. Features of Controller

The Controller shall consist of CPU with minimum 32-bit processor, shall have inbuilt three phase power inputs, interface ports – USB, GPRS & Ethernet; internal health monitoring and logging facility; inbuilt flash memory for data storage; and shall support minimum 2 Analogue and 2 Digital inputs.

Controller shall have the provision to store last 30 days data at one-hour interval. All these data are accessible for reading, recording by downloading through HHT (Handheld Unit) through optical port or USB/Bluetooth given on controller front. For HHT, a smart phone-based solution for collecting /accessing data is also acceptable.

The controller shall have a built-in calendar and a local Real Time Clock (RTC) having an accuracy of +/- 1 minute per year or better, synchronized with remote time server, to enable functionality even in case of communication network failure. A separate internal Lithium battery back-up shall be provided for continuous operation of controller RTC for at least two years under controller un-powered conditions.

Controller shall be able to carry out switching operations based on Astronomical calendar of the location.

Controller shall facilitate local operation in case of emergency or during maintenance with proper security verification.

Controller shall be able to detect switch weld condition and generate alarm.

Controller shall be able to log minimum last scheduled and unscheduled events including scheduled switching events, faults, abnormal power conditions and maintenance.

Controller shall additionally be able to log minimum last the power availability events.

The controller shall have protection logic to monitor the abnormal conditions like overload & over voltage conditions, against the benchmark/ threshold limits configured in it and carry out auto switching to disconnect the system if the abnormal condition prevails over predefined period. The controller shall reconnect after the normal system conditions are resumed. All such unscheduled switching activities shall be logged in the system.

Controller shall be provided with a 6-digit LCD to display the controller parameters/ data. Proper universal interface port (USB, Optical etc.) or device shall be provided to access all the stored data within the controller as well as to configure the controller locally either by a Handheld Unit or by connecting to a laptop in a secured manner. Configuration allows user to set operating modes, ON/OFF timings, RTC configuration, Updating GPS locations, Astronomical Clock etc.

The CPU of the controller shall be well protected against overvoltage and surges up to 10 kV as per EN 61000-4-5; Burst pulses up to 4 kV as per EN 61000-4-4.

All the controllers shall be traceable when mapped through GPS coordinate.

The controller shall support digital and analogue measurements.

Controller shall have following constructional specifications

Controller case and terminal blocks shall be made of fire-resistant material

Sealing arrangement - As per IS 13779 and CEA Metering regulations 2006

Insulation shall withstand an insulation test of 4 KV and impulse test at 6 KV
Latching Relay/Bi-Stable Switch/Isolation device should conform to IEC - 61036/ 61037 9.6
Communication Module of the Controller in the FP

The module shall operate on 240 V AC single phase power supply

Ability to communicate with remote central server/ CLOUD securely via cellular networks (GSM / GPRS) and/ or RF networks. All data shall be secured by encrypting them by 128-bit encryption.

Communication network between CCMS unit and central server should be GSM/GPRS: Quad band 850/900/1800/1900 MHz4G, and communication method shall be TCP – IP via GPRS / 3G and/ or RF SMS (iv) The module shall be a Two-way communicator

The Module shall be able to send data regarding energy usage, ON/OFF status etc. from controller as well as give commands from a central server/ CLOUD for switching ON/OFF scheduling etc.

Ability to remotely upgrade the CCMS device firmware from central server

Battery Module

The Controller (CPU), Communication module etc. shall be provided with battery backup for 12 Hrs. to function during failure of grid power.

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The battery shall help CPU to store all the data and send a main power failure alarm to the remote server/ Cloud before it shuts down safely.

4.18.3. Software Application Features

The web application shall be offered through the web or as per the Employer's Requirements at the time of execution.

The application shall enable receipt & storage of all the field data with a time stamp in Cloud or in-house local server.

The application shall facilitate to communicate, control and configure the each Switching point FP controllers remotely. The application shall be suitable to manage the data traffic from the field to the Cloud or Server.

Operation Time - It should be able to record LED luminaires glowing and non-glowing hours of a particular FP (Group).

The System should be suitable for third party integration if required.

Report Generation – shall enable Users to generate various reports related to the system performance parameters such as energy consumed report, lamp and system failure report, actual hours of operation, uptime (%), etc. as well as based on historical data on daily, monthly, quarterly or annually basis as the case may be from the data/readings received from the units. The reports shall be generated in Xcel as well as Graphical format.

The application should facilitate Roles and Permissions requirements at different level of user hierarchy. It should manage system access for different levels with multiple privileges for different purpose, including Administrator access to configure, workflow access for operations, and public access for viewing and uploading status.

Web application shall ensure system security and safety for users at different levels with security password for various users.

It should be possible to configure Switching point remotely through web application. Remote configuration includes setting new ON/OFF timings, setting RTC time, viewing the Real time data of each switching point, Energy meter parameters, Resetting of the any unit, time synchronization of controller with that of Server and GPS clock etc.

The minimum interval for the update of data should be 15 minutes but programmable up to 1 minute. Asset Management

Application shall provide a map application that gives an overview of all Feeder Pillars on a street map or GIS map or a satellite image.

Web application software shall offer asset management feature and allow user to locate SPC through GPS coordinates. It also enables user to identify each SPC with unique/Asset ID with additional information like Wattage, Make, Installation date, replacement date, Replacement defect tracking. It is also possible to link details of every streetlight with reference to switching point.

Dashboard – Web application shall provide a comprehensive dashboard with real time status of switching point, real time faults of various switching points, system uptime %, power consumption, power consumption, graphical representation of cumulative data etc.

The application software should be flexible to cater to customized requirement which are not foreseen at this point of time but are deemed necessary during the execution and O&M. Separate tabs shall lead to details regarding monitoring & control parameters like Alerts,

Maps, Configuration, Reports, uptime, fault penalty, history, energy savings, power failure, operational hour, lamp failure etc.

Each Switching Point FP shall be represented by a separate Tab on the dashboard to show the switch point summary indicating the FP details, rating, location, meter parameters, history of alerts, active alerts, link to the map page, etc.

The application shall generate alarm and alerts through SMSs for any type of abnormal system conditions and faults as listed below to designated users which should not be less than six in numbers.

It should describe the abnormality or fault in short as well as highlight the same with different colours to indicate the status with respect to time – within 12 hrs., in next 12 hrs., beyond a day etc. It shall provide monthly reports on the faults through email. Penalty as indicated in the Service Benchmark for the contractor shall be calculated based on these reports.

Application should be able to track the failure of lamps in a switching point by triggering alarm due to significant drop in power consumption. The application should display the no. of faulty lights for each phase separately instead of giving a total figure of faulty lights for all the 3 phases together.

Application shall protect and report Jamming/ hacking attempts and maintain status-quo in cases of such attempts i.e. if lights are ON, they should remain ON till the default OFF time recorded in the system. In case lights are OFF at the time of Jamming / hacking attempt, lights should remain OFF till default ON time recorded in the system

Software to have complaint handling system for light failures, with citizen interface and means of communicating repair update to complaining citizen through SMS.

Ability to remotely upgrade the CCMS device firmware from central server.

The system shall display the following minimum faults in alarms

- Phase-wise currents on crossing threshold values
- Phase-wise voltages on crossing threshold values - Under/over voltage detection
- Main breaker error
- Contactor fault
- Circuit breaker off
- Circuit phase errors (fuse, breaker, etc.)
- Main power failure
- Leakage to ground
- Manual switch activated
- Control cabinet door open
- Low Power Factor
- Communication failure with server
- Theft Alert
- Group failure of Lights

The software shall enable to divide the city lights in certain zones as per the Employer's requirement and assign access to the concern authorities for control and monitoring from their mobile or laptop.

All alarms shall be notified in near real-time via SMS and email to responsible maintenance team.

The system shall support auto switching of streetlight according to light sensor input

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The system shall support auto switching of streetlight according to input. Graphical view of the electrical consumption readings shall be available online for monitoring of the hourly, daily and monthly electricity consumption.

All Software's License shall be in the name of the Employer. All costs shall be perpetual cost or onetime cost. CONTRACTOR shall provide all the upgrades to the system software and system security during the contract period without any additional cost.

The Software Application shall be supported by the CONTRACTOR even after the contract period.

In case of CLOUD server, the CLOUD registration shall be done in the name of Employer. Only Administrative rights shall be provided to the contractor during the contract period. The CLOUD services shall be intact upon renewal every year after the contract period. The CLOUD shall not be OEM specific and shall be independent of OEM so that after the completion of contract period there should be no dependence on OEM for cloud services.

4.19. Earthing System

All the non-current carrying metal parts of the electrical installation and mechanical equipment's shall be earthed properly. The cables armour and sheath, electric panel boards, lighting fixtures, ceiling and exhaust fan and all other parts made of metal shall be bonded together and connected by means of specified earthing system. An earth continuity conductor shall be installed with all the feeders and circuits and shall be connected from the earth bar of the panel boards to the conduit system, earth stud of the switch box, lighting fixture, earth pin of the socket outlets and to any metallic wall plates used. All the enclosures of motors shall be also connected to the earthing system.

4.19.1. Sizing of earth conductor

Sizing of earth conductor for receiving station, HV equipment and main LV panels etc. shall be based on actual fault current calculated.

Earthing grid near substation station & earthing grids for other building shall be connected at ground floor for equipotential bonding & to minimize overall resistance of earthing path.

Earthing grids of electronic \ IT equipment shall be separate & shall not be connected to general earthing grids with prior consent from user. Electronic \ IT equipment earthing grids for various buildings can be interconnected for equipotential bonding & to minimize overall resistance of earthing path

For lighting & power circuits cross sectional area of earthing conductor shall not be smaller than half of the largest current carrying conductor subject to an upper limit of 80 Sq.mm. If the area of the largest current carrying conductor or bus bar exceeds 160 sq.mm then two or more earthing conductors shall be used in parallel, to provide at least half the cross-sectional area of the current carrying conductor or bus bars. All fixtures, outlet boxes, junction boxes and power circuits up to 15 amps shall be earthed with PVC insulated copper wire

4.19.2. Prohibited Connections

Neutral conductor, sprinkler pipes, or pipes conveying gas, water or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lightning protection system conductors shall not be used as a means of earthing an installation or even as a link in an earthing system. The electrical resistance measured between earth connection at the main L T panel and any other point on the completed installation shall be low enough to permit the passage of current necessary to operate or circuit breakers and shall not exceed 1

ohm. All switches carrying medium voltage shall relate to earth by two separate and distinct connections. The earthing conductors inside the building wherever exposed shall be properly protected from mechanical injury by running the same in G I pipe of adequate size. The overlapping in strips at joints where required, shall be minimum 75 mm. The joints shall be riveted and brazed in case of copper and by welding / bolting in case of GI in an approved manner. Sweated lugs of adequate capacity and size shall be used for termination of all conductor wires above 6 sq.mm size. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and other oily substances and properly tinned. Equi-potential bonding of all metallic structures shall be done.

4.19.3. GI Plate Electrode Earth Pit- Conventional Earth

Earth Pit:

The earth station shall be as shown on the drawing and shall be used for equipment earthing.

Earthing electrode shall be 600 x 600 x 6.3 mm thick GI plate electrode, with CPC cable or GI strips from earth plate electrode to inspection chamber, 50 mm dia medium class GI pipe, CI funnel with 20 gauge GI wire mesh, masonry chamber 1000 X 500 mm with concrete base as per IS3043 with CI manhole cover with frame painted with bitumastic paint and packing with mixture of charcoal and common salt around plate electrode including digging of pit up to permanent moisture level but not less than 3 meters and back filling as required

The earth resistance shall be maintained with a suitable soil treatment as shown on the drawing.

The resistance of each earth station shall not exceed 1 ohm.

The earth lead shall be fixed to the pipe with a nut and safety set screws. The clamp shall be permanently accessible.

The earthing grid and the earthing conductor shall be hot dip Galvanized iron strips of the size as shown in the drawing.

Copper bond rod with funnel of approved quality shall be used for watering the earth electrode \ station.

The block masonry chamber with chequered plate shall be provided for housing the above referred funnel and the rod.

The hardware and other consumables for earthing installation shall be hot dip Galvanized iron material as shown on the drawing.

4.19.4. Bonding System:

Earth lead shall be Galvanized steel as specified with sizes shown on drawings. Galvanized steel buried in the ground shall be protected with bitumen and hessian wrap or polythene faced hessian and bitumen coating. At road crossing necessary hume pipes shall be laid. Earth lead run on surface of wall or ceiling shall be fixed on saddles so that strip is at least 8 mm away from the wall surface.

The complete earthing system shall be mechanically and electrically bonded to provide an independent return path to the earth source.

Wherever crossing is required, earthing jumper shall be of insulated wires.

Equipotential bars within substation area where the neutral earthing shall be connected to equipment from earth pit.

4.19.5. Maintenance free Earthing Electrode System/ Chemical Earthing

In maintenance free earthing copper bonded earthing rod electrode shall be of 14.35 mm in diameter and 3-meter length. The rod shall be placed in a 150 mm dia an augured hole in the ground and then surrounded by ground enhancement material in either a dry form or premixed in slurry. Once set, ground enhancement material becomes hard and as such holds positively to the rod as well as surrounding ground.

Earth rod offered shall have passed the test required of BS7430/ ANSI/ UL467 and confirm to the adhesion of the copper coating to the steel core (Design feature that prevents the ingress of moister and subsequently the integrity of the rod.

Minimum 0.25 mm thickness of copper shall be deposited over the steel core as per BS 7430/ UL 467. Average life of the ground rod shall be 30 years in most soil.

Ground enhancement material shall be as per IEEE-80 clause 14.5d with a resistivity of less than 0.12 ohm-meter. The ground enhancement material shall be permanent and not leach any chemicals into the ground. The pH value of the ground enhancement material shall be 6.9 to 7.2 of 100 gm/ lit @ 20 deg.C.

Minimum 30 Kg of ground enhancement material shall provide for each earth electrode. Inspection chamber shall be of 400 x 500 mm with concrete base CI manhole cover with frame painted with bitumastic paint. 2 Nos. of 50 x 6 mm cross section & 300 mm long copper strip to be clamped with copper cladded rod electrode have sufficient no's (But not less than 4 Nos.) of 10 mm GI nuts & bolts for connection to the equipment / interconnection to the other pits to form equi-potential bonding.

4.19.6. Structural Earth Pile Electrode - Rebar Connected:

General:

For earthing of the electrical system, earth piles will be used with incorporating rebar encased in super low impedance aggregate shall be used.

The demarcation of earthing system for the tower is as follows:

Civil contractor is responsible for earth piling & providing test links as per contract documents from level B4 to Podium 0 Level.

Electrical contractor to take hand over from civil contractor & shall be responsible for further installation, testing, commissioning & certification of the system.

The resistance between earthing system and the general mass of earth shall not be greater than 5 ohm.

The resistance to earth shall be measured at the following: -

At each electrical system ground or system neutral ground.

At one point each grounding system used to ground electrical equipment enclosures.

At one point each grounding system used to ground wiring system enclosures such as metal conduits and cable sheaths or armored.

All earthing conductors shall be of high conductivity G.I as specified in contract documents and able to protect against mechanical damage. The cross-sectional area of earth conductor shall be selected as per short circuit study and relevant calculation. However, the contractor shall use the sizes specified in the bill of quantities of the Tender. The earth mats shall comprise the complete earth electrodes, earth strips/grids, earth inspection chambers, earth leads, main earth terminals, earth test link boxes at ground level, etc. Each individual earthing system shall have earth leads connecting its main earth terminal directly to an earth electrode underground as specified.

All earthing products/accessories shall be in accordance to IS 3043.

The mating surface of all tapes at joints etc. shall be cleaned before clamping and riveted with proper connector or exothermic welded. All connections to electrical apparatus shall be made by bolted connection in a visible and accessible position.

4.18.6.1 Earth Pile Electrode:

Earth pile electrode connections shall be checked & confirmed before accepting from the civil contractor. Handing over documentation shall be done and kept for record.

Connections shall be capable of providing high pressure contact between the earth electrodes and the earth leads to achieve low contact resistance.

At each inspection enclosure a separate earth electrode shall be provide and installed to provide for continuity of earthing connection during testing.

4.18.6.2 Earth Strip:

Earth strips/grids shall be of bare GI strips as specified or as per design.

Earth strips shall be riveted or jointed with proper connection to the earth electrodes.

In order to minimize the mutual inductance between strips, earth strips shall be positioned at a distance not less than 3m apart unless otherwise specified.

4.18.6.3 Rebars:

Structural Rebars are used for earth conductivity. The electrical contractor after Podium 0 level is responsible for overall system installation & certification.

The test links, clamps, bolts, connection to be carried out by the electrical contractor as specified in the contract documents

4.18.6.4 Circuit Protective Conductor:

Circuit protective conductor (CPC) is a system of conductors joining together all exposed conductive parts and connecting them to the main earth terminal.

The purpose of circuit protective conductor is to provide a path for earth fault circuit so that the protective device will operate to remove dangerous potential differences during a fault condition.

The circuit protective conductors shall take the form of separate cable with a sheath in green/yellow colour or G.I tape with sleeves as specified in the drawing. For all cables the CPC shall be FR insulated.

All exposed non-current carrying metal parts of light fittings, switchgears, motors, enclosures, etc. shall be effectively earthed by circuit protective conductors for earth continuity protection.
For equipment where an earth terminal is provided, the earth continuity wire shall be firmly clamped. Where no earth terminal is provided, the exposed metal part shall be cleaned of paint and surface rust before welding the earth continuity lead.

The minimum size of the principal protective conductors shall be in accordance with to the current edition of IS: 3043.

The external earth terminal on the outside of the end panel of any switchboard shall be connected to the main earth bar provided in two independent points.

Circuit protective conductors shall be provided in electrical and mechanical rooms and along the routes for the bonding of all exposed conductive parts and extraneous conductive parts. A suitably sized earth terminal shall be provided at each zone of the building for this purpose.

All exposed conductive parts shall be effectively connected in an approved manner to the principal protective conductors. The circuit protective conductors shall be single core /AL cables or high conductivity Hot dipped GI tapes specified.

Metallic conduit shall not be accepted as an earth continuity conductor. A separate insulated continuity conductor of size 100% of the phase conductor subject to the minimum shall be provided.

The earth continuity conductor be drawn inside the conduit shall be insulated.

Non-metallic conduit shall have an insulated earth continuity conductor of the same size for metallic conduit. All metal junction and switch boxes shall have an inside earth stud to which the earth conductor shall be connected. The earth conductor shall be distinctly coloured (Green or Green / Yellow) for easy identification.

Armoured cable shall be earthed by two distinct earth connections to the armouring at both the ends and the size of connection being as for the metallic conduit.

In the case of unarmoured cable, an earth continuity conductor shall either be run outside along with the cable or shall form a separate insulated core of the cable.

Three phase power panel and distribution boards shall have two distinct earth connections of the size correlated to the incoming cable size.

4.20. Lightning Protection System

The specifications given below relates to the testing and supplying of connectivity with rebar & Facade for bonding, lighting surge protective devices of Lighting Protection system in schedule of quantities at Site:

4.20.1. General:

The lightning protection system designed shall comprise of connectivity & continuity of Earth through Structural Earth Piles, Structural Column rebars, Façade metal members through Stainless steel lugs, BMU unit & GI mesh on Roof level, Lightning surge protection for power lines/ELV lines etc. as shown in standards details & layouts.

The system shall comprise of following elements:

- Air Termination network

- Structural columns
- Structural slabs
- Façade
- Roof steelwork and other equipment.
- Down conductors
- Pile Caps
- Earth Pits
- Bi metallic test clamps
- Electronic Surge Suppression Devices.
- External Metal structure
- All architectural metallic extensions from building façade

4.20.2. Air Terminations:

Air terminations shall consist of horizontal conductors in the form of networks as per respective codes as specified above.

4.20.3. Down Conductors:

The respective codes cover the use of down conductors of various types including the use of strips, rod, reinforcing bars and structural steel stanchions. Any good conductor which may from part of the building structure can be included, appropriately joined to the air and earth terminations and in general the higher the number of down conductors used, the lower the risk of side-flashing and other undesirable phenomena.

Likewise, large conductors reduce the risk of side-flashing especially if insulated.

The down conductor system should, where practicable, be directly routed from the air termination to the earth termination network and be symmetrically placed around the outside walls of the structure starting from the corners.

Pattern and number of down conductors, joints, bonds and test joints shall be as per the recommendations of made in respective code as mentioned in section 1.4.& as per contract document.

The façade to structural rebar connection is through using plates, bi-metallic clamps, stainless steel as shown in the contract documents.

4.20.4. Earth Termination Network:

Nominated earth pits identified on the Contract documents shall be used as earth electrodes and shall be connected to the relevant down conductor, these generally comprise reinforcing in the building structure.

The whole of the earth termination network should have a combined resistance to earth not exceeding 10 (ten) ohms without taking account of any bonding to other services. Reference shall be made to respective codes as mentioned in section 1.4 for further details. Earthing lugs to be checked for stainless steel availability.

Connectors/Fittings/Fasteners and Hardware:

Provide all connectors, fittings, fasteners, hardware, clamps, guards, lugs, etc., as required to connect, interconnect and install all parts of the system (maximum cable fasteners spacing - 1 meter).

Fabricated from copper/GI/AL metal and approved for use intended.

Provide connections rated and approved for application between dissimilar metals required for Façade connectivity as per standard Detail & bill of quantities.

The demarcation of earthing system for the tower is as follows:

Civil contractor is responsible for earth piling & providing test links as per contract documents from level B4 to Podium 0 Level.
Electrical contractor to take hand over from civil contractor & shall be responsible for further installation, testing, commissioning & certification of the system.

4.20.5. Specific Requirement:

Carry out the risk assessment system and guarantee that the system shall be capable of protecting the building against a lightning strike.

Conductors of the lightning protection system shall not relate to the conductors of the safety earthing system above ground level.

All metallic structures within a vicinity of 2000 mm in air shall be bonded to the conductors of lightning protection system.

All exterior metallic conductor shall be connected to the lightning protection system.

4.20.6. Lightning Surge Protective Devices:

- **Transient-Voltage Surge Suppression:**

  The Main LT Supply panel shall be equipped with TVSS as defined in the IEEE standard 1100(1999). The response time of TVSS shall be ≤ 0.5 nanoseconds. and shall be listed with UL-1449-2. The TVSS shall provide up to 40dB for RFI & EMI noise attenuation.

  The occurrences of damages in the hardware as well as software are increasing due to over voltage surges passed on to the equipment through electrical or data lines. Normally surge works like slow poison by internally weakening the IC or transistors, eventually resulting in breakdown of the instrument. Large surges of the magnitude to 100KA or above can destroy the equipment completely.

  Surges pass through any and all copper lines within the premises including power lines, data lines or any other communication lines. They are produced both externally and internally.

  External surges are produced by natural lighting or erratic power supply.

  Internally surges are generated by motors, drives, Generator, AC, copiers or any other heavy-duty Office equipment.

- **Surge Arrestors:**

  Comply with UL 1449.

  Modular design (with field-replaceable modules).

  Fabrication using bolted compression lugs for internal wiring.

  Integral disconnect switch.

Arrangement with wire connections to phase buses, neutral bus, and ground bus.

LED indicator lights for power and protection status.

Audible alarm, with silencing switch, to indicate when protection has failed.

Four-digit transient-event counter set to totalize transient surges.

Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2.

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CHAPTER – 5

5. OUTLINE ELECTRICAL SPECIFICATIONS-BUILDINGS

5.1. L.V. Panels, Enclosed Switchgear

The scope of work shall cover design, manufacture, supply, installation, testing and commissioning of all LT Distribution Panels, Switchboards, and Distribution Boards suitable for 415 volts, 3-phase, 50 Hz, 4-wire system, comprising of circuit breakers, bus bars, wires interconnections, metering, protection, earthing and SCADA / BMS Compatibility etc., meeting the requirements shown in schematic diagrams, and as specified in this specification.

The Contractor shall undertake and to provide discrimination study for the complete LT distribution system from the source to downstream to the final circuit for application of protective device. The study shall be provided in paper and electronic format for approval by the Engineer in Charge.

The Distribution Panels and Switchboards shall be design and procured for 415 volts, 3-phase, 50 Hz, 4-wire power distribution for Building illumination (internal / external), Ventilation,& HVAC, lifesaving services, small power, control and monitoring equipment including emergency power for essential services.

Main switch board and Panel (inclining MLP and Emergency Panels) shall confirm to Form 4B and rest of Panel of Form 3b Type 2 to be used as per IEC.

The details of Distribution Panels and Switchboards etc. has been described under previous chapter - 4, the same is equally appreciable.

5.2. LED Light Fixtures for Interior Illumination

5.2.1. Scope

This specification covers the design, material specification, manufacture, testing at works, inspection and delivery at site of light fittings and their associated accessories.

5.2.2. Standards

The light fittings and their associated accessories such as LED/lamps / tubes, reflector, housings, ballasts/Drivers etc. shall comply with the latest applicable standards. All luminaries, lamps and accessories shall be of same make.

5.2.3. Earthing

Each light fitting shall be provided with an earthing terminal suitable for connection to the earthing conductor. All metal or metal enclosed parts of the housing shall be bonded to the earthing terminal to ensure satisfactory earth continuity throughout the fixture.

5.2.4. Painting / Finish

All surfaces of the fittings shall be thoroughly cleaned and degreased. The fittings shall be free from scale, rust, sharp edges and burrs. The housing shall be stove-enameled / epoxy stove-enameled / vitreous enameled or anodized as indicated under various types of fitting.

The finish of the fitting shall be such that no bright spots are produced either by direct light source or by reflection.

LED Fitting

Pressure die –cast aluminium housing /CRCA sheet steel housin, aesthetically designed with corrosion resistant powder coated body for heat dissipation. Injection molded PC diffuser for better light transmission and to avoid the POT hole effect. It has got lumen maintenance of L70@ 50,000 burning hours. Universal voltage driver from 100v to 270v/60HZ with mis-wiring protection. Nominal power factor of >0.92, driver efficiency greater than 85% and THD- <15%. Low depth dimension to support the lesser mounting height of ceiling with AC ducts.

Conformance Standards for LED lamps:

LM80 compliance certificate to be provided by the LED manufacturer. LED data sheet should comprise of lumen output, junction temperature, pad temperature, thermal resistance, and LED driver current.

The luminaire shall conform to IEC 60598 or equivalent standard and the driver should comply with IEC 61347-2-13, IEC 61547, CISPR-15, IEC 62124 and IEC 62384.

Luminaire should be tested as per BIS 10322 standards and following Test Reports should be submitted: Heat Resistance Test, Thermal Test, Ingress Protection Test, Drop Test, Vibration Test, Electrical / Insulation Resistance Test, Endurance Test, Humidity Test, Photometry Test (LM 79 Report), Electronics Test.

LED Fitting:

For LED light fittings, the complete luminaire should have a warranty for 5 years which includes the housing + LED + Driver, During the procurement of LED lighting, the following specification should be followed: -

Technical Requirements for LED

LED efficacy shall be greater than 100 Lumens/Watt (for luminaire system wattage up to 45W) & 120 Lumens/Watt (for luminaire system wattage above 45W) @ 350mA drive current.

In respect of LEDs of higher power ratings, drive current greater than 350mA can be accepted if the LED's LM 80 / IS: 16105 test reports support the same.

LED used should be of SMD or COB type.

LM – 80 / IS: 16105 Test Reports of specific LED at the soldering point temperature of 85degC for the driving current at which the LEDs shall be driven, shall be obtained during procurement.
Reported life Span of LEDs used in the Luminaire shall be greater than 50,000 Hrs. at the soldering point temperature of 850C and at the luminaire driving current.

The LEDs shall comply to Photo biological Safety norms as per IEC 62471 / EN 64271 / IS:16108.

Colour temperature of the proposed – 4000K to 5700K, as per ANSI standard C78.377A).

Colour point should fall within the 7Step McAdam as per ANSi standard C78.377A

Colour Rendering Index (CRI); Greater than or equal to 80.

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The make and model of the fitting shall be approved by the Employer before the purchase.

Technical requirements for LED driver

Min. efficiency of driver:
85% (for driver power output rating ≤ 100W);
90% (for driver power output rating > 100W).

Power factor of complete fitting: Greater than 0.90

Input Operating Voltage: 140 V to 277V AC.

In – build high and low voltage cut – offs: 140V (Low) and 277V (High)

Short circuit protection / Open load protection

Driver Surge Protection standard: Min 3kV. If a site / location is prone to lightning and surges, 10 k V surge protection (external to the driver circuit) to be provided with the luminaire. The Surge Protection Device (SPD) should fail safe (i.e. without leading to fire hazard) and its failed status should be clearly visible through a flag/indication.

Total Harmonic Distortion (THD): Less than 20% at full load

Tc (Maximum Driver case temperature) must be declared for the luminaire.
Isolated driver should be used.

Potting of LED Driver: For driver power output rating ≤ 50W, potted driver shall be preferable (but not mandatory). But for driver power output rating > 50W, potted driver shall be a mandatory requirement.

The power supply shall be connected to be LED PCBs through proper connectors.

CMI/EMC compliance: Compliance to the following EMI/EMC standards:

- CISPR 15/IS:6573
- IEC: 61547 (reference standards are listed as follows)
- IEC 61000 – 4 – 2 / IS:14700 P art 3: Sec 2
- IEC 61000 – 4 – 3
- IEC 61000 – 4 – 4 / IS: 14700 Part 3L Sec 4
- IEC 61000 – 4 – 6
- IEC 61000 – 4 – 11 / IS: 14700 Part 3: Sec 11
- IEC: 61000 – 3 – 2 (Class C) / IS:1534 Part 1 (d) IEC: 61 000 – 3 – 3 / IS 14700: part 3: Sec2
- Driver shall comply with the safety requirements laid down in IEC: 61347 – 2 – 13 / EN:61347 – 2 – 13 / IS: 15885 – 2 – 13.

Driver shall also comply with the performance requirements as per IEC: 62384 / IS: 16104.
Technical requirements of electronic components used:

The circuit boards and electronic components to be used in the luminaire should be of rating / type to provide reliable functioning. Following shall be the requirements during procurement;

Junction temperature rating of I.C. shall be obtained for the luminaire.

Capacitor type and temperature rating shall be obtained for the luminaire.

Material of resister shall be furnished Junction / channel temperature rating of switching device s like MOSFET and transistor shall be obtained.

MCPCB is to be used for mounting of LEDs

FR4 grade PCBs of min. thickness of 1.6 mm shall be used in driver circuits

Technical requirements of luminaire

The luminaire shall have LM – 78 / IS: 16106 test report from a NABL accredited laboratory.

The min. system lumen efficacy of the luminaire shall be as follows:
80 lm / W (luminaire system wattage ≤ 45)
90 lm / W (luminaire system wattage ≥ 45)

The luminaire must have secondary lens/optics. Though the secondary lens/optics does result in minor loss of lumens, it is nevertheless a must to distribute the light output of the LED s so as to achieve the desired polar curve characteristics for the luminaire – no exemption shall be permitted on this account. The material of lens should preferably be PMMA.

Color temperature: 5700K (5665±355K, as per ANSI standard C78.377A)

CRI: Greater than or equal to 80

Housing of luminaire: Pressure die – cast LM6/ADC12/LM24 housing

Cover type: Toughened glass or UV stabilized polycarbonate cover

Housing protection:

For indoor applications IP – 42 or better.

For outdoor applications IP – 65 or better.

(If the LEDs and LED Driver are in different compartments, then the two compartments must be individually IP – 65.

Impact Resistance: IK – 05 (Indoor)

Impact Resistance: IK – 08 (Outdoor)

Temperature rise test: When the luminaire has stabilized thermally, soldering point temperature of the LEDs must be equal to or less than 85 deg C. Temperature rise (above ambient) of heart sink should generally remain within 20deg C – relaxation on this account can be granted as long as the soldering point temperature limit of 85 deg C is not violated and there is no unacceptable outcome.

During procurement, the photometric data report in respect of the luminaire offered (through DIALux, AGi32) should be obtained.

IES Photometric File is also to be supplied and firms to be warned of serious consequences against submission of a tempered/doctored report.

Conformance Standards for LED lamps:

LM80 compliance certificate to be adhered by the LED manufacturer. LED data sheet should comprise of lumen output, junction temperature, pad temperature, thermal resistance, and LED drive current.

STRABAG AG IV

MMRDA

The luminaire shall conform to IEC 60598 or equivalent standard and the driver should comply with IEC 61347-2-13, IEC 61547, CISPR-15, IEC 62124 and IEC 62384.

Luminaire should be tested as per BIS 10322 standards and following Test Reports should be submitted: Heat Resistance Test, Thermal Test, Ingress Protection Test, Drop Test, Vibration Test, Electrical / Insulation Resistance Test, Endurance Test, Humidity Test,

5.3. Internal Wiring

5.3.1. General

The internal wiring shall be provided for following applications in Box girder internal service spaces, Toll Plazas & Associated Buildings on the bridge.

- General Power – Single Phase Modular Power Sockets with Switch – 6/16A, 16A
- UPS Power - Single Phase Modular Power Sockets with Switch – 6/16A, 16A in groups for Workstations in Toll booths, ITS Power Requirements on Bridge.
- HVAC – Single Phase Modular Power Sockets with Switch – 6/16A per VRF IDU,
- HVAC – Single Phase Metal Clad Industrial Weatherproof Sockets with ELMCB (30mA Sensitivity) – 20A, 25A, 32A as per DX-Split AC Unit as per the kW Rating
- Lighting – As per lighting circuit design for Normal & Emergency Lighting

Below table spells out minimum power points requirements to be fulfilled by the Contractor.

Application/ Service	UPS Power			Raw Power		
	UPS Power Modular Socket & Switch Outlet	Single Phase Industrial Socket with ELMCB	Power Distribution Unit	Raw Power Modular Socket & Switch Outlet	Single Phase Industrial Socket with ELMCB	Three Phase Industrial Socket with ELMCB
Workstations in - Offices/ Staff Areas/ Manager Cabins/ Reception/ Ticketing Cabins/ Control Rooms - (ITS, CCTV, HTMS, ATCC etc.) / Toll Booth	2No, s of 6/16A (in group) per W/S			1No, s of 16A per W/S		
Server Room/ Network Equipment Room	2No, s of 6/16A (in group) per W/S	1 No, s 25A per IT Rack/ Server (as kW Rating)	As Per IT & ITS equipment power requirements	2No, s of 6/16A per Room		
Electrical Room/ MV Switchgear Room/ Generator Room/ Mechanical Room/ Metering Room				2No, s of 6/16A per Room		
Conference Room	6No, s of 6/16A per Conference Room			4No, s of 16A per Conference Room		

Application/ Service	UPS Power			Raw Power		
	UPS Power Modular Socket & Switch Outlet	Single Phase Industrial Socket with ELMCB	Power Distribution Unit	Raw Power Modular Socket & Switch Outlet	Single Phase Industrial Socket with ELMCB	Three Phase Industrial Socket with ELMCB
Kitchen /Pantry				4 No, s of 16A		
DX Split AC Units					25A or 32A per DX Split AC Unit (as kW Rating)	
VRF Indoor Units (IDU)				1No, s of 6/16A per IDU		
Water Cooler / RO Unit				1No, s of 16A per Unit		
Exhaust Fan in Toilets				1No, s of 16A per Unit		
Hand Dryers in Toilets				1No, s of 16A per Unit		
Electrical Vehicle Charging Units (Only for MAIN ADMINISTRATION AND COMMAND CONTROL CENTER at CHIRLE)						4 No, s of 32A

5.3.2. System of Wiring

The system of wiring shall consist of PVC insulated multi stranded copper stranded conductor flexible LSZH (Low smoke zero halogen) / ZHFR (Zero Halogen Fire Retardant) / FRLS wires in metallic / nonmetallic (Rigid heavy Duty ISI -marked Low smoke fire retarded PVC Conduits of minimum 2mm Wall thickness and Sizes starting from 20 mm diameter) conduits and shall be concealed or surface mounted above false ceiling as called for.

Prior to laying and fixing of conduits, the contractor shall mark the conduit route, carefully examine the working drawings prepared by him and approved by the Consultant indicating the layout, satisfy himself about the non-interference in the route, sufficiency of number and sizes of conduits, location of junction boxes, sizes and location of switch boxes and other relevant details. Any discrepancy found shall be brought to the notice of the Owner's site representative. Any modifications suggested by the contractor should get written approval before the actual laying of conduits is commenced.

In laying of conduits, it is important that not more than two right angle bends are provided for each circuit without a pull box. No junction box shall be provided in the entire length of conduit run for drawing of wires. Only switch outlets, lighting fixture outlets, equipment power outlets and socket outlets shall be considered for drawing of wires.

5.3.3. Metal Conduits & Accessories

Conduits

Conduits and Accessories shall conform to latest edition of Indian Standards IS-9537 part 1 & 2. 16/14 (16 gauge up to 32mm diameter & 14 gauge above 32 mm diameter) gauge screwed GI or MS painted conduits as specified on schedule of quantities shall be used. Joints between conduits and accessories shall be securely made by standard accessories, as per IS-2667, IS-3837 and IS-5133 to ensure earth continuity. All conduit accessories shall be threaded type only. Threaded metal shall be painted with bitumastic paint.

Only approved make of conduits and accessories shall be used.

Conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

Note.: Whatever materials required to be billed by the Contractor should come on site with proper Challan Numbers and quantity mentioned in each such Challan.

Joints

All jointing shall be subject to the approval of the Owner's site representative. The threads and sockets shall be free from grease and oil. End termination of conduit on GI boxes shall be by means of hexagon check nuts & spring washer on both sides of the conduit. The joints in conduits shall be free of burrs to avoid damage to insulation of conductors while pulling them through the conduits. Rubberized bushes shall be used in the conduit entry and exit from DBs, switch boxes etc., so that wires are protected from damage to insulation of the incoming and outgoing wires.

Recessed or Exposed Conduits

All conduits shall be as per tender specifications \ Schedule of Quantities.

Flexible Conduits

Flexible conduits shall be made of heavy gauge MS strip galvanized after making the spiral. Both edges of the strip shall have interlocking to avoid opening. Flexible conduit shall be heat resistant, lead coated steel, water leak, fire and rust proof. The flexible conduit shall be heat resistant on continuous temperature up to 150 deg. C and intermittent temperature up to 200 deg. C. The flexible conduit shall be corrosion resistant as per IS-3480 & BS-731.

5.3.4. PVC Conduit and Accessories

PVC Conduit

Conduits and accessories shall conform to latest edition of IS-9537 part 3 and shall be heavy duty with minimum wall thickness of 2.0 mm rigid tubes which are unscrewed without coupling and with plain ends. All conduits used shall be ISI-marked and shall not be less than 20 mm diameter.

Heavy duty Low smoke FR PVC conduit shall be used for exposed wiring unless otherwise specified.

The layout of conduit should be such that any condensation or sweating inside the conduit is drained out. Suitable precaution should also be taken to prevent entry of insects inside the conduit.

PVC Conduit Accessories

Accessories used for conduit shall be of a same approved brand and type as used for conduit complying to relevant IS code.

All accessories used shall be of standard white or black colour, identical to conduit used.

Plain conduits shall be joined by slip type of couplers with manufacturer's standard sealing cement.

All conduit entries to outlet boxes, trunking and switchgear are to be made with adaptors female thread and screwed male bushes.

PVC-switch and socket boxes with round knockouts are to be used. The colours of these boxes and the conduits shall be the same.

Standard PVC circular junction boxes are to be used with conduits for intersection, Tee-junction, angle-junction and terminal. For the drawing-in of cables, standard circular through boxes shall be used.

Samples of accessories shall be submitted for approval prior to installation.

All jointing of PVC conduits shall be by means of adhesive jointing. Adequate expansion joints shall be allowed to take up the expansion of PVC conduits. Conduit shall have the solvent cement capabilities for permanent joint and all conduit joints shall be made by using the solvent cements.

5.3.5. Bends in Conduit

Where necessary, bends or diversions may be achieved by means of bends and / or circular cast iron boxes with inspection cover and with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with the finished wall surface. No bends shall have radius less than 7.5 cm or three times the outside diameter of the conduits. For metallic conduits, bends of defined radius shall be made by compactly filling fine sand inside the conduit length, to avoid non-uniform shape, once the bend is done. Proper jigs shall be used to ensure that the Enameling /Galvanizing of the Conduit is not damaged.

5.3.6. Fixing of Conduits

All conduits shall be installed to avoid direct exposure to steam, hot water or any other process pipes. After the conduits, junction boxes, outlet boxes and switch boxes are installed in position, their outlets shall be properly plugged or covered so that water, mortar, rodents and insects, insects or any other foreign matter does not enter into the conduit system. Surface conduits shall be fixed by means of heavy gauge GI saddles secured at intervals not more than 1000 mm, and on either side of couplers or bends or similar fitting saddles shall be fixed at 300 mm from centre of each fitting. For conduit fixing suitable PVC/Nylon fasteners shall be used.

The saddles should not be less than 24 gauge for conduits up to 25mm dia and not less than 20 gauge for larger diameter conduits. The corresponding widths shall be 19mm & 25mm. Where conduit pipes are to be laid along the trusses, steel joint etc. the same shall be secured by means of special clamps made of MS. Whereas it is not possible to drill holes in the trusses members suitable clamps with bolts and nuts shall be used (as per instruction of Engineer in charge).

For 25mm diameter conduit width of clip shall be 19mm and of 20SWG. For conduit of 32 mm and above, width of clip shall be 25mm and of 18SWG.

Where conduit pipes are to be laid above false ceiling, either conduit pipes shall be clamp to false ceiling framework or suspended with suitable supports from the soffit of slab. For conduit pipe run along with wall, the conduit pipe shall be clamped to wall above false ceiling in uniform pattern with special clamps if required to be approved by the Engineer at site

Recessed conduiting shall be done by making chase in the masonry by chase cutter; the conduit shall be fixed in the chase by means of GI hooks not more than 600 mm apart. After fixing of conduit the chase shall be filled with cement mortar after fixing of chicken mesh and brought to the original finish level of the surface to the entire satisfaction of Owner.

The chase in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of building under construction, conduit shall be buried in the wall before plastering and shall be finished neatly after erection of conduit. In case of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in the position along with the building work. Entire work of chasing the wall, fixing the conduit in chases, and burying the conduit in mortar before plastering shall form part of point wiring work. The conduit pipe shall be fixed by means of staples or by means of saddles not more than 60cm apart or by any other approved means of fixing. Fixing of standard bends and elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with treated with some approved preservative compound to secure protection against rust. Suitable inspection boxes to the barest minimum requirements shall be provided to permit periodical inspection and to facilitate replacement of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating holes shall be provided in the inspection box covers. Wherever the length of conduit run is more than 10 meters, then circular junction box shall be provided. Each pipe should be connecting through junction box.

5.3.7. Switch outlets and Junction Boxes

All outlet boxes for switches, sockets and other receptacles shall be rust proof and shall be of 1.6 mm thick mild steel sheets with HOT dipped galvanizing, having smooth external and internal surfaces to true finish. All outlet boxes for receiving plug sockets and switches shall be fabricated to approved sizes. All boxes shall have adequate number of knock out holes of required diameter and earthing terminal screws. Outlet boxes shall generally be of 50mm depth subject to maximum depth of 65 mm.
All fitting shall be fitted in flush pattern. Floor boxes shall be confirming to NF EN 60 670

5.3.8. Inspection Boxes

50 mm dia. inspection boxes and pull boxes shall have smooth external and internal finish to facilitate removal and replacement of wires, where required.

The conduit of each circuit or section shall be completed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirement by means of special approved type of earthing clamp effectively fastened to conduit pipe in a workmen like manner for a perfect continuity between the earth and conduit. Gas, Water pipe shall not be used as earth medium.

5.3.9. Fish Wire

To facilitate subsequent drawing of wires in the conduit, GI fish wires of 2.0 mm (14 SWG) shall be provided along with the laying of recessed conduit.

5.3.10. Conductors

All PVC insulated copper conductor flexible LSZH or ZHFR or FRLS as specified in SOQ, wires shall conform in all respects to Standards as listed under sub-head Indian Standards and shall be IS approved and ISI marked.

5.3.11. Bunching of Wires

Wires carrying current shall be so bunched that the outgoing and return wires are drawn into the same conduit. Wires originating from two different phases shall not run in the same conduit. All wires shall have ferrules for identification. Lighting and power circuits shall be separate. Each Power/ Light Circuit 's Neutral shall be individual per Circuit and shall not be looped from any other Circuit.

5.3.12. Drawing Conductors

The drawing and jointing of PVC insulated copper conductor wires shall be executed with due regard to the following precautions. While drawing wires through conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors. There shall be no sharp bends. Wire reel stands to be used for pulling of wires to avoid kinks. Care shall be exercised while drawing the wires from reels, by taking appropriate measures to ensure that wires are not spread on ground, causing dust and dirt accumulation on the new wires.

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into metallic Conduits are given below:

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	5	10	14	--	--
2.5	5	8	12	--	--
4	3	7	10	--	--
6	2	5	8	--	--
10	--	3	5	6	--
16	--	2	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into rigid nonmetallic or PVC Conduits are given below:

Size of wires Nominal Cross Section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	7	12	16	--	--
2.5	5	10	14	--	--
4	4	8	12	--	--
6	3	6	8	--	--
10	--	4	5	6	--
16	--	3	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Insulation shall be removed by insulation stripper only. Few Strands of wires shall not be cut/reduced for convenience in connecting into terminals. The terminals shall have enough cross-sectional area to take all strands and its connecting brass screws shall have flats

ends. All looped joints shall be connected through terminal block/connectors. The pressure applied to tighten terminal screws shall be just adequate, neither too much nor too less. All light points shall be terminated through a connector.

Conductors having nominal cross-sectional areas exceeding 10 sq.mm shall always be provided with cable sockets. At all bolted terminals brass flat washer of large area and approved steel spring washer shall be used. Brass nuts and bolts with brass washers shall be used for all connections.

Only licensed wiremen (Before doing the work or before appointing him on site contractor must submit his wiring license to Owner) and cable jointers shall be employed to do jointing work. Before entrusting cable jointing work to any technician, or before appointing Cable Jointers or Wiremen on Site, Contractor must submit such Technicians' / Wireman's / Cable Jointer's licensee to Owner.

All wires and cables shall be embossed with the manufacturer's label with ISI mark and shall be brought to site in original packing. For all internal wiring, FRLS or ZHFR PVC insulated wires of 1100 volts grade shall be used.

The sub-circuit wiring for point shall be carried out in loop system and no joints shall be allowed in the length of the conductors. No wire shall be drawn into any conduit until all defective work of conduit installation of any nature that may cause injury to wire is completed. Care shall be taken while pulling out the wires so that no damage occurs to conduits/wire itself, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction. The minimum size of PVC insulated copper conductor wires for all sub-circuit wiring for light points shall be minimum 2.5 sq.mm copper. Separate neutral to be pulled for each circuit.

Cables Copper conductor cables/ wires only will be used for main/submain/ circuit/ point wiring.
Minimum size of wiring:

Light Wiring	: 2.5 sq.mm.
Power Wiring	: 4.0 sq.mm.
Power circuit rated	: More than 1 KW, Size as per calculation.
Insulation	: Copper conductor cable shall be PVC insulated conforming to BIS Specification.
Multi stranded	: Cables are permitted to be used.

5.3.13. Joints

All joints shall be made at main switches, distribution boards. socket outlets, lighting outlets and switches boxes only. No joints shall be made in conduits and in junction boxes. Conductors shall be continuous from outlet to inlet.

5.3.14. Mains and Sub-Mains

Mains and sub-mains cable or wires where called for shall be of the rated capacity and approved make. Every main and sub main wires shall be drawn into an independent adequate size of conduit. Earthing shall be in conformity with relevant IS codes and calculations shall be submitted for verification. An independent earth wire of the proper rating shall be provided for every single phase sub-main. For every 3 -phase sub-main, 2 Nos. earth wires of proper rating shall be provided along with the sub-main. The earth wire shall be drawn along with circuit wires through conduit. Where mains and sub-mains cables are connected to switchgear, enough extra lengths of cable shall be provided to facilitate

easy connections and maintenance. Where ever necessary, powder-coated 1.6 mm thick sheet steel covering (also called trunking) shall be provided to cover the group of conduits and cables entering and exiting the Wall mounted/Floor mounted Sub DBs, DBs, and FDBs, so that the Installation looks neat .The colour of such sheet steel covering (trunking) shall be matching with the colour of the SDBs, DBs and FDBs

5.3.15. Load Balancing

Balancing of circuits in three phase installation shall be as planned by the Contractor in the Good for Construction drawings and shall be verified from the Employer or Employer's Representative before the commencement of wiring and shall be strictly adhered to.

5.3.16. Colour Code of Conductors

Colour code shall be maintained as indicated by the Consultant for the entire wiring installations. Red, yellow, blue shall be for three phases, black for neutral and green with yellow band shall be for earthing.

5.3.17. Floor Raceway

Floor raceway shall be of minimum 1.6 mm thick pre galvanized sheet steel unless otherwise specified. Dimensions for the same shall be as per the detail design by the Contractor. The raceways shall be as per the make specified in the tender. The raceways shall be free of any sort of welding edges or other sharp edges to protect cutting of wires during pulling. The raceways shall be laid with use of junction boxes fabricated from 2mm thick pre galvanized sheet steel.

Junction Boxes: Junction boxes made of sheet metal having a corrosion resistant finish. Provide access opening with heavy gauge inner plate and capable of minimum leveling adjustment of 3/8 inch after base has been fastened in floor slab. Provide junction box with 4 screws for adjusting height and leveling complete box. Provide the following additional features junction box raceway openings to match raceway system.

Contractor to provide hold-down strap for securing raceway in the floor

5.3.18. Installation

INSPECTION: Examine areas and conditions under which underfloor raceways are to be installed, and substrate which will support raceways.

GENERAL: Install underfloor raceways as indicated, in accordance with manufacturer's written instructions, applicable requirements of NFPA 70, and National Electrical Contractors Association (NECA) "Standard of Installation" and complying with recognized industry practices.

COORDINATION: Coordinate with other work including metal and concrete deck work, as necessary to interface installation of electrical raceways and components of other work. Plan and route underfloor raceway systems to prevent interference with other work without increasing thickness of floor construction.

5.4. Switches, Receptacles (Modular),

5.4.1. Switches

All switches shall be enclosed type flush mounted suitable for 240 volts AC. All switches shall be fixed inside the switch boxes on adjustable flat M S strips/plates with tapped holes and brass machine screws, leaving ample space at the back and sides for accommodating wires. Switch controlling the light point shall be connected to the phase wire of the circuit and load shall be restricted to maximum 800 watts per switch & maximum 1500 watts per circuit. All wiring accessories shall be BIS approved. Perfect alignment shall be maintained while fixing of the back boxes.

All switches and sockets are modular type which shall be made of fire retardant; self-extinguish polycarbonate plastic, able to withstand the glow wire test ai 960 deg. C.

The switches shall confirm IS 3854 :1997, The internal design of terminals and contact shall make the switch capable of high overload conditions, the switch shall be of flush type with silver inlay contact on pure copper

All switches, sockets, telephone outlets, TV controlling the lights or fans shall be connected to the phase wire of the circuit. Switches shall be located at 1200mm above finished floor level unless otherwise indicated on drawings.

Switches shall be suitable for indoor or outdoor service according to location housed in standardized purpose manufactured galvanized steel boxes completed with conduit knockouts made up into single or multi-gang units employing a grid switch system of fully interchangeable components at standardized fixing centers of matching switches of different types and ratings but of identical dimensions, push buttons, neon indicator lamps, blanking units, grids, steel boxes and plates all capable of integration into standard composite assemblies in any combination as required.

Grids shall be adjustable for variation in depth of plaster and for squaring errors and of the same type for surface or flush mounting.

Switches located on brick or concrete walls shall be mounted in horizontal arrangement in plaster depth steel boxes or in galvanized steel boxes using box suspension straps and cover plates. Countersunk screws shall be provided for fixing to the conduit boxes.

Switches for external use shall be of weatherproof construction with IP65 rating unless otherwise specified.

Samples of all switches, conduit boxes and plaster depth boxes shall be submitted to the Engineer for approval prior to installation.

Switches shall be rated for 6 Amps (minimum light switch rating 6A), 16 Amps or 20 Amps (as determined by circuit load). Inductive lighting circuit shall be assessed at twice the steady state connected load current.

5.4.2. Socket Outlet

Socket outlets shall be of the three pins. All socket shall fully comply with IS 1293: 2005 specifications. All wiring accessories shall be BIS approved.

The switch controlling the socket outlet shall be on the phase wire of the circuit and not more than two socket outlets of 16 amps shall be connected on one circuit. An earth wire shall be provided along with the circuit wires and shall be connected to earthing screw inside the box. All sockets shall be shuttered type.

a. Every socket outlet shall be controlled by an individual switch unless mentioned otherwise.

b. The switch controlling the socket outlet shall be on the 'Live' side of the line.

c. 6 amps and 16 amps socket outlet shall normally be fixed at any convenient height above the floor level as desired by the Architect. The switch for 6 and 16 amps, socket outlet shall be kept along with the socket outlet. However, in special case, if desired by the Architect the 6 amp. socket outlet can be placed at the normal switch level.

16 amps socket outlet in the kitchen/ pantry shall be fixed at any convenient height above working platform.

In a room containing a fixed bath or shower, there shall be no socket outlet and there shall be no provision for connecting a portable appliance. Any stationary appliance connected permanently in the bathroom shall be controlled by an isolator switch or circuit breaker having outlets at such location where water / moisture does not effect. Generally, switches and outlets shall be planned at a minimum distance of 1.5 Meter away from any water supply outlet, so that splashed water may not affect the live installation.

d. Where socket outlets are placed at lower level, they shall be enclosed in a suitable metallic box with the system of wiring adopted or shutter type sockets shall be provided as specified.

e. In an earthed system of supply, a socket outlet and plug shall be of three pin type, the third terminal shall be connected to earth.

f. Conductors connecting electrical appliance with socket outlet shall be flexible twin cord with an earthing cord which shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance.

g. Where use of shutter type of interlocking type of socket is required for any special installation, the items should be separately and specifically listed in the Schedule of Quantities of that work.

h. All switches, sockets, telephone and TV outlets etc. shall be fixed on 3mm thick phenolic laminated sheet cover unless otherwise called for in drawing or BOQ. Flush cover plate shall be secured to the box with counter sunk brass screws & cup washers.

i. All 6Amp and 16Amp socket outlet shall be modular type 5/6 pin respectively. Each outlet shall have a switch located beside the socket preferable on the same flush cover plate.

j. The earth terminal of the socket shall be connected to the earth wire.

Generally, switch socket outlets shall be positioned 300 mm above floor level except in plant rooms, kitchen, etc. where they shall be positioned 1400 mm above floor level or 150 mm above counters or benches as per requirement unless otherwise specified.

5.5. UPS & Batteries

5.5.1. General Requirements

a. The scope of work shall cover design, manufacture, supply, installation, testing and commissioning of UPS system including of all related equipment's together with all accessories and auxiliaries as per specifications.

b. The system shall be fully operational and shall comply with the specified codes and standards.

c. The contractor shall be responsible for providing all materials, equipment's and engineering services specified or which are required to fulfil the intent of ensuring reliability of the total work covered under these specifications within his quoted price.

d. Supply and installation of the UPS system covered under this specification shall conform to the latest editions of codes and standards mentioned in the Special Conditions of Contract, as applicable, and all other applicable Standards.

e. The contractor shall submit his offer for UPS systems as indicated in the tender document.

f. All components of the UPS equipment shall have Surge Withstand Capability (SWC) to meet the requirements of ANSI C62.41-1980. ANSI C 37.90a, IEEE Standard 472-1974.

g. All components of UPS system shall withstand short circuit current without any damage.

h. Following general requirements shall be met for ensuring proper circuit protection.

1. Fuses shall not be larger than 125% of the transformer primary circuit current where the secondary circuit fuse protection has not been provided.

   Where the secondary fuses are sized not larger than 125% of the secondary current of the transformer, fuses shall not be required in the primary circuit, provided the primary feeder fuses are not larger than 250% of the transformer primary current.

2. All the neutral conductors in three phase UPS systems shall be sized equal to at least 200% of the maximum phase current. In addition, all the isolators and circuit breakers used in three phase UPS system shall also to be rated such that the neutral poles shall take at least 200% of the maximum phase current.

3. All control shall be designed and positioned such that possibility of inadvertent or accidental operations are eliminated.

4. All UPS system cabinets, frames and power equipment shall be double earthed.

5. For modular system, to achieve higher reliability and availability of the system Individual battery bank and individual static bypasses per UPS or per Module shall be preferred within the architecture of the UPS.

i. The UPS design shall ensure that a single component/ device failure shall not result in failure of the entire UPS system. The design of UPS System shall be modular rack mountable, compact having all cabling internal and from the front without any need to access other sides to permit easy maintenance.

j. The various overload capacities of inverters, static switch and step-down transformer/ voltage stabilizer as specified herein are the minimum requirements. However, if the Contractor's offered system has better overload capacities for the above devices, the same shall be highlighted by the Contractor in his bid.

k. The UPS system offered by the contractor shall be suitable for operating continuously at the rated capacity indicated in tender within ambient temperature 0-40 deg.C and relative humidity of 0 to 95% non-condensing. Also, the UPS system shall be suitable for operation as per full rating up to 1000 meters above sea level without derating. The Contractor shall furnish a certificate towards compliance on ambient conditions permissible.

l. The UPS system to be supplied by the contractor shall have maximum humming noise level of 65 DB one meter away from the UPS cabinets.

m. Suppression of Radio Interference shall be provided to meet statutory requirements.

n. Detailed literature should be provided showing Quality Assurance Procedure adhered to.

o. The contractor shall submit detailed item by item compliance statement along with the tender.

5.5.2. Functional Requirements

a. Contractor shall furnish On-Line Uninterruptible Power Supply (UPS) system of continuous duty of the ratings mentioned in Bill of Quantities. Each UPS shall give regulated filtered & uninterruptible power supply as described in the specifications.

b. Contractor shall note that the KVA ratings of the UPS systems shall be guaranteed at 40 deg.C ambient temperature. In case contractor's standard UPS KVA rating are based at a lower temperature, the contractor must consider a derating factor of at least 1.5% per deg.C for arriving at the specified UPS capacity at 40 deg.C ambient temperature.

c. In case the calculated /specified UPS capacity is not the same as one of the standard KVA ratings of the UPS manufacturer, the next higher standard KVA rating shall be selected. UPS of non-standard rating shall not be acceptable.

d. UPS system supplied by the contractor shall be the latest state of the art technology system fully digitalized using microprocessor controlled full wave rectification and IGBT inverter.

e. Batteries shall be sealed maintenance free valve regulated lead acid specially meant for UPS application. UPS shall be able to charge VRLA and NiCa batteries too.

f. Monitoring and control system shall also be state of the art technology LCD touch panel type providing all relevant data described in this document.

g. The monitoring and control system shall be capable of RS485 with MODBUS protocol input software for connecting to customer's computer system for data display and monitoring.

h. All necessary components required for protecting UPS equipment and connected inputs and outputs shall be furnished by the Contractor as an integral part of the UPS system.

i. The control logic power supply shall have redundant power supply AC input and the system battery as power sources.

j. The UPS systems shall include but not be limited to the following equipment:

- UPS system including 100% capacity float-cum-boost charger with 100% sealed valve regulated lead acid batteries with guaranteed battery life of 5 years.
- Suitable factory-built battery cabinet or shelf for housing the batteries, including terminal isolator / breaker and power disconnect device. The enclosure shall conform to IP 20 as minimum.
- All cables, connectors, accessories like trunking, cable trays, conduits etc. required for connection between battery and the UPS unit.

k. In case of modular UPS design, each UPS module shall have hot-swappable capability. In a parallel redundant system, if one UPS module fails, the UPS system shall have the capability to replace the faulty UPS module ONLINE without transfer the load on by-pass.

5.5.3. Static Converter

The static converter (rectifier) shall be a multi-functional converter providing functions of power conversion, battery charging and shall have the additional functions of input power factor improvement and current harmonics reduction. The converter equipment shall include all necessary independent decentralized control circuitry and device to conform requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc. as given below.

The converter shall be a solid state static PWM converter using Insulated Gate Bipolar Transistors (IGBT) or Intelligent Power Module (IPM) transistors and shall include intelligent features like the drive circuitry, over current protection, over temperature protection, control power failure protection and short circuit protection.

The IGBT / IPM transistors shall enable high speed switching at 6 KHz thus reducing the heat dissipation in the UPS and thereby providing high efficiency.

The PWM converter shall be used to achieve unity power factor and reduce input current harmonics at full load independent of the load and thus improve the overall input power factor of the converter achieving input KVA savings.

The converter (rectifier) shall accept a wide range of input voltage and frequency tolerances without using the batteries to supply the inverter.

During any step inverter load change (0-100%) the converter shall only supply 100% current to the inverter. The battery shall not be cycled at any time during this step load changes.

Input Current Limit

The converter logic shall provide input current limiting by limiting the DC output current. Two (2) line-side current transformers shall be employed as a means of sensing the current amplitude. The converter logic shall also be capable of providing auxiliary current limited when the logic is signaled to do so via an external dry contact closure (e.g. UPS fed from generator). The converter shall be capable of supplying overload current in excess to the full load rating. It shall also have enough capacity to provide power to a fully loaded inverter while simultaneously recharging the system battery to 95% of full capacity within 10 times the discharge time. The DC output current limit values shall be as follows:

- Rectifier output current (maximum) 100%.
- Rectifier output current (aux.) 25% - 100% variable.

Note: 100% current shall be under the battery recharging mode.

Battery Charge Current Limitations

Battery charging shall work with a min. DC- voltage ripple (e.g. smaller 2 % or ripple free). The battery charger shall have the possibility to charge the battery depending of their temperature. The converter logic shall provide current limiting function of battery charging to prevent the battery from damage. The following battery current limit and protection shall be provided.

- Battery charge current limit 10% of battery Ah rate.
- Over-current protection at 120% of above item.

Voltage Regulation

The rectifier / charger output voltage including variation effects of input voltage does not deviate by more than +/- 1% of the nominal output voltage, due to the following conditions:

- Form 0 to 100% loading.
- Rectifier input variations of voltage and frequency within the limitations.
- Environmental condition variations within the limitations

Automatic Input Current Walk-in

The converter logic shall employ circuitry to allow a delayed and timed ramping of input current. Subsequent to energizing the converter input, the ramping of current shall be delayed by a maximum of 3to 5 seconds. Upon starting the walk-in process, the ramping of current is timed to assume the load gradually within 1 through 60 seconds (every 1 second selectable).

Input Overload Protection

The A/C input fuses shall be provided at the converter input as a means of overload protection.
The AC maximum current shall be controlled by the Converter.

Equalizing Charge Timer

The UPS logic shall provide an electronic automatic equalize charge timer which shall be selectable 24 hours for Lead Acid type or 8 hours for alkaline type batteries. The charger shall be limiting the battery ripple < 2 %. The timer circuit once activated shall provide a high rate equalizing charge voltage to the system battery for the selected time. The circuit shall also be capable of manual activation via the LCD touch panel mounted on the front door. The level of equalizing voltage shall be equal to that stated by the battery manufacturer. Upon completion of the timer count, the converter output voltage shall automatically return to the specified float voltage.

Step Load Change

During any step inverter load change (0-100%), only the converter shall supply 100% current to the inverter. The batteries shall not be cycled at any time during these step load changes.

Input Voltage

The converter shall be fed from the Normal Power Supply source.

The converter shall meet the specifications given in data sheets in addition to other requirements stated above.

5.5.4. Static Inverter

The static inverter shall be of solid-state type using proven Pulse Width Modulation (PWM) technique. The inverter equipment shall include all necessary control circuitry and devices to conform requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc. as given below.

The inverter shall utilize Insulated Gate Bipolar Transistors (IGBT) or Intelligent Power Module (IPM) Transistors which shall provide intelligent features like the drive circuitry, over-current protection, over temperature protection, control power failure protection and short circuit protection.

The IGBT / IPM transistors shall enable high speed switching of 6 Khz thus reducing the heat dissipation in the UPS and thereby providing high efficiency.

The UPS shall utilize both Voltage and Current feedback control circuits so that the inverter shall act not only as a constant voltage source but also as a load required current source. This shall enable the inverter to quickly adapt to the changing load current value and wave shape.

Voltage Regulation

The inverter output voltage shall not deviate by more than + 1% RMS due to the following steady state conditions:

- From 0 to 100% loading
- Inverter DC input voltage varies from maximum to minimum.
- Environmental conditions variations within the limitations

Frequency Control

The inverter output frequency shall be controlled by an oscillator internal to the UPS module logic. It shall be capable of synchronizing to an external reference (e.g. the bypass source or another UPS module) or operating asynchronously. The oscillator shall maintain synchronization with the external reference within the limitations set hereunder. The inverter shall operate on self-run mode without synchronism if the bypass frequency exceeds the set value. The oscillator, while running asynchronously, shall maintain the frequency as 50 Hz + 0.01% (or + 0.005 Hz). Automatic adjustment of phase relationship between inverter output and standby bypass source shall be gradual at a controlled slew rate which shall be adjustable at the rate of 0.5, 1.0, 2.0, 3.0 Hz / second. (Default 2.0 Hz / second).

The inverter output frequency shall not vary during steady state or transient operation due to the following conditions:

- From 0 to 100% loading.
- Inverter DC input varies from maximum to minimum.
- Environmental condition variations within the limitations

Output Voltage Harmonic Distortion

The inverter output shall limit the amount of harmonic content to the values stated in section 4.8. The use of excessive or additional filtering shall not be required to limit the harmonic content thus maintaining a high level of efficiency, reliability and original equipment footprint.

Output Overload Capability

The inverter output shall be capable of providing an overload current while maintaining rated output voltage to the values stated in section 4.8. An LED indicator shall be located on the control panel to identify this condition. If the time limit associated with the overload condition expires or the overload is in excess of the set current amplitude, the load shall be transferred to the bypass source without interruption.

Inverter Current Limit

The inverter output shall be limited to 150% of rated load current. The two sensing locations shall operate separately and independently thus providing redundancy and, in the event of a failure, preventing unnecessary damage to power transistor components / fuses. Load current above 150% shall cause an immediate transfer of the load to the bypass source for fault clearing.

Inverter Overload Protection

The AC output from the inverter shall utilize fuses for overload protection. The inverter shall utilize a contactor to isolate the inverter output from the critical bus.

The inverter fuses shall be the fast-acting semiconductor type.

The inverter output isolation contactor shall be located in the UPS module and shall be controlled by the internal UPS module system logic.

The inverter shall meet the following specifications in addition to other requirements stated in the enclosed data sheets.

Built-in Isolation Transformer

UPS system design should include built-in or external isolation transformer to provide neutral separation ensuing that the output neutral will be independent of incoming neutral. This will enable critical load to isolate from the problems like incoming neutral open or, short or, variations in neutral to earth voltage due to sudden loading in neighboring installation. Whenever isolation transformer is provided, it shall have K factor as given in the enclosed data sheet and shall have galvanic isolation of more than 1000 mega ohms to affect common mode noise rejection of : up to 10 kHz >120 dbs, 10 to 50 kHz > 90 dbs, and 50kHz to 1 MHz > 50 dbs.

However, in case of transformer less UPS design, necessary protection system like Electronic DC Protection System (EDCP) shall be incorporated at the output of UPS to prevent DC component, arising out of fault of inverter IGBT, to enter into supply system on load side. In such cases, separate Isolation transformer shall be provided externally.

Reverse Phase Sequence Protection

In the event of Phase sequence reversal at the input, UPS system shall continue to work on the main power supply, or UPS systems shall go into battery mode, and shall not trip the UPS system. Wrong phase rotation on the input of the converter (rectifier) shall not stop the inverter neither switching the UPS into battery mode.

5.5.5. Bypass and Static Transfer Switch

A bypass circuit shall be provided as an alternate source of power other than the inverter. A high-speed switch shall be used for the critical load during automatic transfers to the bypass circuit. The static switch shall be fully sized to conduct the full nominal current as well the full overload capability of the UPS. There shall not be any wrap around contactors parallel to the static switch. The static switch shall drive power from an upstream bypass feed circuit breaker internal to the UPS module provided for overload protection. The bypass circuit shall be capable of supplying the UPS rated load current and provide fault clearing current. The UPS system logic shall employ sensing which shall cause the static switch to energize within 150 microseconds thus providing an uninterrupted transfer to the bypass source when any of the following limitations shall exceed:

- Inverter output under voltage or over voltage.
- Overload beyond the capability of the inverter
- DC circuit under voltage or over voltage
- End voltage of system battery is reached.
- Bypass source present and available
- System failure (eg. Logic fail, fuse blown, etc.)

Keeping the above requirements in view, the static switch shall have the following minimum rating.

- Capacity continuous equal to 100% of continuous rating of the inverter.
- Capacity overload equivalent to overload characteristics specified for UPS.

Automatic Re-Transfer

In the event that the critical load must be transferred to the bypass source due to an overload, the UPS system logic monitors the overload condition and, upon the overload being cleared, perform an automatic re-transfer back to the inverter output. The UPS system logic shall only allow a re-transfer to occur three times within a ten-minute period. Re-transfer shall be inhibited on the fourth transfer due to the likelihood of a recurring problem at the UPS load distribution. The re-transfer a load to the inverter shall also be inhibited due to the limitations.

Manual Transfer

The UPS shall be capable of transferring the critical load to / from the bypass source via LCD touch panel. When performing manual transfer to inverter or automatic re-transfers, the UPS system logic shall force the inverter output voltage to match the bypass input voltage and then parallel the inverter and bypass source providing a make-before-break transition allowing a controlled walk-in of load current to the inverter.

Maintenance Bypass Switch (MBS)

The UPS shall include as standard equipment, a zero-energy maintenance bypass switch. Full UPS wrap-around enables personnel to do work inside the UPS module or maintenance bypass switchboard without danger for high voltage conditions.

5.5.6. Ups Battery System

a. The UPS system shall, as an integral part, provide battery system for backup time as specified in the Schedule (Full Load) standby capacity.

b. The latest state of the art Valve Regulated Sealed Maintenance Free Lead Acid Batteries shall be used with a 20 hours discharge rating.

c. The battery system shall be sized to provide backup time as specified in the schedule of quantity when the UPS is supplying 100% rated load at 0.8 load power factor.

d. An ageing factor of 15% shall be applied to the capacity arrived at, to allow for compensation against capacity loss during float operation.

e. The battery system design shall be provided with necessary devices to prevent deep discharge beyond recommended limits to prevent the batteries discharging beyond end cell voltage specified by the battery maker. The connections from battery to battery shall be by using copper bus bar strips and the entire battery system shall be used in IP20 steel cabinet enclosure or on shelves and shall be like the UPS enclosure.

f. All batteries shall be clearly identified, and identification numbers marked on the batteries and a schematic diagram along with the complete calculations, including manufacturers supporting curves, shall be submitted with the tender.

g. The UPS shall have a properly rated and sized circuit breaker to isolate it from the battery

h. In modular system, the battery system shall be able to be individual per modules as well be able to be configured as a common battery for a whole n+1 system. Individual battery per module shall be preferred

5.5.7. Operation

The UPS shall be designed to operate as a true on-line, double conversion Voltage and Frequency Independent (VFI) system in the following modes:

a. Under normal operation, the UPS load will be fed from the Inverter with the bypass switch inhibited. The Converter, apart from providing DC power to the Inverter, also charges the battery under the float charge mode. The battery charge system shall have float charge, equalizing charge and recovery charge modes, to replenish the batteries self-discharging part while the battery is fully charged, equalizing the battery cell voltage to a constant value forcibly, and recharging the battery system to the required values when the batteries have been used, respectively.

b. The Inverter shall constantly monitor the AC source frequency and shall be in synchronization with the AC input source till the frequency of the AC input source is within synchronizing limit and if the frequency of the standby source exceeds the synchronizing limit the Inverter will work on its own internal oscillator maintaining an output frequency of 50 Hz +/- 0.01% under all conditions of load. When the Inverter operates on its internal oscillator, it shall continuously monitor the frequency of the input source and when the input source frequency returns to within synchronization limit, the Inverter shall automatically synchronize itself with the input A/C source frequency and use it as a signal for Inverter output frequency control.

c. Battery Operation

   i. When the A/C input voltage drops below specified limits or in case of a power failure the Inverter continues to supply AC power of constant voltage and constant frequency utilizing the battery system as a power source until the input voltage returns to normal requirement. When the power supply is resumed or the input voltage returns to limits, the Converter shall automatically start, and the load fed for normal operation status.

ii. If the power failure continues beyond battery backup time or the battery voltage drops to the final discharge voltage, the Inverter should automatically stop and at the same time transferring the load to the bypass circuit. On resumption of power supply, the Converter shall automatically re-start the operations and charge the batteries with minimized AC ripple whereas the Inverter should inhibit automatic start and should be started manually.

d. Bypass Operation:

When power is supplied from the Inverter in synchronization with the bypass, it shall accomplish the following:

i. When the UPS output current reaches overload status it shall automatically transfer the load to bypass circuit with no interruption and when the overload status is cleared it automatically re-transfers the load to Inverter.

ii. When the battery final discharge condition is reached, the load shall automatically be transferred to the bypass circuit without interruption.

iii. In case of failure of the UPS, the load shall be automatically transferred to the bypass circuit with no interruption and when the failure is cleared, re-transfer the load to the Inverter shall be done manually.

iv. There should be provision made in the system to prevent, when necessary, asynchronous transfer.

v. When the UPS goes on bypass mode in any of the conditions described above and if at that time there is no bypass power supply available due to power failure, the UPS shall remain in standby mode and as soon as the bypass power supply is available will transfer the load to bypass

vi. A maintenance bypass transfer switch shall be provided with lock and key arrangement and should be manually done by authorized personnel only.

5.5.8. Additional Requirements for Modular System

Whenever modular system required to be implemented, UPS system shall conform to following additional requirements.

1. Non-redundant system.

All the UPS units connected in parallel are required to supply the full rated load within the same cabinet. If a UPS unit power or control module should malfunction, the load shall be transferred automatically to the bypass line via each of the UPS units with their static bypass switches being triggered simultaneously. The battery set shall consist of at least two strings so that in the event of a battery malfunction the affected string is automatically isolated from the system thereby ensuring battery autonomy is retained, albeit of a shorter duration.

2. Redundant operation

The UPS system shall operate in an N+n configuration where N is the number of UPS units connected in parallel to support the load and n is the number of UPS units connected in parallel to provide the co-efficiency of redundancy. The value of n is generally 1. However, this may be higher than 1 requirement, as specified in BOQ

The parallel UPS units shall be capable of operation from a common DC bus or with a separate DC supply for each UPS unit. In either case the batteries shall be configured so that the failure of one battery string (common DC. bus) or the failure of one battery set (separate DC supply for each UPS) provides battery redundancy whereby the specified autonomy at full load is maintained.

The malfunction of one of the UPS unit's power or control modules shall cause that UPS unit to be automatically isolated from the system and the remaining UPS units shall continue to support the load. Replacement or repair of a faulty UPS unit shall be achieved ONLINE without disturbance to the connected load or necessity to switch off the load.

5.5.9. Battery Monitoring System

a. The Battery Monitoring System shall provide for the automatic acquisition, trending, alarming and storage of information from every cell or jar in a battery bank. It will have the interactive ability to first identify and then provide an isolated equalizing charge current to any individual cell or jar that deviates below a user-specified set point, from the cell average, within the same string or bank.

b. The Battery Monitoring System shall test the relative charge state and health of each individual cell or jar by injecting a DC current, recording the magnitude of this current & comparing it to previous benchmark values. Systems that require battery discharge for testing are not acceptable. The system shall provide estimated backup time remaining during an actual discharge.

c. The Battery Monitoring System shall monitor and maintain historical files for:
   i. Individual cell or jar voltage
   ii. Total bank voltage
   iii. Discharge current
   iv. Ambient and pilot cell temperature
   v. Relative current response value

d. Display shall be via local LCD display, with capability for viewing at a remote terminal. All files shall be written to a fixed solid-state disk within the enclosure. All functions shall be accessible via modem using common communications software.

e. The system shall operate a "form C" relay contact when any parameter is in alarm. Alarm data shall be written to a file in ASCII format for future retrieval.

f. The system shall be capable of remote communications for remote access to all functions via modem or ANSI terminal.

g. The Battery Monitoring System shall be capable of monitoring a minimum 264 jars per string, 9 parallel strings per system, 6 cells per jar.

h. Resolution shall be 12-bit accuracy, with up to 10 per second channel test rate.

i. Cell voltage measurements must be made to within plus or minus 5 milli volts over the entire operating and temperature range.

j. Documentation, Manuals and installation documentation for the equipment shall be provided which lists block diagrams, schematics parts list and theory of operating for each unique component of the system. Installation drawings and documentation shall be site specific for each string at this facility. Marked up building drawings shall be provided to show any changes to building wiring including power wiring and communications cables.

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k. The system shall be factory tested fully and completely before shipment.

5.5.10. Cabinet and Enclosures

The entire UPS system, including all components like inverter, static switch, maintenance bypass, shall be housed in free-standing steel type factory-finished enclosures complying with the protection standards of IP20. For modular system, the housing shall include all wires to able the rack mountable modules to be hot swapped without any need to disconnect power cabling or without any need to put the load on bypass during swap operations. The enclosure shall be open able using a special tool for internal access. The color shall be light grey. All parts for maintenance requirement shall be front accessible

Ventilation

Forced air-cooling shall be provided to allow components to operate within their rated temperature specified. The cooling fans shall have thermal relays protection using a latched cut fire re-setting, as a protection for the cooling fans.

Similarly, the backup battery system shall also be housed as described earlier in an IP20 cabinet.

5.5.11. Control and Monitoring

a. The UPS shall utilize state of the art full DDC control software driven Control and Monitoring System.

b. It shall be provided with LED displays.

c. The UPS logic should provide one set of normally open dry contact / relay output to allow interfacing of UPS operating status to an external system and should be capable of providing, as a minimum, 10 numbers status and, should the UPS manufacturer's standard product does not provide such software, the Contractor must add additional equipment and cost for the same.

d. The UPS shall also have an RS485 port with MODBUS interface card if required for interfacing to BAS system or client's centralized computer network.

e. LCD touch panel (Optional)

i. The UPS shall be provided with an operator friendly large-scale LCD touch panel.

ii. The LCD touch panel shall also include graphic measurement display, operational procedures of each activity, fault status display and have capability to record at least 50 faults.

iii. The touch screen panel shall clearly define specified areas for operational function, execution and message display.

iv. It should be possible to operate the entire UPS system and its components and obtain all measurements and data through the touch screen operation. The measurement software should provide capability to measure phase voltage, current in each phase, frequency, power factor, available battery time etc.

v. Under all operating conditions, the system software should have capability for displaying fault alarm automatically. The tenderer should describe in detail the faults that would be displayed under this mode.

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5.5.12. UPS Testing

a. The Contractor shall perform the following tests, as a minimum, at site prior to handing over, to confirm the functional and the performance specification of the UPS as specified. All required test equipment like Digital Oscilloscope, Voltage Regulator and Measurement Meters etc. shall be the responsibility of the Contractor without any additional cost.

b. The Contractor shall demonstrate as a minimum the following features on site by providing all required test equipment, such as power factor improvement, input current THD, output voltage THD, output frequency and all other performance monitoring requirements detailed before as required by the Employer.

5.6. Inverter for Emergency Lighting With 90 Minutes Battery Backup

The single-phase Double Conversion Online inverter shall provide AC power to the load, in pure sine wave form.

Simultaneously it will provide DC power to the battery bank and Battery energy management will ensure that the battery will be maintained in fully charged condition with the help of Float Cum Boost Charger (Multistage Charging Technique) in all feasible circumstances.

The inverter should be specifically designed to support AC loads of lighting load & shall supply these emergency lighting loads in MTHL Project Buildings for at least 90 minutes incise of power failure.

There should be appropriate LED and LCD display showing Input as well as Output Related all annunciations with the help of LED & LCD Display, refer to technical Specifications Sheet given below.

S. No.	Specifications	Features	Standard Parameters
1	Input AC range	Under Voltage Under Voltage restoration Over Voltage Over Voltage restoration	180+1- 5 V 185 +1- 5 V 280 +/- 5 V 255 +/- 5 V
2	Output on Inverter Mode	Maximum power Minimum Efficiency Voltage (Inverter mode) Frequency (Inverter mode) Overload Transfer time	As specified 85 % 230 V Nominal +/- 12% 50 Hz +/- 2% > 110% for 10 minutes 30 mS
3	Conversion	Switching device Harmonic distortion	IGBT. <5 %
4	Inverter mode protection	Low battery Battery reverse Overload Short Circuit	Electronic trip Through fuse Electronic trip Electronic trip
5	Mains mode protection	Overload Short Circuit Charger	Through MCB Through MCB

S. No.	Specifications	Features	Standard Parameters
8	Battery	Charging tine	10 — 12 hours
7	Battery charger	Constant voltage with current limit'	10 amp with boost voltage & float voltage as per manufacturer's specification High power factor boost charger
8	LED Display	Switch On. Inverter ON. Low battery Pre-alarm. Battery low. Mains ON. Smart charge. Overload. Short Circuit. Battery fuse fail. Battery reverse. MCB Trip.	As per manufacturer's standard specification
9	Alarms	Low battery Pre-Alarm Overload Pre-alarm Short Circuit MCB Trip	Continuous beeping Continuous beeping Continuous beeping Continuous beeping
10	Environmental	Operating temperature	0 - 40° C
		Storage temperature	0 - 40° C
		Humidity	0 -95 % RH non-condensing
11	Enclosure	CRCA sheet minimum 1.2 mm thick, powder coated with approved colour shade	Aesthetically Wished, duly pre-treated and powder coated.

The Project Buildings shall have independent inverter with Battery System to feed the emergency lights and exit signages in the Project Buildings. The battery back-up time shall be minimum 90minutes as per NBC2016.

10% of the normal lighting load shall be considered as an emergency lighting load in each building.

5.7. 415V Diesel Generator Set

5.7.1. General

The scope of work shall cover design, manufacture, supply, installation, testing and commissioning of DG set with self-acoustic enclosure and exhaust system (self-standing Chimney) shall be installed as stipulated in the Central Pollution Control Board (CPCB) norms. The contractor shall develop these requirement and prepare detail design and assessed capacities of D.G. Set in coordination with actual load values as require for Illumination, Ventilation, HVAC, Fire Fighting, water supply, Power Sockets, UPS, IT Equipment and other lifesaving equipment to fulfill the Employer's Requirements.

Diesel Generator set with self-acoustic enclosure, Engine mounted radiator - cooled type complete with an individual fuel tank (Day tank – 990ltrs) with inbuilt AMF Control panel are proposed as an Emergency back-up source which is to cater 100% of connected loads. Additional Fuel tank of 990ltrs (minimum) shall be considered for each DG set, above ground.

The DG sets will automatically turn "ON" with less than 1 minute of lead time in case of outage of power normal power supply and shall automatically be turn "Off" within stipulated time after normal power is resumed, therefore shall be equipped with AMF Control panel for the operation of DG set ON/OFF automatically.

The D.G. Set shall be monitored through BMS System. Contractor shall ensure compatibility and protocols with BMS System.

5.7.2. Scope

The scope of this section consists of but not necessarily limited to the following:

a. The contractor shall supply, deliver to site, hoisting into position, install, test and commission the standby power generating set together with the necessary controls and switchboards as specified and indicated in the Drawings. Protection circuits, control wiring and interlock circuits not specified or indicated in the Drawings but deemed necessary for the safe operation of the generating system shall be provided without any additional cost to complete the system.

b. Provide manufacturer's factory representative's services, including coordination, start-up and testing supervision at site.

c. Testing (factory and field), start-up supervision, training and providing necessary documentation and tools for operation.

d. Carry out performance test run at site.

e. 500kVA, 630KVA & 1000kVA are the indicative capacities for Sewri Sub-command centre, Shivajinagar Sub-command Centre & Gawan Main Central Command Centre respectively.

5.7.3. Submission

i) For bidding

The Contractor shall submit offer with the following documents in two sets.

- Schedule of deviations from technical specifications.
- List of proposed makes, for the items listed in the tender.
- Technical datasheets indicating overall dimensions & Catalogues of major items, highlighting the offered models.
- Overall GA drawing with Day oil tank details, residential silencer, heat exchanger details (as applicable).
- Structural support drawings.
- To submit operation logic.
- Supporting structure details of pipelines, chimney etc.
- Other documents and comments, if any.

ii) For approval before construction/erection

The contractor shall submit the following documents for all the supplies, the sub-contractor(if any) shall submit the following documents in 4 sets for approval.

- General arrangement drawings, with all dimensions, showing space-requirements, weights (for transport and service conditions), requirements of civil works/foundation, fixing and mounting facilities, connection devices, etc.
- Electrical drawings, showing power and control single line and functional/control multi line diagrams, terminal blocks, components' list with make, type, quantity, etc.
- Detailed drawing of cooling water system (if applicable) complete with cooling tower and pump sizing calculation, design drawing of residential silencer, AMF/PLC control drawings as applicable.
- Quality assurance plan and bar-chart showing manufacturing schedule.

The contractor shall incorporate all comments and submit revised drawings in stipulated time till all drawings are finally approved for manufacturing.

iii) Final Submission

The Contractor shall submit the following documents, reflecting the true final as built situation, in 6 sets, and one soft copy in CD.

- The drawings including wiring diagrams as revised and "as built".
- Inspection and preliminary testing certificates and reports and shipping release.
- Test certificates of kWh meters from Government approved Lab or Electric Supply Co. of concerned area.
- Guarantee certificates.
- Instruction & maintenance manuals, Cataloguers etc.
- Any other certificate / report as called for by the Employer.

5.7.4. Product Capacity

Actual power output shall be assessed as per detail design by the Contractor and shall be approved by the Employer or the Employer's Representative.

Diesel Engine

The diesel engine shall be of the 4-stroke cycle, prime rated continuous, multi-cylinder direct injection, compression ignition type operating at a speed of 1500 rpm and shall be silent, vibration free while in operation and comply Center / State Pollution Control Board and shall conform to BS:649/5514.

The engine shall be complete with radiator cooled type engine, fan, lubricating oil pump, lubrication oil pressure gauge (or microprocess built-in display), tachometer, digital or electronic type governor, integrated hours-run recorder, over-speed trip and all other necessary auxiliaries.

The brake horsepower of the engine with all attached accessories as specified shall not be less than that which is required by the full load rating of the alternator at site operating conditions taking into consideration losses, plus a reserve factor of at least 10%.

Starting

Starting system of the standby generator shall be of a heavy-duty electric motor complete with a 24 V.D.C. (2x12V) heavy-duty battery of 300 AH or as recommended by the manufacturer. The electric motor shall be capable of cranking the engine to achieve the rated speed in less than 10 seconds from the initiation of the starting process. The electric

start battery shall be of adequate capacity for 3 successive starts. Time delay relays shall be incorporated to provide a rest period of 1-5 seconds (adjustable) before each successive start and a time lag period of 19-100 seconds (adjustable) before the system lock out due to failure of the 3rd start to crank up the engine.

The generator set shall be provided with a micro-processor-based control system which is manufactured to provide automatic starting, monitoring, and control functions for the generator set. Interface to BMS system according to point schedule on drawings shall be provided.

The control system shall include an engine governor control, which shall function to provide steady state frequency regulation. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

Speed Regulation

The governor shall be capable of regulating the speed of the engine within the limits approximately 10% of the rated speed and maximum voltage dip of 10% within 4 seconds due to a sudden application of 0 to 60% of full load in first step and 60 to 100% of full load in next step or removal of total full load. The steady load speed shall vary within the limits of approximately 1% of the rated speed.

Cooling

The engine cooling system shall be of radiator type or a heat exchanger type system to cool the engine as well as the body to minimize heat radiated into the generator room. The cooling circuit shall exchange heat through a heat exchanger capable to remove the heat generated under continuous full load operation. OEM shall specify the water quality & coolant type required.

Lubricator

The lubricating system shall be by a positive displacement oil pump providing a positive force feed to all lubricating points.

Exhaust System

Adequately sized piping and fittings shall be installed to carry the engine exhaust discharge into the atmosphere at a height as indicated in the drawings & as per the requirement of Center / State Pollution Control Board or Pollution Control Committee as the case may be.

M.S. epoxy painted structural support and vibration arrestors for D.G. set chimney to specify along with drawing for statutory clearance.

Mufflers shall be installed to reduce the engine exhaust noise at the outlet of muffler to noise level as permitted at site as per MPCB/CPCB requirements. Flexible connection shall be provided between the engine and the fixed piping.

Fuel Piping and Fuel Tank Installation

The complete system shall include engineering, supply, installation, testing and commissioning of tank for storage of fuel, pumps, piping, valves and control system.

Engine instrument panel

An instrument panel mounted on the engine shall be provided and shall comprise the following flush-mounted instruments and gauges:

Cooling water inlet and outlet temperature

Lubricating oil pressure gauge

Tachometer, positive driven

Hour counter with hour totalizer.

Protection Devices

Warning indication and automatic shut-down shall be provided for the following:

Low oil pressure shutdown and alarm

High coolant temperature alarm

High coolant temperature shutdown

Fail to crank shutdown

Over cranking shutdown

Overspeed shutdown

Low & high DC voltage alarm

Low battery alarm

Low fuel-day tank alarm

High and Low AC voltage shutdown

Under frequency shutdown

Over current and alarm and shutdown

Short circuit shutdown

Earth fault alarm

Overload alarm

Emergency stop

Failure indication lights and alarm for all fault conditions shall be provided on control panel for restoring the operation to normal.

The starting circuit shall be disconnected in the event of any of the above shutdowns.

5.7.5. Alternator

The alternator shall be brush less synchronous drip proof, self-ventilated and screen-protected and directly coupled on to the diesel engine by flexible coupling and shall be continuously rated for site operating conditions and conform to BS 5000 (part99) or IS 4722.

The full load output voltage shall be 415 volts, 3 phase, 4 wire, 50 Hz at 0.8 power factor with neutral solidly earth with the frequency maintained at 50 Hertz at all time under any load condition including transient overload due to motor starting etc.

The rotor shall consist of the main alternator field poles the brushless exciter and its rectifier module, all bolted on a common alternator shaft. The rotor shall be mechanically and electrically balance up to 135% of the rated speed. The insulation of the alternator shall be non-hygroscopic, Class "F".

The rectifier module of the exciter shall be impregnated with epoxy resin and shall be capable of withstanding without damage or deterioration of the thermal, centrifugal and other stresses that is experienced during normal or short circuit conditions. Rectifiers shall be of silicon type.

The voltage build up shall be of self-excitation using the residual voltage of the alternator through a solid-state voltage regulator. The voltage regulator shall be capable of maintaining the voltage regulation to ± 1% independent of power factor, heating and 5% of speed variation. The voltage output of the alternator shall also be capable of manual adjustable to ± 5% of the rated voltage.

The response of the voltage regulator shall be less than 10 millisecond. The voltage dip shall not exceed 10% when a rated continuous load is supplied to 0 to 60% of full load in first step and 60 to 100% of full load in next step and the correction time shall not exceed 200 millisecond. When the rated load is withdrawn, the voltage overshoot shall not exceed 20%.

The automatic voltage regulator and the exciter shall be manufactured to withstand 50% overload at a constant terminal voltage.

A permanent magnet generator (PMG) or APER or as per manufacturer standards, shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of motor current for not more than 10 seconds.

Excitation System

a. The alternator shall be provided with a complete rotating diode type brushless excitation system, capable of supplying the excitation current of the generator under all conditions of output from no load to full load and capable of maintaining voltage of the generator constant at one particular value.

b. The exciter shall have class 'H' insulation.

c. The excitation system shall comprise a shaft driven AC exciter with rotating rectifiers. The rectifiers shall have in-built protection for over voltage.

d. The exciter shall be fast response type and shall be designed to have a low time constant to minimize voltage transients under severe load changes. The excitation voltage response ratio shall be at least 0.8.

e. The rated current of the main exciter shall be at least 10% more than the alternator rated exciter current and it shall have 40% overload capability for 10 seconds.

f. No external supply shall be required during starting and normal running of the alternator.

Automatic Voltage Regulator

a. An automatic high speed, dead band type voltage regulator shall be provided, complete with all accessories. The regulation system shall be provided with equipment for automatic and manual control.

b. The regulator shall regulate the output voltage from generator current and potential signals. Series compounding transformer shall be provided to enable maintaining adequate terminal voltage in the event of terminal faults. Alternatively, excitation system shall be provided with arrangement for field forcing. Contractor shall coordinate suitability of protection relays for generator with the operational characteristics of automatic voltage regulator, specially under short circuit conditions.

c. Voltage regulation and steady state modulation shall be within (+) / (-) 1% of the line voltage.

d. Necessary equipment for field suppression and surge protection shall be provided.

e. The response time of exciter and the generator shall be properly matched to avoid hunting.

f. AVR system shall be provided with equipment for automatic and remote operation / control.

g. Necessary equipment shall be furnished for the following.

- To prevent automatic rise of field voltage in case of failure of potential supply.
- To initiate transfer from automatic to manual control of excitation on fuse failure on the generator potential signal.

Mounting Arrangement

The engine and the alternator shall be coupled by means of Direct Coupling and both shall be mounted on the same base frame to ensure perfect alignment of the engine and the alternator with rigid construction to ensure minimum vibration. The base frame shall be provided with lifting facilities and pre-drilled foundation holes for permanent installation on pre-prepared concrete foundation.

5.7.6. Interface with Building Automation System

All necessary hardware's / software's to integrate the Generator microprocessor panel to BAS system shall be provided free of cost by generator manufacturer / supplier.

For the integration of Microprocessor Panel of the generator with the Building Automation System, an Interface Control Document shall be developed by BAS Contractor. It shall be responsibility of Generator Contractor to provide following minimum to BAS Contractor for preparing the interface.

a. Hardware Protocol of Microprocessor panel.
b. Software Protocol of Microprocessor panel.
c. Communication structure relating to collection of message / event information.
d. Description of the formatted packets / blocks of data which construct controller commands / responses.
e. Written permission to BAS contractor to develop the interface without any financial implication.

5.7.7. Acoustic Treatment

The Contractor shall submit calculations, engineering, supply and install the acoustic treatment for the Generator Room to ensure that the noise level is not more than 75 dBA measured at 1.0m externally away from the doors and louvers of the Generator Room. All DG sets up to 1000 kVA shall be provided with its own outdoor type acoustic enclosure duly tested and approved for 75 dBs as per norms of central / local pollution control board.

5.7.8. Execution

Testing and Commissioning

All the necessary comprehensive tests shall be performed to the approval and satisfaction of the Project Manager at the completion of installation. Before the commencement of acceptance testing, the installation shall be in a state of practical completion and shall have completed all the preliminary testing and adjusted the equipment to its proper running order.

A full ten (10) days' notice of his readiness for carrying out acceptance tests shall be given to the Project Manager.

Prior to the date of giving such notice a complete details schedule of the tests to be carried out shall be submitted to the Project Manager for his approval and alterations and additions to the schedule are required to be made.

Notwithstanding his approval of the testing schedule the Project Manager may at any time before or during the testing period direct further tests to be carried out that he considers necessary.

Any variation to the program me for the testing period shall be at the discretion of the Project Manager.

Upon completion of all above tests, four (4) sets of the test results shall be submitted for the approval of Project Manager. All test reports submitted shall be endorsed by all parties witnessing the test including the contractor's and manufacturer's Qualified Personnel.

No acceptance tests shall be carried out except in the presence of the Project Manager or their authorized representatives appointed for the purpose.

The Contractor shall provide at his own cost all materials, including electric power, instrument test set, fuel, lubricants and other consumable, Load Bank required for the tests and adjustments of the equipment and for carrying out the acceptance tests and any re-tests that may be necessitated by failure of the installation or by any other causes within his control.

The Contractor shall ensure that the fuel supplied for use in acceptance tests is part of a batch for which certified test data is available. Two copies of the test certificate shall be supplied to the Project Manager prior to the commencement of tests.

During the testing period the Contractor shall appoint a qualified personal to carry out the checking and testing the testing instrument (equipment which are to be used for the test) including accurately calibrated test equipment for checking the accuracy of gauges and instruments forming part of or supplied with the installation.

Prior to commencement of testing a detailed list of the equipment shall be submitted to the Project Manager for his approval and no item on the list shall be removed from the site without his consent until the completion of testing.

5.7.9. DG Controller and Automatic Mains Failure

Scope

The scope of this section comprised of design, procurement, fabrication, supply, installation earthing, testing & commissioning of Synchronizing, and AMF/Aux. panels. These panels shall be suitable for operation on 3 Phase 415 volts, 50 cycles. The Enclosure shall be. Suitable thickness as per type approval Certificate of CPCB and should have CPRI/ERDA/ NABL accredited Lab approved.

Synchronizing panels and AMF/Aux. panels shall comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-13947-1993.

Construction Features

Technical and Functional Requirement including construction for the Panel / Switch Board, Bus Bar, Breakers and auxiliaries etc. has been specified with this specification, under previous Chapter – 4, the same constructional and technical feature is applicable with the AMF Panel. The contractor shall develop design and drawing for acceptable for approval the Engineer.

The DG Controller and Automatic Mains Failure panels shall be 2 mm thick sheet steel cabinet dead front, floor / wall mounting type IP 54 (IEC) for indoor installation and shall be form 3b construction.

5.7.10. DG Controller Function

General

The auto synchronizing cum LT panel shall have DG controller with following general requirements for AMF start, Auto synchronizing and Auto Load sharing functions.

AMF function

In the case of failure of normal power supply of individual substations

1. Generator to start after a prefixed time of three second on any of the following conditions:
   a. Total absence of voltage.
   b. Failure of one or two phases.
   c. Under voltage below 375 volts.
   d. Overvoltage of more than 6%.
2. After a lapse of 10-12 seconds normal power supply breaker to open and Generator supply breaker to close.
3. All auxiliaries (Cooling Tower Fan, Pump etc.) to run automatically.

In the case of Resumption of Normal Power supply:

1. Generator breaker to open and normal power supply breaker to close after three seconds on resumption of normal power on the following conditions.

a. All the three phases available at the normal supply breaker.
b. 380-415 volts available at the normal supply breaker.

2. Generator to over run for the three minutes and stop automatically.

3. All auxiliaries to stop automatically.

4. Generator to be ready for the next operation automatically.

5.7.11. Auto Synchronizing & Auto Load sharing function

A. Sequence of Operation in Auto Mode.

In auto mode Master GENERATOR set (Selected by DG controller) shall start through cranking relay & close its ACB / NIC after verifying frequency and voltage. However, the transfer of load shall take place only when the generator output reaches 90% of its rated voltage and frequency.
As load increases beyond 90% (settable from 80 to 100%) of ratings of DG set which is running, other generator will start and synchronize on the same bus. Required no of DG sets as per demand shall run, synchronized automatically and shall feed the loads accordingly

As the load increases or decreases, accordingly switching ON and OFF the generator on the synchronizing bus shall continue with the help of DG controller. If any time only one Generator coming, and the load is increased suddenly more than the available capacity then noncritical load shall drop out from the bus automatically through DG controller and same shall come on automatically if other Generator shall start and synchronize on the same bus.

Auto Synchronizing system shall verify the phase angle of all the sets and compensate for ACB closing time by initiating closing of the breaker ahead of the actual predictable synchronism hereby ensuring a phase difference of zero degree. The breaker closing command shall not be given at a phase angle difference of + 4% in any circumstances.

The synchronizing system shall operate the generator ISOCHRONOUS mode by setting Droop to Zero. The system shall have a direct analogue interface with the AVR & Governor for direct bias control. No motorized potentiometers shall be acceptable.

- Failure of any synchronizing module shall not disturb the synchronizing of other generator.
- Failure of any one DG controller shall not affect the synchronizing system which shall be independent of each other.

System shall also monitor the slip frequency and the Beat Voltage of the machine or system.

NIC of First generator shall remain in Ckt. In the event of shutting OFF First Set, NIC of any other generator shall close first before tripping NIC of first set. It shall be possible to alter sequence of generator starting through, manual selection or through, Man Machine interface.

Active and reactive power shall be made equal on all the machines automatically with the help of ACTIVE LOAD BALANCING System through Governor Control.

In event of set failing to Synchronize, Alarm from annunciator shall invite attention of OPERATOR for manual intervention.

LOAD MANAGEMENT SYSTEM shall have 64 output contacts for tripping various loads by field wiring and trip the ACB of different generator and give ALARM for shutting OFF generator in accordance with predefined parameters to avoid underloading, overloading, cascading effect of tripping and unnecessary FUEL WASTAGE.

On the removal of load, generator ACB's & Bus Coupler ACB's shall be switched OFF in preset sequence with time delays to cover DIPS. Generator shall continue to run for 3 Minutes at reduced speed after generator ACB has been switched OFF.

DG controller System shall have compatibility for interface with PC (for Graphic Displays / Report Generation).

All axillaries (Cooling tower fan, pumps supply air fans etc.) to come on Automatically.

Engine start stop control system shall be mounted on the generator panel.

Note:
2.0 KVA on-line single-phase input / single phase output (230 V) UPS with 30 minutes battery backup to be provided along with the synchronizing panel.

B. Sequence of Operation in Manual Mode
(Through DG controller)

- In the manual mode master generator set shall be started by pressing 'Engine Start' Push Button (PB)
- When Engine starting push button is pressed cranking relay shall be energized and give starting signal to the engine.

- After full voltage is build up, breaker of the Master generator shall close manually with the help of breaker control switch.

- When breaker Control switch is turned to 'CLOSE' position, breaker as per following sequence:

  a. DG controller /Main Selector Switch shall be in Manual Mode.
  b. Solo/Parallel Selector Switch being in 'Solo' mode.
  c. With the conditions mentioned above fulfilled and breaker control switch in 'Close' position, Neutral contactor shall be energized.
  d. Closing command to the generator breaker shall be given.

- under manual mode care shall be taken, to synchronize the follower generator sets with the 'Master' before closing its breaker.

- For synchronizing the generator in manual mode, voltage/frequency raise/low commands shall be given to Alternator/Engine with the help of 'Joy sticks' provided in the Relay/Synchronizing Panel.

  While synchronizing the generator, manually, all the parameters viz. voltage, frequency and phase rotation shall be monitored with the help of Double voltmeter, Double Frequency Meter and Synchrony scope provided in the Relay/Synchronizing Panel and breaker shall be closed only when all the three parameters are matched properly.

- Active/Reactive load sharing between all the running sets in manual mode shall be managed by raising/lowering voltage/frequency with the help of joy sticks.

- During the parallel operation of Power Generating sets in 'Manual Mode', Neutral contact of only master generator shall close. This shall be assured by interlocking the neutral contactors of all the generator.

5.7.12. Summary of Functions

The following functions shall be performed by the controller for Synchronizing the generating sets.

- Automatic starting of generating sets.
- Automatic Synchronization of all available generating sets.
- Automatic load sharing between generators, active as well as reactive load sharing.
- Starting & stopping of generators as per load requirement.
- Monitoring of engine & alternator condition and protections.
- Complete load management as per requirement.

The control functions shall be as follows:

Engine Control

- Engine pre-glow control
- Fuel solenoid control
- Engine starter control
- KVA controlled cool-down timer
- Speed monitoring
- Over-speed protection
- Oil pressure monitoring
- Water temperature monitoring
- Battery voltage monitoring.

Engine Protective Features

- High / Low coolant temperature
- High / Low oil pressure
- Over-speed
- Start Failure

Generator Protective Features

- Over / Under voltage.
- Over / Under Frequency
- Reverse Power (Inverse time delay)
- Loss of Excitation
- Over Current (Inverse time delay)

MMRDA

- Loss of Utility power detection
- Load Surge
- Current Unbalance
- Voltage Unbalance

Real (KW) Load Control

- True RMS power calculations accurate control
- Configurable loading / unloading ramp rates.
- Isochronous load sharing
- Soft Utility transfer function
- Externally adjustable base load of process reference levels with independent ramp rates.

Dynamic Synchronizing (Mandatory Features)

- Digital signal processing to eliminate harmonic issues
- Adjustable phase window, voltage window, dwell times
- Safe dead bus closing logic internal to the control
- Multiple shot re-closing with adjustable time delays
- Manual voltage & speed adjusts for manual synchronizing

Reactive (KVAR) Control

- VAR sharing on isolated busses using %age base reactive load sharing.
- Power factor or VAR control when base loaded
- Externally adjustable VAR of PF set point levels.

Control System

- All the electrical parameters are monitored centrally through DG controller. All the electrical data is brought to the DG controller & then DG controller controls the complete Synchronizing, Load Control & Management system.
- No motorized potentioners are used. AVR & Governor are given direct bias control (Analog / Plum Commands).
- There are two options provided for control, monitoring & data logging functions.
  a. Graphic display terminal with printer option
  b. IBM PC based complete SCADA station (PC-PLC connection over Ethernet-100 Mbps).

- Min PC requirements:
  a. Windows NT or 2000 professional
  b. P-IV, 256 MB, 40 GB, FDD, 52 X CD ROM, MM Speakers, LAN (Ethernet Port), 2 x USB ports, 2 x COM ports, 1 x Parallel port.
  c. 15" colour monitor
  d. 132 Col. Dot matrix printer

5.7.13. Synchronizing Logic

The system shall be capable of a dynamic synchronization as described above, where the generator frequency is controlled to be slightly higher than the bus bar frequency, when the breaker closes. This shall ensure that the generator will start to take load the moment the generator breaker is closed. The frequency difference between generator & bus bar now of synchronization shall be programmed. Breaker time shall be adjusted to ensure breaker closure at the exact point of synchronization. System shall control the voltage under synchronization if necessary.

Channel No.	Inscription
01	G-1 Fails to Synchronize
02	G-1 Fails to Start
03	G-1 Neutral Discrepancy
04	G-1 ACB Fails to Close
05	G-2 Fails to Synchronize
06	G-2 Fails to Start
07	G-2 Neutral Discrepancy
08	G-2 ACB Fails to Close
09	Bus Coupler ACB-1 Fails to close

During synchronization system shall supervising the frequency of the generator voltage to make sure that the genset is not unstable due to a cold fuel / genset or an uneven fuel supply. The two frequencies must be within the accepted slip-frequency in 200 mili sec before synchronization.

The system shall synchronize the generator to the bus, when all below conditions are fulfilled:

- A control order is given by setting the input "start synchronizing / regulating"
- Feedback signal from breaker "GCB open" is present.
- Bus bar voltage is present
- Generator voltage is present

The voltage regulator in the system shall start when the frequency is within 90% of nominal frequency.

System shall close the breaker without synchronization, when all the following conditions are fulfilled:

- Display setting "Black busbar operation is ON.
- A control order is given by setting the input "start synchronizing / regulating"
- Feedback signal from breaker "GCB open" is present.
- Bus bar voltage is not present (Black bus bar)
- Generator voltage is present.

Monitoring

Following electrical parameters shall be monitored by DG controller-based system, which shall be connected through set of CT / PT's & shall indicate the following:

- Voltage – all phases (Line & Phase both)
- Current – all phases.
- Frequency
- Power factor
- KVAR
- KVARH
- KW
- KWH

All these parameters shall be displayed & shall be used for Load Management & Safety functions. Limits can be assigned to each parameter in the PLC for alarm & recording / logging purposes.

System shall include the following features:

- The system shall work on Isochronous principle thus avoiding the problem of Droop adjustment. The frequency shall remain constant at all loads.
- Automatic dead bus closing.
- Active & reactive load sharing.
- Modular system & each module shall be independent of the other. The breakdown of one section shall not effect the other.
- The synchronizing module shall directly communicate with the electronic governors and shall connect to the load control lines of governor directly.

Solid State Annunciator for Auto Synchronizing Panel (Typical for Two DG with Bus Coupler)

5.7.14. Indication

The followings Indicating Light shall essentially be provided:

- 1 No. Spring charged Indicating Light.
- 1 No. Neutral ON Indicating Light.
- 1 No. Neutral OFF Indicating Light
- 1 No. Trip Indicating Light
- 3 Nos. Ph. Indicating Light
- 1 No. ACB ON Indicating Light
- 1 No. ACB OFF Indicating Light
- 1 Set Control MCB.
- 1 set push buttons for generator start / stop, master changing, speed decrease / speed increase, voltage decrease / voltage increase.

5.7.15. Protection through Relays

(Applicable for both synchronizing and AMF panel)

Following protection shall be provided through relay both for the stator side and the rotor side:

i) Differential Protection (87 G)

Relay shall be percentage biased, low impedance differential relay with following features:

Relay shall provide percentage biased differential protection with dual slope characteristics.

ii) Restricted Earth fault Relay: Relay shall have REF protection element (64R), which shall monitor the generator for internal earth faults. It has a built-in O/C protection, as a backup.

iii) Over voltage and under voltage protection.

In addition to above, following relays to be provided

- Master Trip Relay
- Trip Circuit Supervision Relay
- Engine Cranking Relay

5.7.16. **Metering** for Each Generator

As mentioned in the Schedule of Quantities.

5.7.17. **Annunciation**

Annunciation with Hooter, Test, Accept and Reset P.B. and Annunciator.

16 Window Solid State Annunciator for each DG sets.

Channel No.	Inscription
01	Set fails to start (only alarm)
02	Over current (breaker trip)
03	Earth Fault (Breaker trip)
04	Excitation Failure (Engine should be stop with breaker trip)
05	Reverse Power (Breaker trip)
06	Emergency Shutdown (Breaker will trip with engine stop command)
07	Over speed (Breaker will trip with engine stop command)
08	Low Lube Oil pressure (Breaker will trip with engine stop command)
09	High Water Temperature (Breaker will trip with engine stop command
10	Under Voltage (Breaker trip)
11.	Over Voltage (Breaker trip)
12	Bearing Temperature high (breaker will trip with engine stop command)
13.	Under Frequency (Breaker trip)
14	Over Frequency (Breaker trip)
15.	Winding Temperature High Breaker with trip with engine stop command)
16.	Low fuel oil level (only alarm at preset level.

5.7.18. **Battery** Charger

General

The battery charger shall be Float cum Boost type Thyristor controlled. The charger shall have selector switch for Auto Float – Boost / Manual Float / Manual Boost Mode of operation. During Auto Float – Boost Mode, Automatic Changeover shall take place from

Float Mode to Boost mode and Vice-Versa. This means that when the Batteries are fully charged the charging shall automatically change from Boost charge to trickle charge.

Construction Feature

The battery charger shall be housed in sheet steel cubicle of Angle Iron framework with sheet steel panels of 1.6 mm thickness. Louvers shall be provided in the cabinet for the ventilation. The cubicle shall be painted in Siemens Grey shade RAL7032 of IS-5. Four wheels shall be provided at the base.

Performance

The D.C output voltage of Float / Boost charger shall be stabilized within ± 2% for AC input variation of 230 V ± 10%, frequency variation of 50 Hz ± 5% and DC load variation of 0-100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content will be within 3% of DC output nominal voltage.

There shall be provision to select Auto Float / Manual Float / Manual Boost modes. During Auto Float Mode the battery charging shall automatically changeover from Boost Mode to Float Mode and Vice Versa. During Manual Float / Boost modes it shall be possible to set the output volts by separate potentiometers.

The battery charger shall have automatic output current limiting feature.

Components

The battery charger shall essentially comprise of the following

- 1 No. double pole ON/OFF MCB at AC input.
- 1 No. pilot lamp to indicate charger ON.
- 1 No. Main Transformer: Double wound, naturally air cooled, having copper winding.
- 1 set single phase full wave bridge rectifier consisting of 2 Nos. diodes and 2 Nos. SCRs, liberally rated, mounted on heat sinks and complete with resistor / condenser network for surge suppression.
- 1 No. rotary switch to select auto float / manual float / manual boost. During auto float mode automatic changeover shall take place from float mode to boost mode and vice versa.
- 1 set solid state constant potential controller to stabilize the DC output voltage of the float cum boost charger at ± 2% of time set value for AC input voltage variation of 230 V ± 10%, frequency variation of ± 5% from 50 Hz and simultaneous load variation of 0-100% and also complete with Current Limiting Circuit to drop the Float Charger output voltage upon overloads to enable the battery to take over.
- 1 No. electronic controller to automatically changeover battery charging from boost to float and vice versa.
- 1 No. DC ammeter and toggle switch to read charger output current and battery charge / discharge current.
- 1 No. moving coil DC voltmeter to read the DC output voltage.
- 2 set potentiometers to adjust the output voltage during manual /auto float and boost modes.

- 2 No. double pole ON/OFF MCB at DC output, 1 No. at charger output and the other at load.
- 2 set DC output terminals. 1 set for the load and the other set for the battery.
- Alarm Annunciation: Visual and audible alarm with manual accept reset facility shall be provided for the following:

  a. AC mains fail
  b. Charger Fail
  c. Load / Output overvolt.

Rating

AC Input	:	230 V + 10% AC 50 Hz single phase.
DC Output	:	To float / boost charge 180 AH batteries and supply a continuous load.
Current Rating	:	30.0 Amps
Float Mode	:	27.0 V nominal (Adjustable) between 24-28.0 V.
Boost Mode	:	29.0 V nominal (Adjustable) between 24-32.0 V.
Voltage Regulation	:	± 2% for AC input variation of 230 V ± 10%. Frequency Variation of 50 Hz ± 5% and DC load variation 0-100%

5.7.19. Performance Tests

The schedule of tests to be performed in the Factory Acceptance Test shall include the following:

On each of three separate days and before any other operation of the diesel-alternator on that day three successful manual start-up operations to be accomplished.

Three separate manual start-up operations each within one minute of the diesel-alternator being shut down after running continuously for not less than one hour and attaining normal engine running temperatures.

Three separate automatic start-up operations with simulation of "mains failure". In all or any of these tests the diesel-alternator may be out on load by the automatic closing of the emergency power supply circuit breaker.

Three separate automatic shutdown operations, each initiated by mechanical simulation of a "low pressure" condition.

Three separate automatic shutdown operations, each initiated by manual instigation of an "over-speed" condition.

Three separate abortive start-up operations, each inducing "failure to start" shut down.

The load tests shall be carried out at manufacturer's works as follows before dispatch:

Idle Run	-	05 mins
25% Load	-	15 mins
50% Load	-	30 mins
75% Load	-	30 mins
100% Load	-	60 mins
110% Load	-	60 mins

At the completion of the test, readings shall be taken of Voltage, Frequency, Current, Temperature, Vibration, Fuel ratio to Unit produced, Flue analysis and the following:

Insulation resistance – rotor, stator, exciter – to earth;

Insulation resistance – between stator windings;

Alternator rotor and exciter armature temperature

Noise level measurement of DG set in acoustic enclosure as per specification

Site Test

Upon the delivery to the site and if the generator set is required to re-assemble on site, similar tests shall be carried out by the Contractor to ensure that the performance is not degraded.

The tests, but not limited to are:

Diesel engine-Generator coupling and shafts alignment.

On load 'mains failure' simulation test

Safety devices test

Remote monitoring

Auxiliary contacts etc.

Load tests.

BMS interface test

Load tests shall be carried out through building load (minimum 50%).

Additional Load test at any load other than building load or 100% load at site shall be optional which shall be quoted separately and will be decided by the Client. Cost to arrange the load bank for purpose of testing at site shall be included in the this separately quoted rate.

5.7.20. **PAINTING** OF PIPE WORK

All pipe work, other than buried pipes, shall be painted immediately after installation with at least one coat of red primer and two (2) finishing coats of best quality aluminum paint. The colour will be determined by the Project Manager on site.

5.7.21. VIBRATION CONTROL

The complete generator assembly shall be isolated on static deflection unhoused spring-neoprene in series isolator with non-skid neoprene pads. Start-up and shut down rocking restraint snuffers shall be provided at four corners of base frame.

All fuel line pipes shall be cushioned with a layer of harness and neoprene pad at attached points.

All pipe work and engine silencers shall be suspended on static deflection spring-neoprene in-series hangers.

Detail calculation and proposal for justifying the size and provision shall be provided for Project Manager Review prior to the installation.

Emission standards for Diesel Engines (Engine rating more than 800 KW) for generating sets

Acronyms Used

MW	:	Mega (106) Watt
NOx	:	Oxides of Nitrogen
NO2	:	Nitrogen Dioxide
O2	:	Oxygen
NMHC	:	Non-Methane Hydrocarbon
C	:	Carbon
PM	:	Particulate Matter
CO	:	Carbon Monoxide
SO2	:	Sulphur Dioxide
ppmv	:	Part per million (106) by volume
FO	:	Furnace Oil
HSD	:	High speed diesel
LDO	:	Light Diesel Oil
LSHS	:	Low Sulphur Heavy Stock
kPa	:	Kilo Pascal
mm	:	Milli (103) meter
kg/hr	:	Kilo (103) gram per hour
mg / Nm3	:	Milli (103) gram per Normal metre cubic

Area Categories A & B are defined as follows:

Category A: Areas within the municipal limits of towns / cities having population more than 10 lakhs and upto 5 km beyond the municipal limits of such towns / cities.

Category B: Areas not covered by Category A

The standards shall be regulated by the State Pollution Control Boards or Pollution Control Committees, as the case may be.

LIMITS OF NOISE FOR POWER GENERATING SETS (UPTO 1000 KVA) MANUFACTURED ON OR AFTER THE 1ST JULY 2003

Applicability

These rules apply to Generator sets upto 1000 KVA rated output, installed on or after 1st July 2003.

Requirement of Certification

Every manufacturer or importer of Power Generating set must have valid certificates of Type Approval and valid certificates of conformity of production for each year, for all the product models being manufactured or imported after 1st July 2003 with the specified noise limit.

All Power Generators shall have a valid Type Approval certificate and conformity of production certificate.

All Power Generator shall have conformance label meeting the requirements.

The conformance label shall contain the following information:

- Name and address of the supplier (if the address is described in the Owner's manual, it may not be included in the label).
- Statement "This product conforms to the Environment (Protection) Rules, 1986"
- Noise limit viz. 75 dB(A) at 1 m.
- Type approval certificate number.
- Date of manufacturer of the product.

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 testing of Generator and to give such certificates:

- Automotive Research Association of India, Pune.
- National Physical Laboratory, New Delhi.
- Naval Science & Technology Laboratory, Palghat
- National Acrospace Laboratory, Bangalore

5.8. Solar PV Generation Plant

5.8.1. General

The detail specification including functional and technical requirement for Solar System is specified under Chapter – 5, of this document.

In order to promote renewable and green energy sources, the available space on roof top of service buildings is likely to be utilized by use of roof mounted Solar Panels on the MTHL Project.

The contractor shall develop feasible study for optimum use of solar energy and design, procure, install - Grid tied SPV system (without battery) along with necessary features to supplement the grid power during daytime.

5.8.2. References Standards

Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications, as specified herein or otherwise wherever such specifications are available and applicable.

All equipment will comply with codes and standards, and other national and international codes of practice as listed below.

- IEC 61215 / IS14286: Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval
- IEC 61730 – 1: Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
- IEC 61730 – 2: Photovoltaic (PV) module safety qualification – Part 2: Requirements for Testing
- IEC 62804-1: Photovoltaic modules – test methods for the detection of potential induced degradation – Part 1: Crystalline silicon
- MNRE guidelines of 2014-15 under JNNSM
- The Inverter shall be designed to accept the PV array output and shall be listed to UL1741, IEEE 1547, IEEE 929 standards.

5.8.3. Component and Parts

Solar PV system shall consist of following equipment / components.

- Solar PV modules consisting of required number of crystalline PV cells
- Grid interactive Power Conditioning Unit with Remote Monitoring System
- Mounting structures
- Junction Boxes.
- Earthing and lightening protections
- IR/UV protected PVC Cables, pipes & accessories
- Data Acquisition System (To monitor & log-in AC Voltage, AC Output current, Output Power, Power factor, DC Input Voltage, DC Input Current, Time Active, Time disabled, Time Idle, Power produced, Protective function limits (Viz-AC Over voltage, AC Under voltage, Over frequency, Under frequency ground fault, PV starting voltage, PV stopping voltage).

5.8.4. General Requirements

All PV Panels and materials shall of a quality accepted by the Employer without any damage or breakage during transportation or installation. All metal parts shall be protected on site from rust, corrosion and dirt by properly storing, packing and covering.

The primary components of the PV System shall include rooftop integrated PV Array with auto tracking system, DC source circuit combiner boxes (outdoor duty – IP 65), DC disconnects (IP 65), electrical room disconnects and combiner, DC-AC inverter, necessary cabling, conduiting, panels etc.

Solar panels shall be installed in shadow free area.

System Requirements

Photo voltaic panels shall be polycrystalline silicon technology. Solar Panels shall be efficient & of suitable capacity to form an array of required capacity. Each module will be rated for maximum system voltage up to 1000VDC.

Solar panels shall be extremely light weight. Each solar module shall be provided with Anodized Aluminium frame to protect the module. The back of the module will be covered with a layer of mylar.

PV module Terminal box shall be IP65 with four terminal connection blocks.

PV module shall be suitable for roof temperature up to 85°C & shall be suitable for installation on roof having slope between 3° and 60°.

Each of PV circuit combiners will be designed and rated to combine series strings of Photo voltaic panels, as required. PV circuit shall be protected by DC MCBs of suitable rating. Each Circuit combiner will be provided with surge suppression device.

DC disconnects shall be designed and rated for DC power disconnecting under load.

Each DC disconnect will be provided with surge suppression device.

Exterior and interior conduit associated with the PV system shall be of appropriate Diameter. Exposed PV module wiring shall be kept to a minimum, will be properly rated for sunlight & hot temperatures associated with the PV array.

All cables shall be 1.1 KV, stranded copper, HR PVC insulation and continuous Power cables will be sized for a voltage drop of 1 % or less between PV modules and inverter.

The DC to AC Power Inverter shall be 3-phase, 50Hz, 415VAC.The inverter shall be a grid-interactive, non-battery-based, IP65, operating temperature range – 40 deg C above ambient.

The inverter peak efficiency shall not be less than 95%.

The inverter shall start, synchronize, operate, and disconnect automatically without the need for user action or intervention.

The inverter shall be protected for AC over/under voltage, AC under/over frequency, over temperature, AC and DC over current, DC over voltage etc.

Inverter will be provided with LCD display, RS485 communication.

The PV system shall have dedicated meter that records only the AC Output from the inverter of the PV system. All system components, including meters, shall comply with all applicable codes& standards.

5.9. LIST OF MAKES

SR. NO.	ITEM	MAKE / VANDOR
1	11KV RECEIVING STATION FROM BEST	Technocrafts, ABB, Siemens,
	HT METERING KIOSK	HUFFEN/LUCY ELECTRIC
	HT PANEL BUILDER	

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SR. NO.	ITEM	MAKE / VANDOR
	11KV LOAD BREAK SWITCH (SF6 INSULATED)	ABB/ SIEMENS/ SCHNEIDER
	11KV SF6 CIRCUIT BREAKER / VCB	ABB/ SIEMENS/ SCHNEIDER
	RELAYS	SCHNEIDER / AREVA / GE/ALSTOM/SIEMENS/ABB
	SMF BATTRIES &	EXIDE/ HIPOWER/ AMARON/ HBL KNIFE
	BATTERY CHARGER	EXIDE/ HIPOWER/ AMARON/ HBL KNIFE
	CONTROL /SIGNAL CABLE	POLYCAB/HAVELLS/Finolex
	MULTICORE FLEXIBLE CABLE	POLYCAB/HAVELLS/Finolex
2	11KV HV XLPE (E) CABLES,	
	11KV H.V. CABLE (XLPE)	RABIN, DUCAB, KEI, Polycab, Hawells
	11KV JOINTING KIT & TERMINATION	RAYCHEM/3M BIRLA
	BIMETALIC LUGS	COMET/COSMOSS/DOWELLS/HEX BRASS
3	CSS	
	COMPACT SECONDARY SUBSTATIONS WITH DRY TYPE TRANSFORMERS	C&S
	11KV LOAD BREAK SWITCH (SF6 INSULATED)	ABB/ SIEMENS/ SCHNEIDER
	11KV SF6 CIRCUIT BREAKER / VCB	ABB/ SIEMENS/ SCHNEIDER
	RELAYS	SCHNEIDER / AREVA / GE/ALSTOM/SIEMENS/ABB
4	1.1KV LV XLPE CABLES	
	1.1KV LV XLPE CABLES	RABIN, DUCAB, KEI
	CABLE GLANDS DOUBLE COMPRESSION WITH EARTHING LINKS	COMET/COSMOSS/BALIGA
	BIMETALIC LUGS	COMET/COSMOSS/DOWELLS/HEX BRASS
	1.1KV LV XLPE CABLES JOINTING KIT & TERMINATION	RAYCHEM/3M BIRLA
5	LT PANELS	Authorized Panel Builder of OEM
	LT PANELS BUILDER	ARROW/ZENITH/SCOTT/MARINE ELECTRICALS
	LT POWER/LIGHTING FEEDER PILLAR BUILDER	Authorized Panel Builder of OEM

SR. NO.	ITEM	MAKE / VANDOR
	DISTRIBUTION BOARDS	ABB / LEGRAND/HAVELLS/SCHNEIDER/INDOASIAN /
	SPD (SURGE ARRASTER)	PHEONIX CONTACT / OBO
	LT ACB	SCHNEIDER (MASTERPACT NW) / ABB/ SIEMENS/ LEGRAND (DMX3) / L&T (U POWER)
	LT MCCB	LEGRANDS, SIEMENS
	MCB'S ("C"/D CURVE)/DB/ELCB/RCBO	LEGRAND/HAGER//SCHNEIDER (MERLIN-GERIN)/ABB/L&T
	LT CONTACTORS	SIEMENS/ABB/SCHNEIDER (MERLIN-GERIN)
	PVC INSULATED COPPER CONDUCTORS FRLS WIRES 650/1100VOLTS	POLYCAB/KEI/HAVELLS/FINOLEX
	MULTIFUNCTION METER/AMMETER/VOLTMETER	SCHNEIDER (CONSERVE) /DUCATI/ RISHABH/SELEC
	ENERGY METER	SCHNEIDER (CONSERVE) /DUCATI/ RISHABH/SELEC
	LOAD MANAGER	SCHNEIDER (CONSERVE) /DUCATI/ RISHABH/SELEC
	INDICATING LAMPS	SCHNEIDER / L & T / SALZER
	ELECTRIC TIMER	LEGRAND / L&T / RISHABH
	ROTARY SWITCH	KEYCEE / L&T
	PUSH BUTTON AND PUSH BUTTON SET	RANK/BCH/L&T/TEKIC
	SELECTOR SWITCH, TOGGLE SWITCH	KEYCEE / L&T
	TIMER	ABB/GE POWER CONTROL/LARSEN & TOUBRO/LEGRAND/SCHNEIDER ELECTRIC/SIEMENS
	LT SERVO AUTOMATIC VOLTAGE STABILIZER & ISOLATION TRANSFORMERS	AUTOMATIC ELECTRIC/ NEEL CONTROLS/ RECON/ DATSON/ NUMARIC/EMERSON
	BATTERY CHRGERS	VOLTSTAT,
6	ILLUMINATION	
	FUNCTIONAL LED LIGHT FIXTURES	PHILIPS(SIGNIFY) / BAJAJ/ /CROMPTON
	DECORATIVE LED LIGHT FIXTURES	PHILIPS(SIGNIFY) / BAJAJ/ /NERI / CROMPTON

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SR. NO.	ITEM	MAKE / VANDOR
	OUTDOOR DECORATIVE LED LIGHT LUMINAIRE	PHILIPS(SIGNIFY) / BAJAJ/ /NERI / CROMPTON
	LED STREET LIGHTS	PHILIPS(SIGNIFY)/CROMPTON/ BAJAJ/ /NERI/LIGHTING TECHNOLOGIES
	LED FLOOD LIGHTS	PHILIPS(SIGNIFY) / CROMPTON/ BAJAJ//LIGHTING TECHNOLOGIES
	LED HIGH MAST LIGHTING SYSTEM	/ BAJAJ///VALMONT
	MOTORS	CROMPTON GREAVES/KIRLOSKAR/ SIEMENS/ABB
	DOUBLE DRUM WINCH	ISI MARKED WITH TYPE TEST CERTIFICATE
	STAINLESS STEEL WIRE ROPE	BHARAT WIRE ROPES / USHA MARTIN/ SAFELIFT
	OCTAGONAL / CONICAL SMART STREET LIGHTING POLE	PHILIPS(SIGNIFY) / BAJAJ/NERI/VALMONT
	EMBEDED LED LIGHTS	PHILIPS(SIGNIFY) / CROMPTON /BAJAJ/WIPRO/NERI
7	CENTRALIZED LIGHTING CONTROL & MONITORING SYSTEM	
	CENTRALIZED LIGHTING CONTROL & MONITORING SYSTEM	PHILIPS(SIGNIFY) / BAJAJ/WIPRO
	DMX CONTROLLERS	PHILIPS(SIGNIFY) / BAJAJ/WIPRO/ LUTRON/LEGRAND/CRESTRON / CROMPTON
	WORKSTATION FOR LIGHTING CONTROL & MONITORING SYSTEM	DELL/HP/ASUS/LENOVO
	SERVER FOR LIGHTING CONTROL & MONITORING SYSTEM	IBM/CISCO/DELL/HP
	DMX CABLES & CONNECTORS	PHILIPS/LUTRON/LEGRAND/ CRESTRON
	ARMOURED FIBER OPTIC CABLES, LIU, PIGTAILS & CONNECTORS	LEGRAND/MOLEX/3M/SYSTIMAX/PANDUIT/ SCHNIDER /D-LINK
	ARMOURED SCHIELDED CAT6 CABLES	MOLEX/LEGRAND/SCHNIDER/3M/SYSTIMAX/ PANDUIT/ D-LINK
8	CABLE TRAYS & CONDUITS	
	CABLE TRAY	ELECON, RMCOM, TRUE LADDER, INDIANA
	RACEWAY (GI CHANNELS)	ELECON, RMCOM, TRUE LADDER, INDIANA

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SR. NO.	ITEM	MAKE / VANDOR
	CABLE TRAY SUPPORTS & HANGERS	PROFAB/INDIANA/LEGRAND
	PVC CONDUITS AND ACCESSORIES	AKG / BEC /PRECISION/POLYCAB
	M.S. /GICONDUIT AND ACCESSORIES	AKG / BEC / VIMCO
9	UPS & BATTRIES	
	UPS SYSTEM	FUJI ELECTRIK
	SMF BATTRIES	ENERSYS/C&D/HOPPECKE/EXCIDE/AMRON
10	SWITCHES, SOCKETS & OTHER ACCESSORIES	
	INDUSTRIAL SOCKETS	NEPTUNE/SCHNEIDER/HENSEL / CLIPSAL/LEGRAND
	METAL CLAD SOCKET WITH MCB	NEPTUNE/SCHNEIDER/HENSEL / CLIPSAL/LEGRAND
	PVC WEATHERPROOF JUNCTION BOX	NEPTUNE/SCHNEIDER/HENSEL / CLIPSAL/LEGRAND
	PVC METALIC JUNCTION BOX	NEPTUNE/SCHNEIDER/HENSEL / CLIPSAL/LEGRAND
11	EARTHING & LIGHTNING PROTECTION SYSTEM	
	EARTHING SYSTEM COMPONENTS	OBO / ABB-FURGE/ DEHN/ INDELAC/ASHLOCK
	LIGHTNING PROTECTION SYSTEM COMPONENTS	OBO / ABB-FURGE/ DEHN/ INDELAC/ASHLOCK
12	PVC WIRES	
	STRANDED FRLS PVC INSULATED COPPER WIRE	POLYCAB/ KEI/ HAVELLS/ FINOLEX/ R R KABEL/ LAPP
	FLEXIBLE FRLS PVC INSULATED COPPER WIRE	POLYCAB/ KEI/ HAVELLS/ FINOLEX/ R R KABEL/ LAPP
13	PVC TAPE	STEEL GRIP/3M
14	OBSTRUCTION BEACON LIGHTING (LED TYPE)	ACTOS/BAJAJ/AMA/SYSCA/PHILIPS
15	415V DG SETS	PERKINS, KIRLOSKAR, CUMMINS,
16	SOLAR PV SYSTEM COMPONENTS	ACCEPTABLE MNRE APPROVED MAKE
16	CEILING FANS & EXHAUST FANS	CROMPTON GREAVES/ ALMONARD/ HAVELLES/ ORIENT/ BAJAJ
17	ELEVATORS (LIFTS)	KONE, JHONSON, OTIS, SCHNAIDER

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SR. NO.	ITEM	MAKE / VANDOR
18	EMERGENCY LIGHITNG INVERTER SYSTEM	SCHNEIDER/EATON/VERITV/DELTA/MICROTEK/SU-KAM/LUMINOUS/NUMERIC/ EMERSON

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CHAPTER – 6

6. DESIGN BASIS FOR HVAC -BUILDING:

6.1. Climatic Design Data

The following criteria have been considered in design:

6.1.1. Basis of Design

The design criterion as prescribed under Chapter shall be applicable herewith for selection of equipment and rating.

1) Outdoor Design Conditions

Outdoor Design Conditions for Mumbai are based on ISHRAE DATABOOK 2017 corresponding to 0.4% annual cumulative frequency of occurrence and are considered as follows:

Cooling (Summer)

DB (Dry Bulb)	:	35.1 Deg C
WB (Wet Bulb)	:	23.2 Deg C
Specific Humidity	:	13g/kg DA

Dehumidification (Monsoon)

WB (Wet Bulb)	:	27.7 Deg C
MC DB (Mean Coincident Dry Bulb)	:	31.4 Deg C
Specific Humidity	:	22.1g/kg DA

2) Seismic design

Building shall be designed for Seismic Zone III as per IS 1893

3) Indoor Design Conditions

Following indoor design conditions for centrally air-conditioned spaces are proposed.

Space	Indoor Conditions		Lighting	Outdoor Air Ventilation Rate Based on ASHRAE 62.1 2016
	Temp °C (°F)	(W/Sqft)	Relative Humidity %	
Offices	24±1°C (75±2°F)	1.0	Between 40% and 60% No specific RH control	5 cfm/person +0.06 cfm/sqft
Lift Lobby / Common Areas	24±1°C (75±2°F)	1.0	Between 40% and 60% No specific RH control	5 cfm/person +0.06 cfm/sqft
Server rooms	22±1°C (71.5±2°F)	1.0	Between 40% and 60% Humidifier to be provided in case of PACs	5 cfm/person +0.06 cfm/sqft
UPS rooms	25±1°C (77±2°F)	1.0	Between 40% and 60% No specific RH control	5 cfm/person +0.06 cfm/sqft
Battery rooms	25±1°C (77±2°F)	1.0	Between 40% and 60% No specific RH control	5 cfm/person +0.06 cfm/sqft

Cafeteria	25±1°C (77±2°F)	1.0	Upto 70% No specific TH control	7.5 cfm/person +0.06 cfm/sqft

4) _____Ventilation

Space	Exhaust / purge
Toilet	6 – 10 ACPH (asper NBC).
DG Room	Air cooled DG shall have its own ventilation fans
Enclosed Car Parks	6 ACPH for normal operation, accelerated to 12ACPH in case of fire operation.
Battery room	1cfm/sqft for H2 removal 12 ACPH for fire operation
Generator room	For gensets without acoustic enclosure: Max 5 Deg C temperature rise across room or as per DG manufacturer's recommendation, whichever higher For air cooled gensets, provide auxiliary cooling fan
Pantry (Non-cooking kitchen)	12ACPH
Kitchens (full cooking)	As per catering consultant's directive
Change Rooms / lockers	6ACPH
STP	30ACPH, with openings equal to 50% floor space for natural ventilation
WTP	30ACPH for plantroom area
Other Plantrooms	15ACPH

5) Emergency Ventilation

Space	Exhaust / purge
Lift well (for buildings over 15M in height)	50pa w.r.t ambient
Stairwell pressurization	2 Nos x 0.5 sqM openings on opposite or adjacent walls of the mumty for naturally ventilates stairwells 50pa w.r.t ambient for enclosed stairwells
Lift lobby / fire escape corridor	30pa w.r.t ambient
Enclosed Car parks	6ACPH for normal operation Additional 6ACPH for fire operation

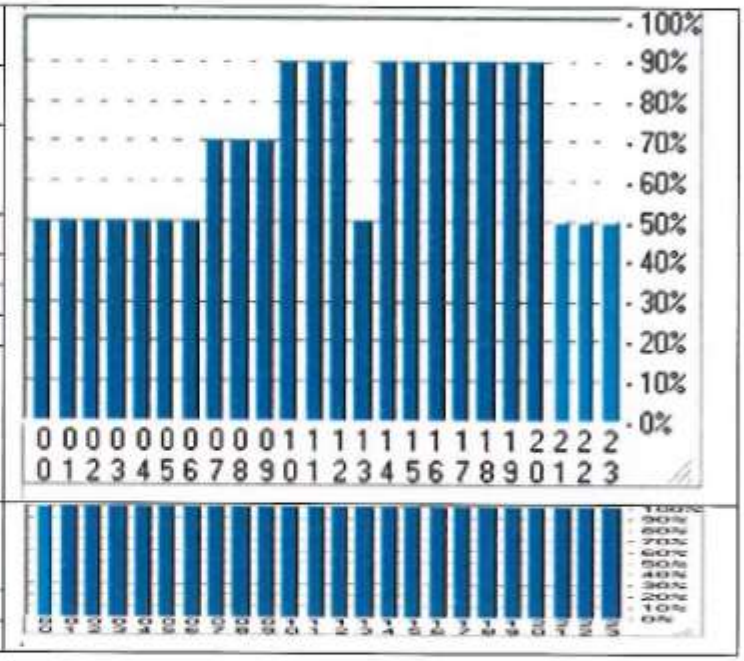
6) Construction data

Parameters	Values	Remarks
Wall	U = 0.1 Btu / hr ft2 °F (0.56 w/m2 °K)	To be confirmed by Contractor Civil team
Roof Options		
Insulated Roof	U = 0.067 Btu / hr ft2 °F (0.34 w/m2 °K)	Contractor civil team to provide U value of 0.06 Btu / hr ft2 °F of the roof slab considering over deck / underdeck insulation

Glass Specifications	Double Glass with following details: a. Glazing U = 0.61 Btu / hr ft2 °F SHGC: 0.56 60%WWR	Wall window ratio to be confirmed by contractor civil team based on energy efficiency targets and daylight analysis

7) OCCUPANCY SCHEDULES

Offices	
Hours	% Occupancy
00-06	50 (for night staff & 24x7 offices)
07-09	70
10-12	90
13	50
14-20	90
21-23	50



Control rooms / server room	
Hours	% occupancy
00-23	100

8) Design Parameters:

Variable Refrigerant Flow (VRF) System

Performance rating for the VRF system shall be based on following design parameters.

Refrigerant for VRF units	:	Refrigerant for VRF should be – HFA R410A / 407C, (as per NBC).
Maximum input power for VRF at full load	:	1.21 IKW/TR

9) Ventilation Fan:

Maximum fan outlet velocity for fan upto 450 mm dia.	:	9.14 m/sec (1800 fpm)
Maximum fan outlet velocity for fan above 450 mm dia.	:	12 m/sec (2400 fpm)
Maximum fan speed for fans upto 450 mm dia.	:	1440 RPM
Maximum fan speed for fans above 450 mm dia.	:	1000 RPM

10) **Duct Design**

Maximum flow velocity in duct for air conditioning	:	9.1 m/sec (1800 fpm).
Maximum flow velocity in duct for ventilation in Plant room, toilet exhaust and kitchen exhaust	:	7.5 to 12.5 m/sec (1500-2500 fpm)
Maximum friction	:	0.65 Pa/m run Inch WG/100ft run)

6.2. Main Administration and Command Control (Gavan)

1) SYSTEM LOAD

HVAC LOADS for MAIN ADMINISTRATION AND COMMAND CONTROL CENTER at GAVAN						
Floor/ Area /Room	**Carpet Area as per (Sqft.)**	**TR (150 sq.ft./TR)**	**Cooling load (kWc)**	**Total cooling load (kWc)**	**Electrical kW**	**Indoor unit selection**
Ground Floor						
Locker Room	530.98	3.54	12.46			Cassette Type or Duct-able.
Secured Entry	83.42	0.56	1.96			hi-wall VRF
Cashier	287.50	1.92	6.75			hi-wall VRF
Toll Pass Ticketing	67.92	0.45	1.59			hi-wall VRF
Reception	742.17	4.95	17.42			ceiling suspended ductable VRF unit
Locker Room	530.98	3.54	12.46	66.66	23.00	Cassette Type or Duct-able.
OPD	347.03	2.31	8.14			hi-wall VRF
Consulting	108.28	0.72	2.54			hi-wall VRF
Rest Room	75.45	0.50	1.77			hi-wall VRF
Visitor's Ticketing	26.05	0.17	0.61			hi-wall VRF
Visitor's Access to Gallery	40.69	0.27	0.95			hi-wall VRF
First Floor						
Documents Room	293.64	1.96	6.89			hi-wall VRF
Manager Room	523.34	3.49	12.28			cassette VRF
Staff Workstations	1384.67	9.23	32.49	80.45	28.00	2# ceiling suspended ductable VRF unit
Sales Room	229.59	1.53	5.39			hi-wall VRF
Nursing	231.21	1.54	5.43			hi-wall VRF
Dormetry	428.73	2.86	10.06			hi-wall VRF
Kitchen	233.58	1.56	5.48			hi-wall VRF
Pantry	103.38	0.69	2.43			hi-wall VRF

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HVAC LOADS for MAIN ADMINISTRATION AND COMMAND CONTROL CENTER at GAVAN						
Floor/ Area /Room	**Carpet Area as per (Sqft.)**	**TR (150 sq.ft./TR)**	**Cooling load (kWc)**	**Total cooling load (kWc)**	**Electrical kW**	**Indoor unit selection**
UPS Room	521.19	3.47	12.23	12.23	5.00	2# hi-wall (1w +1s DX)
Electrical Room	725.41	4.84	17.02	17.02	6.00	2# hi-wall (1w +1s DX)
Second Floor						
Server Room	526.14	5.26	18.52	18.52	7.00	2# DX PAC
CITY ITS UPS Room	1023.65	6.82	24.02	24.02	9.00	3# hi-wall (1w +1s DX)
Network Equipment Room	229.59	1.53				hi-wall VRF
ITS Control Room	435.08	2.90				2# VRF hi-wall + 2# DX hi-wall standby
HTMS Control Room	293.64	1.96				1# VRF hi-wall + 2# DX (1w+1s)
Toll Control Room (Manager + Staff W/S Room)	1235.16	8.23	24.32	30.00		2# ceiling suspended ductable VRF unit
ITS Staff Room	231.21	1.54				hi-wall VRF
Pre-Conference	126.91	0.85				hi-wall VRF
Reception Area	336.69	2.24				cassette VRF
Conference Room	529.05	3.53				cassette VRF
Staff Room	231.21	1.54				hi-wall VRF
Electrical Room	331.10	2.21	7.77	7.77	3.00	2# hi-wall (1w +1s DX)
Third Floor						
Server Room	526.14	5.26	18.52	18.52	7.00	2# DX PAC
Documents Room	293.64	2.94	10.34	106.66	37.00	hi-wall VRF
HTMS Control Room	1235.16	8.23	28.99			2# hi-wall (1w VRF +1s DX)
Emergency Call Box	229.59	1.53	5.39			hi-wall VRF
VMS	231.21	1.54	5.43			hi-wall VRF
Met. OBS Room	529.05	3.53	12.41			2# cassette VRF
Staff Room	231.21	1.54	5.43			hi-wall VRF
CCTV Room	435.08	2.90	10.21			2# VRF hi-wall + 1# dx hi-wall standby

HVAC LOADS for MAIN ADMINISTRATION AND COMMAND CONTROL CENTER at GAVAN						
Floor/ Area /Room	Carpet Area as per (Sqft.)	TR (150 sq.ft./TR)	Cooling load (kWc)	Total cooling load (kWc)	Electrical kW	Indoor unit selection
ATCC Room	864.56	5.76	20.29			2# VRF hi-wall + 1# dx hi-wall stand by
Waiting Area	348.98	2.33	8.19			cassette VRF
Electrical Room	331.10	2.21	7.77	7.77	3.00	2# hi-wall (1w +1s DX)
Fourth Floor						
Pre-Conference	90.09	0.60	2.11			hi-wall VRF
Pre-Conference	90.09	0.60	2.11			hi-wall VRF
Conference Room	649.28	4.33	15.24	44.08	16.00	2# cassette Type
Conference Room	649.28	4.33	15.24			2# cassette Type
Reception	348.98	2.33	8.19			2# cassette VRF
Information Kiosk	50.77	0.34	1.19			hi-wall VRF

Notes

1. $: These loads are based on thumb rule. The values and equipment selections may be inaccurate and serve as a guide for possible system solution. Contractor shall submit proper load calculation as part of detailed working Indoor unit types shall be selected by Contractor and approved by the Engineer
2. Electrical equipment heat rejections to be confirmed and added when calculating final heat loads.
3. The heat load on account of electrical loads, rooms area and occupancies as indicated above are for reference only, however, the contractor shall liable to undertake detail design and develop the sizes and rating as per actual site conditions.

6.2.1. System Description

Variable Refrigerant Flow Control System

The air conditioning system shall consist of air cooled centralized outdoor unit comprising of multiple scroll compressors for each area. All air-conditioned spaces in the building shall be provided with required capacity indoor unit (type- hi- wall/ducted/cassette). These indoor units shall be connected to outdoor units through copper refrigerant pipe system. Compressor in the outdoor unit shall be connected to a variable frequency drive whereby refrigerant flow through copper pipe shall be varied based on the AC load. The outdoor unit shall have built-in energy efficiency features like capacity control, oil return operation controls, intelligent defrost control and compressor control etc.

VRF system

The indoor units shall be similar in operation and appearance as conventional indoor units of split units and provide independent on-off control, temperature setting etc.

4 WAY CASSETTE	Ductable unit	one-way cassette unit
		
		

The system shall provide considerable energy saving over traditional air-conditioning system (consisting of split units) due to following features: -

Individual accurate temperature control

Multiple compressors in outdoor unit (8 HP & Above) in conjunction with inverter drive compressor to modulate refrigerant flow based on requirement.

Minimizing heat transfer losses due to superior refrigerant piping system with ecofriendly refrigerant. Temperature setting of each indoor unit shall be controllable through individual corded micro-processor-based controller.

The outdoor units will be mounted on Service Slab / space allocated by architect in open space available.

The indoor and the outdoor units would be interconnected with refrigerant piping and cabling. Piping shall be duly supported with cable trays

Each indoor unit's hall be provided with a wireless controller (for hi-wall type units) or wired wall mountable controllers for ductable units

Refrigerant pipes from outdoor unit to wall indoor split units shall generally be routed along the perimeter of walls or beam leading to the DX wall mounted high wall split unit. These pipes shall be enclosed within bulkheads / pelmets / false beams and necessary aesthetic treatment by the Architect is required to blend with the interior if there is no false ceiling

The Condensate drainpipes will be routed to nearest drain point. Preferably gravity drained condensate drain arrangement shall be prioritized by locating the indoor units close to drain points or by selecting ductable units for large spaces instead of hi-walls or cassette units. If the same is not possible, the indoor unit's hall include a condensate pump for pumping out the condensate

Scope of supply shall include mounting frames and stands as required for installation

DX units for critical area such as UPS and SERVER room

Systems are designed and selected keeping in mind the limited space availability for accommodating all services equipment and operational flexibility for UPS and SERVER area

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Provision of Space must be considered for the Industrial type Split Units for smaller rooms and DX PACs for larger rooms. This system will provide year-round thermal environmental for proposed area considering all the constraints.

Indoor units selected would be in accordance to the interior requirement matching to the system performance, to achieve the desired room conditions.

Units will eb selected in 1W+1S configuration. If VRF Outdoors are connected to these units, the two indoor units in each room shall be connected to different outdoor units

The outdoor units will be mounted on Service Slab / space allocated by architect in open space available.

The indoor and the outdoor units would be interconnected with refrigerant piping and cabling. Piping shall be duly supported with cable trays

Every specific zone or room would be provided with a self-diagnostic cordless remote controller to have individual system control.

Refrigerant pipes from outdoor unit to wall indoor split units shall generally be routed along the perimeter of walls or beam leading to the DX wall mounted high wall split unit. These pipes shall be enclosed within bulkheads / pelmets / false beams and necessary aesthetic treatment by the Architect is required to blend with the interior if there is no false ceiling.

The Condensate drainpipes will be routed to nearest drain point.

Scope of supply shall include mounting frames and stands as required for installation

DX units for Electrical room

Remote Control

Car Park Ventilation

As defined in the National Building Code of India, car parking areas shall be treated as naturally ventilated if they meet the following criteria

0.4sqM opening per running meter on façade
No part of the parking should be more than 30M from façade
50% of perimeter (length) should be open or 75% of perimeter has 50% openings.
As per architectural design, all car parks meet this norm, hence no car parking ventilation is required

Plant Room Ventilation

Plant rooms shall be provided with mechanical ventilation. The system shall consist of tube axial or propeller fans for supply & exhaust air. Ventilation air quantity shall be considered as per latest NBC

Battery Room Ventilation

Battery rooms shall be ventilated using 2 Nos fans per room

Fan-A	Sized for 1cfm/sqft and scheduled to operate based on H2 sensor located within the room. The motor shall be spark-proof. The panel shall be provided with in-built timer to switch OFF the fan after a preset time (say 300 seconds) once triggered
Fan-B	Sized for 12ACPH as scheduled to operate of signal from fire alarm panel. This fan and motor shall be fire rated to 250 Deg C for 2 hours or as indicated in the specifications

Tunnel ventilation

A tunnel is planned from the toll plaza to the main building for ferrying cash manually to the main building. The same shall be ventilated at 12ACPH. Roof extractor type ventilation fans shall be provided for ventilating the tunnel with fresh air intake at one end and exhaust at another end. Both fresh air and exhaust shall be provided with curb walls that prevent water ingress. The fans shall be fire rated as per EN12101 at 250 Deg C for 2.5 hours

Staircase / Lift Well Pressurization

All staircases above ground floor adjacent to ambient shall be naturally ventilated. with minimum opening of 0.5 sq.mt.each landing, hence,

For stairwells which are enclosed inside the building, pressurization shall be provided to maintain the stairwell at 50pa with respect to ambient

Lift wells shall be provided with pressurization with pressure of 50 Pascal by supplying the air through supply air fans installed on roof top.

Lift lobbies shall be pressurized at 30pa with respect to ambient to prevent ingress of smoke during fire evacuation. Protection through pressurization shall be extended to any egress corridors connecting to the lift lobbies

Axial Fan

Cabinet Type Centrifugal fan

Suitable make up arrangement shall be provided to the battery room for inlet of fresh air when fan operates

6.2.2. General Ventilation

Generator room ventilation

Generator room ventilation shall apply to open DG sets located within building floor print

Generators shall be air-cooled (radiator cooled) type. The radiator fan itself shall provide required air flow through the room. To achieve this, the radiator and fan shall be enclosed in a plenum. When operating, the radiator fan shall draw air from within the generator room and discharge the same outside through the plenu box. The plenum will act as a cowl to prevent any hot air recirculation within the room. The radiator fan shall be designed to maintain a 5 Deg C dT across the DG room and the heat rejection of the alternator, switch gear and engine skin radiation shall be considered for the purpose. Makeup air shall be drawn in through a set of louver located on the alternator side. The room shall be acoustically insulated and both fresh air and exhaust louvers shall be provided with attenuators to reduce sound outsode DG room to 75dBA. After the DG has come off load, the DG will continue to operated at no load for a short period of time to prevent radiator water heat soak. Subsequently, an auxiliary fan shall be operated to remove residual heat inertia from the room and DG shell. The auxiliary fan shall operate till room temperature reached 5 Deg C above ambient or for 30 minutes, whichever earlier

Ventilation cash handling rooms

Due to possibility of pathogens on the surface of currency notes, cash handling rooms shall be air-conditioned separately from the rest of the spaces. Though the refrigerant side can be common, there shall be no return air taken from cash handling rooms. Also, these rooms

shall be provided air equal to a dedicated exhaust of 0.5 cfm / sqft. These rooms shall be maintained at a slight negative pressure with respect to ambient

Mechanical Ventilation for Toilets & Kitchen

Wall mounted exhaust fan with back draft damper are proposed for individual toilets on external wall and Ceiling suspended exhaust fan are proposed for toilets not having walls exposed to atmosphere. louvered area at each exhaust air opening is proposed.

For kitchen exhaust, individual fan is proposed in each kitchen. Fan will be provided with back draft damper to avoid recirculation of air back in the kitchen. louvered area at each exhaust air opening is proposed.

Rewarming pantries will be provided with a simple exhaust system with no pretreatment of exhaust air. Full cooling kitchens shall be provided with electrostatic scrubbers in the exhaust streams to remove the cooking grease from air stream before discharge to ambient

6.2.3. Air Distribution7

Air Distribution System:

All ducts shall be factory fabricated from galvanized steel sheets (Class VII) light coating of zinc, nominal 180 gm/sq.m. Surface area and Lock Forming Quality prime material along with mill test certificates, of various thicknesses ranging from 26 gauge to 18 gauge according to duct sizes and in accordance with SMACNA standards. Galvanized steel sheets shall be produced by hot dip process. Grilles/ diffusers shall be powder coated extruded aluminium construction and shall be provided as per the requirement of interior design.

Insulation:

Insulation: Insulation material for ducts & pipes shall be closed cell electrometric nitrile rubber or cross-linked polyethylene foam. Nitrile rubber pre-moulded pipe sections shall be used for branch pipes of smaller diameter only. Pipes provided with thermal insulation shall be provided with protective coating against mechanical damages. All exposed thermal insulation shall be provided with Aluminum cladding including those inside the plant room.

Sound & Vibration isolator:

Mechanical services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source to achieve acceptable noise rating for NC levels for occupied spaces. Vibration isolators shall be designed for minimum isolation efficiency of 90%. All items of rotating / reciprocating plant and equipment shall be isolated from the foundation / structure using anti-vibration materials, mountings or spring-loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.

Sound Attenuators / acoustic lining shall be installed in ducts in accordance with requirements of drawings and shall be as per specifications. Acoustic performance of the attenuators (net insertion loss) shall meet or exceed the specified values

Seismic resistance

Building services and all equipment shall be provided with seismic bracings to withstand earthquake as per seismic zone. Calculations for seismic design shall be included with the detailed submissions

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6.3. Sub-Administration Center at Shivajinagar Interchange

SYSTEM LOAD

HVAC LOADS FOR SUB- ADMINISTRATION CENTER AT SHIVAJINAGAR INTERCHANGE						
Floor/ Area /Room	Carpet Area (Sqft)*	TR ($)	Cooling load (kWc)	Total cooling load (kWc)	Electrical kWe	Indoor unit selection
GROUND FLOOR						
medical officer cabin	97.36	0.65	2.28	38.04	13.10	hi-wall VRF
Cashier	136.38	0.91	3.20			hi-wall VRF
OPD Area & First Aid	511.08	3.41	11.99			cassette VRF
Nursing Staff Room	101.18	0.67	2.37			hi-wall VRF
Manager	198.59	1.32	4.66			hi-wall VRF
Audit	92.03	0.61	2.16			hi-wall VRF
Documents	101.07	0.67	2.37			hi-wall VRF
Reception	383.19	2.55	8.99			cassette VRF
FIRST FLOOR						
Server Room	139.18	0.93	3.27	3.27	2.00	2# DX PACs
UPS Room	296.98	1.98	6.97	6.97	3.00	2# hi-wall (1w +1s DX)
Reception/Preconference						
IT Staff	141.01	0.94	3.31	18.10	7.00	hi-wall VRF
Conference Room	387.39	2.58	9.09			hi-wall VRF
Staff Workstation Room	242.73	1.62	5.70			hi-wall VRF

Notes

1. $: These loads are based on thumb rule. The values and equipment selections may be inaccurate and serve as a guide for possible system solution. Contractor shall submit proper load calculation as part of detailed working Indoor unit types shall be selected by Contractor and approved by the Engineer
2. Electrical equipment heat rejections to be confirmed and added when calculating final heat loads.
3. The heat load on account of electrical loads, rooms area and occupancies as indicated above are for reference only, however, the contractor shall liable to undertake detail design and develop the sizes and rating as per actual site conditions.

6.3.1. System Description

Variable Refrigerant Flow Control System

The air conditioning system shall consist of air cooled centralized outdoor unit comprising of multiple scroll compressors for each area. All air-conditioned spaces in the building shall be provided with required capacity indoor unit (type- hi- wall/ducted/cassette). These indoor units shall be connected to outdoor units through copper refrigerant pipe system.

Compressor in the outdoor unit shall be connected to a variable frequency drive whereby refrigerant flow through copper pipe shall be varied based on the AC load. The outdoor unit shall have built-in energy efficiency features like capacity control, oil return operation controls, intelligent defrost control and compressor control etc.

VRF system

The indoor units shall be similar in operation and appearance as conventional indoor units of split units and provide independent on-off control, temperature setting etc.

4 WAY CASSETTE	Ductable unit	one-way cassette unit
		
		

The system shall provide considerable energy saving over traditional air-conditioning system (consisting of split units) due to following features: -

Individual accurate temperature control

Multiple compressors in outdoor unit (8 HP & Above) in conjunction with inverter drive compressor to modulate refrigerant flow based on requirement.

Minimizing heat transfer losses due to superior refrigerant piping system with ecofriendly refrigerant. Temperature setting of each indoor unit shall be controllable through individual corded micro-processor-based controller.

The outdoor units will be mounted on Service Slab / space allocated by architect in open space available.

The indoor and the outdoor units would be interconnected with refrigerant piping and cabling. Piping shall be duly supported with cable trays

Each indoor unit's hall be provided with a wireless controller (for hi-wall type units) or wired wall mountable controllers for ductable units

Refrigerant pipes from outdoor unit to wall indoor split units shall generally be routed along the perimeter of walls or beam leading to the DX wall mounted high wall split unit. These pipes shall be enclosed within bulkheads / pelmets / false beams and necessary aesthetic treatment by the Architect is required to blend with the interior if there is no false ceiling

The Condensate drainpipes will be routed to nearest drain point. Preferably gravity drained condensate drain arrangement shall be prioritized by locating the indoor units close to drain points or by selecting ductable units for large spaces instead of hi-walls or cassette units. If the same is not possible, the indoor unit's hall include a condensate pump for pumping out the condensate

Scope of supply shall include mounting frames and stands as required for installation

DX units for critical area such as UPS and SERVER room

Systems are designed and selected keeping in mind the limited space availability for accommodating all services equipment and operational flexibility for UPS and SERVER area

Provision of Space must be considered for the Industrial type Split Units for smaller rooms and DX PACs for larger rooms. This system will provide year-round thermal environmental for proposed area considering all the constraints.
Indoor units selected would be in accordance to the interior requirement matching to the system performance, to achieve the desired room conditions.

Units will eb selected in 1W+1S configuration. If VRF Outdoors are connected to these units, the two indoor units in each room shall be connected to different outdoor units

The outdoor units will be mounted on Service Slab / space allocated by architect in open space available.

The indoor and the outdoor units would be interconnected with refrigerant piping and cabling. Piping shall be duly supported with cable trays

Every specific zone or room would be provided with a self-diagnostic cordless remote controller to have individual system control.

Refrigerant pipes from outdoor unit to wall indoor split units shall generally be routed along the perimeter of walls or beam leading to the DX wall mounted high wall split unit. These pipes shall be enclosed within bulkheads / pelmets / false beams and necessary aesthetic treatment by the Architect is required to blend with the interior if there is no false ceiling.

The Condensate drainpipes will be routed to nearest drain point.

Scope of supply shall include mounting frames and stands as required for installation

Car Park Ventilation

As defined in the National Building Code of India, car parking areas shall be treated as naturally ventilated if they meet the following criteria

- 0.4sqM opening per running meter on façade
- No part of the parking should be more than 30M from façade
- 50% of perimeter (length) should be open or 75% of perimeter has 50% openings.

If these conditions are not satisfied, car park shall be mechanically ventilated at 6ACPH normal and 12 ACPH in case of fire. Car Park Ventilation under Normal Case – (25ppm<CO<40 PPM)

As all car parking's satisfy above conditions, car park mechanical ventilation is not provided

Plant Room Ventilation

Plant rooms shall be provided with mechanical ventilation. The system shall consist of tube axial or propeller fans for supply & exhaust air. Ventilation air quantity shall be considered as per NBC 2016.

Battery Room Ventilation

Battery rooms shall be ventilated using 2 Nos fans per room

Fan-A	Sized for 1cfm/sqft and scheduled to operate based on H2 sensor located within the room. The motor shall be spark-proof. The panel shall be provided with in-built timer to switch OFF the fan after a preset time (say 300 seconds) once triggered
Fan-B	Sized for 12ACPH as scheduled to operate of signal from fire alarm panel. This fan and motor shall be fire rated to 250 Deg C for 2 hours or as indicated in the specifications

Tunnel ventilation

A tunnel is planned from the toll plaza to the main building for ferrying cash manually to the main building. The same shall be ventilated at 12ACPH. Roof extractor type ventilation fans shall be provided for ventilating the tunnel with fresh air intake at one end and exhaust at another end. Both fresh air and exhaust shall be provided with curb walls that prevent water ingress. The fans shall be fire rated as per EN12101 at 250 Deg C for 2.5 hours

6.3.2. General Ventilation

Generator room ventilation

Generator room ventilation shall apply to open DG sets located within building floor print

Generators shall be air-cooled (radiator cooled) type. The radiator fan itself shall provide required air flow through the room. To achieve this, the radiator and fan shall be enclosed in a plenum. When operating, the radiator fan shall draw air from within the generator room and discharge the same outside through the plenu box. The plenum will act as a cowl to prevent any hot air recirculation within the room. The radiator fan shall be designed to maintain a 5 Deg C dT across the DG room and the heat rejection of the alternator, switch gear and engine skin radiation shall be considered for the purpose. Makeup air shall be drawn in through a set of louvers located on the alternator side. The room shall be acoustically insulated and both fresh air and exhaust louvers shall be provided with attenuators to reduce sound outside DG room to 75dBA. After the DG has come off load, the DG will continue to operate at no load for a short period of time to prevent radiator water heat soak. Subsequently, an auxiliary fan shall be operated to remove residual heat inertia from the room and DG shell. The auxiliary fan shall operate till room temperature reached 5 Deg C above ambient or for 30 minutes, whichever earlier

Ventilation cash handling rooms

Due to possibility of pathogens on the surface of currency notes, cash handling rooms shall be air-conditioned separately from the rest of the spaces. Though the refrigerant side can be common, there shall be no return air taken from cash handling rooms. Also, these rooms shall be provided air equal to a dedicated exhaust of 0.5 cfm / sqft. These rooms shall be maintained at a slight negative pressure with respect to ambient

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Mechanical Ventilation for Toilets & Kitchen

Wall mounted exhaust fan with back draft damper are proposed for individual toilets on external wall and Ceiling suspended exhaust fan are proposed for toilets not having walls exposed to atmosphere. louvered area at each exhaust air opening is proposed.

For kitchen exhaust, individual fan is proposed in each kitchen. Fan will be provided with back draft damper to avoid recirculation of air back in the kitchen. louvered area at each exhaust air opening is proposed.

Rewarming pantries will be provided with a simple exhaust system with no pretreatment of exhaust air. Full cooling kitchens shall be provided with electrostatic scrubbers in the exhaust streams to remove the cooking grease from air stream before discharge to ambient

6.3.3. Air Distribution System

Air Distribution

All ducts shall be factory fabricated from galvanized steel sheets (Class VII) light coating of zinc, nominal 180 gm/sq.m. Surface area and Lock Forming Quality prime material along with mill test certificates, of various thicknesses ranging from 26 gauge to 18 gauge according to duct sizes and in accordance with SMACNA standards. Galvanized steel sheets shall be produced by hot dip process. Grilles/ diffusers shall be powder coated extruded aluminium construction and shall be provided as per the requirement of interior design.
Insulation:

Insulation: Insulation material for ducts & pipes shall be closed cell electrometric nitrile rubber or cross-linked polyethylene foam. Nitrile rubber pre-moulded pipe sections shall be used for branch pipes of smaller diameter only. Pipes provided with thermal insulation shall be provided with protective coating against mechanical damages. All exposed thermal insulation shall be provided with Aluminum cladding including those inside the plant room.

Sound & Vibration isolator:

Mechanical services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source to achieve acceptable noise rating for NC levels for occupied spaces. Vibration isolators shall be designed for minimum isolation efficiency of 90%. All items of rotating / reciprocating plant and equipment shall be isolated from the foundation / structure using anti-vibration materials, mountings or spring-loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.

Sound Attenuators / acoustic lining shall be installed in ducts in accordance with requirements of drawings and shall be as per specifications. Acoustic performance of the attenuators (net insertion loss) shall meet or exceed the specified values

Seismic resistance

Building services and all equipment shall be provided with seismic bracings to withstand earthquake as per seismic zone. Calculations for seismic design shall be included with the detailed submissions

MMRDA

6.4. Sub-Administration and Command Control Center at Sewri

SYSTEM LOAD

Floor/ Area /Room	Carpet Area (Sqft)*	TR ($)	Cooling load (kWc)	Total cooling load (kWc)	Electrical kWe	Indoor unit selection
GROUND FLOOR						
medical officer cabin	97.31	0.65	2.28	39.31	14.00	hi-wall VRF
OPD Area & First Aid	511.08	3.41	11.99			cassette VRF
Nursing Staff Room	164.69	1.10	3.86			hi-wall VRF
Area for Police Chowki	902.23	6.01	21.17			ductable VRF unit
FIRST FLOOR						
Server Room	101.18	0.67	2.37	2.37	1.00	2# DX PAC
UPS Room	188.58	1.26	4.43	4.43	2.00	2# hi-wall (1w +1s DX)
Documents	159.13	1.06	3.73	25.71	9.00	hi-wall VRF
Reception/Pre-Conference	277.39	1.85	6.51			cassette VRF
Conference Room	387.39	2.58	9.09			cassette type
Audit	89.66	0.60	2.10			hi-wall VRF
Manager	181.91	1.21	4.27			hi-wall VRF
SECOND FLOOR						
IT Staff Room	101.07	0.67	2.37	42.55	15.00	hi-wall VRF
N/W Equipment Room	186.97	1.25	4.39			hi-wall VRF
VMSS Room	95.48	0.64	2.24			hi-wall VRF
Emergency Call Box	97.09	0.65	2.28			cassette VRF
CCTV Room	297.94	1.99	6.99			1# DX hi-wall & 1# VRF hi-wall (1w+1s)
HTMS Room	345.74	2.30	8.11			1# DX hi-wall & 1# VRF hi-wall (1w+1s)
Control Room	443.37	2.96	10.40			1# DX hi-wall & 1# VRF hi-wall (1w+1s)
ATCC Room	245.63	1.64	5.76			1# DX hi-wall & 1# VRF hi-wall (1w+1s)

Notes

1) $: These loads are based on thumb rule. The values and equipment selections may be inaccurate and serve as a guide for possible system solution. Contractor shall submit proper load calculation as part of detailed working Indoor unit types shall be selected by Contractor and approved by the Engineer

2) Electrical equipment heat rejections to be confirmed and added when calculating final heat loads.

3) The heat load on account of electrical loads, rooms area and occupancies as indicated above are for reference only, however, the contractor shall liable to undertake detail design and develop the sizes and rating as per actual site conditions.

6.4.1. System Description

Variable Refrigerant Flow Control System

The air conditioning system shall consist of air cooled centralized outdoor unit comprising of multiple scroll compressors for each area. All air-conditioned spaces in the building shall be provided with required capacity indoor unit (type- hi- wall/ducted/cassette). These indoor units shall be connected to outdoor units through copper refrigerant pipe system. Compressor in the outdoor unit shall be connected to a variable frequency drive whereby refrigerant flow through copper pipe shall be varied based on the AC load. The outdoor unit shall have built-in energy efficiency features like capacity control, oil return operation controls, intelligent defrost control and compressor control etc.

VRF system

The indoor units shall be similar in operation and appearance as conventional indoor units of split units and provide independent on-off control, temperature setting etc.

4 WAY CASSETTE	Ductable unit	one-way cassette unit
		

The system shall provide considerable energy saving over traditional air-conditioning system (consisting of split units) due to following features: -

Individual accurate temperature

Multiple compressors in outdoor unit (8 HP & Above) in conjunction with inverter drive compressor to modulate refrigerant flow based on requirement.

Minimizing heat transfer losses due to superior refrigerant piping system with ecofriendly refrigerant. Temperature setting of each indoor unit shall be controllable through individual corded micro-processor-based controller.

The outdoor units will be mounted on Service Slab / space allocated by architect in open space available.

The indoor and the outdoor units would be interconnected with refrigerant piping and cabling. Piping shall be duly supported with cable trays

Each indoor unit's hall be provided with a wireless controller (for hi-wall type units) or wired wall mountable controllers for ductable units

Refrigerant pipes from outdoor unit to wall indoor split units shall generally be routed along the perimeter of walls or beam leading to the DX wall mounted high wall split unit. These pipes shall be enclosed within bulkheads / pelmets / false beams and necessary aesthetic treatment by the Architect is required to blend with the interior if there is no false ceiling

The Condensate drainpipes will be routed to nearest drain point. Preferably gravity drained condensate drain arrangement shall be prioritized by locating the indoor units close to drain points or by selecting ductable units for large spaces instead of hi-walls or cassette units. If the same is not possible, the indoor units hsll include a condensate pump for pumping out the condensate

Scope of supply shall include mounting frames and stands as required for installation

DX units for critical area such as UPS and SERVER room

Systems are designed and selected keeping in mind the limited space availability for accommodating all services equipment and operational flexibility for UPS and SERVER area Provision of Space must be considered for the Industrial type Split Units for smaller rooms and DX PACs for larger rooms. This system will provide year-round thermal environmental for proposed area considering all the constraints.

Indoor units selected would be in accordance to the interior requirement matching to the system performance, to achieve the desired room conditions.

Units will eb selected in 1W+1S configuration. If VRF Outdoors are connected to these units, the two indoor units in each room shall be connected to different outdoor units

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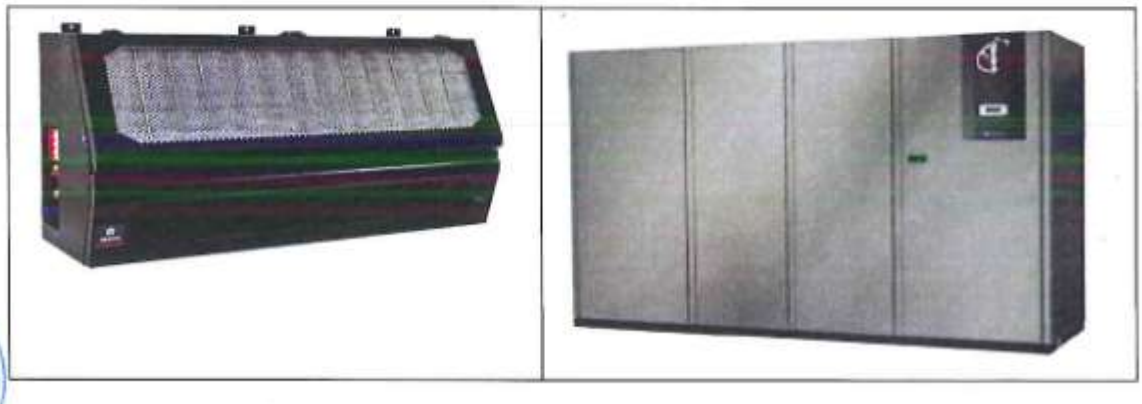
Scope of supply shall include mounting frames and stands as required for installation



Notes

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Indoor unit types shall be selected by Contractor and approved by the Engineer

Electrical equipment heat rejections to be confirmed and added when calculating final heat loads

Car Park Ventilation

As defined in the National Building Code of India, car parking areas shall be treated as naturally ventilated if they meet the following criteria

- 0.4sqM opening per running meter on façade
- No part of the parking should be more than 30M from façade
- 50% of perimeter (length) should be open or 75% of perimeter has 50% openings.

If these conditions are not satisfied, car park shall be mechanically ventilated at 6ACPH normal and 12 ACPH in case of fire

As all car parking areas comply with above conditions, mechanical ventilation is not required for parking

Plant Room Ventilation

Plant rooms shall be provided with mechanical ventilation. The system shall consist of tube axial or propeller fans for supply & exhaust air. Ventilation air quantity shall be considered as per NBC 2016.

Battery Room Ventilation

Battery rooms shall be ventilated using 2 Nos fans per room

Fan-A	Sized for 1cfm/sqft and scheduled to operate based on H2 sensor located within the room. The motor shall be spark-proof. The panel shall be provided with in-built timer to switch OFF the fan after a preset time (say 300 seconds) once triggered
Fan-B	Sized for 12ACPH as scheduled to operate of signal from fire alarm panel. This fan and motor shall be fire rated to 250 Deg C for 2 hours or as indicated in the specifications

6.4.2. General Ventilation

Generator room ventilation

Generator room ventilation shall apply to open DG sets located within building floor print

Generators shall be air-cooled (radiator cooled) type. The radiator fan itself shall provide required air flow through the room. To achieve this, the radiator and fan shall be enclosed in a plenum. When operating, the radiator fan shall draw air from within the generator room and discharge the same outside through the plenu box. The plenum will act as a cowl to prevent any hot air recirculation within the room. The radiator fan shall be designed to maintain a 5 Deg C dT across the DG room and the heat rejection of the alternator, switch gear and engine skin radiation shall be considered for the purpose. Makeup air shall be drawn in through a set of louvers located on the alternator side. The room shall be acoustically insulated and both fresh air and exhaust louvers shall be provided with attenuators to reduce sound outside DG room to 75dBA. After the DG has come off load, the DG will continue to operate at no load for a short period of time to prevent radiator water heat soak. Subsequently, an auxiliary fan shall be operated to remove residual heat

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Mechanical Ventilation for Toilets & Kitchen

Wall mounted exhaust fan with back draft damper are proposed for individual toilets on external wall and Ceiling suspended exhaust fan are proposed for toilets not having walls exposed to atmosphere. louvered area at each exhaust air opening is proposed.

For kitchen exhaust, individual fan is proposed in each kitchen. Fan will be provided with back draft damper to avoid recirculation of air back in the kitchen. louvered area at each exhaust air opening is proposed.

Rewarming pantries will be provided with a simple exhaust system with no pretreatment of exhaust air. Full cooling kitchens shall be provided with electrostatic scrubbers in the exhaust streams to remove the cooking grease from air stream before discharge to ambient

6.4.3. Air Distribution

Air Distribution System:

All ducts shall be factory fabricated from galvanized steel sheets (Class VII) light coating of zinc, nominal 180 gm/sq.m. Surface area and Lock Forming Quality prime material along with mill test certificates, of various thicknesses ranging from 26 gauge to 18 gauge according to duct sizes and in accordance with SMACNA standards. Galvanized steel sheets shall be produced by hot dip process. Grilles/ diffusers shall be powder coated extruded aluminium construction and shall be provided as per the requirement of interior design.

Insulation:

Insulation: Insulation material for ducts & pipes shall be closed cell electrometric nitrile rubber or cross-linked polyethylene foam. Nitrile rubber pre-moulded pipe sections shall be used for branch pipes of smaller diameter only. Pipes provided with thermal insulation shall be provided with protective coating against mechanical damages. All exposed thermal insulation shall be provided with Aluminum cladding including those inside the plant room.

Sound & Vibration isolator:

Mechanical services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source to achieve acceptable noise rating for NC levels for occupied spaces. Vibration isolators shall be designed for minimum isolation efficiency of 90%. All items of rotating / reciprocating plant and equipment shall be isolated from the foundation / structure using anti-vibration materials, mountings or spring-loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.

Sound Attenuators / acoustic lining shall be installed in ducts in accordance with requirements of drawings and shall be as per specifications. Acoustic performance of the attenuators (net insertion loss) shall meet or exceed the specified values

Seismic resistance

Building services and all equipment shall be provided with seismic bracings to withstand earthquake as per seismic zone. Calculations for seismic design shall be included with the detailed submissions

CHAPTER – 7

7. OUTLINE HVAC SPECIFICATIONS-BUILDING:

7.1. Air Cooled Packaged and Split Air Conditioning Units

7.1.1. Type

The Units shall consist of hermetically sealed Scroll compressor, motor, air cooled condenser, sump heaters (for packaged units only), integral refrigerant piping and wiring, all mounted on a steel frame.

Indoor unit to be installed for Split Unit within building, shall be housed in insulated cabinet consisting of cooling coil, blower with motor, filter & insulated drain pan.

The Air-Cooled Packaged Unit shall consist of hermetically sealed Scroll compressor, motor, sump heaters, integral refrigerant piping and control panel duly wired to compressor and air-cooled condenser all mounted on a steel frame. The Air-cooled condenser with fan duly mounted on a common frame shall be installed on the wall openings with suitable angle iron / channel frame to be provided by contractor. The suitable starters, switches, power & control cabling between Air Cooled Packaged Unit and Air-Cooled Condenser shall be included by the contractor.

7.1.2. Capacity

The refrigeration capacity of Packaged Unit and Room Air Conditioners, split unit shall be as shown on Approved Drawings

7.1.3. Compressor and Motor

Compressor shall be hermetic Scroll, serviceable type and shall have dual pressure stat, and an operating oil charge. The motor shall be suction gas cooled and shall be sealed against dirt and moisture. The motor shall be suitable for 415±10% volts or 230±10 % volts, 50 Hz, A.C. supply.

7.1.4. Refrigerant Piping and Controls

Refrigerant piping and fittings interconnecting compressor and condenser shall be all copper and valves shall be brass / gunmetal construction.

7.1.5. Casing

The indoor & outdoor units shall be sectionalized / cabinet construction. Indoor units shall be consisting of fan section, coil section, filter section, and drain pan. Outdoor unit shall consist of condenser coil, fan & compressor. In case of package units, the compressor shall be mounted within the indoor units and in case of split unit, the compressor shall be mounted with the outdoor units. Each section shall be constructed of thick sheet steel all

welded / bolted construction, adequately reinforced with structural members and provided with enough access panels for proper lubrication and maintenance. Base panel shall be constructed of fabricated steel structure provided with an under frame suitably braced. Each unit shall include one piece drain pan constructed of 20-gauge galvanized sheet steel plate. Drain pan shall extend under coil and fan sections with drain connections. Removable panels in fan and coil sections shall provide access to all internal parts. Panels shall be internally lined with 2.5 cm thick fibre glass as per section "Insulation" for the thermal insulation and acoustic lining.

7.1.6. Fan Motor and Drive

Fan motor shall be suitable for 415 ± 10% volts or 230±10% volts, 50 Hz, A.C. Supply, Single phase, motors shall be provided with permanent capacitor. Motors shall be especially designed for quite operation and motor speed shall not exceed 1440 rpm.

7.1.7. Fan

Fan wheels and housing shall be fabricated from heavy gauge steel. Fan wheels shall be of double-width, double inlet forward-curve, multi-blade type enclosed in a housing and mounted on a common shaft. Fan housing shall be made of die-formed steel sheets with stream-lined inlets to ensure smooth air flow into the fans, fan shaft bearing shall be oil/grease assembly shall be statically and hydraulically balanced. Fan speed shall not exceed 1000 rpm and maximum fan outlet velocity shall be 550 meters per minute.

7.1.8. Heat Exchanger Coils

Coils shall be of fin and tube type having aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and air velocity across each coil shall not exceed 100 meters per minute. The coil shall be pitched in the unit casing for proper drainage. Each coil shall be factory-tested at 21 Kg. per sq.cm air pressure under water. Tube shall be mechanically / hydraulically expanded for minimum thermal contract resistance with fins. The number of fins shall be 4 to 5 per cm..

7.1.9. Vibration Isolators

The indoor and outdoor units shall be provided with ribbed rubber pad vibration isolators.

7.1.10. Painting

Units shall be factory finished with durable alkyd spray enamel. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

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7.1.11. Performance Rating

The unit shall be selected for the lowest operating noise level. Capacity rating and power consumption with operating points clearly indicated shall be submitted with the bids and verified at the time of testing and commissioning of the installation.

7.2. Variable Refrigerant Flow System

7.2.1. Type

Unit shall be air cooled, variable refrigerant volume air conditioner consisting of one outdoor unit and multiple indoor units. Each indoor unit having capability to cool independently for the requirement of the rooms.

It shall be possible to connect multiple indoor unit on one refrigerant circuit. The indoor units on any circuit can be of different type and controlled individually. Following type of indoor units shall be connected to the system:

- Ceiling mounted cassette type.
- Ceiling mounted ductable type.
- Wall mounted Hi-Wall type.

Compressor installed in outdoor unit shall be equipped with capacity control mechanism, and capable of changing the rotating speed / mass flow rate of refrigerant by scroll / rotary compressor RPM to follow variations in cooling. Outdoor unit shall be suitable for mix-match connection of all type of indoor units.

The refrigerant piping between indoor units and outdoor units shall be extended upto 100m with maximum 50 m level difference without any oil traps. Oil recovery system shall be managed without disturbance to normal operation cycle of the system / compressor.

Both indoor unit and outdoor unit shall be factory assembled, tested and filled with first charge of refrigerant before delivery at site.

7.2.2. Selection Criteria for VRF Unit

The manufacturer to certify that the proposed unit shall be operational un-interrupted at temperature 3°C plus peak ambient dry bulb temperature of design city.

Manufacturer to submit OEM letter for continuous operational range of the unit.

Manufacturer to submit OEM de-rating charts for indoor and outdoor unit capacity rating at project specific design conditions and refrigerant piping lift and distance.

ADP of unit selected should not be lower than 11.11°C (52°F) for high wall units and 10.56°C (51°F) for concealed ductable and cassette units.

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7.2.3. Outdoor Unit

The outdoor unit shall be factory assembled; weatherproof casing constructed from heavy gauge mild steel panels with powder coated finish.

All outdoor units above 8 HP rating shall have minimum two number scroll / rotary compressors.

In case of outdoor units with multiple compressor, the operation shall not be disrupted with failure of any compressor.

The noise level shall not be more than 60 dB (A) at normal operation measured horizontally 1m away and 1.5 m above ground level.

The outdoor unit shall be modular in design with possible future expansions.

The unit shall be provided with microprocessor control panel.

7.2.4. Compressor

The compressor shall be high efficiency scroll / twin rotary type and capable for capacity controlling. It shall change the speed / refrigerant mass flow rate in accordance to the variation in cooling load requirement. Refrigerant mass flow rate can be changed by speed modulation of compressor / mechanical control system. System shall incorporate liquid sub-cooling mechanism.

The inverter shall be IGBT (insulated gate bipolar transistor) type for efficient and quiet operation.

All outdoor units shall have multiple steps of capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated. Forced lubrication may also be employed.

Oil heater shall be provided in the compressor casing.

7.2.5. Heat Exchanger

The Heat Exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fan coil and larger surface area.

The fins shall have anticorrosion treatment for Heat Exchanger Coil. The treatment shall be suitable for areas of high pollution, moisture and salt laden air.

The casings, fans, motors etc. shall also be with anti-corrosion treatment as a standard feature.

The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical / horizontal discharge. Each fan shall have a safety guard.

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7.2.6. Refrigerant Circuit

The Refrigerant Circuit shall include and liquid receiver /accumulator, liquid & gas shut off valves and a solenoid valve. All necessary safety devices shall be provided to ensure the safety operation of the system.

7.2.7. Safety Devices

All necessary safety devices shall be provided to ensure safe operation of the system.

Following safety devices shall be part of the outdoor unit: high pressure switch, low pressure switch, fuse, crankcase heater, fusible plug, over current protection for inverter, and short recycling guard timer.

7.2.8. Piping

All connections of Refrigerant piping shall be in high grade Copper of Refrigeration quality with Eddy Current Testing and material test Certificates.

All connections, tees, reducers etc. shall be standard make fittings.

Insulation of cold lines shall be carried out with nitrile rubber insulation sheets and tubes of appropriate thickness so that condensation does not occur.

For individual Piping 50 / 100 mm wide Aluminium Tape shall be used at joints of Piping with Bands for identification.

For outdoor piping, the finish shall be woven GRP Mat finished with coloured Epoxy paints to withstand outside ambient conditions and UV Radiation.

7.2.9. Oil Recovery System

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigerant piping.
System shall be designed for proper oil return to compressor along with the distribution of oil to individual compressor.

The refrigerant piping shall be extended upped 100 M with 50-M level difference without oil traps.

7.2.10. Indoor Units

Units shall be factory assembled, wired, piped and tested.

Units shall have DX coils with copper tubes and bonded aluminium fins for highly efficient heat transfer.

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Units shall have Centrifugal fans for adequate amount of Air circulation and low Noise.

Units shall have inlet filters, which are easily cleanable and replaceable.

All components of Units are easily accessible for connection, repairs and maintenance.

Units shall have very low noise.

All units with Factory manufactured Units Grills shall have auto swing feature for proper Air distribution.

All unit shall be controlled by electronic Expansion Valves only.

All units mounted inside the ceiling shall have fans capable of sustaining duct connections, and special filters if necessary.

Visible indoor units shall have wireless remotes.

Concealed indoor units shall have sensor mounted on supply air grilles / diffusers which can be controlled with wireless remotes.

Anticorrosion treatment for avoiding corrosion of coils.

All units shall have adequate insulation or Lining to avoid condensation.

Cooling coil and refrigeration parameters shall be designed in such a way that supply air temperature shall not be less than 140C or 10C above room dew point temp, whichever is more. Contractor shall guarantee inside conditions with selected supply air temperature.

7.2.11. Ceiling Mounted Cassette Type Unit (Multi-Flow Type)

The unit shall be ceiling mounted type. The unit shall include pre-filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized steel. The body shall be light in weight and shall be possible to suspend from four corners.

Unit shall have an external attractive panel for supply and return air. Unit shall have four-way supply air grilles on sides and return air grille in centre.

Each unit shall have high lift drain pump, fresh air intake provision and very low operating sound.

7.2.12. Ceiling Mounted Ductable Type Unit

Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan section & DX-coil section. The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for ductable arrangement.

7.2.13. High Wall Mounted Units

The units shall be high wall mounted type. The unit shall include pre-filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

Unit shall have an attractive external casing with supply and return air grills.

7.2.14. Central Remote Controller

A multi-functional microprocessor based centralized controller (central remote controller) shall be supplied

The controller shall be able to control upto minimum 64 nos. of indoor units with zoning option and / or in case of larger installation should provide bigger controller with the following functions.

- Temperature setting for each zone, or group, or indoor unit.
- On/Off as a zone or individual unit.
- Indication of operating condition.
- Select ON of all operation modes for each zone.
- The controller shall have wide screen liquid crystal display and shall be wired by a non-polar 2 / 3 wire transmission cable to 1000m away from the indoor unit.
- The controller shall be integrated to BAS system thru software for monitoring & controlling of all above parameters including start/ stop of each indoor / outdoor unit. All necessary interface cards / units should be supplied as a part of the system to integrate to the BAS Software.

7.2.15. Unified On/Off Controller

Unified ON / OFF controller shall be supplied

The controller shall be able to control minimum 2 groups (each group containing maximum 16 indoor units) or 128 nos. of indoor units with the following functions.

On / Off as a zone or individual unit.
Indication of operation condition of each group.
Select one of 4 operation modes.

The controller shall be wired by a non-polar 2 wire transmission cable to distance of 1 km away from indoor unit.

The controller shall be integrated to BAS system thru software for monitoring & controlling of all above parameters including start/ stop of each indoor / outdoor unit. All necessary interface cards / units should be supplied as a part of the system to integrate to the BAS Software.

7.2.16. Condensate:

25mm dia uPVC pipes, 40mm dia uPVC headers & fittings shall be used for condensate, from Evaporator Unit to drain point. The joints shall be properly sealed so that there is no water leakage. U-trap shall be provided at the end. Additional insulation drain tray shall be provided below the Evaporator Unit

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7.2.17. Mounting

All indoor units shall be mounted with Brackets, Hangers etc. with proper size anchor Fasteners.

7.2.18. Electrical Installation

Complete electrical installation shall be included with the unit

7.3. Precision Air Conditioning Units

7.3.1. Type

The precision Air Conditioning Unit shall be DX Air Cooled single coil units

The Precision air-conditioning Unit shall be complete with microprocessor controller and shall consist of hermetically sealed Scroll compressors, evaporator fan, motor, strip heaters, humidifier, integral refrigerant piping and control panel duly wired to compressor and air/water cooled condenser all mounted on a steel frame. Micro-processor panel shall be BMS Compatible with open protocol for software integration. The Air-cooled condenser with fan duly mounted on a common frame shall be installed on the wall openings / terrace with suitable angle iron / channel frame to be provided by contractor. The suitable starters, switches, power control cabling between Indoor unit and outdoor unit shall be included

7.3.2. Capacity

The refrigeration capacity and air quantity for the unit shall be as shown in Approved Drawings Manufacturer shall select unit capacity software selection at tender design conditions.

7.3.3. Casing

The indoor & outdoor units shall be sectionalized / cabinet construction. Indoor units shall be consisting of compressor and motor, fan section, coil section, heater and humidification section, filter section, and drain pan. Each section shall be constructed of thick sheet steel all welded / bolted construction, adequately reinforced with structural members and provided with enough access panels for proper lubrication and maintenance. Base panel shall be constructed of fabricated steel structure provided with an under frame suitably braced. Drain pan shall extend under coil and fan sections with drain connections.

The indoor unit cabinet shall be of double skin sandwich panel construction (all four side) with 25± 2 mm thick panel made of galvanized steel, The panels should be insulated with AO class insulation with Mineral wool of 32 Kg/CUM density, suitably treated for weather protection, corrosion resistant and shall be powder coated.

Units shall have hinged, quick opening access door in the fan & coil section and in filter section where filters are not accessible from outside. Access doors shall be double skin type.

Outdoor unit shall consist of condenser coil and propeller type fan for air cooled unit and shell & tube condenser for water cooled units.

Lugs shall be provided for lifting / easy handling of machines.

7.3.4. Compressor & Motor

The compressor shall be hermetic sealed type and suitable for operation on Eco-friendly refrigerant R-410a.
The compressor shall have dual pressure stat and an operating oil charge. The motor shall be suction gas cooled and shall be sealed against dirt and moisture.

The motor shall be suitable for 415± 10% V, 50 Hz, 3 Phases AC supply. The compressor shall be in separate compartment isolated from air stream to permit servicing without shutting down the system.

Compressor shall be installed on spring mounted floating platform / rubber pads or manufacturers recommended approved mounting. Suitable overload protection shall be provided in compressor. Isolating valves shall be provided at suction & discharge. Compressor shall be fitted with electrically operated oil heaters with built-in thermostats and the heaters shall be automatically actuated when the compressor is stopped. In built time delay shall be provided for restart of compressor

7.3.5. Variable Capacity Compressor

The compressor shall be capable of operation of variable capacity by using brushless AC/DC inverter /digital scroll compressor. The compressor should necessary provision of oil return on part load operations

7.3.6. Evaporator Section

Evaporator coil shall be of fin and tube type having hydrophilic coated aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and air velocity across each coil shall not exceed 500 FPM. The coil shall be minimum 3 row deep for DX coil.

A condensate drip tray of stainless-steel construction of minimum 18 SWG thick, duly insulated shall be provided.

Dehumidification shall be achieved by reducing the air flow of the EC fans which thereby would reduce the ADP of the cooling coil to achieve dehumidification.

The Microprocessor panel should be able to perform auto changeover from Chilled water to DX mode and vice versa as and when required due to start and stop of the chilled water. The controller should also be able to start unit on DX mode, in case the chilled water temperature rises and is unable to maintain inside conditions. Manual change over provision shall also be provided.

Blower Section

The unit shall be under floor / top discharge type and should be able to deliver between 550-600 CFM per ton. Total external static pressure shall be minimum 2.5 mm of WG for floor / top discharged units. Units with top discharge shall be designed for required static pressure as per actual ducting arrangement.

The units should be equipped with direct driven backward curved plug fans with electronically commutated brushless motors suitable for 415 ± 10% V, 3 Phase, 50 Hz AC supply. The motor's high efficiently should make for less energy absorption, especially at partial loads and during starting. The motor shall be of IP 54 or IP 55 grade. The fan shall be directly coupled having a maximum speed of 1400 p.m. The fan speed shall be controlled through microprocessor panel based on temperature & humidity set points. Fan motor assembly shall be statically and hydraulically balanced and designed for quite operation.

7.3.7. Humidifier & Heaters

The humidifier and heaters shall be a built-in feature in each machine individually. Humidification shall be provided by boiling water in steam generator/infrared humidifiers. The steam shall be evenly distributed into the supply air stream of the Air Conditioning Unit. The humidifier shall be self-cleaning and capable of delivering variable capacity steam from 30 % to 100% of its total capacity with help of microprocessor. The humidifier shall be fully serviceable with replaceable electrodes. Wastewater shall be flushed from the humidifier by initiation of water supply valve via U-trap. The microprocessor should be able to display the current drawn and actual steam output in the microprocessor.

Heater should be of minimum two stages & heating circuit shall include dual safety protection through loss of air and manual reset high temperature controls.

Electric strip heaters shall be of the low temperature totally enclosed strip type fitted with radiation fins and suitable for operating at black heat. If overheating occurs, a safety thermostat should cut off the voltage supply to the heaters and triggers an alarm. Microprocessor should be able to control the humidification and heating through suitable sensors.

7.3.8. Filters

Each unit shall be provided with a factory assembled filter section containing washable synthetic type air filters having anodized GI/aluminum frame. The media shall be supported with HDPE mesh on one side and aluminum mesh on other side. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed either from aluminum alloy or GI powder coated. Filter banks face velocities shall not exceed 150 Mt. / minute. The filter shall be suitable for high efficiency dust filtration of minimum MERV 8 / EU4.

7.3.9. Refrigerant Piping & Controls

Refrigerant piping and fittings within the unit shall be of copper and valves shall be of brass / gunmetal construction. Piping thickness shall be designed based on type of refrigerant and superheated gas pressure at full load, corresponding to ambient dry bulb temperature of 52°C.

The refrigeration system shall be of the Single/Multiple circuit direct expansion type and incorporate hermetic scroll compressors. The system shall include a manual reset high pressure control; auto reset low pressure switch, safety valve, and charging/access ports in each circuit.

Each refrigerant circuit shall include the following items:

a. Electronic Expansion Valve with transducers to enable display of Discharge, Suction Pressures along with Superheat on the microprocessor.
b. Liquid line drier / filter.
c. Liquid Line Sight Glass with Moisture indicator.
d. Hand shut off valves / Shredder valves.
e. Liquid line receiver.
f. Liquid Line Solenoid Valve for interception of Liquid Refrigerant

The serviceable / removable components shall have union connection for easily removal / assembly.

All external pipe work shall be carried out with 18G refrigerant quality copper tube and where bends are required; the same shall be completed using either a proprietary bending tool or radius fittings.

7.3.10. Air Cooled Condenser

Each condenser unit shall consist of a heat rejecting coil block constructed from copper tubes expanded on to straight aluminum fins. The coil shall be factory epoxy coated for protection against corrosive environment.

The fan shall be selected for low speed quiet operation. The fan shall be directly driven by a motor of speed not exceeding 1000 RPM and constructed from sheet and cast aluminium. When compressor stops condenser fan shall also stop after a suitable time delay.

The fan should be complete with an automatic stepless fan speed controller to maintain constant head under varying ambient conditions. The housing for fan speed controller & isolator shall be of IP 65 grade.

The condenser shall be flexible for mounting in both horizontal and vertical positions.

The entire assembly shall be supported by a corrosion treated frame having four legs.

7.3.11. Electrical System

The electrical power system shall confirm to relevant IS standard. A main isolator (MCB) shall be provided by the side of each unit, sized to meet the system total power requirement.

Within the panel individual power loads shall be distributed equally across the three phases.

All individual wires shall be of cross-linked polythene insulated, armoured Copper cabling with a low smoke and flame sheath (XLPE/SWA/LSF) and color coded or shall be

numbered at their point of termination to facilitate servicing. Low voltage control wiring and power wiring shall be segregated from each other.

The following shall be incorporated:

a. Contactors for automatic Micro Processor Control
b. Single phase preventers
c. Separate overload preventer for all individual components.

7.3.12. Safety Controls

Following minimum safety controls shall be provided for each unit:

High pressure trip - Manual reset (for each compressor)
Low pressure trip - Manual reset (for each compressor)

7.3.13. Safety Interlocks

Operation of heaters & humidifier shall be possible only when blower fan is in operation.

Condenser fan shall stop after a suitable time delay on Compressor's stopping.

Microprocessor Controls

Following information shall be available on the display on the units.

a. Room temperature and humidity.
b. Supply fan working status
c. Compressor working status
d. Condenser fans working status.
e. Electric heaters working status
f. Humidifier working status.
g. Manual / Auto unit status.
h. Clogged Filter status
i. Temperature set point.
j. Humidity set point.
k. Working hours of main component i.e. compressors, fans, humidifier etc.
l. Unit working hours.
m. Current date and time.
n. Type of alarm (with automatic reset or block)
o. The last 100 intervened alarms.

The microprocessor shall be able to perform following functions:

a. Testing of the working of display system.
b. Password for unit calibration values modification.
c. Automatic re-start of program.
d. Cooling capacity control.
e. Compressor starting timer.
f. Humidifier capacity limitation.
g. Date and time of last 100 intervened alarm.
h. Start / Stop status storage.
i. Random starting of the unit.
j. Outlet for the connection to remote system.

k. Temperature and humidity set point calibration.
l. Delay of General Alarm activation.
m. Alarm calibration.

7.3.14. Painting

Units shall be factory finished with durable alkyd spray enamel. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

7.3.15. Performance Rating

The unit shall be selected for the lowest operating noise level (65 dBA at 3m). Capacity rating and power consumption with operating points clearly indicated shall be submitted with the tenders and verified at the time of testing and commissioning of the installation. For site verification of working of humidification / dehumidification systems, set point RH shall be changed below / above (respectively) actual RH. Similar procedure shall be adopted for temperature control system. Test report shall indicate selected set point for RH and temperature and achieved values of these process variables after humidification / dehumidification cycles are activated.

7.4. Fans

7.4.1. Type

Centrifugal, in-line propeller fans and roof mounted units shall be of the type as indicated on Approved Drawings

7.4.2. Capacity

The air-moving capacity of fans shall be as shown on approved Drawings

7.4.3. Centrifugal Fan

Centrifugal fan shall be DWDI / SWSI Class I construction arrangement 3 (i.e. bearings on both the sides) for DWDI fans complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

a. Housing shall be constructed of 14-gauge sheet steel welded/bolted construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans (greater than 1250mm dia), however neoprene / asbestos packing should be provided throughout split joints to make it airtight.

18-gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

b. Fan Wheel shall be backward-curved/inclined non-over loading type. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mm dia, fan outlet velocity shall not exceed 550 meter/minute and maximum fan speed shall not exceed 1450 rpm. For fans above 450 mm dia, the outlet velocity shall be within 700 meter/minute and maximum fan speed shall not exceed 1000 RPM. High static pressure fan speed shall be as per manufacturer.

c. Shaft shall be constructed of steel, turned, ground and polished.

d. Bearings: shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type.

e. Motor: Fan motor shall be energy efficient and suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, and of approved make. Motor name plate horsepower shall exceed brake horsepower by a minimum of 10%. Motor shall be designed especially for quiet operation and motor speed shall not exceed 1440 rpm. The fan and motor combination selected for the required performance shall be of the most efficient (smallest horsepower), so that sound level is lowest. Motor shall have a minimum efficiency of IE3 or as per relevant BIS/NEMA codes.

Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.

g. Vibration Isolation: MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through resist flex vibration isolators. The concrete foundation shall be at least 15 cm above the finished floor level.

Centrifugal fans for smoke extract application shall have external belt drive and motor. Fan & casing shall be internally rated for 250oC for 2 hours.

Fan shall confirm to AMCA standard 211 and 311.Fan must be tested in accordance with ANSI/AMCA standard 210 – 99 and AMCA standard 300- 96 in an AMCA accredited lab. Fans shall be certified to bear the AMCA label for Air and sound performance.

7.4.4. Axial Flow Fan

7.4.4.1. Axial Flow Fan (Standard)

Fan shall be complete with motor, motor mount, belt driven (or direct driven) and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

a. Casing: shall be constructed of heavy gauge sheet steel. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be of structural steel thickness as per OEM standards capable to handle the weight of the motor and properly machined to receive the flange.

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An inspection door with handle and neoprene gasket shall be provided. Casing shall have flanged connection on both ends for ducted applications. Fan casing are with internal punched inlet and outlet flanges to prevent air leakage, for size upto 1600 mm dia and shall be constructed of rolled steel with a continuous seam welded. Support brackets for ceiling suspension shall be welded/bolted to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be hot dip galvanized with minimum 220 GSM zinc coating.

b. Rotor: hub and blades shall be cast aluminium /aluminium alloy construction. Blades shall be die-formed aero foil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Rotor shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. Taper lock bushing shall be used to mount the propeller to the motor shaft. The impeller and fan casing shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

c. Motor: shall be energy efficient IE 2/IE 3 (as per IS 12615) squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, provided with class 'F' insulation. Motor shall be specially designed for quiet operation. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Fan total efficiency should not be less than 70 %. Sound level for fresh air fans should not be more than 70 Dba @ 3mtr distance and for pressurization fans should not be more than 85 Dba@ 3mtr under hemispherical reverberant room conditions. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit.

d. Drive: to fan shall be direct.

e. Vibration Isolation: The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of heavy-duty spring isolators type.

f. Accessories: The following accessories shall be provided with all fans:

   i. Outlet cone for static pressure regain.

   ii. Inlet cone.

Fans shall be factory assembled and shipped with all accessories.

Axial Flow Fan shall be AMCA certified for Air and Sound performance in accordance to AMCA 210 and AMCA 300. Fan shall be suitable for both indoor and outdoor application with all accessories. Base fan performance shall be at standard conditions. (density 1.2 Kg/Cu.mt.)/ actual altitude conditions. AMCA seal shall appear in the technical submittal of fan.

7.4.4.2. Axial Flow Fan (For fire, Smoke and heat exhaust)

Fan shall be suitable for mounting in duct or wall / floor / slab as required. Fan shall be complete with motor, motor mount, (or direct driven) and vibration isolation type, suspension arrangement as per approved for approved shop drawings.

a. Casing: shall be constructed of heavy gage sheet steel and shall withstand minimum of 250 deg.C for minimum 2 hrs. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be of structural steel thickness as per OEM standards and suitable to handle the weight of the motor and propeller, machined to receive motor flange.

   An inspection door with handle and neoprene gasket shall be provided. Casing shall have flanged connection on both ends for ducted applications. Fan casing are with internal punched inlet and outlet flanges to prevent air leakage, for size upto 1600 mm dia and shall be constructed of rolled steel with a continuous seam welded confirming to UL standards. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be hot dip galvanized with minimum 220 GSM zinc coating.

b. Rotor : hub and blades shall be cast aluminum /aluminium alloy construction and shall withstand minimum temperature of 250 deg for a minimum of 2 hrs. Blades shall be die-formed aero foil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Rotor shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided for sizes above 180. Taper lock bushing shall be used to mount the propeller to the motor shaft. The impeller and fan casing shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

c. Motor: shall be energy efficient IE2/IE3 (as per IS 12615)squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, provided with class 'H' smoke spill insulation. Motor shall be specially designed for quiet operation. Fan total efficiency should not be less than 70%. Sound level for normal exhaust air fans should not be more than 75 dBA @ 3mtr and for smoke spill exhaust fans should not be more than 85 Dba @ 3 mtr under hemi spherical reverberant room conditions. All high temperature fans should be either EN 12101 -3 or UL listed for high temperature (UL power and smoke ventilation listed) for minimum of 250 deg. For minimum 2 hrs. and should be UL or CE labelled. Motor conduit box shall be mounted on exterior of the fan casing and lead wires from motor to the conduit box shall be protected from the air stream by enclosing in the flexible metal conduit/vane. Motor shall have minimum efficiency of IE 2

d. Drive: Fan shall be provided through direct.

e. Vibration Isolation: The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of heavy-duty spring isolators type.

f. Accessories: The following accessories shall be provided with all fans:

   i. Outlet cone for static pressure regain.
   ii. Inlet cone.

Fans shall be factory assembled and shipped with all accessories confirming to UL standards.

All high temperature fan assembly(fan, impeller, fan casing, motor base frame along with motor) to be used for fire applications shall bear the certification/listing of UL/CE (in addition of being AMCA certified for sound and air performance) confirming to UL standard for "Power Ventilation for smoke control system" or EN 12101-3-2002 smoke and heat control system specification for power and smoke ventilation.

Axial Flow Fan shall be AMCA certified for Air and Sound performance in accordance to AMCA 210 & AMCA 300 for both indoor and outdoor application with all accessories. Base fan performance shall be at standard conditions (density 1.2 Kg/Cu.mt.)/actual altitude conditions.

7.4.4.3. Propeller Fan

Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

a. Mounting Plate shall be of steel construction, square with streamlined venturi inlet (reversed for supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16-gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

b. Fan Blades shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.

c. Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.

d. Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with prelubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for 415±6% volts, 50 cycles 3 phase power supply, and for smaller fans shall be suitable for 220 ± 6% volts, 50 cycles single phase power supply. Motors shall be suitable for either horizontal or vertical service as indicated on Drawings

e. Accessories: The following accessories shall be provided with propeller fans:

    i. Wire guard on inlet side and bird-screen at the outlet.
    ii. Fixed or gravity louvers built into a steel frame at the outlet.
    iii. Regulator for controlling fan speed for single phase fan motor.
    iv. Single phase preventers for 3 phase fans.

7.4.4.4. Roof Mounted Fan

Roof mounted fan shall be centrifugal fans, direct driven or belt driven as shown on approved drawing, complete with motor drive, and housing with weather-proof cowl.

a. Housing: Fan housing shall be constructed of heavy gauge aluminum includes exterior housing, curb cap, wind band, and motor compartment housing and shall have a rigid internal support structure. Curb cap base to be fully welded to wind band to ensure a leak proof construction. Tack welding, bolting, and caulking are not acceptable. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Breather tube shall be provided to allow entry of fresh air for motor cooling and shall be suitable to allow electrical wiring to be run through it. The entire assembly shall be suitable for outdoor applications and raised from the roof terrace sufficiently to prevent down-flow of rainwater accumulated on the terrace. 18 gage galvanized steel mesh bird-screen shall be provided on all discharge cowls around the outlet area.

discharge cowl shall be hinged along one edge for easy access to motor and drive for inspection and maintenance.

b. Fans: shall be backwardly inclined centrifugal wheel or propeller type as required, designed for maximum efficiency, minimum turbulence and quiet operation. Fan shall be statically and dynamically balanced.

c. Motor: Motor shall be high efficiency with a minimum of IE2 efficiency level and shall be made to IEC design. Motors are heavy duty ball bearing type to match with the fan load and furnished at the specific voltage and phase and shall be mounted on vibration isolators, out of the airstream. Bearings shall be designed for vertical mounting. Motor name-plate horsepower shall be such that the motor shall not be overloaded in the entire range of rated speed. Motor and fan assembly shall be easily removable. There should be a provision to draw fresh air into the motor compartment through an area free of discharge contaminants for the motor cooling. It should be easily accessible for maintenance.

d. Fan Bearings: shall be heavy duty, self-aligning sleeve/ball bearings designed for thrust load and sealed for grease retention.

e. Backdraft Damper: Roof-mounted fan shall be equipped with a rattle-free backdraft damper to prevent air from re-entering the fan when fan is not in operation, thus sealing completely in closed position. Damper shall be chatter proof under all conditions.

f. Vibration Isolation: The motor and fan assembly shall be isolated from the base with vibration isolators.

7.4.4.5. Inline Fans

Circular Inline Fans

Circular inline Centrifugal duct fan shall be a straight through radial fan. It should be compact.

The fan shall cope with high pressure and long duct runs, whilst still operating at an acceptable sound level.

The circular inline fans should be moisture resistant and should be approved for installing in humi or damp environments. The fans should be rated IP-44 when installed in a duct system. The casing should be manufactured from pre galvanized steel. Automatic thermo – contact shall open if the temperature within the motor windings becomes excessive. Fan should be equipped with CE certified external rotor single phase asynchronous motor. Fan shall be AMCA certified for Air and sound performance in accordance with AMCA 210 and AMCA 300.

Cabinet Inline Fans

The Cabinet of the cabinet inline fans should be manufactured in 20-gauge galvanized steel complete with inlet and outlet spigots. The Mounting brackets and access panel should be fitted as per manufacturer standard. The impeller of the fans should be with high efficiency forward curved DIDW type. The scroll of the fans should be fabricated with galvanized sheet steel. The motor of the fans shall be Squirrel cage induction type with bearings sealed for life. The motor shall be suitable for single phase electrical supply. The cabinet of the fan shall be of double skin construction with 20-gauge GI outer skin with 25 mm glass wool wrapped tissue paper and covered with 20-gauge perforated GI sheet from inside. Fan shall be AMCA certified for Air and sound performance in accordance with AMCA 210 and AMCA 300.

7.4.4.6. Performance Data

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

7.4.4.7. Testing

Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

7.5. Dry Scrubbers

Air Cleaning System utilizing Industrial Electrostatic Air Cleaners (and Odor Removal System) shall be incorporated with the Kitchen Exhaust System to remove Cooking exhaust contaminants (such as grease, cooking fumes, oil mist and smoke) and odor to comply with NEA requirements.

The Industrial Electrostatic Air Cleaners (IEAC) shall be installed ideally along with duct after the cooker hood.

The IEAC shall be interlocked to the kitchen exhaust air fan.

The Kitchen Exhaust Air Treatment shall consist of a 2-stage process.

1st stage – Industrial Grade Electrostatic Air Cleaner
2nd stage – Activated Carbon Bank / Built in UV Ozone Lamps with the IEAC

7.5.1. Type

The unit shall be CE certified and of the type

7.5.2. Technical Parameters

The unit shall provide efficiency of 90% or better for single pass base on ASHRAE test method at flow rates of 800 – 1500 CFM per module (supported by sample test report by a US laboratory). Multiple units can be joined together for increased volume. The system shall be suitable to connect to fan section with average velocity of 500 FPM across air cleaner.

7.5.3. Industrial Grade Electrostatic Air Cleaner (IEAC)

The first stage shall be an Industrial Grade Electrostatic Air Cleaner. The supplier must have at least 10 years' experience with good track record in maintaining and servicing such equipment.

7.5.4. Equipment Specifications

The unit shall be designed and constructed and supplied by a manufacturer specializing in the research, design and manufacture of products specified in this section with a minimum of ten years of documented experience, and capable of issuing complete catalog data on the total product.

The Industrial Electronic Air Cleaning System shall be supplied as a one-piece factory joined assembly of individual section(s) selected to treat oil mist, smoke, fume, grease & dust / powder problems.

7.5.5. Unit Housing

Housing shall be constructed with minimum 1.4 mm thick galvanized steel sheet (16 gauge) with reinforced structure and powder coated to protect against rust and corrosion. It shall have a hinged door for cell access, located one side to the unit. The door shall be gasketed to prevent air leakage. There shall be a safety interlock switch to cut off primary supply when the access door is opened.

7.5.6. Base Construction

The sections are to be mounted on a structural C-channel or floor mounting or ceiling suspension. Lifting lugs shall be incorporated in the base channel to allow for rigging

7.5.7. Finish

The external finish shall be a durable industrial grade semi-gloss epoxy coating.

7.5.8. Ionizing-Collecting Cells

Ionizing-Collecting Cell(s) shall be of one-piece construction consisting of a series of repelling and collection plates. Both repelling and collector plates shall be aluminium alloy material, rigidly retained in place with tubular spacers and tie rods. Each plate shall be corrugated, perpendicular to airflow direction. Each cell shall weigh not more than 16 kg with at least 9 ionizing wires.

Ionizer

Ionizing electrodes / wires shall be of tungsten material, rigidly supported both vertically and laterally. Ionizing electrode to ground electrode spacing shall be 1.0" (25 mm). High voltage support insulators shall be of Teflon material for dielectric strength.

7.5.9. Air Handling Capacity

Each Ionizing / Collecting Cell shall be capable of handling up to 3000 cmh of air. There shall be one to four such ionizing / collecting cells per module. Each module shall handle up to 3000 CMH, 6000 CMH, 9000 CMH and 12000 CMH per module respectively. Multiple units of the same or different modules may be needed to handle higher air flow capacities.

7.5.10. Design Consideration

To achieve effective performance, the proposed IEAC shall fulfill the following design consideration

a. Test Report

The rated efficiency shall be up to 95% based on the NIOSH 5026 OIL MIST TEST. Past on situ test reports of 90% to 95% of the said test method must be submitted.

The Industrial Electrostatic Air Cleaner must also be rated at 90% to 95% ASHRAE Std 52.2 and the test report shall not be more 5 years old must be submitted.

b. Contact Time

The air velocity entering the IEAC's Ionizing & Collection Cell Section shall be at 2.5 m/sec to a maximum of 3.2 m/sec, parallel pass. Ionizing and cell dimensions must be indicated, and proper calculation shall be submitted prior to the installation of the equipment.

The contact time shall be at least 0.1 second.

c. Collection Area

Minimum Filtration Area shall be 2 m2 per 1000 CMH

7.5.11. Power Supply:

Power supplies shall be 100% solid state, operate on 240 VAC, 50 HZ, 1 Phase input and provide a dual high voltage output of 12 to 13 KVDC for the ionizer and 6.0 to 6.5 KVDC for the collector, in normal operation conditions. Current output at the high tension shall be 12mA. A maximum power output for the solid-state power supply shall be from 50 watts to up to 150 watts to maintain the specified collection efficiency.

Electrical interlocks shall be provided to prevent access to the high voltage components without first interrupting the primary input power. The power supply shall operate over a temperature range of -32 degrees F to 140 degrees F and shall have self-protect overload cut off switch. They shall have 02 LED lights to indicate the performance status of the ionizing/collecting cell.

High voltage output components in the power supply shall be sealed with epoxy for moisture resistance.

7.5.12. Outstanding Features:

The power pack shall incorporate a short circuit arc protection with automatic power restoration system to prevent overload. Should arcing takes place (due to collection cells being loaded with contaminants or should there be a fault in the unit), the power pack shall be able to automatically cut off the supply to stop the arcing and reset after a few seconds. This is to prevent and drastically reduce the risk of fire from continuous arcing.

7.5.13. BMS (Building Management System) Interface:

The power supply (pack) shall have a 2 wire dry contacts (NO/NC) for remote link to Building Management System. This is for performance indication of the air cleaning system. Should there be a fault or if service is required, the dry contacts close, and a signal is sent to the building BMS System. Should there be multiple units, all the dry contacts can be looped into a set of signal. This ensures proper monitoring of the status of each unit.

7.5.14. Performance Indicator Lights:

There shall be 2 LED lights (Green & Red) installed on the access door of the unit to indicate the status of the air cleaning system.

7.5.15. Electrical:

Factory wiring will be in accordance with the National Electrical Code. Required field wiring shall conform to the National Electrical Code and any local code requirements. The manufacturer shall be informed of any local variances to the National Electrical Code.

7.5.16. Approval / Code Requirements

1. The EAC shall be tested in accordance to CE Certification. It shall comply with
   Directives : 2006/95/EC Low Voltage
   : 2004/108/EC Electromagnetic Compatibility

2 It shall also meet the following standards

Standards : EN 60335-1:2012, EN 60335-2-65:2003+A11:2012
: EN 55014-1:2006+A2:2011,EN 550142:1997+A2:2008,
: EN 6100-3-2:2006+A2:2009, EN 61000-3-3:2013

7.6. Piping

7.6.1. Scope

All piping inclusive of fittings and valves shall follow the applicable Indian Standards. All welders used for piping erection shall be well qualified (certificate should be submitted to Project Manager for approval) and shall have minimum 8 to 10 years' experience.

7.6.2. Pipe Sizes

Pipe sizes shall be as required for the individual fluid flows as recommended by OEMs.

7.6.3. Cold Water and Drain Piping

a. All pipes to be used for cold water (makeup), drain, condensate drain and fittings shall be GI / U-PVC.

b. All jointing in the pipe system shall be by screwed joints and/or by screwed flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.

c. All pipes supports shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed.

d. Fittings shall be galvanized steel `medium class' malleable casting of pressure rating suitable for the piping system. Supply of flanges shall include bolts, nuts, gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections, or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping and are not separately identified

e. Gate valves, globe valves, check valves and strainers shall be similar to those specified for chilled, condensing and hot water piping.

f. For proper drainage of AHU Condensate, 'U' trap shall be provided in the drain piping.

g. All condensate drain piping shall be insulated and painted

7.6.4. Refrigerant Piping

a. All refrigerant pipes and fittings shall be hard drawn copper tubes and wrought copper / brass fittings suitable for connection with silver solder / phos-copper.

b. All joints in copper piping shall be sweat joints using low temperature brazing and / or silver solder. Before joining any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using carbon dioxide / nitrogen.

c. Refrigerant lines shall be sized to limit pressure drop between the evaporator and condensing unit to less than 0.2 kg per sq.cm.

d. Sight glass with moisture indicator and removable type combination dryer cum filter with MS housing and brass wire mesh / punched brass sheet shall be installed in liquid line of the refrigeration system incorporating a three-valve bypass. After ninety days of operation, liquid line drier cartridges shall be replaced.

e. Heat exchanger shall be MS heavy duty pipe in pipe type and without any joint in the inner pipe.

f. Horizontal suction line shall be pitched towards the compressor and no reducers shall be provided for proper oil return.

g. After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using Freon mixed with nitrogen / carbon dioxide at a pressure of 20 kg per sq. cm (high side) and 10 kg per sq. cm (low side). Pressure shall be maintained in the system for a minimum of 12 hours. The system shall then be evacuated to a minimum vacuum of 70 cm of mercury and held for 24 hours. Vacuum shall be checked with a vacuum gage.

h. All refrigeration piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturer.

7.6.5. Piping Installation

a. The Contractor, on award of the work, shall prepare detailed shop drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in the building through which pipes are designed to pass.

Pipe shall be cut only with hack saw blades and welding rods shall not be used for this purpose.

b. Piping shall be properly supported on, or suspended from, stands, clamps, hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers and be responsible for their structural sufficiency.

All pipes shall be supported with pipes and channels from floor or ceiling with necessary PUF pipe supports and resist flex sheet.

c. Pipe supports shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black. Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following:

Pipe size	Spacing between supports	Rod Size
Upto 12 mm	1.5 Meter	10 mm
15 to 25 mm	2.0-meter	10 mm
30 to 150 mm	2.0-meter	10 mm

d. Vertical pipes passing through floors shall be plumb and parallel to wall. Pipes shall be supported on alternate floor. U clamps with resist flex sheet shall be provided to keep the pipe in position.

e. Bull heading in water/refrigerant piping shall be avoided.

f. Pipe sleeves at least 3 mm thick, 50 mm / 100 mm larger in diameter than condenser / chilled water pipes respectively shall be provided wherever pipes pass through

retaining wall and slab. Annular space shall be filled with fiberglass and finished with retainer rings welded on the ends of the sleeve.

g. Wherever pipes pass through the brick or masonry / slab openings, the gaps shall be sealed with fire sealant such as fire barrier caulks.

h. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 20 gage metal sheets shall be provided between the insulation and the clamp, saddle or roller, extending at least 15 cm on both sides of the clamp, saddles or roller.

j. All piping work shall be carried out in a workman like manner, causing minimum disturbance to the existing services, buildings and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipes, supports, and pressure testing for each area shall be carried out in one stretch.

k. Contractor shall carefully determine cutout to be provided and clearly point out locations for civil work

l. The Contractor shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.

m. All pipes shall be accurately cut to the required size in accordance with relevant BIS Codes, edges beveled, and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.

n. All buried pipes shall be cleaned and coated with zinc chromate primer and bitumen paint and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters and wrapped with three layers of fibre glass tissue, each layer laid in bitumen.

q. Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.

r. Whenever services like piping, ducting and cabling are passing through floor slab, shaft or fire zone wall, opening around services shall be closed with fire retardant material. Contractor shall use either fire compound or fire barriers for this purpose. Fire compound shall be in form of powder and shall be mixed with water in proportion suggested by OEM. Mixed compound shall be poured in shuttering and grid of 30 x 30 x 1.2mm angles placed as 150mm center to center. Minimum thickness of pour shall be 100mm and shall be for fire integrity of 120minutes. Angles shall be securely welded to building re-bars (if left during construction) or fastened to concrete floor.

Fire barrier shall be in form of high-density rock wool slabs with surface treated for fire retardation. Minimum thickness of the slab shall be 100mm and shall be for fire integrity of 120 minutes. Slabs shall be tightly friction fitted in the shaft to cover all open spaces.

7.6.6. Steel Wire Rope Hangers & Supports:

Wire Hangers shall be used to suspend all static HVAC & Mechanical services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed

threaded M6 (or M8, M10) stud, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel lock) at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip. Only wire and/or supports supplied and/or approved, shall be used with the system.

Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, UL NEBS, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by ULC and CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope should be manufactured to BSEN 12385: 2002

The contractor shall select the correct specification of wire hanger to use for supporting each service from Table 1 below. Each size is designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required is determined using the following formula.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. Lengths from 1-10m lengths. Specials can be made, check with manufacturer. No in–line joints should be made in the rope.

Table. 1

Wire (Gripple) Hanger Safe Working Loads		
Hange rsize	**minimum breaking load of Wire Rope (kg/lbs)**	**working load limit (kg/lbs)**
No. 1	80kg/176 lbs	0-10 kg / 0-22 lbs
No. 2	260kg/572 lbs	10-45 kg / 23-100 lbs
No. 3	580kg/1276 lbs	45-90 kg / 101-200 lbs
No. 4	1500kg/3300 lbs	90-225 kg / 210-495 lbs
No. 5	2160kg/4752 lbs	225-325 kg / 496-715 lbs
No. 6	2500kg/5500 lbs	325-500 kg / 715-1100 lbs

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless-steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. Comply with manufacturer's load ratings and recommended installation procedures.

Mechanical Supports – Gripple Hanger Supports are suitable for: Drainage Pipes, Gas Pipes, Refrigeration Pipes, Condensation Water Pipes.

Piping Supports: Rigid supports may be used in conjunction with Gripple hangers to assist with alignment of services as per the Schedule. These can be at 30m intervals or so depending on the run of the service. Rigid support must also be used in conjunction with Gripple hangers with pipe work at each change of direction or connection. For insulated

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pipe, provide protective sleeve to protect the entire circumference of the pipe insulation. Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

Any other Gripple solution can be used based on manufacturer's recommendation on site conditions after prior approval. Support piping in accordance with Schedule I, II & III specified below:

For further technical information, refer to manufacturers catalogue and installation guide. Comply with manufacturer's load ratings and recommended installation procedures. All supporting system to be provided by same manufacturer.

SCHEDULE – I : BARE PIPE / PIPE INSULATED WITH NITRILE RUBBER

Pipe Size (mm dia)	Wt. of Pipe + Water + insulation (kg / mt)	Spacing between pipe supports (mt)	Total Wt. of Pipe between two supports (kg)	Gripple Hanger size
12-40	7	2	14	No. 2
50-65	15.22	2	30	No. 2
80	34.73	2	69	No. 3
100-200	73	2	146	No. 4
250 & above	Rigid supports to be used as per pipe hanger Schedule – III			

7.6.7. Pipe Hanger Schedule III:

Rigid Supports for pipes to be used in conjunction with wire supports:

Rigid supports if required in conjunction with wire hangers shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between.

PIPE SIZE (mm)	PIPE SUPPORT
UP TO 50 Ø	40×40×6 M.S ANGLE

7.6.8. Testing

a. During construction, the contractor shall properly cap all lines, to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.

b. All piping shall be tested to hydrostatic / pneumatic test pressure of at least two times the maximum operating pressure, but not less than 10 kg per sq. cm gage for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved

c. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

d. Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.

Duct diameter mm	Upto 50 mm Wg static pressure (+ve)		51 – 250 mm Wg static pressure (+ve)		Upto 50 mm Wg static pressure (-ve)	
	Spiral seam gauge	Longitudinal seam gauge	Spiral seam gauge	Longitudinal seam gauge	Spiral seam gauge	Longitudinal seam gauge
Upto 650	26	24	24	22	24	22
651-900	24	22	22	20	22	20
901 – 1250	22	20	20	20	20	18
1251 – 1500	20	18	18	18	18	16
1501 – 2100	18	16	18	16	16	14

7.7.2. Fabrication Standards & Equipment

All duct construction and installation shall be in accordance with SMACNA standards. In addition, ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts

Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
Factory fabricated and factory boxed ducts shall be used upto 1 M side. Ducts above 1M side may be supplied to site in L profiles.

All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines

All edges to be machine treated using lock formers, flangers and rollers for turning up edges
In the case of ambiguity, SMACNA codes to be followed for duct fabrication and installation

Kitchen exhaust ducting shall be with 16 G MS / 18G SS welded construction. Suitable access doors shall be provided at every 3m. Provision shall be made for firefighting agency to install duct mounted sprinklers at every 3m. Generally, exhaust ducts shall have slope towards kitchen hood. Spot Welded M.S Stuck-up pins shall be provided facilitating insulation of the Duct

7.7.3. Duct Construction

All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes.

a) Ducts shall be acoustically lined and insulated as per approved drawings. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.

b) Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness.

c) Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

d) All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.

e) All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS / 16gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces or equivalent stiffening as per SMACNA and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Alternatively, plenums can be made in multiple parts and joined with 4 Bolt slip-on flange system with suitable reinforcement as per SMACNA. Access doors shall be not less than 45cm x 45cm in size.

f) Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.

g) Self-adhesive Neoprene rubber / UV resistant PVC foam lining 5mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.

h) All fire rated duct, smoke exhaust ducts shall be quoted with flame bar BWII or equivalent to achieve the required fire rating also all the related accessories gaskets shall be suitable for the required fire rating.

7.7.4. Pre-insulated ducts

Pre-Insulated Ducting shall be fabricated from 20 mm thickness air duct panel sheet having dimensions of 3000 (Length) mm by 1200 (Width) mm and produced and Sandwiched with Polyisocyanurate (PIR) first quality insulating Foam having 35 Kg / m3 density. The Ducting Sheet shall have Lacquered & Embossed Aluminium facing on both sides.

Insulating foam material shall be Expanded Rigid Polyisocyanurate foam having Closed cell content not less than 95%, CFC/ HCFC free, Non-Toxic, Noncombustible, zero ozone depletion, Zero Global Warming Potential and Non ignitable.

Ducting panels shall comply with following or equivalent standards and manufacturer should produce M1 & F1 certification for Fire & Toxicity test results.

- BS 476: PART 6--Fire Propagation for Products
- BS 476: PART 7--- Surface Flame Spread (Class 1)
- Class O Fire Rating as per Building Regulation requirements.
- Thermal Conductivity Coefficient at 100C--0.022 W/m. K
- Smoke Opacity Index—less than 10
- Rigidity class: 200000 Nm m2/mm
- Water vapor permeability of laminations = 0

All required accessories; Connecting Flanges, Invisible Bayonet, Adhesive, Sealant, Duct Supports shall be part of ducting work for fabrication of the HVAC ducting in Square, rectangle, radius, offset construction etc., appropriate sizes of Aluminium flanges with self-adhesive good quality gasket shall be provided as a joinery or connection of duct pieces.

Excellent quality Silicon Neutral Sealant of Approved make along with fire rated PVC corners shall be used for sealing of all joints & corners.

MMRDA

Complete ducting shall be installed incorporating duct supports such as galvanized angles, threaded rods, self-adhesive brackets, etc.

Panel Specifications: --

Description	Internal Areas of Building	External Areas of Building
Dimensions of panel	3000 x 1200 mm	3000 x 1200 mm
Thickness of panel	20 mm	20/30 mm
Thickness of aluminium laminations	60/60 microns	60/200 microns
Density of the foam	35 kg/m3	35 kg/m3
Surface finish	Embossed both sides	Embossed both sides
Anti-rust lacquer	2 gm/m2 both sides	2 gm/m2 both sides

7.7.5. Installation Practice

All ducts shall be installed in strict accordance with approved shop drawings to be prepared by the Contractor:

The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings.

a. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.

b. If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of Engineer

c. All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes (as per clause 27.13) or threaded rods and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab or wall as per approved general installation drawings / approved shop drawings. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting.

d. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using using braided wire rope shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of threaded rods, the rod diameters shall be as per reference standards

e. Alternatively, all ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel rod under ducts.

The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats or fully threaded galvanized rods can be screwed into the anchor fasteners.

f. Ducting over furred ceiling shall be supported from the slab above, or from beams after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time

g. Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.

h. All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

i. Duct shall not rest on false ceiling and shall be flat bottom type. Taper pieces shall taper from top.

7.7.6. Dampers

a. Dampers: All duct dampers shall be opposed blade louver dampers of robust 16 GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.

b. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall always have an indicating device clearly showing the damper position.

c. Dampers shall be placed in ducts at every branch supply or return air duct connection, for the proper volume control and balancing of the air distribution system.

d. Pressure relief dampers: Pressure relief dampers shall be constructed with 18G Aluminum construction with parallel blade construction. Leaf's shall be 100% airtight upon closure. Leaf's shall be loaded with spring pressure of stiffness (k value) or counterweight corresponding to set point pressure.

e. Non return damper (Back draft damper): Non return damper shall be constructed out of 18G GSS. Blades shall ensure 100% air leak proof performance on closure. Design shall ensure that no rattling noise is produced at design duty.

7.7.7. Fire & Smoke Dampers

a. All supply and return air ducts at AHU room crossings and at all floor crossings or as indicated in the drawings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span. The dampers shall meet the requirements of NFPA90A, 92A and 92B. Dampers shall have a fire rating of 1.5 Hrs. in accordance with latest edition of UL555 and shall be classified as Leakage Class 2 1 smoke damper in accordance with latest version of UL555S. Each fire/smoke damper shall be AMCA licensed and bear the AMCA seal for air Performance. Pressure drop shall not exceed 7.5Pa when tested at 300m/min face velocity on 600x600mm size damper. Actuator shall be UL listed.

b. Each damper shall be supplied with factory mounted sleeve of galvanized steel of thickness as per SMACNA and of minimum 500mm long or depending up on the wall thickness. The damper shall be fitted in to sleeve either using spot welding, crimping or self-tapping screws. All welded joints shall be finished using heat resistance steel paint. UL listed and approved Silicon sealant shall be applied at all corners as well as at joints between damper frame and sleeve. Damper Frame shall be a roll formed structural hat channel, reinforced at corners, formed from a single piece of 1.6mm galvanized steel. Damper blades shall be airfoil shaped (equivalent to 2mm thickness strength) roll formed using 0.7mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. Blade edge seals shall be silicone rubber and galvanized steel mechanically locked into the blade edge (adhesive type seals are not acceptable). Side Jam seals of stainless steel and Top and bottom seals of galvanized steel shall be provided. All galvanized steel used shall be with minimum 180 gm / sqm Zinc coating. Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module, jack shafted together. Multiple actuators shall be provided for large dampers with higher torque requirements as prescribed in UL.

c. The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct / return air duct. Electric Actuator of suitable Torque and as approved by UL shall be factory mounted and tested. The actuator shall be provided with 230V 1 Phase power supply from AHU panel / emergency panel and shall include necessary transformer for its operation. In addition, actuator shall have elevated temperature rating of 350 deg.F. Electric Actuator shall have been energized hold open tested for a period of at least one year with no spring return failure. Each fire/smoke damper shall be equipped with a heat actuated release device which shall allow controlled closure of damper rather than instantaneous to prevent accident. (Electrical fusible link). The EFL shall allow the damper to reopen automatically after a test, smoke detection or power failure condition. The damper shall be equipped with a device to indicate OPEN and CLOSE position of Damper blades through a link mounted on the damper blade.

d. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 230 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:

- Potential free contacts for AHU fan ON/ Off and remote alarm indication.
- Accept signal from external smoke / fire detection system for tripping the electrical actuator.
- Test and reset facility.

- Indicating lights / contacts to indicate the following status:
- Power Supply On
- Alarm
- Damper open and close position.

e. Actuators shall be mounted on the sleeve by the damper supplier as per UL guidelines and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with its control panel. Control panel shall be wall mounted type.

f. Hooking up the Motor Operated Damper to Fire Detection / Fire Management System shall be by contractor. All necessary materials including power cabling between control panels to fire dampers actuator for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.

g. Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.

h. Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.

i. Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing and installation at site.

j. Fire/smoke damper shall be provided with factory fitted sleeves and connecting flange and mounting angles for installation; however, access doors shall be provided in the ducts within AHU room in accordance with the manufacturer's recommendations.

k. The Contractor shall also furnish to the Owner, the necessary additional spare actuators and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

7.7.8. Fire Dampers

a. Whenever a supply/return duct crosses from one fire zone to another, it shall be provided with approved fire damper of at least 1½ hour fire rating as per as per latest standard of UL555 and tested by CBRI. This shall be curtain type or multileaf type fire damper.

b. Curtain type fire damper blades shall be one piece folded high strength minimum 24G galvanized steel construction and will be spring return type. In normal position, these blades shall be gathered and stacked at the frame head providing maximum air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 74oC (165°F).

The HVAC contractor shall supply UL classified Fire Dampers meeting or exceeding the specifications. Fire Dampers shall have a fire rating of 1.5/3 Hrs.as specified in BOQ, in accordance with latest edition of UL555.

Multileaf type fire damper shall be equipped with UL labelled Fusible Link with Temperature setting 74oC (165°F). Fire dampers shall have been tested to close under dynamic air flow conditions with pressure up to 1000 pa and velocities up to 10.2 m

/sec. Fire damper shall be approved for Horizontal or vertical installation as may be required by the location shown in the drawings. Each Fire damper shall be AMCA licensed and shall bear the AMCA seal for air performance.

Damper Frame shall be a roll formed structural hat channel, reinforced at corners, formed from a single piece of 1.5mm galvanized steel. Damper blades shall be roll formed 3-v groove (1.5mm thick) or airfoil shaped in case of 3 Hrs. fire rating (equivalent to 2.0mm thickness strength) roll formed using 1.0 mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. All galvanized steel used shall be with minimum 275 gm / sqm Zinc coating Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module jack shafted together.

Fire damper shall be equipped with an electric limit switch to indicate open and close position of the damper blades.

Fire Damper shall be installed in wall or floor opening using galvanized steel sleeve of minimum 500mm length of sheet thickness for fire & smoke damper as per SMACNA and as per Installation instruction of Manufacturer.

c. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.

d. Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.

e. The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), minimum of 5% of the total number installed, at the time of commissioning of the installation.

7.7.9. Supply and Return Air Registers

Supply & return air registers shall be of either steel or aluminium sections. Steel construction registers shall have primer Coat finish whereas extruded aluminium registers shall be either Anodized or Powder Coated. These registers shall have individually adjustable louvers both horizontal and vertical. Supply air registers shall be provided with key operated opposed blade extruded aluminium volume control damper anodized in matt black shade. The register should be constructed with 1 mm thick frame, blade of 0.8 mm thick and opposed blade dampers of 1 mm thick.

The registers shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air register shall be extruded aluminium construction with fixed horizontal bars at 15 Deg. inclination & flange on two sides only. The thickness of the fixed bar louvers shall be minimum 5mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Engineer

The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminium anodized in black color shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.

a. All registers shall be selected in consultation with the Engineer. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Engineer for each type of register.

b. All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it must be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.

c. Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to +45-degree horizontal arc and upto 30-degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.

d. Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.

e. All volume control dampers shall be anodized aluminium in mat black shade having 1 mm minimum thickness.

7.7.10. Supply and Return Air Diffusers

Mild steel diffusers/dampers shall be factory coated with rust-resistant primer. Aluminium diffusers shall be powder coated & made from extruded aluminium section. The diffuser should be constructed with 1 mm thick frame, blade of 0.8 mm thick and opposed blade dampers of 1 mm thick.

a. Rectangular Diffusers shall be steel / extruded aluminium construction, square & rectangular diffusers with flush fixed pattern for different spaces. These shall be selected in consultation with the Engineer. These shall be procured only after obtaining written approval from Engineer for each type of diffuser.

b. Supply air diffusers shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings as re-required in specific applications. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.

c. Linear Diffuser shall be extruded aluminium construction with removable core, one- or two-way blow type. Supply air diffusers shall be provided with volume control/ balancing dampers within the supply air collar. Diffusers for different spaces shall be selected in consultation with the Engineer. All diffusers shall have volume control dampers of extruded aluminium construction anodized in mat black shade.

d. Slot Diffuser shall be extruded aluminium construction multiplot type with air pattern controller provided in each slot. Supply air diffusers shall be provided with Hit & Miss volume control dampers in each slot of the supply air diffusers. Diffusers for different spaces shall be selected in consultation with the Engineer

e. Server room shall be provided with floor grilles. Grilles shall be of nominal size of 600mm x 600mm and shall be fitted in floor tile of false floor. Grille shall be with dampers for flow control. Grill shall be heavy duty 16G Aluminium and shall take care of human traffic load. Damper shall be operable in situ without requirement of removal of grille.

7.7.11. Fire Rated Ductwork

Ducting for kitchen exhaust & fire evacuation, staircase pressurization if not in a separate shaft shall be fire rated as per following specifications.

a. All fire rated ductwork constructed for mechanical or dual ventilation / pressurization/ basement car park/smoke extract systems and shall be fabricated from Lock Forming Quality grade prime galvanized steel sheet, constructed to enhanced SMACNA American / DW144 European standard to either low, medium or high velocity/ pressure.

b. Test requirement of fire rated ductwork should be tested to BS476: Part 24 [1987] and ISO 6944 providing required fire rating for Stability and Integrity.

c. Stability: the ability of a duct, ductwork & the support system to remain intact & fulfill their intended function for a specified period, when tested to the requirements of BS476: Part 24 and ISO 6944.

d. Integrity: the ability of a duct or ductwork to remain free of cracks, holes or openings outside the compartment in which the fire is present for a specified period, when tested to the requirements of BS476 Part 24 ISO 6944.

e. Insulation: the ability of a duct or ductwork to maintain its separating function without developing temperatures on its external surface outside the compartment in which the fire is present, which exceeds, (i) 140OC as an average value above ambient & or, (ii) 180OC as maximum value above ambient at any point, when tested for a specified period of time to the requirements of BS476: Part 24 ISO 6944.

f. It's important that the fire rated ductwork has a smooth internal surface in order to minimize the pressure loss within the fire rated ductwork system thereby reduce the power requirements.

g. All fire rated ducts for Smoke Extract shall have Stability / Integrity and Insulation for smoke temperatures up to 300OC upto 1.5 hrs., restriction of the duct due to twisting or buckling after the fire test shall not cause 25% or more reduction in cross sectional area proven by certification from an independent test house.

h. Each duct shall have fire rated coating. Fire rated coating compound used for construction of fire rated ductwork shall be protected with minimum 0.7mm to 1mm nominal thickness tested to properties as per the requirements of BS 476: 6 & 7, including non-combustibility Class O and fire propagation - Class 1 surface spread of flame & materials in accordance with Building Regulations.

i. Fire duct to be tested / assessed to BS476: Part 24 for all sizes up to 25 meters x 3 meters cross-sectional area and fully certified to vertical and horizontal plane.

j. Fire rated duct fabricated to Method 3 of BS 5588: Part 9, factory produced. The coating compound shall be applied either offsite or onsite on the ground, dried and cured.

k. Fire duct expansion under fire conditions shall not exceed following:

- at 430OC an expansion of 0.006106mm per mm
- at 600OC an expansion of 0.00852mm per mm
- at 1100OC an expansion of 0.01562mm per mm.

7.7.12. HVAC Supports

Braided wire Hanger Supports are suitable for: Rectangular duct, Spiral Duct, Oval Duct, Fabric Duct, Diffusers, plenum boxes

7.7.13. Ducting Supports:

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter or 2 meter, whichever smaller. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using braided wire supports shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method (refer to typical drawings) under ducts at no greater than 3000mm centre, for 3001mm-above appropriate size angle along with neoprene pad in between the duct & MS angle should be used with prior approval. All vertical duct work shall be supported by structural members on each floor slab. Duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger wires shall then hang around the ducting. Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connection or as per approved drawings. Support ducting in accordance with Schedule I specified below. Any other braided wire supports solution can be used based on manufacturer's recommendation on site conditions after prior approval. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided, refer to manufacturer's recommendations.

Wire Hangers should have been independently tested by Lloyds Register, APAVE, TUV, CSA, Intertek approved by CSA and comply with the requirements of DW/144 and BSRIA – wire rope suspension systems.

Wire Hangers shall be independently tested by reputed third party testing organization to sustain safe working load for 120 min at elevated temperatures of 175 deg.C or above.

Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Construction manager/consultant. In no case shall any duct be supported from false ceiling Hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building. All supports of pipe shall be taken from structural slab/wall by means of fastener.

Catenary Supports: Refer to manufacturer's recommendations on Catenary supports with C-clip, special care should be taken with tensioning of the wire and angles at which the installation of services is made.

Stainless Steel Supports should be provided for food, chemical and High Corrosion areas near coastlines.

For further technical information refer to manufacturers catalogue and installation guide. Comply with manufacturer's load ratings and recommended installation procedures.

Schedule I: Duct Hanger Schedule

For ducts with external SP upto 250 Pa

Maximum Duct Size (mm)	Gauge	Hanger size
1 - 500	26	No. 1 or 2
501 - 750	26	No. 1 or 2
751 - 900	26	No. 2
901 - 1200	24	No. 2 or 3
1201 - 1500	22	No. 3
1501 - 1800	22	No. 3 or 4
1801-2100	20	No. 3 or 4
2101-3000	18	No. 4
3001 - above (Trapeze type support Arrangement)	18	No. 3 or 4

For ducts with external SP upto 500 Pa

Maximum Duct Size (mm)	Gauge	Hanger size
1–400 mm	26	No. 2
401-700 mm	24	No. 2 or 3
701-900 mm	24	No. 2 or 3
901-1000 mm	22	No. 3 or 4
1001-1200 mm	22	No. 3 or 4
1201-2100 mm	22	No. 3 or 4
2101 - 3000mm	18	No. 4
3001 - above (Trapeze type support Arrangement)	18	No. 3 or 4

Notes: All supports are considered at 2400 mm interval in above table and may vary as per the design but should not be greater than 2400mm.

All units shall be adequately secured and supported in an approved manner using wire hanger suspension Y fit solution as per manufacturers' recommendation with prior approval.

Rigid Supports to be used in conjunction with wire supports:

Rigid supports if required in conjunction with wire hangers shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black or H.D. Galvanized as per interior requirement. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between. If the MS angle at the bottom if required as per design should be as per following table:

Longer size of Duct (mm)	Type of Joints
Up to 750	25x25x3 mm L angle with M8 nuts & bolts
751-1000	25x25x3 mm L angle with M8 nuts & bolts
1001-1500	40x40x5 mm L angle with M8 nuts & bolts

1501-2250	50x50x5 mm L angle with M10 nuts & bolts
2251 & above	50x50x6 mm L angle with M10 nuts & bolts

All the supporting system should be supplied from the same manufacturer.

Alternatively, ducts can be supported by means of threaded galvanized rods as per schedule given in standard installation detail drawings

7.7.14. Flexible Duct

Insulated flexible duct should be UL 181 CLASS I AIR DUCT LISTED AND LABELLED WITH NFPA 90A & 90B AND SEAL OF AIR DIFFUSION COUNCIL with double lamination of tough polyester which encapsulates steel helix wire forms the air tight inner core, double layer core wrapped in a multiple thickness of fiberglass wool with R Value 4.2, Green guard certification of fiberglass wool must. Reinforced and sheathed in a rugged and durable tridirectionally reinforced metalized polyester jacket.

Flexible duct connections should be made as per UL181 listing procedure with proper flexible right forming brace connection allowing right connections for flexible duct into energy efficient. and Strapping the flexible duct connections with flexible duct strap ties.

7.7.15. Testing and Balancing

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection.

The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to or less/excess than 5 percent of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

7.8. QUALITY ASSURANCE, INSPECTION, TESTING AND COMMISSIONING

The following quality assurance, inspection, testing and commissioning procedures shall be required to be carried out upon award of work.

I. Provide quality assurance program (QAP), works quality assurance program (WQAP), field quality assurance program (FQAP) and quality plan.

II. Tests at manufacturer's works.

III. Perform site tests and commissioning.

7.8.1. Submittals

I. After award of work following information shall be submitted.

a. Quality Assurance Program (QAP)
b. Works Quality Assurance program me (WQAP)
c. Field Quality Assurance Programmed (FQAP)

II. For inspection and testing, submit inspection and testing procedures, program me, record sheets applicable at each hold point.

III. After completion of testing, submit test records, packaging, transportation and storage instructions and methods.

IV. For site installation and commissioning, submit installation methods or procedures, notification and procedures for precommission and commissioning.

V. After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

7.8.2. Quality Assurance Concept and Control

I. Minimum requirements for establishing and implementing a quality assurance program me shall be applied to all aspects of the work necessary for carrying out the contract. Quality assurance shall extend to material parts, components, systems and services as a means of obtaining and sustaining the reliability of critical items, operating performance, maintenance and safety.

II. Acceptance of the Contractor's quality assurance program me does not relieve the Contractor's obligation to comply with the requirement of the contract document. If the program me is found to be ineffective, then the Owner's site representative reserves the right to request for necessary revisions of the program me.

III. The Contractor is required to produce readily identifiable documentary evidence covering the extent and details of both his own and his sub contractor's quality assurances system as follows:

a. Quality Assurance Program (QAP)
b. Works Quality Assurance program me (WQAP)
c. Field Quality Assurance Programmed (FQAP)
d. Quality Plan.

IV. These documents shall be prepared separately and submitted to the Owner's site representative at the time of starting the work.

V. Quality Plan and Manual shall be prepared by the Contractor for all items and services to be supplied, after the contract has been placed, but before commencement of fabrication, and shall be subject to evaluation and acceptance by the Owner's site representative before start of work.

7.8.3. Quality Assurance Manual (QAM)

I. The QAM shall be a general comprehensive document outlining the Contractor's basic organization, policies and procedures. The information to be given in the QAM shall include but not limited to:

a. Quality Policy.

b. Quality Assurance Programmed

c. Organization Structure showing inter relationships.

d. Functional responsibilities and levels of authority.

e. Lines of communication.

f. Customer relations.

g. Laboratory Facilities.

Works Quality Assurance Programmed (WQAP)

II. The WQAP shall identify the Contractor's Quality Assurance Programmed at works applicable throughout all phases of Contract performance, including design, procurement, manufacture, inspection and testing. It shall identify each of the program me elements to be designed, developed, executed and maintained by the Contractor for the purpose of ensuring that all supplies and services comply with this specification.

III. The information to be given under this program me shall include but not limited to:

a. Organization and Responsibility.

b. Contract Review.

c. Design and Document Control.

d. Procurement Control.

e. Production Control.

f. Control on Sub-contractors.

g. In-process Quality Control and Traceability.

h. Inspection and Testing.

i. Control of Non-conformances.

j. Corrective Action.

k. Control of Inspection, Measuring and Test Equipment.

l. Handling, Storage, Packaging and Delivery.

m. Records.

n. Quality Audits.

o. After - Sales Servicing.

7.8.4. Field Quality Assurance Programmed (FQAP)

I. This program me shall identify the Contractor's Quality Assurance Programmed at site applicable throughout site construction, erection and commissioning. It is the underlying philosophy that the quality built into the product at works shall be maintained throughout the construction and commissioning stages.

II. While, in principle, the FQAP shall include the items discussed in WQAP, it shall, however, be approached differently to consider site conditions.

III. The FQAP shall include, but not limited to the following information:

a. Organization and responsibility.

b. Control of Drawings and Documentation.

c. Product Checklist.

d. Control and Traceability of Purchased materials and services.

e. Receipt Inspection of materials at site.

f. Material Storage Control.

g. Inspection and Examination Procedures.

h. Control of Painting and Insulation Works.

j. Pre-commissioning.

k. Commissioning.

l. Control of Non-conformances.

m. Corrective Action.

n. Control of Inspection, Measuring and Test Equipment.

p. Records.

q. Completion Documents.

r. List of recommended spares and tools.

s. Personal Training.

t. Servicing during Defects Liability Period.

7.8.5. Quality Plan

I. The contractor shall be required to prepare manufacturing and construction/erection quality plans for all equipment items and services. The quality plan shall also define the involvement of Owner's site representative in the inspection and test programmers.

II. The Quality Plan shall incorporate as appropriate:

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a. Charts indicating flow of materials, parts and components through manufacturing quality control inspection and test to delivery and erection.

b. The charts shall indicate the location of hold points for quality control, inspection and test beyond which manufacture shall not continue until the action required by the hold point is met, and the documentation required is generated.

c. The control documents associated with each hold point, i.e. drawings, material, specification, Works Process Schedule (WPS), Process Quality Records (PQR), quality control methods and procedures and acceptance standards.

7.8.6. Site Quality Control Section

I. The Contractor's Quality Control (Q.C.) section shall be headed by an experienced Quality Control Engineer. He shall be assisted by other supervisors. The section shall be an independent one, reporting to the contractor's Site Manager only on administrative matters, but otherwise under full control by the Contractor's Corporate Quality System Management.

II. The Contractor's Q.C. Section shall liaise closely with the Owner's site representative in charge of Quality Assurance/Quality Control, and to whom it shall give fullest cooperation. It is the underlying principle of this contract document that while the Contractor's Q.C. Engineer implements the Contractor's Quality Programmed, the adequacy and effectiveness of that implementation shall be audited by the Owner's site representative whose recommendations on improving or maintaining quality shall be acted upon promptly by the Contractor's Q.C. Section.

7.8.7. Inspection and Testing

I. All equipment and components supplied may be subjected to inspection and tests by the Consultant/ Owner's site representative during manufacture, erection/installation and after completion. The inspection and tests shall include but not be limited by the requirements of this contract document. Prior to inspection and testing, the equipment shall undergo pre-service cleaning and protection.

II. Tenderers shall state and guarantee the technical listed in the Schedule of Technical Data. These guarantees and shall be binding and shall not be varied without the written permission of the Owner's site representative.

III. No tolerances shall be allowed other than the tolerances specified or permitted in the relevant approved Standards, unless otherwise stated.

IV. If the guaranteed performance of any item of equipment is not met and / or if any item fails to comply with the specification requirement in any respect whatsoever at any stage of manufacture, test or erection, the Owner's site representative may reject the item, or defective component thereof, whichever he considers necessary; and after adjustment or modification as directed by the Owner's site representative, the contractor shall submit the item for further inspection and /or test.

V. The approval of the Owner's site representative of inspection and/or test results shall not prejudice the right of the Owner's site representative to reject an item of equipment if it does not comply with the contract document when erected, does not or prove completely satisfactory in service.

VI. The Contractor shall be responsible for the timely transmission of the relevant and appropriate sections of the contract document to manufacturers and sub-contractors for the proper execution of all tests at their works as per contract specifications.

7.8.8. Tests at Manufacturer's Works

I. All tests to be performed during manufacture, fabrication and inspection shall be agreed with the Consultant/ Owner's site representative prior to commencement of the work. The Contractor shall prepare the details of the schedule and submit these to the Consultant/ Owner's site representative for approval. It must be ensured that adequate relevant information on the design code/standard employed, the manufacture /fabrication/assembly procedure and the attendant quality control steps proposed are made available to the Consultant/Owner's site representative who will mark in the appropriate spaces his intention to attend or waive the invited tests, or inspections.

II. A minimum of twenty-one days' notice of the readiness of equipment for test or inspection shall be provided to the Owner's site representative by the Contractor (whether the tests be held at the Contractors of Sub-contractor's works). The subject items should remain available for Owner's site representative inspection and test up to a minimum 10 days beyond the agreed date of witnessing the test. Every facility in respect of access, drawings, instruments and manpower shall be provided by the Contractor and sub-contractor to enable the Owner's site representative to carry out the necessary inspection and testing of the Plant.

III. No plant shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, all tests called for have been successfully carried out in the presence of the Owner's site representative or approved for shipment, or alternatively inspection has been waived.

IV. Functional electrical, mechanical and hydraulic tests shall be carried out on completed assemblies in the works. The extent of these tests and method of recording the results shall be submitted to, and agreed by, the Owner's site representative in sufficient time to enable the tests to be satisfactorily witnesses, or if necessary for any changes required to the proposed program me of tests to be agreed.

V. The Consultant/Owner's site representative reserves the right to visit the Manufacturer's works at any reasonable time during fabrication of equipment and to familiarize himself with the progress made and the quantity of the work to date.

VI. Within 30 days of completion of any tests, triplicate sets of all principal test records, test certificates and correction and performance curves shall be supplied to the Owner's site representative.

VII. These test records, certificates and performance curves shall be supplied for all tests, whether they have been witnessed by the Owner's site representative or not. The information given on such test certificates and curves shall be en[illegible]

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identify the material or equipment to which the certificate refers and should also bear the Contract reference title.

VIII. When all equipment has been tested, the test certificates from all works and site tests shall be compiled by the Contractor into volumes and bound in an approved from complete with index and four copies of each volume shall be supplied to Consultant/ Owner's site representative.

IX. Stage wise inspection of equipment in factory in waived.

7.8.9. Performance Tests at Manufacturer's Woks

I. All equipment may be subjected to routine performance tests at the Manufacturer's Works in accordance with the relevant ANSI, ASME, ASTM, BIS standard including operating tests of complete assemblies to ensure correct operation of apparatus and components.

II. Fans, compressor, and other rotating equipment shall be given full load tests and run to 15% over speed for 5 minutes to check vibration. Main and auxiliary gear boxes shall be subjected to shock load tests and a six-hour endurance run at rated speed and maximum torque.

III. The Contractor shall submit single line diagrams including the layout of the Plant together with the location of test instrumentation and the principal dimensions of the layout. All calculations to derive performance data shall be made strictly in accordance with format given in the approved standards. Any alterations or deviations from the approved standard test layout or formulae shall be subjected to the prior approval of the Owner's Site Representative.

IV. The performance test shall be conducted over the full operating range of the pump to a closed valve condition and a minimum of five measurement points covering the full range shall be taken. Curves indicating Quality vs. Head, Quantity vs. Power absorbed, and Quantity vs. Pump efficiency shall be provided. In addition, a curve of the NPSH required vs. Quantity shall be provided except when the suction conditions do not require this test. Any proposal for the omission of this test shall be to the approval of the Consultant/ Owner's site representative.

V. On completion of the tests the Contractor shall submit a report showing the test results obtained together with the curves corrected to the site operating conditions.

7.9. Testing, Adjusting and Balancing

a. Testing, adjusting and balancing of heating, ventilating and air-conditioning systems at site.

b. Testing, adjusting and balancing of exhaust system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : 2011 HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution system.

7.9.1. Performance

a) Verify design conformity.

b) Establish fluid flow rates, volumes and operating pressures.

c) Take electrical power readings for each motor.

d) Establish operating sound and vibration levels.

e) Adjust and balance to design parameters.

f) Record and report result as per the formats specified.

7.9.2. Definitions

a)	Test	:	To determine quantitative performance of equipment.
b)	Adjust patterns at	:	To regulate for specified fluid flow rates and air terminal equipment (e.g. reduce fan speed, throttling etc.)
c)	Balance branches	:	To proportion within distribution system (sub mains, and terminals) in accordance with design quantities.

7.9.3. Testing, Adjusting and Balancing (Tab) Procedures

The following procedures shall be directly followed in TAB of the total system.

Before commencement of each one of the TAB procedure explained hereunder, the contractor shall intimate the PMC about his readiness to conduct the TAB procedures in the format given in these specifications.

7.9.4. Description of System and Requirements

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

a) All supply return and outside air systems.
b) All exhaust air systems.
c) All chilled water systems.
d) All cooling tower (condenser) water systems.
e) Emergency purge systems.

7.9.5. Air Systems

I. Air Handlers Performance

The TAB procedure shall establish the right selection and performance of the AHUs with the following results:

a) Air-IN DB and WB temperature.
b) Air-OUT DB and WB temperature.
c) Dew point air leaving.
d) Sensible heat flow.
e) Latent heat flow.
f) Sensible heat factor.
g) Fan air volume.
h) Fan air outlet velocity.
i) Fan static pressure.
j) Fan power consumption.
k) Fan speed.

II. Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers and Accubalance for grilles and diffusers.

III. The Preparatory Work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals:

a. All outside air intake, return air and exhaust air dampers are in proper position.

b. All system volume dampers and fire dampers are in fully open position.

c. All access doors are installed & are airtight.

d. Grilles are installed & dampers are fully open.

e. Provision and accessibility of usage of TAB instruments for traverse measurements are available.

f. All windows, doors are in position.

g. Duct system are of proper construction and are equipped with turning vanes and joints are sealed.

h. Test holes and plugs for ducting.

7.9.6. Hydronic System Balancing

The Hydronic system shall involve the checking and balancing of all water pumps, piping network (main & branches), the heat exchange equipment like cooling and heating coils, condensers and chillers and cooling towers in order to provide design water flows.

I. The essential preparation work, must be done by the HVAC contractor prior to actual testing, adjusting and balancing of HVAC system and ensure following:

a) Availability of coordinated drawings and approved submittals and system sketch with design water flows specified thereon.
b) Hydronic system is free of leaks, is hydrostatically tested and is thoroughly cleaned, flushed and refilled.
c) Hydronic system is vented.

II. The contractor shall confirm completion of the basic procedures and prepare check lists for readiness of system balance.

a) Check pumps operation for proper rotation and motor current drawn etc.

b) Confirm that provisions for TAB measurements (Temperature, pressure and flow measurements) have been made.

c) Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the present position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.

Balancing work for both Chilled Water System and Condenser Water System shall be carried out in a professional manner and test reports in the specified format shall be prepared and presented to the PMC/Consultants for approval.

7.9.7. Readiness for Commencement of Tab

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

7.9.8. Tab Instruments

I. Air Measuring Instruments

a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.

b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8386/ 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.

c. Pitot tube.

d. Electronic Rotary Vane Anemometer TSI make or equivalent.

e. Accubalance Flow Measuring Hood TSI make or equivalent.

[All above instruments shall have a valid certification from a reputed testing institution.

II. Hydronic Measuring Instruments

For measurement of water flow across balancing valves, instruments as provided by the manufacturer of the valves specific to the type of valves shall be need. This shall include but not be limited to differential pressure manometers. Temperature shall be measured using electric thermometers from thermo wells provided at strategic location by the HVAC contractor.

The water balancing shall be carried out being computer simulation program provided / certified by the balancing valve manufacturer.

III. Rotation Measuring Instrument

Electronic Digital Tachometer.

IV. Temperature & RH Measuring Instrument

TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

V. Electrical Measuring Devices

Clamp on Volt ammeter.
Continuity Meter.

VI. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each circulating water pump, water chilling unit, air handling unit and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the PMC.

Sound level readings shall be taken at ten (10) locations in the building as selected by the PMC. The readings shall be taken on an Octave Band analyzer in a manner acceptable to him. The contractor shall submit test equipment data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All test shall be performed in the presence of PMC/Consultant.

SYSTEM READY TO BALANCE

CHECK LIST

	Ready		Date		Ready		Date
	Yes	No.	Corrected		Yes	No	Corrected
1. HVAC Units (AHU)							
a) General				**e) Vibration isolation**			
Louvers installed				Springs and compression			
Manual dampers open & locked				Base level and free			
Automatic dampers set properly							
Housing Construction-leakage				**2. Duct systems**			
Access doors-leakage				**a) General**			
Condensate drain piping and pan				Manual dampers open & locked			
Free from dirt and debris				Access doors closed and tight			

	Ready		Date		Ready		Date
	Yes	No.	Corrected		Yes	No.	Corrected
Nameplate data				Fire dampers open and accessible			
b) Filters				Terminal units open and set			
Type and size				Registers and diffusers open and set			
Number				Turning vanes in square elbows			
Clean				Provisions made for TAB measurements.			
Frame-Leakage				Systems installed as per plans.			
c) Coils				Ductwork sealed as required			
Size and rows				**b) Architectural**			
Fin spacing and condition				Windows installed and closed.			
Obstructions and / or debris				Doors closed as required.			
Airflow and direction				Ceiling plenums installed and sealed.			
Piping leakage				Access doors closed and tight			
Correct piping Connections and flow				Air shafts and openings as required			
Valves open or set				**3. Pumps.**			
Air vents or steam traps				**a) Motors.**			
Provisions made for TAB measurements				Rotation			
d) Fans.				Lubrication			
Rotation.				Alignment			
Wheel clearance and balance				Set screws tight			
Bearing and motor lubrication				Guards in place			
Drive alignment				Tank level and controls.			
Belt t tension.				Starters and disconnect switches			
Drive set screws tight				Electrical service & connections.			
Belt guard in place				Nameplate data.			
Flexible duct connector alignment				**5. Refrigeration Equipment**			
Starters and disconnect switches				Crankcase heaters energized			
Electrical service & connections.				Operating controls and devices.			
Nameplate data				Safety controls and devices.			
b) Piping				Valves open			
Correct flow				Piping connections and flow			
Correct connections				Flexible connectors			

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	Ready		Date		Ready		Date
	Yes	No.	Corrected		Yes	No.	Corrected
Leakage				Oil level and lubrication			
Valves open or set				Alignment and drives.			
Strainer clean				Guards in place.			
Air vented				Vibration isolation.			
Flexible connectors				Starters, contactors and disconnect switches.			
Provisions made for TAB measurements				Electrical connectors.			
c) Bases				Nameplate data.			
Vibration isolation.				**7. Controls System**			
Grouting				Data centers.			
Leveling.				Outdoor return air reset			
8. Other Checks.				Economizer			
a) Other trades or personnel notified of TAB work requirements.				Static pressure			
b) Preliminary data complete				Room controls.			
c) Test report forms prepared.							

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INSTRUMENT CALIBRATION REPORT

PROJECT _____

INSTRUMENT / SERIAL NO.	APPLICATION	DATES OF USE	CALIBRATION TEST DATE.

REMARKS.

TEST DATE _____ READINGS BY _____

AIR HANDLING EQUIPMENT TEST REPORT

PROJECT_____ **SYSTEM / UNIT**_____

LOCATION_____

UNIT	DATA		MOTOR	DATA
Make/Model No.			Make / Frame	
Type/Size			H.P / RPM	
Serial Number			Volts/Phase/cycles	
Arr./Class			F.L amps.	
Discharge			Pully Diam/Bore	
Pully diam/Bore			Pully /Distance.	
No. Belts/make/size				
No.Filters/type.size (Pre.)				
No.Filters/type/size (secondary)				

TEST DATA	DESIGN	ACTUAL		TEST DATA	DESIGN	ACTUAL
Total Cfm				Discharge S.P		
Total S.P						
Fan RPM				Cooling Coil S.P		
Motor Volts. T1 T2 T3 T3 T1				Filters S.P		
Outside air Cfm						
Return air Cfm						

REMARKS.

TEST DATE_____ READINGS BY _____

MMRDA

COOLING / HEATING TEST REPORT (AHU)
PROJECT _____

COIL DATA	COIL NO.	COIL NO.	COIL NO.	COIL NO.
System Number				
Location				
Coil Type				
No. Rows Fins/In				
Manufacturer				
Model Number				
Face Area, Sq.Ft.				

TEST DATA	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL
Air Qty. CFM								
Air Vel.FPM								
Press.Drop In.								
Out.Air DB/WB								
Ret. Air DB/WB								
Ent.Air DB/WB								
Lvg.Air DB/WB								
Air AT								
Waer flow. GPM								
Press.Drop.PSI								
Ent.Water Temp								
Lvg .Water Temp								
Water AT								
Exp.Valve/Refrig								
Refrig.Suction Pr.								
Refrig.Suct.Temp								
Inlet Steam press.								

REMARKS.

TEST DATE _____ READINGS BY _____

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FAN COIL TEST REPORT

PROJECT_____ **DATE**_____

LOCATION_____

MANUFACTURER_____

AREA SERVED	FCU MAKE	CAPACITY TR	TEMPERATURE DEG. F	
			GRILLE	ROOM

REMARKS.

TEST DATE _____ READINGS BY _____

MMRDA

FAN TEST REPORT

PROJECT_____

FAN DATA	FAN NO.	FAN NO.	FAN NO.
Location			
Service			
Manufacturer			
Model No.			
Serial No.			
Type / Class			
Motor Make / Style			
Motor H.P/RPM/ Frame			
Volts/Phase/Cycles			
F.L Amps.			
Motor pully Diam./Bore			
Fan pully Diam./Bore			
No. Belts/ Make/Size			
Pully Distance.			

TEST DATA	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL
CFM						
FAN RPM						
S.P IN/OUT						
TOTAL S.P						
Voltage T1 T2 T3 T3 T1						
Amperage T1 T2 T3						

REMARKS:

TEST DATE:_____ READINGS BY _____

MMRDA

RECTANGULAR DUCT
TRAVERSE REPORT

PROJECT_____**SYSTEM**_____

LOCATION / ZONE_____**ACTUAL AIR TEMP.** _____**DUCT S.P**_____

DUCT SIZE_____SQ.FT._____	REQUIRED FPM_____CFM_____	ACTUAL FPM_____CFM_____

POSITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
VELOCITY SUB TOTALS															

REMARKS.

TEST DATE_____ READINGS BY _____

MMRDA

GRILLES AND DIFFUSERS

TEST REPORT.

PROJECT_____ **SYSTEM** _____

OUTLET MANUFACTURER_____**TEST APPARATUS**_____

AREA	OUTLET			DESIGN		PRLIMINARY				FINAL		
SERVED	NO.	TYPE	SIZE	CFM	VEL	VELOR CFM	VEL.OR CFM			VEL	CFM	

REMARKS.

TEST DATE_____ READINGS BY _____

MMRDA

7.10. Identification of Services

7.10.1. Valve Labels and Charts

Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and " as fitted" drawings. The labels shall be made from 3 ply (black / white/ black) Traffolyte material showing white letters and figures on a black background. Labels to be tied to each valve with chromium plated linked chain.

A wall mounted, glass covered plan to the approval of the Architect / Engineer shall be provided and displayed in each plant room showing the plant layout with pipe work, valve diagram and valve schedule indicating size, service, duty, etc.

7.10.2. Identification of Services.

Pipe work and duct work shall be identified by colour bands 150 mm. wide or colour triangles of at least 150 mm. / side. The bands of triangles shall be applied at termination points, junctions, entries and exits of plant rooms, walls and ducts, and control points to readily identify the service, but spacing shall not exceed 4.0 metres.

7.10.3. Pipe work Services :-

For pipe work services and its insulation, the colours of the bands shall comply with BS. 1710: 1971.

Basic colours for pipeline identification :

Pipeline Contents	BS. 4800 Colour Reference	Colour.
Water	12 D 45	Green
Steam	10 A 03	Grey
Oils	06 C 39	Brown
Gas	08 C 35	Yellow / Brown
Air	20 E 51	Blue
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

Colour code indicator bands shall be applied as colour bands over the basic identification colour in the various combinations as listed below :-

Pipeline Contents	Colour Bands to BS. 4800
Water Services :	
Cooling	00 E 55
Fresh / drinking	18 E 53
Boiler feed	04 D 45/00 E 55 / 04 D 45
Condensate	04 D 45/14 E 53 / 04 D 45
Chilled	00 D 55/14 E 53 / 00 D 45
Central Heating Services :	
Below 100o C	18 E 55/04 D 45/18 E 53

Above 100o C	04 D 45/18 E 53 /04 D 45
Cold Water Storage Tanks :	00 E 55/18 E 53/00 E 55
Hot Water Supply	00 E 55/04 D 45/00 E 55
Hydraulic Power	04 C 33
Sea / River Untreated	Basic Colour only
Fire Extinguishing	04 E 53
Steam Services :	Basic Colour only
Air : Compressed	Basic Colour only
Vacuum	White.
Town Gas : Manufactured	14 E 53
Natural	10 E 53
Oils :	
Diesel	00 E 55
Lubricating	14 E 53
Hydraulic Power	04 C 53
Transformer	04 D 45
Drainage and other fluids :	Basic Colour only
Electrical Services :	Basic Colour only

In addition to the colour bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows :-

High Temperature Hot Water	HTHW
Medium Temperature Hot Water	MTHW
Low Temperature Hot Water	LTHW
Chilled Water	CHW
Condenser Water	CONDW
Steam	ST
Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

7.10.4. Duct Work Services :

For Duct work services and its insulation, the colours of the triangles shall comply with BS.1710 : 1971. The size of the symbol will depend on the size of the duct and the viewing distance, but the minimum size should not be less than 150 mm. length per side. One apex of the triangle shall point in the direction of airflow.

Services	Colour	BS.4800 Colour Reference
Conditioned Air	Red and Blue	04 E 53 / 18 E 53

Ward Air	Yellow	10 E 53
Fresh Air	Green	14 E 53
Exhaust / Extract / Recirculated Air	Grey	AA 0 09
Foul Air	Brown	06 C 39
Dual Duct System Hot Supply Air	Red	04 E 53
Cold Supply Air	Blue	18 E 53

In addition to the colour triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service, identified as follows :-

Supply Air	S
Return Air	R
Fresh Air	F
Exhaust Air	E

The colour banding and triangles shall be manufactured from self-adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

7.11. Noise Control

The scope of this section comprises of the supply, installation, testing and commissioning of noise and vibration control equipment and accessories.

7.11.1. Standards

The testing of all noise control equipment and the methods used in measuring the noise rating of air conditioning plant and equipment shall be in accordance with the relevant sections of the following British Standards, unless otherwise stated :

BS 4718 : 1971	Methods of Test of Silencers for Air Distribution Systems.
BS 2750 : Parts 1-9:1980	Laboratory and Field Measurement of Airborne Sound Insulation of Various Building Elements. Recommendations for Field Laboratory Measurement of Airborne and Impact Sound Transmission in Buildings.
BS 3638 : 1987	Methods of Measurement of Sound Adsorption in a Reverberation Room.
BS 4773 : Part 2: 1976	Acoustic Testing.
BS 4856 :	

Part 2: 1976	Acoustic performance without additional ducting of forced fan convection equipment.
Part 5: 1976	Acoustic performance with additional ducting of forced fan convection equipment.
BS 4857 : Par 2:1978 (1983)	Acoustic Testing and Rating of High-Pressure Terminal Reheat Units.
BS 4954 : Par 2:1978 (1987)	Acoustic Testing and Rating of Induction Units.
BS 5643 : 1984	Glossary of Refrigeration, Heating, Ventilating and Air Conditioning Terms.

7.11.2. General

Mechanical services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source where illustrated on the tender drawings and plant and equipment schedules to achieve acceptable noise rating specified for occupied areas.

In addition to the provisions specified in the Specification, attention must be given to the following details at time of ordering plant and equipment and their installation :-

a. All moving plant , machinery and apparatus shall be statically and dynamically balanced at manufacturers works and certificates issued.

b. The isolation of moving plant, machinery and apparatus including lines equipment from the building structure.

c. Where duct work and pipe work services pass through walls, floors and ceilings, or where supported shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure and minimize the outbreak of noise from plant rooms.

d. The reduction of noise breakout from plant rooms and the selection of externally mounted equipment and plant to meet ambient noise level requirements of the Specifications.

e. Electrical conduits and connections to all moving plant and equipment shall be carried out in flexible conduit and cables to prevent the transmission of vibration to the structure and nullify the provisions of anti-vibration mountings.

f. All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units.

   Duct work connections to the fan inlets / outlets shall be concentricity aligned so that the flexible connections are not subjected to any strain and not used as a means of correcting bas misalignment.

g. All resilient acoustic absorbing materials shall be nonflammable, vermin and rot proof and shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.

h. Where practicable, silencers shall be built into walls and floors to prevent the flanking of noise the duct work systems and their penetrations sealed in the manner previously described.

Where this is not feasible, the exposed surface of the duct work between the silencer and the wall subjected to noise infiltration shall be acoustically clad as specified.

i. Contractor to demonstrate design NC levels in the areas with FFT (Fast Fourier Transform) analyzer.

7.11.3. Silencers

At tender stage all silencers as required to meet specifications will be selected based on preliminary sound power levels obtained from fan/air handling unit manufacturers or fan duties to achieve a noise rating in the occupied space as specified in " Basis of Design"

All plant attenuators shall be selected to maintain noise criteria given in this Specification.

Attenuators shall be constructed from high quality pre-galvanized steel sheet casings with lock formed joints along the casing length. Angle iron cross jointing flanges shall be fitted to silencer casings, drilled as required and finished with zinc cromet primer paint.

Acoustic splitters shall be formed by chancel section pre-galvanized sheet steel framework retaining acoustic fill of a density to attain the required performance. Splitters shall have round nose ends to give smooth entry and exit conditions to minimize air pressure drops.

The acoustic fill shall be protected from the air flow by 22 swg minimum perforated galvanized sheet steel.

All silencers shall be selected against a maximum allowable air pressure drop of 75 a.

It will be the responsibility of the Contractor at the time of placing orders for fan equipment to obtain from the manufacturers, certified sound power levels to enable the selected duct silencers to be checked against the original design information, prior to orders being placed.

7.11.4. Anti-Vibration Mountings.

All items of rotating and reciprocating plant and equipment shall be isolated from the structure using anti-vibration materials, mountings or spring-loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.

Centrifugal fans and motors within air handling units shall be isolated from the frame of the air handling unit by suitable anti-vibration mountings. Fan discharge air connections shall be fitted with approved flexible connections internally isolating the fan scroll from the air handling unit casing.

Axial flow fans shall be mounted on steel legs as diaphragm plates supported on neoprene in shear anti-vibration mountings or suspended using spring loaded hangers to suite the application.

Centrifugal pumps shall be mounted on inertia bases consisting of reinforced concrete sub base, anti-vibration mountings and concrete filled steel upper plinth. The Contractor shall

be responsible for issuing the steel upper plinth and mountings to the Contractor for building-in.

Pipe work connections to circulating pumps, chillers, cooler coils and other equipment shall be made with flexible connections as per Specifications.

The construction of the anti-vibration mountings shall generally comply with the following : -

Enclosed Spring Mounting (Caged or Restrained Springs)

Each mounting shall consist of cast or fabricated telescopic top and bottom housing enclosing one or more helical steel springs as the principle isolation elements and shall incorporate a built- in levelling device.

The springs shall have an outside diameter of not less than 75% of the operating height and be selected to have at least 50% overload capacity before becoming coil bound.

The bottom plate of each mounting shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

Mountings incorporating snubbers of restraining devices shall be designed so that the snubbing damping or restraining mechanism, is capable of being adjusted to have no significant effect during the normal running of the isolated machine.

Restrained isolator shall be provided on chillers subject to approval by the manufacturers.

7.11.5. Open Spring Mountings.

Each mounting shall consist of one or more helical steel springs as the principal isolation elements and shall incorporate a built-in leveling device. The spring shall be fixed or otherwise securely located to cast or fabricated top and bottom plates and shall have an outside diameter of not less than 75% of the operating height and shall be selected to have at least 50% overload capacity before becoming coil bound.

The bottom plate shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

7.11.6. Neoprene-In-Shear Mountings.

Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant neoprene. Each mounting shall be capable of being fitted with a levelling device, and bolt holes in the base plate and tapped holes in the top plate so that they may be bolted to the floor and equipment where required.

7.11.7. Inertia Bases for Pumps.

The inertia base shall be an all welded mild steel channel frame the minimum depth of which shall be 1/12 of the longest span between isolator but not less than 150 mm filled with concrete the density of which shall be 2300 kg/m3.

The inertia base shall be sufficiently large to provide support for all parts of the equipment, including any component which overhang the equipment base, such as suction and discharge elbows on centrifugal pumps.

The frame shall include pre-located equipment anchor bolts fixed into position and housed in a steel sleeve allowing minor bolt location adjustment.

Isolator support brackets shall be welded into the corners of the base and suitably re-enforced for the load of the equipment and base.

Additional reinforcing roads shall be provided at 200 mm. centres to ensure the concrete and frame is adequately stiffened against distortion.

7.11.8. Flexible Connections

Flexible connections shall be provided on all duct work connections to fans, rotating plant and equipment isolated from structure and anti-vibration materials or mountings. Pipe work and duct work crossing building movement or construction joints shall be installed with flexible connections.

Flexible connections on duct work to fans etc., shall be a minimum / maximum free length of 100 mm. / 200 mm. respectively to minimise noise transmission and noise breakout. They shall be completely free from stress and shall not be required to accept any weight.

Thickness and strength of flexible connection materials shall be suitable to withstand the positive and negative fan pressures to which they will be subjected to and shall not allow perceptible leakage. The materials shall be durable, nonflammable having food acoustical quality.

Flexible connections shall be fitted to all pump suction and discharge connections, chillers and other vibrating equipment and where anti-vibration mounts and inertia basis are fitted.

Flexible connections shall be fitted to all cooler coil chilled water pipe work connections.

Flexible connections shall allow freedom of movement of plant in all plans.

Making flanges to pipe work flexible connections shall be of the smooth faced weld-nick type.

Rubber Bellows shall be fitted as close to the source of vibration at practicable. The pipe at the other end of the bellows shall be a fixed point.

Rubber bellows shall be single convolution of multiply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be able to swivel and be removable. The date of manufacture shall be moulded on the bellows. For traceability membranes shall have an indelible identification showing manufacturer, country of origin, the type and a batch number.

Tie bars with rubber top hat washers shall be used on bellows.

For working temperatures up to 70o C the rubber bellows shall be high tensile synthetic fibre reinforced.

For working temperature between 70oC and 100oC the bellows carcase shall be steel wire mesh reinforced throughout. Steel reinforced bellows shall be manufactured and approved to the Standards.

For temperatures above 100oC bellow shall be multiply stainless steel with Van Stone ends swivel flanges. The overall length shall not exceed 130 mm.

Flexible connections with screwed connections shall be reinforced EPDM rubber hoses and shall have at least one full union to avoid torturing on installation.

Flexible pipe connections on chilled water systems shall be suitable for a working pressure of 10 bar and test pressure of 17 bar.

CHAPTER – 8

8. OUTLINE BUILDING MANAGEMENT SYSTEM SPECIFICATIONS-BUILDING

8.1. General

This Specification describes the minimum standards of the Building Management System (BMS) for Control Centers building and streetlight of MTHL Project. The Works to be executed under the Contract include the "design, engineering development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support" for a complete BMS to fully integrate the control, monitoring, and supervision of Power Supply System viz. HV panel, RMUs, Transformer, Low Voltage Power & Distribution, Emergency Power Supply-DG sets, UPS system, Lighting, Ventilation HVAC, Lifts, Fire Detection and Suppression system, PHE system, on the entire section of MTHL including Service Building Services (Admin & Control Centers). Systems not listed above but that requires BMS as instructed by the client/consultant.
The BMS shall also interface with the requirements for control, monitoring, and supervision as required at the Main Control Centre (MCC) and seamless integration with Admin Building, if require,
The BMS 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 BMS system, wherever this is not explicitly mentioned.

8.2. Scope

The services to be performed by the contractor shall include, but not be limited to, the following:
Design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete BMS, including all PLC 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 and strategic emergency power supply HV panel, RMUs, Transformer, Low Voltage Power & Distribution, Emergency Power Supply-DG sets, UPS system, Lifts, Fire Detection and Suppression system, DG sets, UPS, Lighting Control System, Lifts, Hydraulic System (Tube Well Pumps, 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 BMS shall also interface with the requirements for control, monitoring, and supervision, as required at the Admin Building.

- Earthing of Programmable logic controller and Workstations to the clean earth. Earthing drawing will be submitted to the client for approval.
- Presentations, reviews and audit support as specified in the Specification;
- Interface management as specified in the Specification;
- System operations and maintenance support services;
- Training for the Employer's Engineers and operations & maintenance staff.

- Dismantling, removal and/or disposal of Temporary Works;
- Warranty period after commissioning.
- Transfer of Technology
- Warranty and Maintenance Support System-

The list is not intended to be complete and the contractor shall supplement it adequately for obtaining a satisfactory working bms system as per the detail design requirement.

8.3. Standardization

The Contractor shall, in establishing his design, follow the principles provided below in the design and specification of all plant, equipment and components:

- Similar plant and equipment shall be replaceable/interchangeable, modular in design, adaptable and extendable.
- 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.
- Test standards and standardized equipment shall be selected or built or framed carefully, bench marked, designated and explicitly marked.
- 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).
- The operating system shall be uniform for all systems/sub systems.
- Standards for maintenance planning shall be uniformly categorized.
- Uniform standards shall be designated for procurement, replacement stocking and availability.
- Equipment and accessories shall be provided with uniform standard spare capacity, protection.
- 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.

8.4. Quality Control of Equipment, Components and Material

The contractor shall furnish the following information for each item of equipment as applicable:

- Manufacturer.
- Type and model No. of equipment.
- Nominal capacity
- Power supplies i.e. Voltage & Frequency at which the equipment operates.
- Type of Frame and foundation required for the equipment.
- Space requirements
- Controls & Protection
- Indications/alarm/annunciation Standards
- Insulation class
- EMC Conformance and certification.
- 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.

8.5. Submission of Drawings & Details

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:

- Schematic drawings
- Interlock drawings

- Erection drawings
- Wiring drawings
- As erected/finished drawings
- Any other drawings
- I/O Schedule and Cable Schedule

8.6. Design Considerations

The complete installation shall be in strict accordance with the national and local electrical codes.

(A) All system components are to be designed and built to be fault tolerant:

- Satisfactory operation without damage at 110% and 85% of rated voltage and at +3 hertz & - 1.5 Hz variation in line frequency.
- Static, transient, and short circuit protection on all inputs and outputs.
- Communication lines protected against in-correct wiring, static transients and induced magnetic interference.
- 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 to secure a service life as shown below:

- Control Panels :30 Years
- Cables :30 Years
- Tray, trunking and supports :30 Years
- Sub-assemblies and components :30 Years
- All other equipment :20 Years minimum

(C) Switchboards, equipment, and other control components shall be rated for operation in ambient temperatures of 50 degree C and humidity up to 75% and shall have degree of protection IP- 65.

In the design of switchboards , local control panels, Cabinets of PLC, an allowance of 20 to 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, wireways, (raceways), and brackets, for future expansion.

Parameters for control and monitoring for the various equipment

FUNCTIONS	PLC (Plant Room		Control Room of Central Control Building		
	Conditions	Operations	Status	Alarm	Remote Data
D.G. Set	Incoming HT supply to ASS 1&2 transformers OFF	Bus couplers OFF, start DG set, load breaker ON	Starting the DG set	Warning, Supply failed	warning
	Start command from control panel	start DG set, load breaker OFF		–	-
	Start command from Local or remote			-	-
	DG set running		ON - OFF		
	Incoming HT supply to CSS 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 case not running more than 15 days.	Not run for more than 15 days (Alarm)	Alarm

	Starter battery voltage	If low Log at PLC			
	Lube oil level	Continuous monitoring			
	Fuel level	Continuous monitoring			
	Radiator water level	If low Log at PLC			
	Output voltage	Log at PLC	Within range, indicate on load	Alarm, if out of range	Out of range alarm
	Output frequency	Log at PLC			
	Fuel consumption	Log at PLC	Weekly report generation for fuel consumption rate vs energy output.	-	Weekly report generation for fuel consumption rate vs energy output.
	Energy output	Log at PLC	Continuous monitoring	-	Continuous monitoring
UPS System					
UPS (Electrical)	Input Voltage	-	Continuous monitoring in decimal value	-	
	Battery Voltage	-			
	Charging Current		Continuous monitoring		
	Output Voltage		Continuous monitoring		
	Output frequency		Continuous monitoring in decimal value		
	Load %		Continuous monitoring in decimal value		
	Static bypass/manual Maintenance Bypass		Different graphics Status for various status		
	Mains failure		Alarm		
	Low battery alarm		Alarm		
	Overload and Over temperature		Alarm		
Battery Charger	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 decimal value		
	Mains failure		Alarm		
	Low battery alarm		Alarm		
	Overload and Over temperature		Alarm		
	Charging/Load/Boost Charging Status		Different graphics status for various status		

	Static bypass/manual Maintenance Bypass for Battery		Different graphics status for various status		
Internal -Building and External Road Lighting					
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	
	Hours of operation	Log at PLC	-	-	-
	Energy consumption	Log at PLC	Decimal value		Decimal value
Fire Detection System					
All Zones Areas (Bridge Void)	Alarm situation	Signal at FACP	-	Warning	Warning
All Zones building Areas	Alarm situation	Signal at FAP	-	Warning	Warning
ALL Zones Electrical Installations	Alarm situation	-	Gas release 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
	Device fault/Device isolated	Fault indication		Warning at fixed interval	Warning
	Voltage	Log at LDC		No volt warning	-
Sprinkler	Rise in Temperature	Start Pump	ON	WARNING	Warning
Hydrant	Low Pressure	Start Pump	ON	WARNING	
Electrical Panel and Switch Boards					
	Manual bypass local or auto		Different graphics colour for local or auto	-	-
	DB running	-	DB ON (OFF)	Warning for No Volt in EPP	Warning
	Energy consumption	Log at PLC	Continuous Monitoring in Decimal value	-	Continuous monitoring in Decimal value.
	Voltage	Log at PLC		No volt alarm	
	Trip	Log at PLC	Red colour in graphics	Alarm	
	Communication and setting of ACB Relays	Log at PLC	Control and setting of ACB relays	No volt alarm	Control and setting of ACB relays
	Control supply failure	Log at PLC		No volt alarm	
	Voltage	Log at PLC		No volt alarm	

			Graphics colour shall be green for healthy status		
	Energy consumption	Log at PLC	Continuous monitoring in Decimal value	-	Continuous monitoring in Decimal value
	Voltage	Log at PLC		No volt alarm	
	Trip	Log at PLC	Red colour in graphics	Alarm	
Temperature & humidity monitoring		Log at PLC	Decimal value	Alarm if out of range	
Fire Fighting System					
Fire fighting Pump -(1+1) Main + Standby	Hydrant pressure fall (major)	Start the pump	-	Warning	warning
		Start the pump	-	Warning	warning
	Manual bypass local or auto		Different graphics colour for local or auto	-	-
	Pump running	-	Pump1/2 ON (OFF)	-	-
	Pump failure	Start standby automatically		First pump fail warning	warning
	Standby pump fail	Main pump starts automatically		Second pump fail Alarm	Alarm
	Hours of operation	Log at PLC	-	Not run for more than a week (Alarm)	warning
Jockey pump	Hydrant pressure fall (minor)	Start the pump	-	Warning	-
	Hydrant pressure fall (minor)	Start the pump	-	Warning	-
			-		
	Manual bypass local or auto		Different graphics colour for local or auto	-	-
	Pump running	-	Pump ON (OFF)	-	-
	Pump failure	-		Pump fail warning	warning
	Hours of operation	Log at PLC	-	Not run for more than a week (Alarm)	warning
Domestic Water Pump for Buildings					
Domestic water pumps for Building	Liquid level in the Domestic water tank low	Start pump log at PLC	Low water level in Domestic water tank	Warning, goes OFF when underground tank (Raw water) full	-
(1+1)- Main + Standby	Manual bypass switches local or remote		Red graphics for	-	-

			local, grey for remote.		
	Pump running	-	Pump ON (OFF)	-	-
	Pump failure	-		Standby pump fail warning	warning
	Water level in the Domestic water tank	If full, stop pumping Log at PLC	-	-	-
	A definedtime 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 only)
	Voltage	Log at PLC	-	No volt Warning	-
RAW Water Pump for Building					
Raw water pumps for Buildings	Liquid level in the Raw water tank low	Start pump log at PLC	Low water levelin underground tank (Raw)	Warning, goes OFF when underground tank (Raw water) full	warning
(1+1)- Main + Standby	Manual bypass switches local or remote		Red graphics for local, grey for remote.	-	-
	Pump running	-	Pump ON (OFF)	-	-
	Pump failure	-		Standby pump fails warning	warning
	Water level in the Raw 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 only)
	Voltage	Log at PLC	-	No volt Warning	-
	Pump Tripped	Log at PLC		Warning	Warning

Tube well pumps for buildings					
Tube well pumps for buildings	Liquid level in the underground tank low.	Start pump Log at PLC	Low water levelin underground tank.	Warning, goes OFF when underground tank full	Warning
(1+1)- Main + Standby	Manual bypass switches local or remote		Red graphics for local, grey for remote.	-	-
	Pump running	-	Pump ON (OFF)	-	-
	Pump failure	-		Standby pump fails warning	warning
	Water level in the underground tank	If full, stop pumping Log at PLC	-	-	-
	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 only)
	Voltage	Log at PLC	-	No volt Warning	-
	Pump Tripped	Log at PLC		Warning	Warning

(D) **Location** : The workstation pc shall be installed in the control room of Centralized Control Center. this shall be a separate pc. the Adin workstation shall be provided with similar pc or higher pc/server, as per the requirement.

8.7. Programmable logic controller (PLC)

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.
Location of PLCs shall be chosen such that minimum length of cable will be required between PLC and power db.
PLC can be opened freely, so enough distance from the wall or obstruction will be maintained.
Cables shall be kept at 300 mm from the power cable trays/conduits at all places as entry/exit to db., PLC etc.
Hubs / switches -- these will be installed in separate enclosures near the PLCs/ workstation.
Repeaters-these will be installed in separate enclosure at 90 meters from hub/repeater of the communication cable to boost the signal.
Field sensors- sensors will be located on, or adjacent to, that equipment which is being monitored. for example, it could include sensing the electrical load, water level etc. that changes within building.

8.8. Facility

The BMS 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 para-2.0. of this spec.

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 update the data on restoration of the fault.

Bulk data server facilities for software back up and historical data, including equipment history of maintenance & frequent defects shall be provided at Administration Building to Maintain equipment history of maintenance and frequent defects. The backup historical data shall be available minimum for a month at a time and backup rate shall be fortnightly.

The BMS should activate designated alert for the attention of operations and maintenance staff rapidly to equipment malfunctions, especially those likely to cause uneasiness to the users (for example Road and building lighting system, lifts). SMS to Mobile phones of DGM (O&M) and other designated officials of MTHL regarding high priority alarms, energy audit reports and specific fuel consumption of DG sets.

Provide clear, comprehensive displays and printed logs of equipment status to each operator workstation.

Provide comprehensive displays and printed logs based upon historical data, with the option of overlaying data from earlier periods.

Time-tag all events detected by the BMS system, to 1 millisecond resolution for selected highspeed inputs, and to present this information in logs as a true system-wide sequence of events.

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.

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:

- Visual and Audible Alarms and event logging and printing.
- Operator acknowledgement of alarms.
- Selective display and printing of alarms and of events lists.
- User friendly group display on a single screen of various E&M systems.
- Execution of operator commands with access code security.
- Provision of user-friendly operator sequences.
- Operator entered text messages.
- Access to historical data files of plant status.
- Generation of tabular displays based upon spreadsheets.
- Generation of graphical displays based upon mimic diagrams.
- Generation of printed reports and printed copies of display pages.

- Utilities consumption monitoring and check metering.
- Operator entered data, including tagging, manually entering values and the forcing of status points.
- Automatic logging of selected displays at specified times.
- System timekeeping.

8.9. Specification/requirements for hardware components

Off the shelf supplied items should be supported with DLP to cover the warranty period. The terms should ensure prompt attention & not later than 12 hours. In case the standard warranty terms do not provide such service then the contractor should build in suitable mechanism for prompt attention.

8.10. Programmable Logic Controller (PLC)

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 Workstation (Control Room) which in turn communicates to the Central Server at the Main Control Center via an optimized and event-based TCP/IP protocol.

PLC shall be an intelligent modular, compact system that allows suitable expansion, minimum from 14 up to 1000 I/So 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 Control Room 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.

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.

PLC terminals shall be of the clamp type preferably of cage clamp and shall be provided with isolating links.

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.

A manual switch inside the PLC cabinet shall be provided as a hard-wired facility to disable the operation of control outputs. Change of switch status shall be registered as a system event.

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.

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 IP65 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.

The PLCs shall be suitable for operating in the environment described in the Specification clause.

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/ MTHL.

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.

8.10.1. Internal architecture of PLC

- Microprocessor base CPU
- Input and output interface modules suitable for a mixture of digital, analog and pulse inputs and outputs.
- Terminal for external cable termination
- Thermostat for temperature control Fan
- Power indication lamps
- Document holder
- MCBs for modules, Power supply unit, Fan, CFL lights Tube lights
- Door switches
- Fuses for digital output, input and analog input terminals
- Power supply unit

8.10.2. The PLC processor Salient features:

The PLC processor will be provided the minimum Salient features as under :

- 34 KB user program memory RAM and Flash.
- 0.4 ms/kB bit processing
- Integrated ports: 2xMODBUS or 1xMODBUS.
- 2 interrupt inputs and 2 cyclic tasks.
- Direct access to I/O for fast response.
- Real-time clock.
- It shall have real time clock & time resolution of the clock should be 1msec.
- PLC shall have separate battery for the above clock.
- PLC shall be capable of time stamping the event before communication to BMS.
- The event scanning resolution of PLC should be of 1msec.

8.10.3. The PLC processor language capability

The PLC processor will have the following capability to support language structures

- Structured Text
- Sequential Function Charts
- Ladder Logic
- 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.

8.10.4. Interface Modules

The following hardware described will interface to the field mounted sensors and equipment for control and monitoring.

8.10.5. Digital inputs

- 12 VDC, 24 VDC, 50 VDC, 110 VDC, 110 VAC, 240 VACS (1.5 kV isolation)

8.10.6. Digital Outputs (relay)

- Volt-free contact, 24 VDC, 30 VA
- Volt-free contact, 240 VAC, 125VA

8.10.7. 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

8.10.8. Analog Outputs

- 0-10 VDC, 4-20mA

8.10.9. Pulse Inputs

- 12 VDC, 24 VDC up to 10 pulses/sec (2kV isolation)

8.10.10. Serial Link

- RS 485, RS 232 / V24, RS422

8.10.11. 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.

8.10.12. PLC Programming

- 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.

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- An original copy of the latest manufacturer's proprietary software shall be provided to MTHL upon completion and handover together with all generated site-specific data.
- PLC should be remote programmable from Control Room workstation.

8.10.13. PLC communications

Although the PLC processor specified above will have the capability of communicating directly with a BMS system via Modbus over TCP/IP protocol. In addition to the above, the PLC shall have the capability to be monitored directly using the HTTP protocol.

8.10.14. PLC Cabinet and Panel Internal Wiring

- 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.
- 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.
- 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%.
- 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.
- Wire colours shall comply with the following requirements:

Phases	Red, Yellow, Blue
Neutral	Black
AC Control	Grey
DC Positive	Orange
DC Negative	Lilac
Earth	Green with Yellow trace

- 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 using terminal bridging links as supplied by the terminal manufacturer.
- 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.
- A separate earth bar shall be provided for the termination of all earth wires. Only one wire shall be connected into each termination point.
- Minimum conductor size shall be 1.5mm2.
- Cable glanding plates shall be earthed directly to the control panel earth bar.
- 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.

8.11. Workstation

The central processing equipment shall comprise one high performance real time, digital personal computer, rated with such application, complete with keyboard and mouse, one colour graphic VDU, system printer(s) to log all transaction and alarm printer(s). All the equipment shall be suitable for the power supply voltage of 230VAC +-6% 50Hz +-2%.The central equipment shall be located where shown on the plans and shall meet the following minimum criteria:

8.12. Personal Computer

The Workstation shall be a personal computer (PC) based central, with a minimum feature of full 32-bit processor (Intel Core 2 Duo) 2GHz. ATI/NVIDIA graphics card SATA/SCASI disk drive crashworthiness, high, minimum of 1GB of RAM, high speed DVD-R/RW, 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 Workstation shall be to the latest state-of-the-art performance for similar systems and shall be operated using 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 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 Workstation 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.

8.13. Colour Monitor

The Workstation color monitor shall be 19-inch diagonal nonglare flat LCD flat screen and has minimum VGA resolution of 1024 pixels horizontal, 768 lines vertical and minimum 16 based colors. Workstations shall include all accessories needed to comply to 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.

8.14. Notebook PC

The Contractor shall provide a colour notebook with built-in modem for remote dialing-in for use as a portable programming tool. The colour notebook shall have minimum feature of a high quality colour 14-inch LCD, 640 x 480 pixels min graphic display which supports 256 colours. The colour notebook shall be Intel Centrino Duo/ Core 2 Duo or higher and be complete with min standard 1GB RAM, 160 GB hard disk capacity with high speed disk access, high speed DVD-R/RW, and with 82-key sculptured keyboard (101-keyboard compatible). The notebook shall come with a USB mouse(Optical) for user interacting. The overall weight for the notebook shall not be more than 3 kg. To ensure hardware quality, computer clones shall not be acceptable.

8.15. Printers

The Contractor shall provide printers as specified for recording alarms, operator transactions and system reports. To ensure hardware quality, printers shall be internationally branded, warranted,

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and technical support, spare parts and consumables should be freely available from the manufacturers authorized distributors.

8.16. Dot-Matrix Printer

- 132-column/300 character per second print speed.
- 24 pins dot matrix character structure switchable to 29 x 23 dot matrix for letter quality output with 96 ASCII upper/lower case character set.
- Software selectable under, emphasized, double strike, and expanded (double width) characters capability.
- Adjustable line spacing of six or eight lines per inch with compressed mode option for 220 characters/line and bidirectional printing and logic seeking.

8.17. 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:

- Print speed - Black: up to 20 ppm; color: up to 4 ppm
- First page out - 18 seconds black, 29 seconds color
- Resolution- 600 by 600 dpi
- Memory - 64 MB built-in SDRAM; expandable to 192 MB with one open memory SDRAM DIMM slot
- Duty cycle - 30,000 pages per month
- 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
- Output - 125 sheet face down bin Types Paper (plain, letterhead, prepuce, bond, color, rough, preprinted, recycled)
- Glossy Media, Cover Paper, Color LaserJet Transparencies, labels, envelopes, and card stock
- Compatibility - Interfaces Hi-Speed USB 2.0 port, IEEE 1284-B compliant parallel port
- Hi-Speed USB 2.0, IEEE 1284-B compliant parallel port
- Languages - PCL 6 and Postscript level 3 emulation with automatic language switching
- Font capabilities - 80 TrueType TM internal scalable PCL 6 fonts; 80 TrueType internal scalable HP postscript fonts
- 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.
- Network operating systems - Microsoft Windows 98, 2000, NT 4.0 Me, XP; Mac OS 9.x, OS X Vista
- Network protocols supported - TCP/IP

8.18. 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:

- Can tolerate up to -40 to 85C
- Can tolerate 5-95% humidity
- Provides vibration resistance (IE68-2)
- Withstands power surges (IEEE-472)
- Provide easy DIN-rail mounting
- Are powered directly from 230V AC/110V DC
- Not less than 8-port 10/100 Dual-Speed ports-up to 200Mbps

8.19. Communication

The suitable communication protocol shall be adopted for various communication links .The communication Protocol can be classified as per following requirements:

- The communication between E&M equipment to PLC : MODBUS Protocol
- The communication between PLC to the Control Room Workstation : MODBUS Protocol over TCP/IP.
- The communication between Multifunction Meters and Energy meters and their communication to PLC/Workstation : MODBUS Protocol on RS 232/485 port.
- The communication between Dimming Light Control Panel, Fire Alarm Control Panel, MDB & Electrical panels, Escalator Panels/MCCBs, AMF Panel etc. to the PLC/Control Room Workstation : MODBUS Protocol on RS232/485 Port.
- Communication between Control Room Workstation to Main Control Center : TCP/IP protocol on optic fiber link through TER.

Supply of the hardware essential to integrate all systems for communication link as above.

The communication link between workstations and the Control Centers shall be done using TCP/IP based protocol. All the Control Room workstations and Centralized Control Centers shall be connected in LAN TCP/IP that is being provided at suitable location by the Contractor.

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.

The system should provide instant alarm to the operator about the communication failure.

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.

In the event of a failure of the main communications system, local operation from control panel at each building shall be maintained. Updating of the central database at the Centralized Control Centers shall take place immediately on restoration of the communications link.

Operational changes and expansion will be made without shutdown the system.

8.20. Cables

Cables installed between PLC and DB/Sensors shall be Fire resistant low smoke type. Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq mm. Ethernet cables for networking of PLCs and Workstation shall be provided. 2#3C shielded cables (communication bus) shall be provided over RS232/485.

Moxa card/ Router

For communication with RS 485 port of different panels Moxa card of minimum 8 ports/Router shall be installed with the BMS workstation. Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq mm.

8.21. Specification /Requirement for System Software

8.21.1. Software features

It is necessary to provide a time and date for alarms, which occur, and other significant events, including operator commands. Software will allow the database (points) and operating parameters (time, temperatures, limits etc.) to be modified on-line, by the operator. When a binary contact goes from open to closed, or vice versa, the 'change of state' is reported by the system.

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.

On start-up of certain plant, it takes a finite time before stable conditions are reached and the BMS should allow for automatic lockout of alarms for a preset period following start-up.

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. BMS 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.

Logging of important status information will be provided. The list of such important items shall be provided by contractor for approval of Employer's.

- This should contain, in plain language, identification of the point, status and other data, plus time, date etc.
- It should be possible to call up logs for various 'levels.
- It should be possible to cancel logs under certain conditions.

Facility of summary logs, i.e. the ability to call for a printout, for example, of all points in alarm,

all points off normal, all motors which are running, all points which are locked out, etc.

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.

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.

An alarm should be reported in case of breaking the pre set limit of analogue points such as voltage, current etc.

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 degree C high and has a 0.1degree C differential, it will be constantly going in and out of alarm between 25 degree C and 24.9 degree C. It would probably just as acceptable to have a 2 degree 0 degree C differential which would reduce the number of alarms reported considerably and furthermore, when they did occur, would be more meaningful to the operator.

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.

It should allow start/stop commands to be set up at precise times, with daily variations as well as allowing holiday programming.

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.

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.

A record of consumption of things such as liters of fuel used, kWh etc. will be kept. English language for both input and output will be accepted.

The output information should be grouped in accordance with the make-up of the 'services' systems in the Service buildings rather than the location of the field hardware.

"Prompting' feature will be provided, which takes the operator through the operation step by step, prompting and teaching him as he does it.

Dynamic colour graphics will be used to show the schematic diagram of the system.

Different colours will be used to bring conditions to the attention of the operator. The contractor should submit scheme in this regard for approval of Employer's representative.

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.

Password will restrict access to certain important areas, so it is necessary to control who has access to a BMS, at what level and through which operator devices.

Number of characters of password will not be less than five. Password time-out will be not more than half an hour.

"Database save' feature to copy the system database onto a separate storage medium, usually a disk , will be provided.

Equipment 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.

8.21.2. General

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:

- Local time tagging of events.
- Alarm handling from discrete inputs derived parameters.

- Combining of digital inputs Boolean functions to give conditional outputs.
- 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.

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.

Event processing shall have the following order of precedence, but shall be re-configurable:

- Receipt of manual commands from operator workstations, each of which shall have an assignable level of command priority.
- Pre-defined control sequences.
- High-speed alarms.
- Normal alarms.
- Digital events.
- Clock synchronization (With the master clock at OCC).
- Analogue events.

8.22. Practical Considerations

8.22.1. Design and performance requirements

Equipment or systems comprising several components shall be controlled through the BMS 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.

The contractor shall prepare in clear and logical form documents describing the functions transmitted and the operations carried out at the control room workstation and that at Centralized Control Center. The control and transmission scheme shall be submitted for the consent of the Employer or his representatives.

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.

The BMS supplier 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 BMS 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.

8.22.2. Design Coordination Requirements

The Contractor shall submit a list of all design review documents for the review of the Employer's Representative.

8.22.3. Applicable Design standards

The list of references and standards already given in various chapters. However, the following Standards may be partially or wholly applicable, in respect of BMS design:

SN	Standard/ Code No	Title
1	IEC 445	Identification of equipment terminals and of terminations of certa designated conductors, including general rules for an alphanumeric syste
2	IEC 571-1	General requirements and tests for electronic equipment's
3	IEC 571-3	Components, programmable electronic equipment's and electronic syste reliability
4	IEC 617-12	Binary logic elements-Graphical symbols to represent dependen notation, combinative and sequential element, as well as complex-functi elements
5	IEC 801-3	Radiated electromagnetic field requirements
6	IEC 870-1-1	Tele-control equipment and systems- General considerations
7	IEC 870-2-1	Operating conditions
8	IEC 870-4	Performance requirements
9	IEC 870-5-4	Definition and coding of application information elemen Transmission protocols
10	IEC 1082-1	Preparation of document (Signals, Diagrams)
11	ISO/IEC 4873	Information technology ISO 8-bit code for information interchang Structure and rules for implementation
12	IEC 60848	Preparation of function charts for control systems
13	IEC 61175	Designations for signals and connections
14	IEC 61346(All parts)	Industrial system installation, equipment's and industrial produc Structuring principles and reference designations
15	IEC 61850-Part 2	Glossary
16	IEC 61850-Part 3	General requirements
17	IEC 61850- Part 4	Communication networks and systems in substations- System and Proje management
18	IEC 61850- Part6	Substation automation system configuration description language

19	IEC 61850-7-1	Basic communication structure for substation and feeder equipme Principles and models
20	IEC 61850-10	Conformance testing
21	BS 4737: Part 2	Specification for installed systems for deliberate operation
22	BS 4737: Section 4.	Code of practice for planning and installation
23	BS 4737: Section 4.	Code of practice for maintenance and records
24	BS EN 14908-1:200	Open data communication in building automation, controls and buildi
25	BS EN 50090-2-1	Home and building electronic systems-System overview, Architecture
26	BS EN 50090-2-2	Home and building electronic systems-System overview, General techni
27	BS ISO/IEC 6592	Information technology. Guidelines for the
28	BS 5839-1:200	Code of practice for system design, installation, commissioning a
29	BS EN 54-2 30 Pag	Specification for control and indicating equipment
30	BS 6266 38 Pages	Code of practice for fire protection for electronic data processi
31	BS EN ISO 9000-3	Development, supply, installation and maintenance of computer softwar
32	IS: 1765	Direct current potentiometers
33	IS: 3043	Code of practice for Earthing
34	IS: 3700	Essential rating and characteristics of semiconductor devices
35	IS: 4007 Part1	Terminals for electronic equipment- General requirements
36	IS: 5051 Part 1	Relays for electronic and telecommunication equipment- Gene
37	IEEE 802 series	Local area network
38	ISO 3511	Process measurement control functions and

8.23. 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.

8.23.1. Lightning

The contractor shall ensure that all equipment is 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.

Lightning protection systems shall be in accordance with BS 6651 – "Lightning Protection" or an equivalent Indian/international standard.

All surge suppression equipment shall be self-contained and self-resetting.

8.23.2. Alarm

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 BMS system.

Alarms will flash on the present screen and be audible to the Main controller, it will be messaged to the mobile phone of the Main controller and other concerned MTHL authorities, as decided by the Employer.

8.23.3. Selection of equipment

The contractor should select the equipment, subsystems of the BMS keeping in view the requirements given in this specification.

In their technical bid, the bidders should provide details of systems, its sub-system, components etc.

8.24. Installation

It should be ensured that the noise within the communication links between the PLC and the Control Room Workstation is avoided.

Proper installation techniques should be employed to ensure adequate quality of signals from analogue sensors (transducers) to PLCs.

Adequate measures shall be taken by the contractor to mitigate potential problems confronted due to the various forms of interference.

A semi-rigid, shielded cabling, which is, to a certain extent, self-supporting, can be used for signal and communication wiring.

The Contractor shall supply and install all materials including but not limited to cable tray, brackets, supports and execute all other works needed for supporting and routing all cabling and wiring relating to BMS. The contractor shall interface with Building/ Civil Contractors will make provisions in structures to accommodate the fastenings.

The PLCs should preferably be wall mounted. All floor mounted PLCs will be grouted in the floor, so that vibrations due to metro train movement can be born. If the problem persists then rubber AVMs can be used.

Separate tray, trunking and conduits will be used by the contractor for BMS cabling.

All cables will be laid in tray, trunkings, conduits as appropriate etc. Saddling of cables on the wall shall not be permitted.

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.

Bunching of cables near PLC entry, Power feeder entry and anywhere not permitted.

All trays, trunkings and conduits will be marked with a definite colour and tray will be marked clearly as 'BMS Control'.

A separate team of experienced BMS installation engineer, Software engineer, Electrician, Unskilled persons etc. will be kept for BMS 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.

Scaffold, welding machine, soldering iron and other tools/special tools & plants shall be maintained by the contractor.

Installation, testing schedule will be provided one month before start of work and weekly progress will be submitted to the Employer's representative.

Without complete installation, tray marking, cable tagging and dressing etc., no test will be allowed.

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.

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. 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.

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.

Printed circuit boards shall be used to mount electronic components. The boards shall be of enough thickness to ensure mechanical rigidity. They shall not be the sole support for connectors, fascia panels, handles etc.

All components shall be identified either by carrying a manufacturer's designation or part reference number or unique value in a standard format.

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.

8.25. Testing and Commissioning

8.25.1. Testing General Requirements There will be five type of tests-

Factory Acceptance test for PLC, Workstation and Printer- During the test all logics shall be demonstrated with simulator and sample PLC, Workstation and printer.

Installation test- After delivery of the PLC at the site, this test shall be arranged to check the physical healthiness of the hardware.

Functional test- This test shall be arranged to test the functioning of plc, workstation and printer and communication network.

System acceptance test- This test shall be arranged to test all automation and i/o list, with integration of communication network.

Integrated test- This test shall be arranged to test the integration of the BMS server at Main Control Center and all workstations of different Buildings, if any.

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 BMS 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 BMS 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 BMS 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.

8.25.2. 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

8.25.3. Production Testing

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.

Product Inspection - Contractor's System Integration Testing - This is the contractors own internal and un-witnessed testing on the complete BMS SYSTEM, including all simulation programs necessary to prove the totality of functionality, prior to offering them up to the customers witnessed test(s).

8.25.4. Acceptance

The Contractor shall complete all relevant Production testing before offering any Item, Subsystem or the System 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 clauses of the specification.

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.

Tests shall be conducted to prove the individual and integrated functioning of the system hardware and demonstrate performance in the face of various contingencies.

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 procedure for all sub systems.

8.25.5. Training

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.

Contractor shall train the following minimum staff. Operator staff – 30 Nos.

SN	I/Os	Source	Event	Remarks
	All Room have been provided with Air-conditions			
1.	Room temp.			Through Voltage free contact (VFC)/ RS 485
2.	Room Humidity			Through Voltage free contact (VFC)/ RS 485
3.	All Room have been provided with Air conditions			Through Voltage free contact (VFC) RS 485 for Room Temp.
4.	All Room have been provided with Air conditions			Through Voltage free contact (VFC) RS 485 for Room Humidity
	Electrical Panels Switch Board and Feeder Pillars Shall be provided with energy metering			
1.	Voltage-Phase1			Through RS 485
2.	Voltage-Phase2			Through RS 485
3.	Voltage-Phase3			Through RS 485
4.	Frequency			Through RS 485
5.	PF -3 Phase equivalent			Through RS 485
6.	Current -3 Phase equivalent			Through RS 485
7.	Current-Phase1			Through RS 485
8.	Current-Phase2			Through RS 485
9.	Current-Phase3			Through RS 485
10.	Power factor 3 Phase equivalent Active Power			Through RS 485
11.	Power factor 3 Phase equivaler Reactive Power			Through RS 485
12.	Power factor 3 Phase 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			
1.	Input voltage			Through RS 485
2.	Battery voltage			Through RS 485
3.	Charging current			Through RS 485
4.	Output voltage			Through RS 485
5.	Output frequency			Through RS 485

6.	Load %			Through RS 485
7.	Bypass voltage			Through RS 485
8.	Bypass frequency			Through RS 485
9.	Battery Charger (ESR)			Through RS 485
10.	Input voltage			Through RS 485
11.	Battery voltage			Through RS 485
12.	Charging current			Through RS 485
13.	Output voltage			Through RS 485
14.	Digital Input			Through RS 485
	As per UPS Specification			Through RS 485
1.	D.G. Set			
2.	DG Set ON		Event	Through RS 485
3.	DG Set OFF		Event	Through RS 485
4.	DG Set Trip Alarm		Event	Through RS 485
5.	DG room exhaust fan ON Status		Event	Through RS 485
6.	DG room exhaust fan OFF Status		Event	Through RS 485
7.	DG room Fresh air fan ON Status		Event	Through RS 485
8.	DG room Fresh air fan OFF Status		Event	Through RS 485
9.	Auto/Manual switch		Event	Through RS 485
10.	Lube Oil pressure Low Alarm		Event	Through RS 485
11.	Engine water temp high Alarm		Event	Through RS 485
12.	DG set Battery voltage Low alarm		Event	Through RS 485
13.	DG fuel low level		Event	Through RS 485
14.	DG fuel high level		Event	Through RS 485
	PUMPS			
1.	Domestic Water Pump1 Run Status			Through VFC
2.	Domestic Water Pump1Auto/Manual switc Status			Through VFC
3.	Domestic Water Pump2 Run Status			Through VFC
4.	Domestic Water Pump2 Auto/Manual switc Status			Through VFC
5.	Tube well Pump1 Run Status			Through VFC
6.	Tube well Pump1 Auto/Manual Switch Statu			Through VFC
7.	Fire Pump1 Run Status			Through VFC
8.	Fire Pump1 Auto/Manual Switch Status			Through VFC

9.	Fire Pump2 Run Status			Through VFC
10	Fire Pump 2 Auto/Manual Switch Status			Through VFC
11	Jockey Pump1 Run Status			Through VFC
12	Jockey Pump1 Auto/manual Switch Status			Through VFC
13	Domestic water tank1 100% level		Event	Through VFC
14	Domestic water tank2 25% level		Event	Through VFC
15	Domestic water tank2 75% level		Event	Through VFC
16	Domestic water tank2 100% level		Event	Through VFC
17	Fire water tank1 25% level		Event	Through VFC
18	Fire water tank1 75% level		Event	Through VFC
19	Fire water tank1 100% level		Event	Through VFC
	External - Road Lighting and Internal Building Lighting			
1.	Status of MCB operating for Lightin DBs/Feeder Pillars			Through VFC
2.	Status of Contactors operating for Lightin DBs/Feeder Pillars			Through VFC
3.	Status of MCB operating for Road Lightin DBs/Feeder Pillars			Through VFC
4.	Status of Contactors operating for Roa Lighting DBs/Feeder Pillars			Through VFC
	Main Distribution Board / Panel			
1.	Incomer #1 On status			Through Voltage Free
2.	Incomer #1 OFF status			Through Voltage Free
3.	Incomer #2 On status			Through Voltage Free
4.	Incomer #2 OFF status			Through Voltage Free
5.	Bus Coupler on Status			Through Voltage Free
6.	Bus Coupler OFF Status			Through Voltage Free
7.	Incomer #1 Shunt Trip status			Through Voltage Free
8.	Incomer #2 Shunt Trip status			Through Voltage Free
9.	Bus Coupler Shunt Trip Status			Through Voltage Free
	Sub-Panel/Switchboard / DBs and Feeder Pillars			
1.	Incoming MCCB On Status			Through Voltage Free
2.	Incoming MCCB OFF Status			Through Voltage Free
3.	Incoming MCCB Shunt Trip Status			Through Voltage Free
	Emergency / D.G. Panel / Switch Boards			

MMRDA

1.	Incoming MCCB from DG AMF Panel o Status			Through Voltage Free
2.	Incoming MCCB from DG AMF Panel OF Status			Through Voltage Free
3.	Incoming MCCB from DG AMF Panel Shur Trip Status			Through Voltage Free
4.	Incoming MCCB from Main Panel on Status			Through Voltage Free
5.	Incoming MCCB from Main Panel OFF Statu			Through Voltage Free
6.	Incoming MCCB from Main Panel Shunt Trip Status			Through Voltage Free
	Panel / DBs / Switch Boards for Fire Fighting / Air-conditions / Water Supply and other Services			
	Incoming MCCB /MCB On Status			Through VFC
	Incoming MCCB / MCB OFF Status			Through VFC
	Incoming MCCB / MCBs Shunt Trip Status			Through VFC
	UPS			
1.	Main failure alarm			Through RS 485
2.	No load			Through RS 485
3.	Low battery alarm			Through RS 485
4.	System fault			Through RS 485
5.	Overload			Through RS 485
6.	Over temperature			Through RS 485
7.	Bypass mode for Inverter			Through RS 485
8.	Mains ON			Through RS 485
9.	Mains faulty			Through RS 485
10.	Inverter ON/OFF			Through RS 485
11.	Inverter faulty			Through RS 485
12.	Bypass mode for battery			Through RS 485
13.	Battery Charger (ESR)			Through RS 485
14.	Charging/discharging/boost charging status			Through RS 485
15.	Battery low status			Through RS 485
16.	Mains failure alarm			Through RS 485
17.	Low battery alarm			Through RS 485
18.	Overload and over temperature alarm			Through RS 485
	D.G.Set			
1.	DG start			Through VFC

2.	DG stop			Through VFC
3.	ESPP/A/CP			Through VFC
4.	Incomer ON			Through VFC
5.	Incomer OFF			Through VFC

Engineers/ Managers- 5 Nos.

The Man weeks required for training of above staff shall be indicated by the BMS contractor in their BID.

Operator training will be carried out on site and at the supplier's own training school, as required.

Engineer/ Manager training should concentrate on making them familiar with the capabilities of the system so they he can take full advantage of the BMS in running Control Center.

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.

8.25.6. Input / Output List (Indicative)

The BMS 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. The list below is only indicative and minimum but not exhaustive, the contractor must provide enough I/O including 30% spare capacity to be provided, as required by the client/consultant.

Note : FACP shall also be monitored through BMS/SCADA.

8.26. Automation

When water level becomes lower than a predefined mark, pump will start to fill it. When water level reaches to up-to-mark, pump will stop.

Fire water level will not be less than 90%, at such situation Tube well pump will start, and alarm will be generated.

If main water supply pump fails, then standby pump shall be started automatically.

Based on the detailed design, the Contractor shall develop a detailed BMS input/output point list for all equipment's to be monitored and/or controlled subject to the approval of the Employer's Representative.

Control and monitoring shall be provided primarily at the Control Room It shall be possible, however, to enable secondary control and monitoring of equipment's from Main Control Centers.

Description of basic functions is given in Table below :

Category	Function	
	Specified Category	Description
Monitor and Supervision	CRT- based supervision	Window functions are available, Enabling display of plural supervisory screen at the same time
	Status display of units	Displaying position symbol of

		units with shape, color, flickering
	Fault display	Displaying position symbol of units with shape, color, flickering
	Telemetry value display	Displaying major telemetry values of voltage, current etc.
	Ready for command	Graphics colour will be yellow
	Running status	Graphics colour will be green
	High/Low limit check	Supervision and display of deviation of voltage, current and such telemetry data from High/Low setting values.
	Trip	Trip status of the Breaker will be shown by specific color (Red).
Control	Local	No control from BMS workstation, graphics colour will become red.
	Remote/Auto	Workstation control available, Graphics colour becomes yellow. In Auto state controlled by predefined logic.
Record and Reporting	1) Reporting management a) Daily Report	Automatic collection of various achievemer data, for editing and listing of operationa achievement documents. Reporting and printing out a daily report c data arising from hourly telemeter and incidence occurrence.
	Monthly Report Annual Report	Reporting and printing out a monthly report of data arising from dail report. Reporting and printing out an annual report of data arising from monthly report.
Record and Reporting	2) Message summary record	Reporting and printing out a message list, supported by sorting and editin functions based on specific factors, such as tim and facilities. Reporting the contents of equipmer operation, status change and alarming.
	Message list record Memo recording screen	Reporting the contents of equipment operation, status change and alarming.
Other Functions	1) Change ove remote control to manua control and vice versa	Security protection by log-on password checks (operators, System managers, Programmers). Setting up the scope of right-of-operation with a username, to

	2) Right-of operation supervision an setting. a) Security protection Operation privilege setting	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 of latest version at the time of tender.

CHAPTER – 9

9. OUTLINE ELEVATOR (LIFT) SYSTEM SPECIFICATIONS – BUILDING

9.1. General

This Specification establishes requirements for the design, manufacture, delivery at Site, installation, testing and commissioning, preparation & maintenance and training of maintenance/operation personnel of the machine-room less Elevator system for associative building under MTHL Project of MMRDA. The Contractor shall be required to interface closely with the Designated Contractors working on this vicinity. The Contractor shall also be responsible for obtaining clearances from statutory authorities, whenever required.

9.2. DESIGN AND PERFORMANCE REQUIREMENTS

9.2.1. General

The design, manufacture, supply, installation, testing and commissioning of the Machine-room less Elevators shall meet the design and performance requirements within the design environments specified in this Specification.

9.2.2. Design Environment

Climate Conditions/Operating Environment stipulated in Specification shall apply. Isoceraunic level: based on average thunderstorm days per year as per IS 2309:1989

9.3. Basic Design Philosophy and Requirements

9.3.1. Proven Design

The Contractor shall develop the design based on this specification and on proven and reliable Engineering Practices. The design details shall be submitted with technical data and calculations to the "Engineer/Employer's Representative" for review and approval.

The System, including all Sub-systems and Equipment shall be of proven design.

The Elevator Sub-systems and Equipment proposed by the Contractor shall have been in use and have established their performance reliability on at least two projects under Revenue Service over a period of at least two years.

Where similar equipment or Sub-systems of a different rating are already proven in service, then the design shall be based on such equipment. In case these stipulations are not fulfilled, the Contractor shall furnish enough information to prove the basic soundness and reliability of the offered Sub-system. The design philosophy should meet the following criteria:

1) Application of state-of-the-art Technology
2) Service proven design
3) Design life 30 years
4) Minimum life cycle cost
5) Low maintenance cost
6) Use of interchangeable, modular components
7) Extensive and prominent labelling of parts, cables and wires
8) Use of unique serial numbers for traceability of components

9) High reliability and ensure Zero passenger trapping
10) Low energy consumption
11) System safety
12) Adequate redundancy and factor of safety.
13) Fire and smoke protection
14) Use of fire-retardant materials
15) Environment friendly
16) Adherence to operational performance requirements
17) Maximum utilization of indigenous materials and skills, subject to quality conformity.
18) Specified values for reliability, availability, and maintainability (RAM) for equipment/Components in Elevators.

9.4. Conformity with Governing Specifications and another Statutory requirement

The work shall be carried out in accordance with the following governing specifications and other statutory rules:

1. Central Electricity Authority Regulation 2010 with latest amendments.
2. Indian Electricity Act 2003 with latest amendments.
3. Rules and Regulations prescribed by local authorities as applicable.
4. Relevant, Indian Standards, IEC Standards, EN Standards, British Standards and other National / International standards as applicable.
5. Indian Energy Conservation Act 2001

The Contractor shall furnish information asked for by a statutory body (e.g., Inspector of Elevators,) format as directed by "Engineer/Employer's Representative".

9.5. Codes and Regulations

9.5.1. Local Codes, Regulations and Standards

Unless otherwise stated herein, the design, installation, testing and commissioning shall comply with the latest edition of all applicable standards issued by the Bureau of Indian Standards and other relevant local regulations applicable.

IS – 14665 : All parts (Latest Version).

IS – 15785 : installation and maintenance of Elevators without conventional machine rooms.

IS – 15330 : Installation and Maintenance of Elevators for differently abled Persons – Code of Practice

IS – 7759 : Specification for Elevator doors locking device and controls.

IS-1860: Code of practice for Installation, Operation and Maintenance of Electric passenger and goods Elevators

Additional requirements imposed by statutory or government authorities not listed above shall be complied with.

9.5.2. Additional Standards

Elevators shall comply with the requirements as per latest edition of EN 81 and BS 5655 of the British Standards: Safety rules for the construction and installation of electric Elevators. The provisions related to the application for differently abled persons stated in these codes shall also be complied with.

The Contractor shall also comply with the "Guidelines and space standard for Barrier free Built Environment for Disabled and Elderly Persons" published by C.P.W.D. (Central Public Works Department). India.

The contractor shall comply with the guidelines for safety of Elevator circulated vide A. V. series circular no. 822, issued by Ministry of Urban Development and Poverty Alleviation, Govt. of India vide their letter no. C-31011/1/2001-AVII dated 7.12.2001.

9.6. Scope:

The scope of work includes, but not limited to, following:

1) Provision of Approximately 5 (Five) No's machine room less Elevators in Administration building, Control Centers building for movement of staff including differently abled persons;
2) Signage and graphics on Elevator equipment for guidance of passengers;
3) Provision of necessary signals for BMS for remote control and monitoring of Elevators;
4) All minor civil works including holes for armoured cable entry, louvers and cutouts (by providing proper size wooden blocks to civil contractor) or modifications required for installation of the equipment and restoring to final finishes.
5) Transportation of materials and equipment for installation purposes;
6) Shaft lighting (Bulkhead + Switch and socket + complete wiring) and all Scaffolding works required for Elevators systems.
7) Spare Parts, Special tools, testing and diagnostic equipment and measuring instruments;
8) Contract spares as requires;
9) All cabling and wiring necessary for the Works;
10) The communication cable from Elevator Car (Inside) for connecting emergency telephone for staff to contact the helpline.
11) Enclosures and supporting brackets for housing and fixing equipment;
12) All equipment, fixtures and material required for interface with other Contractors;
13) All software and hardware required for Elevators including development system, license of all applications and Operating System software, etc.;
14) Storage cabinets for spares and records;
15) Provision of Machine-room less and Gear-less Elevators for the movement of disabled and elderly persons.
16) Training and Transfer of Technology.
17) Documentation.
18) Maintenance for specified period.
19) Services.

9.7. Services

The Services to be performed by the Contractor shall include, but not be limited to, the following:

1) Design, manufacture, supply, system quality management, installation, testing including integrated testing and commissioning of the complete system as brought out above;
2) Interface management;
3) System operations and maintenance support services;
4) Training for Employer's staff;
5) Decommissioning, removal and/or disposal of temporary works;
6) Prototyping;
7) Defects liability of Permanent Works after commissioning as stipulated in the contract document; and
8) Obtaining statutory clearances for the commissioning of Elevators from Authorities concerned.

9.7.1. Elevator Schedules

The following table summarizes the no. of Elevators to be provided:

TABLE 1: Type and Rise-wise Details of Elevators

Sr. Nos.	Description	Main Admin Bldg. & CCC Gavan	Admin Bldg. & CCC Shivaji Nagar	Sub Admin Bldg. & CCC Sewri
1	Nos. of Lift(s)	3 nos.	1 no.	1 no.
2	Lift Capacity - Nos. of Passenger	8 Passenger		
3	Lift Capacity - Rated Load	544 kg		
4	Car Size	1,300 mm X 1,100 mm		
5	COP Door Size	800 mm		
6	Lift Shaft Size	1,900 mm X 1,900 mm		
7	Rated Speed	1.0 m/s		
8	Nos. of Floors served	5 nos.	2 nos.	3 nos.
9	Nos. of Landings	5 nos.	2 nos.	3 nos.
10	Total Travel Distance (Lowest Floor's FFL to Top Floor's FFL Height)	14 m	3.5 m	7 m

Note: The above elevators parameters and type & rise wise details are indicative, The Design Build Contractor, however, shall develop the final values under their design in accordance with the site conditions, codes and standards and in consultation with Civil Contractor.

Note:

1) The above Travelling height may vary by ± 0.5 m based on site conditions; however, the contractor shall not be entitled for any extra payment on account of this variation in case height of Elevators.
2) Elevator shall have carrying capacity of 544 kg/ 6 passenger.
3) The building wise number of Elevators, height of Elevator and type of travel of travel within these bands shall be confirmed to the firm 60-90 days after issue of Letter of Acceptance.
4) Car and Landing Door of the elevators shall be either Stainless Steel.

9.8. Documentation

The documentation to be delivered by the Contractor shall include, but not be limited to, the following items:

9.8.1. Design Stage

1) Description of general design philosophy;
2) System reliability, availability, maintainability and safety evaluation reports;
3) Automatic fault identification and isolation arrangement;
4) Determination of equipment ratings;
5) Determination of space requirement;
6) Design and proving protection devices/ systems and its validation,
7) Type test reports for equipment selected;
8) Detailed design drawings and reports;
9) Detailed interface reports and interfacing design drawings;
10) Hazard identification and control documentation.

9.8.2. Construction Stage

1) Construction and Installation Plan including site safety plan,
2) Factory Acceptance Test Plan for equipment;
3) Quality Plans.
4) Installation, operation and maintenance instruction of all equipment;
5) Operation and Maintenance Manuals;
6) Records and drawings of equipment installed;
7) All other records of construction, including hidden parts;
8) Site test report of equipment;
9) As built drawings including interface drawings; and
10) Other documentation as required, by the Employer.

9.9. Other Statutory Requirements

The Contractor shall be fully responsible for obtaining relevant safety certificate or license or any other documents required from statutory authorities for commissioning the regular operation of Machine-room less Elevators. The renewal of the license/safety certificate during DLP will also be the responsibility of the contractor. Fee, if any for obtaining such license/ certificate shall be borne by the contractor.

The Contractor shall submit the relevant safety and clearance certificates obtained for each equipment from the statutory authorities to the "Engineer/Engineer's Representative".

The Contractor shall provide adequate signage and graphics as being statutory requirements, for the safe and proper utilization of each equipment, in adequate number exhibited at required locations.

9.10. DESIGN CRITERIA AND PERFORMANC SPECIFICATION - MACHINE- ROOM LESS ELEVATOR

9.10.1. Introduction

The Buildings under MTHL Project shall be equipped with machine-room less elevators being used in transportation establishment for staff in locations.

9.10.2. General Requirements

Each Elevator shall have its own driving machine. The method of drive shall be Electric Traction with Gear less motor having V3F Control & regenerative braking. The Elevator Sub-systems and Equipment proposed by the contractor shall have been in use and have established their performance reliability over a sufficiently long period of time. In support of the performance certificate from the client user of the system is to be submitted.
All elevators shall be capable of operating satisfactorily and smoothly at a rate of 180 motors starts per hour or above for a period of not less than 10 hours per day, seven day a week, within the environmental conditions as stated in the Specification and at the location where the elevators are to be installed.
The design of the Elevators shall be such that no replacement of major component shall be necessary for a period of 20 years from the date of issue of Certificate of Taking Over. This is based on the requirements that detailed inspections and maintenance are carried out annually, whilst routine cleaning and maintenance are earned out as necessary. The elevators should be designed for minimum life cycle cost. Detailed life cycle cost analysis should be submitted. The necessary data shall be collected by the contractor on his own end without any additional cost to MMRDA: Life of all components should be clearly mentioned in the bid.

Major components shall mean replacement of car frame, car enclosure, car and landing doors, elevator shaft wiring (except travelling cables), guide rails, drive machine and driving sheave but parts attached to these components which are subjected to normal wear and tear are excluded. The other mechanical components should be designed to serve for minimum 20 years period of uses without replacement.

The design of the Elevators shall take into consideration fire prevention, elimination of dust and dirt traps, and easy accessibility for cleaning and routine maintenance.

The gear less drive machine shall be mounted on guide rails accommodated within the elevator shaft. The power switch gear and main control equipment shall suitably locate inside or near the Elevator shaft, the location of which is to be decided in coordination with the Designated Civil Contractors. No separate machine-room will be provided for machine room less elevators. Elevators intended to be procured shall have a carrying capacity (rated load) of at least 544 kg for 8 passengers as defined in the Form of tender. The nominal speed for the Elevators shall be 1.0 m/s in either direction.

Shaft dimension for non-hanging type 544 kg/8 passenger elevator shall be approximately 1900 mm (Width) x 1900 mm (Depth). The Contractor shall take all necessary measures to accommodate the elevators in the above shaft. The Contractor shall co-ordinate/interface with the Designated Civil Contractors for all matters related to shaft size. Any minor variation change in the shaft size (depth) to the tune of +250 mm shall have to be accommodated in the

design by the contractor by way of provision of suitable guide brackets/stainless steel channels without any additional cost to MMRDA. The contractor shall be responsible for any delay on this account.

Elevator car shall have minimum internal dimensions of 1300 mm (Width) X 1100 mm (Depth) for carrying the rated load of 544 kg/8 passengers. The false ceiling height and door shall be so configured that it is feasible to handle a person on a wheelchair.

The approximate headroom of 5000 mm and pit depth of 1650 mm or as applicable under codes and standards shall be provided in the shaft for 8 passenger elevators. The Contractor shall submit in their technical packages the requirement in respect of reaction load on the walls and in the pit and other relevant shaft requirements. The Contractor shall co-ordinate with the Designated Civil Contractors to finalize all the details. The pit depth and overhead dimensions shall be such as to confirm the requirement of bottom and top clearances as per relevant IS.
The leveling accuracy shall be within ± 5 mm of the finished floor level.
The running clearance of each Elevator between the Elevator car threshold and landing door sill shall not be less than 15 mm but not more than 30 mm.

9.11. Electric Traction Drive System

9.11.1. Traction Machine

The construction of all Elevator machines shall conform to IS-14665 and BS 5655: Part 1.

9.11.2. Motor

a) Driving motor shall be of the AC synchronous/asynchronous axial type designed for special duty cycles required for Elevator operation with no slip rings. It should have a high starting torque, high power factor, high efficiency not less than 85% and low energy consumption.
b) For all type of elevators, the motor shall be capable of not less than 180 starts per hour without excessive temperature rise.
c) The maximum temperature rise of the winding shall not exceed 50°C above ambient temperature when operated under normal condition.
d) Provision shall be made to enable the speed to be checked at main Control cubicle.
e) The motor shall carry a nameplate giving full details of its ratings and characteristics.
f) The motor used shall have Class F insulation and shall be designed for 110% of rated load.
g) The insulation resistance of any conductor to the motor frame or earth shall not be less than 0.5MΩ at 50ºC.
h) The fail-safe break shall be adjusted at the manufacturer works to provide a break torque as per EN-81, required to stop and hold the elevator in the down direction.
i) The motor armature shall be dynamically balanced and supported by bearings of ample capacity. The armature and driving sheave shall be properly balance for smooth high-speed elevator performance.

9.11.3. Brake

a) The Electro-magnetic brake shall be of the spring applied and electrically released type.
b) The brake shall be capable of stopping and holding the Elevator car in its downward travel to rest with 125% of its rated load from the maximum governor tripping speed. In this condition the retardation of the Car shall not exceed that resulting from the operation of the Safety gear or stopping on the buffer.
c) Springs used to apply the brake shoes (two nos.) shall be in compression and adequately supported. Power coating or other alternative Anti-corrosion measures to be ensured.
d) Brake linings shall be of renewable incombustible materials and shall be secured to the brake shoes that normal wear shall not weaken their fixings. Band brakes shall not be used.
e) No earth fault, short circuit or residual magnetism shall prevent the brake from being applied in the event of loss of power supply to the Elevator motor and control circuit.
f) A means of adjusting the brake plunger stroke and releasing the brake in emergency shall be provided.
g) The Elevator machine shall be fitted with a manual emergency device capable of having the brake released by hand and requiring a constant effort to keep the brake open. The manual emergency device shall be handling operated. The handle should be robust and able to bear the human intervention. It will be evaluated during detailed design stage.

9.11.4. Driving Sheaves

a) The sheaves shall be manufactured in steel or SG iron and fitted with sealed for life lubricated bearings.
b) The sheaves shall have machined rope grooves that can be reworked for future wear.
c) Adequate provision shall be made to prevent any suspension ropes leaving groove due to rope slack or introduction of foreign objects.

9.11.5. Alignment

a) The brake plunger, collar, sleeve, motor, sheaves and all bearings shall be mounted and assembled so that proper alignment of these parts is maintained.
b) The assembly shall be reviewed and rectified when excessive noise is generated during operation.

9.11.6. Anti-Vibration Supports

The whole traction machine shall be mounted on appropriate anti-vibration supports to minimize noise and vibration.

9.11.7. Encoder

Encoder shall be direct drive, solid state, digital type. These shall be able to update car position at each floor and automatically restore after power loss.

9.12. Hoisting Rope/ Belt

At least three (3) steel wire ropes or three (3) coated steel belts specially manufactured for Elevator use shall be employed for the suspension of Elevator car and counterweight. The diameter/ dimension and specification of rope/coated steel belts for the car and counterweight shall conform to latest version/ amendments of IS: 14665 (Part 4/Sec. 8) and IS: 15785.

A plate giving the number, size and ultimate tensile strength of the rope or steel/ coated steel belt used shall be permanently fixed to the crosshead. Steel rope/ coated steel belt of adequate size and number is to be provided whose capacity/ strength will be verified at design/ test stage. The coated steel belt shall be provided with continuous operating fatigue monitoring system as per IS 15785.

9.12.1.

Before installation, manufacturer's certificates shall be supplied for each set of hoisting ropes/ belts with the data not limited to following:

a) The type of wire rope/belt
b) The diameter/width in mm
c) The manufacturer's rated breaking strength
d) The month and year the ropes were manufactured
e) The manufacturer's name,

9.12.2.

The factor of safety based on maximum static load for car and counterweight ropes shall be least 12.

9.12.3.

The ropes shall be attached to dead-end hitch assemblies, fitting to supporting beams, car frames, counterweights by means of suitable rope/ belt termination. A locking device or anti-twist rope device shall be fitted to the roping system. Alternately approved arrangement for wedge type rope fastening may be used.

9.12.4.

Compensation ropes or chains or any other arrangement shall be provided if necessary, to achieve the levelling required and smooth starting. If chains are provided, they shall be galvanized and enclosed in canvas hose or other accepted means to reduce noise.

9.13. Counterweight

Guide shoes, having non-metallic renewable linings requiring minimum lubrication shall be provided at the top and bottom of the counterweight. The counterweights shall be made of cast iron/wrought iron/ steel and shall be appropriately secured and housed. They shall be of uniform density and physical dimensions.
Counterweights shall be guarded by means of a rigid, galvanized steel sheet screen extending

from a position 300mm above the pit floor to a position at least 2.0 m above the pit floor. The counterweight shall be balanced to 40 to 50 %(±3%) of the rated load.

9.14. Guides and Fixings

1) Planed steel tees shall be provided as guides for the Elevator car and counterweight, as appropriate, erected plumb and fixed securely to the Elevator shaft by steel brackets. The bracket shall be solidly fixed with the RCC beam/bonds. The guide rails shall be connected by steel fish plates
2) The rail contact surfaces of the connecting rail plates and back of the guide rail ends shall be accurately machined and fitted at site to form smooth joints.
3) The stem sections of all guides shall be tongued and grooved to provide matched joints. The guides and their fixings shall be able to withstand the forces imposed by a fully loaded car travelling at or higher than the tripping speed of the governor, due to the application of the safety gear, without permanent deformation or bending due to the uneven loading of the car. The guide rail brackets shall be hot-dipped galvanized.
4) Guide rail brackets shall be of steel and bolted securely to the building or structure steelworks. The brackets shall be designed and located such that the rail will not deflect more than 5 mm under normal operation. There shall be a minimum of two brackets per piece of guide rail and the distance between brackets shall not be more than half the length of each piece of guide rail. The bracket should be fixed to PCC blocks or RCC beams. It is the sole responsibility of the Contractor to interface with Civil contractor to satisfy himself about the shaft strength (as per latest standards) before taking up Elevator installation and get the strength of the shaft wall certified from the civil Contractor.
5) The fixing of guide rails to their brackets and to the building structure shall permit compensation, either automatically or by simple adjustment, due to normal settling of the building or shrinkage of concrete.

9.15. Elevator Car

9.15.1. Guide Shoes

a) Adjustable guide shoes shall be provided and properly fitted at the top and bottom on each side of the car frame and the counterweight frame. The guide shoes shall be slipper type or roller guides as appropriate.
b) Slipper type guide shoes shall be of milled cast iron or steel frame type or sheet metal with non-metallic renewable liners, of low coefficient of friction and good wear resistance, which require minimal lubrication. A drip tray fabricated from galvanized steel sheet shall be provided.
c) Roller guides shall comply with the following requirements:

i) Each roller guide shall consist of three wheels tyred with polyurethane or a durable resilient material, each rotating on ball bearing having sealed-in lubrication, assembled on a substantial metal base. They shall be so mounted as to provide continuous contact of all wheels with the corresponding rail surfaces under all condition of loading and operation. The wheels shall run on three finished rail surfaces. The Contractor shall provide a means of adjustment of spring pressure and of play between shoes and guide rails.

ii) The roller guides shall run on dry guide rails. Sheet metal guards shall be provided to protect the wheels on top of the car and counterweight. The roller wheels for the car shall not exceed 500 rpm and the roller wheels for the counterweight shall not exceed 1000 rpm at rated speed.

iii) The car and the counterweights are to be statically balanced following fitting of all its equipment and finishes prior to fitting the guide shoes.

9.15.2. Car Frame

A suitable car frame fabricated from galvanized cold rolled steel, bolted or welded together to form a rigid structure shall be provided. The deflection of the members carrying the platform shall not exceed 1/1000th of their span under static conditions with the rated load uniformly distributed over the platform. It shall be able to withstand the operation of the safety gear or any condition loading without permanent deformation and shall not transfer the load to the enclosure. The safety factor of the frame shall not be less than five (5).

9.15.3. Car Enclosure

a) Car enclosure shall be fabricated from galvanized steel of not less than 1.5 mm in thickness or any other material where specified and securely fastened to the car platform and so supported that it cannot be loosened or become displaced in ordinary service or on the application of safety gear or on buffer engagement. The design of the final finishes of the walls, ceiling and floor is subject to the Acceptance of the Engineer.

b) No wood or other combustible materials shall be used for any part of the Elevator car including car door and emergency trap door.

c) The enclosure shall be designed and supported such that when subjected to a pressure of 335N applied horizontally at any point over an area of 5 cm2 on the walls from the inside of the cars toward the outside, there shall be no permanent deformation and deflection shall not be more than 10mm.

d) The enclosure shall be insulated to prevent the transmission of noise and vibration from the car frame.

9.15.4. Car Platform

a) The car platform shall be constructed from cold rolled steel (spray galvanized) with steel flooring. The platform shall be designed based on the rated load evenly distributed with a minimum safety factor of five (5). The design of the final floor finish is subject to Acceptance of the Engineer.

b) The car platform shall be insulated to prevent the transmission of noise and vibration from the car frame to the platform.

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The car roof shall be suitably constructed with galvanized sheet steel and reinforced to permit the maintenance and inspection of the Elevator shaft equipment to be carried out by maintenance personnel standing on the car roof. Perforated with mesh construction of the roof or wooden platform(s) on the car roof shall not be acceptable. The car roof shall be fitted with guard rails set as at a height and of suitable dimensions and strength to protect maintenance personnel.

(a) Landing Finishes	
i. Landing Transom Panels	-Scratch Resistant Stainless steel,
ii. Architrave (Fascia/ Jamb)	-Scratch Resistant Stainless steel / Stonework
The fascia at each landing of minimum 300 mm width or as per site condition for fixing the Landing Plate, Indicators, MAP etc. shall be of Scratch Resistant Stainless steel/ Stonework and shall be in scope of elevator contractor.	
iii. Landing Doors	Scratch Resistant Stainless steel, For the glass door, thickness of glass door shall not be less than 10 mm and with the scratch resistant stainless-steel frame. The fire rating of Stainless-Steel Door minimum 2 hour.
(b) Car Finishes	
i. Car Transom Panels	-Scratch Resistant Stainless steel,
ii. Car Door Frame	Scratch Resistant Stainless steel, (without cladding)
iii. Car Wall	
a) Front Panels	-Scratch Resistant Stainless steel
b) Side Panels (including COP(Car Operating Panel))	-Scratch Resistant Stainless steel
c) Back Panels	Scratch Resistant Stainless steel, Joints in all surfaces shall be coordinated. All fixings to be of the hidden secret type(Cover strips at joints are not acceptable)
d) Car Doors	Scratch Resistant Stainless steel, The scratch resistant stainless-steel frame. The Fire rating of Car door shall be complying with the requirement as per the National Building Code.
e) Car Floor	15mm thick Granite/ synthetic artificial stone having anti-slippery design distinguishable through grating of any suitable material which can take the desired load. However, the approval for the colour of granite/ artificial synthetic stone and its specifications will be obtained from the Employer during design/ prototype testing.
f) Car Ceiling	-Scratch Resistant Stainless-steel panels with enough LED down lights or other energy efficient light. ceiling design to be coordinated with the overall station design to the Engineer acceptance.

g) Car Kick-Plates and skirting	-Scratch Resistant Stainless steel
h) Hand/grip rail	-Polished Stainless steel, of straight through type & supported from minimum 3 places.

A toe guard shall be provided for the car doors conforming to Paragraph 8.4 of EN81 Part 1. The toe guard for Elevators shall be made of galvanized sheet steel of not less than 1.5mm thick and painted and shall be adequately braced at the back. The depth of the toe guard shall be enough to prevent any object from being trapped between the underside of the car platform and the landing during re-levelling operation (with a minimum of 700 mm).

9.15.5. Ventilation

a) Each Elevator car shall be adequately ventilated using Cross flow fans to achieve a minimum standard of 20 air changes per hour. The fans shall be located above the suspended ceiling or recessed in the car ceiling as appropriate.
b) A low speed fan of low noise shall be used. The noise level of Fan used for ventilation shall not exceed 50DBA (+5%) at 1 meter away from the fan inside the Elevator car.
c) The effective area of ventilation apertures shall be at least 1% of the car platform area as per EN-81
d) Fan shall automatically start on registering the command/ Auto call for 2 floor elevators. However, fan Switch shall be provided to disable auto-starting of the Fan when not desired.

The car door shall be provided with an electric contact arranged to prevent the normal operation of the Elevator unless the gate is in the closed position. The car door shall be arranged to give the minimum clear opening width as specified.

The car junction box with IP Class 55 protection, for the travelling cables and car enclosure wiring shall be installed at the car top.

Car Interior and Elevator Finishes unless specified elsewhere in this Specification, the following finishes for the Elevator shall be complied with:

All stainless-steel materials specified for car and landing finishes shall be of grade 304 and shall be subject to acceptance of the "Engineer. The degree of ingress protection provided by both Car door and Landing door to the car and the internal machinery shall be IP 54.

All car interiors/architrave, doors and interfaces with civil structure and finishes shall be subject to acceptance of the "Engineer.

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9.15.6. Illumination of Cars and Lighting Fixtures

The minimum illumination level at the floor of the Elevator car shall be 150 lux using energy saving LED light fittings. The light inside the car cabin shall be either of light yellow or white colour. It will be decided during evaluation.

9.15.7. Emergency Lighting

In addition to the normal car lighting provided, a maintenance free emergency light fitting shall be provided in each elevator car, which may be the same type of fitting as the normal car light and shall illuminate immediately and automatically in the event of failure of the normal car lighting electrical supply. The fitting shall incorporate a permanently illuminated signal to indicate mains healthy and shall be connected to the emergency battery. The luminous intensity of the emergency lighting shall not be less than 100 lux measured at floor level and on the car operating panel(s).

9.16. Heavy Duty Elevator Doors

9.16.1. Car and Landing Doors

Heavy duty doors should be of Robust Design shall be provided with horizontal sliding doors complete with door frames and architraves, arranged in center opening with two panels.
Unless otherwise specified, the car and landing door panels shall be imperforate and fabricated from scratch resistant stainless steel of at least 1.5mm thick. The car and landing door should not be cladded. The back of door panels shall be treated with an anti-drumming compound which is non-combustible and shall not emit toxic fume when affected by fire. The compound shall be reviewed without objection by the Engineer.
The door shall be able to withstand horizontal or lateral load according to latest version/ amendments of IS: 14665 (Part 4/sec 6): 2001
The doors shall be provided with keyways for interlocks. Door sills shall be of machined stainless-steel block to provide anti-skidding surface alternatively if door sill is of extruded aluminum, its thickness shall be 5.0 mm with non-slip wearing surface.

9.16.2. Door Hangers and Rollers

The proneness and design of heavy-duty doors shall be specifically evaluated during the detailed design stage.

9.16.3. Door Operators

Operation of Door shall commensurate with elevator motor starts/ stop. The door operator for each Elevator shall consist of a motor, operating mechanism, linkages and switches to give adjustable or variable speed door operation and shall be adjusted to ensure smooth, fast opening and closing. The average door speed shall be between 150 – 250 mm/sec. The car and landing doors shall operate simultaneously and quietly while the Elevator car is levelling.

For the car and landing door made of glass panels with scratch resistant stainless steel frame, Stainless steel cover of not less than 1.5mm thick minimum without cladding or other suitable arrangement for headers shall be provided with Engineer's approval to prevent the door locking devices, door tracks and mechanism from accumulation of dust. For stainless steel elevators, steel door covers shall be made of galvanized steel.

On "Without Attendant" mode, if no command is registered, or due to some abnormality of Elevator safety circuit, after the expiry of a pre-set time interval of 10-30 seconds (Adjustable) the door shall re-open once for 30 seconds (Adjustable so as the commuter can come out) and close.

For Elevators on "With Attendant" operation, the car and landing doors shall open automatically but the closing of doors will be subject to the pressure on "Door Close" button. During the closing motion it shall be possible to reverse quickly and open the doors by pressing of the "Door Open" button.

The door lock shall prevent the car doors from being opened by the door operator or by force when the car is moving or is not stopped within the unlocking zone of a landing. Electric interlocks shall be provided to ensure that Elevator will not operate, if the car door is not closed and locked. If the car door is forced open, the Elevator shall stop, and the alarm activated (even when the Elevator is out of order) until the door is fully closed. The audio-visual alarm signal shall be sent to the relevant landing as well as to Control Room.

9.16.4. Door Safety Devices

Electrically Operated Proximity Detection Device

Electrically operated proximity detector device(s) shall be installed on the leading edge of the car doors. The device(s) shall create a three-dimensional zone of protection for the entire height of the door opening. This zone of detection shall extend a short distance in front of the landing doors. The zone of detection shall move forward as the doors close and the presence of a person, if within this zone, shall activate the detector to stop the closing movement of the doors and re-open them before hitting the person. After a pre-set time, interval (which is programmable) the doors shall start to close again in the absence of further interruption. A passenger entering or leaving the car shall not cause the doors to stop and re-open unless the doors" edge reaches a certain predetermined proximity to the passenger. The contractor shall consider the ambient condition before deciding the sensitivity of the device. This device should not be too sensitive to the sunlight, to result in mal operation.
If the doors are prevented from closing by the pressing of hall and/or car buttons or a person in their path for an adjustable pre-set time, the safety devices, except the mechanical door safety edge / door force limiter, shall be rendered inoperative to cause door reversals. The doors shall proceed to close at a reduced speed and a buzzer located on the car shall sound before and during the closing.

Photocells : Two Photocells shall be provided for each car door for preventing door closing when a passenger is entering or leaving the car. This should act as a backup protection to 3D-infrared curtain.

9.17. Car Operating Panel (COP)

Car operating panels and car call buttons shall be ergonomically designed and of robust construction to the Engineer acceptance. The car operating panel shall be integrated and flush mounted, on one of the side panels. All buttons on the panel shall be of robust design and construction and flush with the panel. All buttons shall be of Jumbo Size with minimum dimension of 50mm x 50mm on the panel shall be of robust design and construction and flush with panel.

The faceplate shall be made of scratch resistant stainless-steel grade 304 finishes. Specifications/ features of various items to be provided in COP are following:

a) A red "Car Overload" indicating lamp with buzzer in Hindi and English Language.
b) Two vertical rows (where appropriate) of car minimum dimension of 50mm x 50mm on the call buttons for floor designations bearing numerals/ alphabets with integrated Braille code for visually impaired.
c) A "Door-Open" button which, when pressed, shall cause the closing door to reopen or when continuously pressed shall keep the door open.
d) A "Door-Close" button which, when pressed, shall cause the door to close to shorten the door open time.
e) An intercom button (self-illuminating feedback type), when pressed, shall allow direct communication with the personnel in the control center. The Contractor shall submit their features and proven Vendor of intercom to Employer/Employer's Representative for notice of no objection.
f) A capacity plate engraved / etched onto the car operating panel shall indicate the rated load in kilograms and the maximum number of passengers to be carried. The size and design of the lettering shall be subject to the notice of no objection of the Employer's Representative.
g) An "ON/OFF" switch whereby the ventilation fan can be switched on and off.
h) Each button shall be of Jumbo type (50 x 50mm) micro-push suitable for heavy duty and vandal proof type. The response light shall be either orange or red when illuminated.

A key operated switch shall be provided on the car operating panel at a suitable location to facilitate Elevator operation as under;

a) One or more switches whereby the following modes of operation can be affected as desired:
b) Fully Automatic with Attendant operation.
c) Automatic with Attendant operation.
d) Operation by Firemen in accordance with local standard and statutory requirements.
e) "UP/DOWN" buttons which shall cause a car to travel in the desired direction. These buttons shall be operative only during the "Attendant" operation.
f) An "ON/OFF" switch whereby the ventilation fan can be switched "ON" or "OFF".
g) The fireman switch shall be provided as per IS-14665(part 5) and statutory requirement.

9.18. Big Size Car Position Indicator

The car position indicators shall be provided inside the car and on each landing in the Hallway. These indicators shall be part of „Car operating panel" inside the car or Call buttons (in the Hallway). The location of the indicators shall have prior notice of no objection of the Engineer/Engineer's Representative.

The faceplate of the car position indicator shall be made of scratch-resistant stainless-steel grade 304. Finish will be approved by Employer/Engineer before start of manufacturing. The Stainless-steel plate should be minimum 2.5mm thick and its mounting arrangement should have two sunken screws. This plate should be pilfering proof. Floor numbers shall be digitally displayed using LCD of 10.4" diagonal size and resolution of 1024 X 768. There shall also be an arrow in motion vividly and dynamically indicating car movement and direction. It shall also be capable of displaying / scrolling simple message such as, floor names like "Concourse, Platform", " Out of service", under maintenance" "overload", fire , ARD operation" etc. The surface of the display unit shall be non-glare type. The samples shall be submitted to the Employer/Employer's representative for approval.

9.19. Elevator Inter-Communication System

The Contractor shall provide an Elevator inter-communication between the Elevator Car, main control cubicle and control center.
The power supply arrangements for handsets/ intercoms shall relate to UPS power supply such so as intercoms working shall not be affected by the failure of main supply.

9.20. No-Smoking Notice

A "SMOKING IS STRICTLY PROHIBITED" sign shall be supplied, and surface mounted on the front return panel in each Elevator. The graphics, lettering and material shall be subject to the acceptance of the "Engineer.

9.21. Certificate Holder

A framed and glazed panel made of stainless steel, suitable to display the Elevator certificate shall be provided above the car operating panel. This shall be subject to the acceptance of the "Engineer

9.22. Hallway Equipment

9.22.1. Landing Doors

a) Fire Rating
Stainless steel landing doors shall have a minimum of 2 hours fire rating. Landing doors with glass panels shall have a minimum of 1-hour fire rating. These doors shall be suitably tested and provided with approved stickers.

b) Door Frames
Door frames shall be of at least 1.5 mm thick scratch resistant stainless steel in suitable finishes and shall comprise head and jamb sections of the same material. The door frames shall be suitably braced and reinforced. The door frame should not be cladded. The frames shall be provided with adjustable wall anchors or comparable devices to permit bonding of these anchors or devices into the walls after the frames are in place. All frames shall be securely fastened to sills and hanger supports and shall be returned to the hoist way side to present a neat appearance.

c) Door Sills
Toe guards like those provided to the car door sill shall be provided beneath each landing door sill.

d) Supports and Covers

Structural steel angles shall be furnished and of enough size to accommodate the door closing equipment. The angles shall be continuous and securely bolted to the sills and the building structure.

Hanger cover plates having car door as well as landing door made of glass with a scratch resistant stainless-steel frame, the hanger cover plates shall be made of stainless steel. These covers shall be removable, and so arranged to ensure hanger accessibility from within the Elevator car for maintenance purposes.

Cover bolts and threaded screws shall be adequately strong with long life and capable of frequent opening and closing.

e) Self-Closing

Gravity or spring actuated self-closing device shall be fitted to the landing doors to automatically re-close the doors when manually opened by means of the emergency unlocking device. The gravity weight shall move freely and quietly within its enclosure fixed at each end of the door sill and be protected from falling into the Elevator shaft due to any reason. This device shall not be accessible to public.

f) Locking Device

i) Each landing door shall be provided with an accepted locking and interlocking device to prevent the operation of the Elevator unless all landing doors are closed and locked.

ii) It shall not be possible to open the landing door from the landing side without a landing door key.

iii) The locking device shall have at least IP 20 protection.

iv) The electric contacts of the door locking device shall open positively independent of gravity.

v) Each landing door panel shall be provided with its own locking device.

vi) Provision shall be made for opening of all landing door locks by means of a landing door key by an authorized person irrespective of the position of the Elevator car.

g) Fascia

Where the gap between the car door sill and surface of the Elevator shaft wall exceed 125 mm, galvanized sheet steel fascia plates of not less than 1.5 mm thick shall be provided. These shall be fixed between the undersides of landing entrance sills and the top of the door hanger case to form a flush surface in the path of travel at the car entrance. The plates shall cover the whole width of the landing door and extend by 150 mm on each side of the door. It shall be rigid and properly reinforced. The fascia plate shall be painted in an accepted colour.

h) Door Profile

To avoid the stocking of fingers in between car frame and car door, profile shall be provided & the gap after provision of profile if any shall not be more than 5 mm. Figure trap safety device shall be provided at both sides of landing door jambs and car door jambs. The door shall stop in case of activation of this safety device in accordance with the recommendation of clause 7.2.3.6.C, 8.6.7.5.C of EN 81

Jumbo type Hall Call Buttons One (1) set of jumbo type of minimum size 50 x 50 mm hall call buttons shall be provided for each Elevator at every floor served. The set of buttons shall be installed on the wall adjacent to each Elevator landing.

i) The faceplate shall be made of scratch resistant stainless-steel grade 304 suitable finishes. The Stainless-steel plate should be minimum 2.5 mm thick and its mounting arrangement should have two Sunken Screws. This plate should be pilfering proof. The hall call buttons shall be micro-push type, suitable for heavy duty and vandal proof. The response light of the call buttons shall be orange or red, when illuminated. When an Elevator arrives at the hall, the illumination shall cease.

j) Hall Position Indicator

One set of Hall lanterns shall be provided for each Elevator at every floor served. The set of lanterns shall be installed on the wall adjacent to or on top of each Elevator landing. The display shall be the same as the car position indicator.

Prior to the car's arrival, the hall lantern shall begin flashing and the chime shall sound twice.

The response light of the "UP" and "DOWN" indication lanterns shall be green and red respectively when illuminated.

9.22.2.

The Elevators equipment (i.e. Indicators, landing call plate, MCB etc.), if any at Ground level should be pilfer proof.

9.22.3.

The Stainless-steel plate of SS 304 with suitable finish for mounting the indicators and landing call buttons should be minimum 2.5mm thick and its mounting arrangement should have two Sunken Screws suiting the design criterion.

9.23. Elevator Functions

The Elevator shall incorporate the following functions.

9.23.1. Door Nudging Feature

If the Elevator doors are kept open longer than the pre-determined time, an override alarm shall sound/announcement to alert the passenger that the doors must close so that system performance is not adversely affected.

9.23.2. Next Landing

The car shall automatically proceed to the nearest floor with a functioning landing door if the car doors fail to open at the designated floor.

9.23.3. Door Load Detector

When an object is caught in or interferes with the opening or closing of the doors, the doors shall reverse direction when an excess load is detected.

9.23.4. Safety Door Edge

When a passenger meets the door safety edge when the doors are closing, the doors shall re-open.

9.23.5. Overload Holding Stop

When the carload exceeds the pre-determined weight, in addition to the overload buzzer with the announcement of overloading, the Elevator shall not operate, and the doors shall remain open. The load measuring device shall be proven product. The load measuring device should be of latest technology and of latest version. The complete technical features of devices that can be used for sensing the overload in the car should be most reliable and defined. The approval for the same shall be obtained from the Employer.

9.23.6. Electronic Door Safety

When passengers are boarding or exiting the car as the doors are closing, the doors shall re-open before touching the passengers.

9.23.7. Homing Service

This function shall automatically home the respective Elevators to the pre-assigned floors. After transporting passengers to the assigned floor, the Elevator shall automatically home to its pre-assigned floor.

9.23.8. Up/Down Selective Collective Automatic Operation & Auto call registration

The Elevator shall automatically respond to the call, when for 2 floor type elevators the hall calls are registered. The elevator shall respond to the call when for more than 2 floor elevators hall calls and car calls are registered.
It shall respond to all registered hall calls and car calls in the direction of service. When no call is registered then after a pre-set adjustable period Elevator car shall come to designated floor and open the door for 30 seconds (adjustable time) and then park the car there with closed door.
Emergency Access Doors: The Elevator contractor shall furnish and install emergency elevator shaft access doors for elevators serving consecutive floors more than 11 m height. The doors shall be properly fire rated and electro - interlocked as per Code to prevent the movement of elevator in case of access door being opened. It shall be of the same finish as the main landing doors. The emergency access doors shall be operable automatically in case of emergency operations like ARD operation, Fire, Seismic conditions etc. Adequate provisions for reaching the respective floors through Car and opening the doors automatically shall be provided. The push buttons or any other measures required for this emergency operation may be placed in a service cabinet in the COP and become active only in case of emergency conditions.

9.24. Operating and Safety Devices

9.24.1.

Each Elevator shall be provided with an overload device of accepted design, which shall operate when the load in the car exceeds the rated load. When activated, this device shall prevent any movement of the Elevator car and shall cause a warning buzzer on the car to be set off and illuminate an "Overload" signal. This device shall be incorporated in the car-operating panel.

9.24.2.

The water sensors in the Elevator pits shall be provided wherever pits are on the ground level or below the ground level. The requirement of water sump in the Elevator pits for such Elevators shall be coordinated with the civil contractor.

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9.24.3.

An inspection control panel shall be fitted on the top of the Elevator car for maintenance purpose. The design of the inspection control panel shall comply with the following requirements and prevent the Elevator car from being operated accidentally:

a) It shall not be possible to control the Elevator car from any other position after the NORMAL/TEST change-over switch has been set to the TEST position. When in the TEST position, the UP and DOWN continuous pressure push buttons within this panel shall become operative.

b) An ON/OFF switch shall be provided which shall render the Elevator inoperative in any mode, when the switch is kept in the „OFF" position.

c) The Elevator car shall only move when all safety devices are in the safe position.

d) The Elevator car shall move in either direction only on continuous pressure of the appropriate direction button at a car speed not exceeding 0.25m/s.

e) The control panel shall incorporate an adequately protected permanently located light fixture with a separate switch and a 15A switch socket outlet.

f) A door operator ON/OFF switch shall be provided. The door operator shall only be operative when the switch is at the "ON" position.

g) Associated with this control, a terminal stop limit switch shall be provided to stop the car from travelling in an upward direction not less than 1.8m from the soffit of the Elevator shaft. When this switch is activated, it shall not stop the car from operating in the down direction.

h) There shall be provision of LED lights inside the shaft & in undercroft of car base which can be controlled from the top landing & from pit it should have an intensity of 200 lux at floor level.

i) All switches and buttons on the inspection control station shall be clearly engraved / marked with their functions. All buttons and switches shall be shrouded against accidental operation, except for the emergency stop button.

9.24.4.

The Elevator shall be provided with a floor-levelling device, which shall automatically bring the Elevator car to stop within ±5 mm of the level of the floor for which a stop has been initiated regardless of the load or direction of travel. In case of ARD mode the car should stop within ± 10mm of the level of floor, this is subject to the Engineer's acceptance at the design stage.

9.24.5.

An automatic re-levelling device shall be provided which returns the Elevator to the floor automatically should the Elevator creep down or move up from floor level due to rope stretch for any distance more than 15 mm. This device shall be operative at all floors served whether the landing and car doors are opened or closed.

9.24.6.

Each Elevator car shall be provided with Progressive type safety gear mounted on the lower member of the car frame structure. This safety gear shall be capable of operating only in the downward direction and capable of stopping the car with full load at the tripping speed of the over speed governor, by gripping the guides and holding the car stationary. The motor circuit shall be opened by a switch on the safety gear before, or at the same time the safety gear is applied. It shall be possible to release the safety gear by raising the Elevator car without the use of any special tools.

9.24.7.

A mechanical device and electrical device shall be provided to prevent the car movement resulting from maintenance / inspection that can be dangerous to persons carrying out maintenance / inspection works from inside the car or car roof.

9.24.8.

An over speed governor shall be provided, which can activate the safety gear in the event of the Elevator exceeding the rated speed by 40%. The tripping of the over-speed governor for the safety gear shall occur when the car speed exceeds 140% the rated speed downwards. A mechanically operated safety switch shall be provided to disconnect the power supply to the motor when the governor is activated. The governor shall be adjusted to operate the safety gear in accordance with the recommended limits set out in IS 14665. The governor rope shall be of steel and shall comply IS: 14665.

9.24.9.

An over speed governor shall be provided to the Counterweight in case of Hanging pit. Contractor is required to interface with the designated Contractor for the requirement of hanging pits.

9.24.10.

A phase protection device and 3 phase as well as single phase earth leakage protection device shall be provided in the main control cubicle of each Elevator to prevent the Elevator car from moving in the event that there is a phase failure, or the phase of the power supply being reversed due to any reason whatsoever. These devices, when activated, shall cause a visual indicator to illuminate on the main control cubicle, until the fault has been rectified.

9.24.11.

As in the case of Power failure (including single phasing / unbalanced phase) Elevator should operate in the Automatic Rescue Device (ARD) and BDT or Electronic Rescue Tool (ERT) mode. The software for providing this feature is subject to the Employer's acceptance.

9.24.12.

Two switches shall be provided in the Elevator shaft, one at bottom landing and other in the pit which, when in the "STOP" position, shall prevent any movement of the Elevator car, including inspection/test operation, until both the switches are set to the "RUN" position. The switching positions shall be prominently labelled. The knob of these switches shall be having luminous paint.

9.25. Electrical Requirements

9.25.1.

Each Elevator shall be provided with a main control cubicle to accommodate all electrical switchgear. A caution notices with the wording "Danger-415V/240V A.C. Do Not Remove Cover Unless Incoming Supply is Switched Off" shall be affixed to the cover/door. The size and shape of the main control cubicle shall be same as that of Maintenance Access Panel (MAP).

9.25.2.

The Elevators shall be designed to operate on a 415V (-±10%) AC, 3 phase, 4 wire, 240V±10% a.c. 50Hz single phase, power supply. Power supply armoured cables up to Elevator's main control cubicle, and routing done up to the entry point in the elevator's shaft shall be supplied by the Designated Electrical Contractors. The Contractor shall coordinate with the respective Contractors to incorporate their requirements. Main switch/MCB Box with ELCB etc. should be as per Employer approved vendors. The shaft CFL lighting (200 lux as per IS 15785), ventilation arrangement and pit socket outlets shall be provided by the elevator contractor. The fixtures and cables will be get approved by the Employer.

9.25.3.

There should be provision of light on the top edge of the elevator door on all landings ensure proper illumination and their identification. The light should be LED type.

9.25.4.

All switchgear and other auxiliary apparatus shall be of accepted design and labelled for identification.

9.25.5.

The control wiring shall be laid out neatly and clearly in cable sleeves and all terminals and cables shall be properly sealed, labelled or marked or tagged for identification.

9.25.6.

All casing, covers, trunking and armouring shall be thoroughly and efficiently earthed and adequate protection shall be provided to prevent fuses and circuit breakers from arcing to earth or between phases.

9.25.7.

Maintenance Access Panel (MAP) should preferably be located at top landing level. Maintenance Access Panel (MAP) & Shaft Electrification Panel (SEP) shall be IP 54, pilfer proof. MAP shall have data downloading facilities for fault diagnostic through RS-485 port and USB port. Fault data logging in MAP should have date & time stamping facilities of 500 events. There should be provision of resettable type counter for the recording no. of the operation of the elevators.

9.25.8.

The design of the contactors and relay contacts shall be such that the break and make contacts shall not be closed at the same time at any position of the armature. The operating conditions shall be as follows:

a) If, one of the break contacts (i.e. normally closed) is closed, all the make contacts are open.
b) If, one of the make contacts (i.e. normally open) is closed, all the break contacts are open.
c) The layout of cards in SEP should be maintenance friendly so that they are easily accessible to the maintainer. This would be evaluated during detailed design.

9.25.9.

In the control and safety circuits, the operating voltage of the mean value in the case of the case of direct current or the r.m.s. value in the case of alternating current, between conductors or between conductor and earth shall not exceed 250V.

9.25.10.

There shall be provision of surge protection, power filters and other necessary equipment to avoid failure or elevator equipment on account of quality of power.

9.25.11.

In the event of failure of the normal electrical supply, the supply to the alarm cum intercom system, emergency car lighting, and the ventilation fan shall be automatically switched to an emergency battery operated power supply (UPS) of E&M system. The elevator contractor shall do the necessary interface with designated contractor for UPS Supply from UPS room to respective Elevator isolator panel. All hoist-way and car top safety switches shall be rated to IP Class 54 (minimum).

9.25.12.

All wiring and apparatus shall be subject to acceptance and suitable for the specified electrical supply. The insulation of all wiring including those within the controller shall be of FRLS for elevated stations complying with the special cable requirement of this specification.

9.25.13.

All field wiring shall be multi-strand copper conductor type. No joints shall be permitted in any cables or wires in any location.

9.25.14.

All Elevator wiring shall be run in galvanized conduit or steel trunking. All conduit outlets shall be bushed with insulating bushes of accepted pattern. All wiring connections to switches and conduits shall be watertight.

9.25.15.

The arrangements of terminals at either end of flexible trailing cables shall be identical or the terminal blocks marked to identify the cables connected to them. The cable boxes and wiring for the car light and the alarm bell shall be entirely independent of the Elevator control wiring. Flexible trailing cables shall be securely clamped at each end so that the weight is not supported by any fixing of the various cores. The outer sheath of these cables shall be of waterproof and flame-retardant material. A total of 10 or 10% of the total number of wires used whichever is more and 2 spare shielded cables shall be provided per Elevator. The outer sheath of these cables shall be waterproof and flame resistance material which shall not emit toxic fume when affected by fire, i.e. FRLS type cables and conductors for Elevated & at-Grade stations shall be used.

9.25.16.

The compatibility of MCB and ELCB used for Elevators shall be verified with the requirement of the Elevators. The MCB & ELCB are in the scope of Elevator Contractor. Termination of main incoming armoured cable on the MCB/ ELCB shall also be responsibility of the elevator contractor.

9.25.17.

Regarding harmonics generation in VVVF system
OEM shall design the VVVF system in such a manner that generation of harmonics is minimal, OEM shall also provide suitable harmonics filters to eliminate harmonics. Ceiling limits for "total harmonic distribution" (THD) shall be as per IEEE 519-1992.

9.26. Provisions of Monitoring Through BMS (Building Management System)

The Contractor shall develop the design for the RMS based on this specification and on proven and reliable Engineering Practices. The design details shall be submitted with technical data to the Engineer for review and approval.
The System, including all Sub-systems and Equipment shall be of proven design. The RMS proposed by the Contractor shall have been in use at major infrastructure projects like Metros, Airports, Railways, etc. with established performance reliability.

The Contractor shall design, supply, install and commission an interactive Remote Monitoring System (RMS) integrated with the BMS and capable of control, monitoring and managing all the operational functions of the equipment, without any additional cost implication to the Employer. The PC based Remote Monitoring Systems (RMS) shall be integrated to be run on the computer of BMS system in the Station Control Room provided by the designated BMS / dedicated Contractor.

Fault data logging should have Date & Time stamping facility. The date and time shall be synchronized with the BMS clock at regular intervals.

The RMS / BMS shall provide continuous monitoring and controlling of the Elevators.

The following monitoring / control function shall be provided for RMS/BMS.

a) _Power On / Off / Power Failure status
b) Trip/fault indicator (Including type of fault) - For all type of faults
c) Safety circuit interruption & Location of tripped safety switch
d) Alarm for Elevator Car
e) Current Operation mode status: Auto / Maintenance / Attendant / Fireman / Overload / full load – bypass / seismic operation/ Fire operation / ARD operation.
f) Digital car position and direction indicator
g) Parking Indication and control
h) RMS Mode / Local mode
i) Down time log.
j) Emergency Stop operation status.
k) VFD drive healthy.
l) Elevator cabin location (graphical) and movements.
m) Door - operation, Open / close status.
n) ARD Battery health status.
o) Some of these interactive controls may include, but are not limited to, entering car and hall calls, Fire Signal for Fire operation, lobby recall, VIP service, Maintenance mode, etc.

The trip signal shall be activated whenever the Elevator is stopped by any fault or emergency stop button during operation. The signal shall be latched on until it is manually re-set or remotely via the RMS. The Elevator shall only be re-started after the "trip" is cleared and the 'trip" signal has been re-set. Re-starting of Elevators shall also be allowed for those fault signals activated by safety devices without the necessities of maintenance personnel to carry out inspection and the safety device is automatically re-set. Detail proposal shall be submitted by the Contractor for review without objection by the Engineer prior to manufacture.

Monitoring Display: Each unit shown on the plan view, shall be individually displayed and shall be visible on the remote monitoring system display terminal without the need to scroll. Each individual unit, when operating "normally," shall be displayed in green. In the event of a malfunction of any individual unit, the unit shall be displayed by a red blinking light on the monitoring system display. Units which are intentionally placed out of service shall be shown as yellow in the display unit. When malfunctioning units, or units intentionally placed out of service, are returned to normal operation the graphical representation for that unit(s) shall automatically return to green. The user shall have the ability to display additional information, such as the cause of fault/alarm, for all units by selecting the unit with a "mouse click" from the plan view of the facility.

The Contractor shall integrate display requirements of different functions of all Elevators into single software so that it can be further easily integrated with BMS software. The Contractor shall develop Graphic User Interface and utility program, icon to operate independently in single and multiscreen mode to integrate with BMS. The screen graphics in respect of choice of size of icons / fonts / diagrams / animation, system of display and background shall be furnished for the approval of the Engineer. The Contractor shall interface with BMS contractor for integration of RMS system with Building Management System.

The BMS PC shall be provided by the Designated Contractor. The Contractor shall coordinate and interface with the Designated Contractor in respect of all matters relating to Remote monitoring and control of Elevators regarding cables, cable trays, LAN ports, power requirements, etc.

The Elevator contractor shall coordinate with the BMS contractor to ensure that all BMS control functions specified shall be executable from the BMS to the specified performance standards, and all monitoring functions shall be able to be displayed to the specified performance standards.

The control functions of the elevator shall only be possible with proper authorization like passwords, etc. before execution of the command.

The controller shall transmit the appropriate message to the BMS within 0.5 s of the change of state of any point monitored by the BMS.

The controller shall execute any command received from the BMS within 0.5s of the command message arriving at the controller, unless an internal automatic control function currently has a defined priority over that command.

The elevator fault/trip signal shall be activated whenever there is a fault in the elevator system, which causes a breakdown. The signal shall be latched on for at least 10 seconds. It shall only be reset after the fault is cleared. The Audio Visual shall be available in the RMS / BMS, with the approval of Engineer.

The alarm signal shall be activated with POP UP and an audio repeated beep till it is reset whenever the alarm inside the elevator car is pressed.

A by-pass switch shall be provided with illuminated indication in the controller for maintenance purpose, which shall de-activate the fault/trip signal to RMS upon switching "ON" and give a "under maintenance" signal to RMS in SCR. The switch shall be labelled in Hindi, Marathi and English subject to approval by the Engineer.

Upon actuation by remote switch from the RMS / BMS for parking on, the elevator shall complete the last landing or car call, if any, and return to the designated landing and stop there with doors of both car and landing open for 15-20 seconds before closing them. The "Not in service" indicator shall be illuminated on the landing indicator automatically for a pre-determined time and then extinguished. The car light and ventilation fan shall be switched off automatically at the same time. The essential buttons e.g. door open, intercom and alarm bell etc. on the car operating panels shall remain functional and illuminated when the elevators have been parked and locked out.

Upon actuation by remote switch from the RMS / BMS for non-parking, the elevator shall be switched back to normal operation and both the car light and ventilation fan shall be switched 'ON' automatically.

The Contractor shall interface with the BMS contractor for integration of RMS system with Building Management System. The Contractor shall also coordinate with BMS contractor to have monitoring of Elevators from OCC.

All the alarm signals generated by the elevator system shall generate an alert POP UP / Alarm screen on the BMS.

Further, the Contractor will have an option to match the protocol of the Software for RMS with that provided by the BMS contractor OR to supply exclusive computer with Software for RMS with a common link to BMS hardware/ software. The hardware configuration shall be subject to approval by the Engineer.

The Contractor shall provide an Ethernet or serial data link for BMS e.g. RS485. The physical characteristics and data transmission protocol proposed shall conform to an internationally recognized publicly available standard like MODBUS, TCPIP. The Contractor shall also provide serial data link of each Elevator, terminated in the interface terminal board (ITB) located in the Station Control Room or Electrical switch room for connection to BMS.

The Elevator contractor shall provide RMS cabling from the Elevator controller to his RMS PC placed in Control Room. The Elevator contractor shall also provide cables from his RMS PC to the BMS PC. Screened cables shall be used for the connection for the data communication.

The cables shall be run in a metallic conduit in the Elevator shaft and thereafter in the cable tray / conduit. The supply, laying and fixing of metallic conduit / cable trays from Elevator control panels to Control Room.

The Elevator Contractor shall coordinate and interface with the designated BMS System Contractor and/or his sub-contractor in respect of conduits / cable-tray sizes, layout, routing and other requirements.

The length of data Cable for RMS from Elevator control Panel to RMS ITB shall be as per the site conditions, for which no adjustment (increase / decrease) in payments shall be applicable. The contractor shall also take corrective measures to overcome the adverse effect if any due to length restriction of connecting cable without any extra cost.

9.27. Special Emergency Operations for Elevators

9.27.1.

The Elevator operation system shall be designed to provide the following emergency operation. The Contractor shall provide the ITBs with terminals for the Designated Contractor to terminate the fire and power failure signals. The Contractor shall provide the cabling up to the ITB.

9.27.2. Emergency Operation of Elevators in the Event of Power Failure

In the event of power failure or power interruption or single phasing (or any problem in the power supply which affect the normal operation of the Elevators), the supply to all Elevators shall be automatically switched over to the emergency power supply. To Automatic Rescue Device (ARD) and the Elevators shall be brought to the designated floor and shall park there with the doors remaining open. In case Power supply to the Elevator is restored through DG set/ Alternate source before the Elevator reaches designated floor even then Emergency Rescue Device will complete its function and shall open the Elevator doors at the designated floor to evacuate the passengers. Thereafter, Elevator designated by the authorized person may resume operation depending on the capacity of emergency power.

9.27.3. Emergency Operation of Elevators in the Event of Fire

In the event of fire when any fire detection devices are activated, all Elevators shall automatically be brought to the designated floor (Ground Floor) and shall park there with the doors open for 15-20 seconds and then close. All Elevators shall automatically be rendered inoperative after it has been brought to the designated floor. The essential buttons such as "Door Open", intercom and alarm bell etc. on the car operating panels shall be remained functional and illuminated. Normal operation of the Elevators shall be manually reset by the operation of a reset key switch.

9.27.4. Emergency Operation of Elevators in the Event of Power Failure and Fire

In the event of power failure and fire, the operation of the Elevators shall be in accordance with the "Emergency Operation of Elevators in the Event of fire" and the power supply shall be from the emergency supply panel at the stations.

9.27.5. Automatic / Emergency Rescue

A battery back-up device to home the Elevators to the landing in the event of power failure shall be provided. This shall be battery operated and shall be able to move the Elevators with any load from no load to full load at reduced speed to the nearest landing and shall open the doors , which shall be achieved by provision of ARD and BOT or ERT. Thereafter, the Elevators door shall remain close until resumption of power supply and the Elevators shall automatically reset to normal. The direction of travel shall depend upon the load in the Elevator which shall be provided by defining different loading condition such as more than 50%/ less than 50%/ at 50%. During this operation all safety features of the Elevator shall remain operational. The rescue time of the device from the time of power failure to the time the doors fully open shall not exceed two minutes. However, the Emergency Rescue Device start time can be adjusted from 0 to 30 sec depending upon resumption of emergency supply from alternative source/ DG sets. The requirement of Emergency Rescue Device/ARD will be finalized during the design stage depending upon availability of power from DG set. The landing accuracy shall be less than ± 10.0 mm. The capacity of the battery when fully charged shall be capable of operating the Elevator at rated load from one landing to another for a minimum of 3 trips without further charging. To ensure this, the same battery should be capable to perform the test for 6 trips without intermediate charging at the time commissioning. The battery shall be housed in a cabinet/ rack with a corrosion proof finish. The device shall immediately stop the Elevator and prevent further movement immediately, if there is a short circuit or open circuit in the inverter output. The rating of the battery must get the notice of no objection by the Employer/Employers representative during the design stage. The power supply indication in MCB/ARD shall be of

red colour to properly distinguish it from other power supplies in MCB's. Over and above the ARD system, a manual lever and push button shall be provided for manual rescuing.

This device shall not modify the Elevator design and all its original safety features. The device shall be an additional accessory to the Elevator and shall not in any way affect the performance of the Elevator.

The performance of the charger and charging rate shall be equivalent to that of the UPS unit. Maintenance free batteries conforming to the relevant Indian or international standard shall be provided. There shall be no tripping of UPS during the working of Rescue Device. The specification of UPS shall be with notice of no objection of employer.

9.28. Elevator Monitoring and Fault diagnostic system

A comprehensive Elevator monitoring and fault diagnostic system shall be provided for each Elevator by the Elevator Contractor. This system shall provide an auxiliary output port on the controller for plugging the laptop and downloading historical data. Other features of Fault diagnostic system will be reviewed at design stage.

9.29. Pit Facilities

Spring buffers/ PU buffer shall be provided in the Elevator pit.
A safety switch to prevent the car from moving when the governor rope tension weight is out of position shall be provided.
Fixed cat ladders shall be provided between the bottom landing and the pit floor by the Contractor.
Two stop switches, one at bottom landing level in the shaft and the other in the pit shall be provided, which, when in the "STOP" position, shall prevent any movement of the Elevator car including movement during inspection operation, until both the switches are set in the "RUN" position. The switch shall have a mushroom head (red). It shall be locked off when pushed and reset manually.
First stop switch shall be accessible from the lower landing on opening of the landing door and the second switch from the pit floor. A stainless-steel faceplate of not less than 2mm in thickness, indelibly marked "Pit Stop Switch" in both English and Hindi characters and with legends to show the "STOP" and "RUN" positions shall be provided and fixed immediately adjacent to the switch. The knob of these switches or plate shall have luminous paint.
The contractor shall do all necessary interfacing for ensuring proper drainage system. Designated Civil Contractor shall provide drainage. But, to ensure proper drainage of Elevator Shaft / Roof shall be the elevator contractor responsibility before starting the installation.

9.30. Corrosion Protection

The Contractor shall take into consideration, the corrosive effect of the atmosphere in the Elevator design.
All steel components shall be hot dipped galvanized in accordance with BS 729, with minimum thickness of 85µm.
All mechanical and cast-iron assemblies shall be cleaned and painted. The running surfaces of car guides shall be treated with an accepted rust preventive compound.
All parts constructed in sheet steel shall be either galvanized by the hot dipped process or fabricated from hot dipped galvanized sheet steel.
All hardware, fastenings, screws and shims shall be hot-dipped galvanized. However, all visible screws and fastenings shall be of stainless steel. Epoxy painting will be permitted only on-site damage repairs.
Wherever galvanization on ferrous components has been damaged in handling the same shall be given two coats of zinc chromate primer and two coats of aluminum paints conforming to IS 2339.

9.31. Provision for the Disabled and Handicapped

All Elevators shall be provided with following features:

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a) Elevator control buttons at locations and height specified in IS 15330.

b) Hall-call buttons at locations and height specified in IS 15330.

c) Handrails, straight through type having minimum 3 supports, shall be provided on the side walls of the Elevator at height & locations specified in IS: 15330. An international symbol of access of the disabled shall be permanently and conspicuously displayed at each Elevator landing next to the Elevator entrance. The signage is to be made part of the Architrave work. Braille notations indicating the floor levels shall be integrated in each button at the handicap COP and handicap hall call buttons.

d) A digital voice system for announcing the car position, opening/closing of doors, direction of travel and messages shall be provided as per IS: 15330.

e) A laminated framed safety mirror of at least half of the size shall be installed on rear panel of both glass and stainless-steel car door type elevators at appropriate position. To facilitate easy reversal / exit of person on wheelchair from the Elevator without the need of rotating the wheelchair in the Elevator.

9.32. Earthing

All the Elevators shall be provided with earthing arrangements as per:

- IS- 1860; latest version
- IS-3043; latest version
- Indian Electricity Rules; latest version
- IS-14665; latest version.

9.33. Special Cable Requirements

All cables used except those within the enclosed controller shall comply with the following requirement:
All Control and power cables shall be rated for minimum grade of 650 V and all power cables for minimum 1.1 kV grade.
The conductor shall be of stranded conductor composed of plain annealed copper wire complying with IEC 228, Class 2.
The insulation shall consist of an extruded layer of cross-linked polyethylene complying with IEC 502.
All cables shall be manufactured from fire retardant, low smoke, halogen free materials for Elevators.
Fire retardant, low smoke, halogen free materials shall meet the following requirements:

a) London Transport Executive Three Metre Cube Smoke Emission Test, using optical measuring instruments. The maximum value of absorbance AO (ON), AO (OFF) shall be 0.8 & 1.2 respectively.

b) The US National Bureau of Standard Smoke Chamber Test used to evaluate plaque samples of materials of constant thickness. (NFPA-258 Smoke Generation of Solid Materials 1982). The maximum specific optical density shall be 170 under the non-piloted condition.

c) The flame propagating criteria of US IEEE Standard 383, with a minimum test short circuit time of five minutes, in the IEEE Standard 383 test.

d) IEC 332 Parts 1 and 3, Category B, tests on single and bunched cables under fire conditions.

e) Limiting Oxygen Index of at least 30, to ASTM D-2863.

f) A temperature index (TI) of 260°C to ASTM D-2863.

g) All insulation is to be moisture and heat resistant, with temperature ratings appropriate to the application conditions, and in no case lower than 90°C.

h) When a sample of the cable is subjected to a combustion test for the determination of the amount of halogen acid gases (other than hydrofluoric acid) as set out in IEC 754 -Part 1 the halogen acid evolved shall not exceed a maximum of 0.5%.

Fire retardant materials shall meet the requirements of item (c), (d), (e), (f) and (g) only.

9.33.1.

The above requirements shall be met without compromising the anti-termite, pest-resistant, mechanical and electrical properties of the cables both during and after installation to meet the other requirements of this Specification.

9.34. Noise Generation

The whole of the elevator assembly, including the opening and closing of the car and landing doors shall be quiet in operation and shall be free of rattling or squeaking noises. Elevator door operation shall be smooth to avoid the transmission of impact noise to the surrounding structure. Noise levels resulting from the operation of the elevator, including direct sound transmission breakout noise and re-radiation of structure borne noise shall not exceed 55 dB(A) (fast response) at 1.5 m from the elevator shaft and 1.5 m above the floor;-.
Machinery noise level under normal operating conditions shall not exceed 70 dB (A) at 1 m from the equipment in free field.
The total noise level in a moving elevator car shall not exceed 55 dB (A) with ventilation fan operating.

9.35. Ride Comfort Parameters:-

Apart from noise, lateral quaking, acceleration jerk and vertical vibration are the other parameter based on which 'Ride Comfort' and its quality is measured. These parameters are defined below (definition as per ISO 18 738):-

- Lateral Quaking " A sideways acceleration/ deceleration measured in gal.
- Acceleration/deceleration
- Jerk

The contractor shall submit the "Ride Comfort Report" whose acceptance shall be subject to the Engineer's approval.

9.36. DESIGN SERVICES : DESIGN REQUIREMENTS

The Contractor shall perform all design functions necessary for the development, manufacture, installation and site testing of Elevators as described in this Specification.

The design of each component shall achieve the minimum service life given below. The failure rate of the components shall not exceed 5%. Failure rate is defined as the number of failures (during the service life) divided by the total quantity of the components in one section.

Elevators	Service life (years)
Safety gear rope	8

Governor	20
Anti-Creep device	20
Hoisting chain/hoisting rope	8
Contractors/relays	10
Traction machine/motor	20

The Service life of each equipment shall be specified by the firm in the design submission.

9.36.1.

The Contractor shall prepare and submit drawings, which clearly illustrate details of equipment down to sub-assembly and component level, equipment locations and configurations. Drawings shall indicate plan views, elevations, sections, charts, tables, schematics and diagrams with legends, dimensions, part numbers, tolerances, setting clearances, materials, etc., as required to cover the facilities being provided under the Contract. Drawings shall also be prepared showing circuit wiring for each of the systems included in the Contract.

9.36.2.

The Contractor shall prepare and submit specifications to provide a clear description of the functional requirements such as, loading, materials, clearances, tolerances, of all equipment and its components planned for use in the Contract. The specifications shall indicate acceptable levels of performance, the expected normal life span, and the mean time between failures (MTBF) for the equipment, materials and workmanship, with due consideration given to the service and environment to which such equipment will be subjected. The Contractor shall identify, by manufacturer and model or part number, each component, which he plans to install under the Contract.

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9.36.3.

The Contractor shall submit the design calculations for the following, to demonstrate how the operational requirements are achieved.

Structural loading to pit and shaft wall.
Heat dissipation value for the Elevator.
Power requirements and efficiency of motor/machine.
Any other information necessary or asked by the Employer.

9.36.4.

The Contractor shall prepare and submit a Quality Assurance program me in accordance with requirements contained in the Specification.

9.36.5.

The Contractor shall submit all applicable data, criteria, standards, directives and information used as a basis for the design of the Elevators.

9.36.6.

The Contractor shall submit catalogues and/or samples for all parts and components used in this Contract as per Employer's Requirement.

9.36.7.

The Contractor shall prepare equipment layout plans and other documents necessary to facilitate the design interface co-ordination with Designated Contractors.

9.37. CO-ORDINATION WITH DESIGNATED CONTRACTORS

The Contractor shall co-ordinate with the Designated Contractors, shall finalize and agree with the Designated Contractors all relevant matters relating to the equipment including but not limited to the following:

a) Space requirements, including tolerances for construction of the civil works.
b) fixing requirements
c) loading
d) interface with architectural finishes
e) Cabling routes, termination details including providing information to the Designated Contractors.
f) Information on embedded parts, box-outs, etc. to enable the Designated Contractors to provide the necessary works.
g) Equipment access route and temporary/permanent Elevating requirements.
h) lighting requirements
i) power requirements
j) ventilation requirements
k) fire protection

l) drainage requirements

9.38. INSTALLATION

The Contractor shall be responsible for the timely and proper setting out of the Works which shall include verifying the positions, levels, dimensions and alignment of Elevator pits, supports, shaft, walls and floor openings, etc. Any error in the civil construction in so far as they relate to the Works shall be immediately brought to the attention of the "Engineer/Engineer's Representative" and the Designated Contractor to allow prompt rectification by the Designated Contractor to avoid delays to the Works. The Contractor shall not be entitled to claim for any additional costs incurred by him arising out of such errors in the civil construction, if such additional costs could reasonably have been avoided had the Contractor carried out timely and proper setting out of the Works.
The Contractor shall ensure that levelling of all landing equipment shall be within ± 1.0mm. The vertical alignment of all door jambs, doors etc. shall be truly plumb to within ± 1.0 mm.
Guide rail shall not be skewed. The distance between guide rails shall be within ± 0.5 mm. Guide rail joints shall be smooth to within 0.1 mm. It shall be erected plumb within ± 1.0 mm.
The Contractor shall provide protection, such as plywood box-up etc., to protect the door, the jamb, decking, from being damaged until the work is handed over at no additional cost. Any damages to the equipment will be the sole responsibility of Contractor and the firm shall replace the damaged part without any extra cost. The equipment will be inspected and tested at the time of taking over of the equipment.
All Elevator landing door gaps shall be less than 4 mm.
The Contractor shall be responsible for the installation of all guide rail brackets, separator, sill supports, hanger brackets including drilling and all related materials. The contractor shall verify and satisfy themselves in respect to the loading capability of the shaft wall holding the bracket etc. If the Contractor feels that load test is necessary / required, then he can arrange the same in co-ordination with civil contractor.
Electrification Panel of elevator shall be fully protected against the ingress of grit, dust and moisture and maintenance friendly enclosure.
All equipment shall be fully protected against the ingress of grit, dust and moisture during delivery, storage and installation.
The equipment shall be delivered at Site in accordance with an accepted installation program me with a minimum temporary storage period to avoid damage.
Access into the station will be either by train or by road depending on site environment and constraints.

The Contractor shall design the equipment to comply with the Site access restrictions and shall ensure that the largest piece of equipment can be brought into the site. Method Statement of Installation shall be submitted for Employer/Employers representative for notice of no objection at least 30 days prior to commencement of the installation. As part of the preliminary design submission the Contractor shall submit to the "Engineer/Engineer's Representative" for notice of no objection a General Method of statement for Installation However, Contractor will submit schedule of tests giving full details of all tests to be carried out.

Once the Elevator shaft is handed over to the contractor to commence installation, he shall be responsible for providing fencing and barricades to protect his working areas during the installation period for the safety of his workers and other personnel working in the buildings until taking over of the Elevators by the Engineer / Employer.

9.39. TESTING AND INSPECTION

9.39.1. General

Tests at places of manufacture to be witnessed by the "Engineer/Engineer's Representative". The Contractor shall submit to the "Engineer/Engineer's Representative" an original and four copies of all Test Reports. All test data shall be certified by the Contractor's Professional Engineer.

The Contractor shall perform all applicable test specified in as per the relevant standards. Any test required as per the applicable safety standards but not specified in this specification shall be performed without any extra cost to Employer.

9.39.2. General Requirements for Type Tests and Acceptance Tests

The Tenderer shall provide details of any type and acceptance tests, which have been carried out on equipment offered, or any additional tests he recommends.

In general, certificates of previous type tests may be accepted at the discretion of the "Engineer/Engineer's Representative", if they are for identical equipment and conditions. Where appropriate, new and /or modified components to meet the requirements of this Specification shall be made available for type testing.

All applicable Type tests as per the relevant standards on equipment shall be carried out strictly as specified in the Specification and procedure of testing shall be submitted to "Engineer" for No Objection.

Type Test should not be older than 5 years

9.39.3. General Requirements for Tests during Manufacture

The Contractor shall carry out all applicable tests during manufacture as specified and propose any additional tests to be carried out as per relevant safety standards. These tests shall be subject to the notice of no objection of the "Engineer/Engineer's Representative". Routine tests shall be integrated with the manufacturing program me. The "Engineer/Engineer's Representative" will, at his discretion, witness the routine tests during the period of manufacture, or accept the records of the Contractor's in-house quality control scheme, where appropriate, as enough evidence for the execution of the routine tests.

On completion of the manufacture of items or sub-assemblies and following completion of the manufacturer's own tests and inspection, the "Engineer/Engineer's Representative" shall be invited to witness such tests as he deems appropriate. The Contractor shall schedule the routine tests to meet the manufacturing program me, whether or not the "Engineer/Engineer's Representative" will be present at the tests, provided advance notice has been served to the "Engineer/Engineer's Representative" in accordance with Clause 9.8 of Volume 3 - General Specification.

The "Engineer/Engineer's Representative" will determine and advise the Contractor of those tests where certification by the manufacturer may be acceptable in lieu of witnessed tests.

Before equipment is dispatched, the "Engineer/Engineer's Representative" will signify his acceptance by signing certificates releasing such equipment from the place of manufacture or test.

9.39.4. Test Specification

The Contractor shall submit for acceptance by the "Engineer/Engineer's Representative", test specifications for type tests, routine tests, tests on site, final acceptance tests and commissioning. The specifications shall detail the methods of conducting the tests, the tools and instruments used.

These test specifications shall include the design values of all quantities to be verified, with allowable tolerance or limits. Summary drawings or diagrams shall be included with the test specifications to show the dimensions and tolerances of all structural assemblies and sub-assemblies. In the case of welded fabrications, key diagrams giving all weld data shall be provided to enable systematic inspection to take place.
Verification of accuracy shall be required for all tools, apparatus, testing jigs, measuring instruments and "go" or "no go" gauges used for the purpose of routine tests.
All test instrument shall be calibrated not more than one year prior to their use. The Contractor shall submit calibration certificate or other documents for proof of Compliance.

9.39.5. Elevator Prototype Tests

One complete Elevator shall be available for the commencement of witness testing after Contract Award.
A complete Elevator system including traction drive system, in addition to the controller, Elevator car enclosure, landing and car doors, protection devices and call fixtures shall be assembled on a test rig or inside a test tower to undergo a comprehensive running and functional testing in accordance with the accepted test specification to verify compliance with the Specification.
The tests shall include the following minimum requirements.
Verification of the suitability of the traction drive system;
Verification of the car operation and response to call fixtures, door operation including the safety edges, all indications and signaling features, and car top control features;
Weight tests on safety gear and measurement of electrical readings and verification of the operating speed under various loading conditions; Verification of riding comfort and levelling accuracy under various load conditions. Verification of the fault indication and fault diagnosis features. Verification of the construction of the various control panels to the specification shall be done. Insulation resistance and high voltage tests shall be conducted in accordance with the test specification. Any additional testing as required by BS 5655 Part 10. A 12-hour duty cycle test, during which the Elevator shall run continuously with the contract load for 12 hours and shall travel up and down with intermediate stops such that the number of starts per hour as specified. Complete functional tests on the isolating transformer and ripple filter. Operation of the battery back-up device and the battery-operated power supply. Simulation of the emergency homing sequence during fire and power failure.

9.39.6. Elevator Site Checking and Inspection

A test and inspection specification shall be prepared for each of the following critical phases of work. Forty-eight hours' notice is required prior to completing these phases to enable the "Engineer/Engineer's Representative" to carry out any checks he deems necessary. The following are the minimum requirements:

a) Setting out the plumb lines;
b) Erection and alignment of guide rails; rail brackets
c) Erection and alignment of landing doors; jamb, sills, header etc.
d) Erection of Elevator shaft and Elevator pit equipment;
e) Erection of car enclosures;
f) Positioning of machine equipment and control cubicles;
g) Installation of the hoist ropes; and governor rope
h) Erection of landing fixtures and car fixtures;
i) Installation of hoist way and Head room trunking prior to installation of wiring;

j) Installation of wiring and cabling

k) Installation of car fixture and car top equipment

l) Earthing and bonding checks

9.40. COMMISSIONING AND ACCEPTANCE TESTS [SAT]

Tests shall be carried out on each Elevator in accordance with the relevant portions of BS 5655, which shall include but not be limited to the following:

(a) Readings on starting current, running current and supply voltage shall be taken at the rated speed of each Elevator in both directions of operation under no load, 20%, 40%, 60%, 80% and full load conditions.

(b) Both power and control wiring of the controller shall be tested between lines connected and earth at 1000V 50Hz. This voltage shall be applied and maintained for one minute. The control wiring shall be separately tested between poles and earth. Immediately following each test, a 1000 Vdc. Insulation tester shall show an insulation resistance of not less than 3 M ohms. All field wiring shall withstand a 1000 V megger test on site and each conductor shall show an insulation resistance to earth of not less than 3 M ohms.

(c) The over-speed governor shall be tested to ensure that it will activate when the speed exceeds 40% of the nominal speed. Functional tests on the safety gear with no load at rated speed by manually tripping the governor. The Elevator car shall be operated up and down several times including tests to demonstrate the levelling operation.

(d) Test on the car and landing doors system

(i) Checking of the condition of the landing and car door for smooth operation,

(ii) Functional tests on the door closing time, door speed, re-opening, safety edge, proximity detection landing and car door contacts of the door lock.

(e) Functional tests on all the landing call buttons, indicators and all function provided in key-switch operated cabinet mounted below the car operating panels.

(f) Functional tests on the emergency call buttons.

(g) Functional tests on the final limit switches, terminal slow down and terminal over travel limit switches.

(h) Functional tests on the following safety switches and devices

i. Overload device.

ii. Phase protection device.

iii. Anti-creep system.

iv. Emergency lowering and raising devices.

v. Pipe rupture device.

vi. Over current protection device.

vii. Counterweight safety (if applicable)

9.40.1. Remote Monitoring System

(a) Functional tests on the UPS unit and 2-hour duration test.

(b) Functional test on the car top maintenance panel.

(c) Testing of the Intercom system.

(d) Compress buffer test.

(e) Running clearance tests.

(f) Functioning test of Elevator management, monitoring and fault diagnostic system.

(g) Noise/ sound level test of equipment and installation.

(h) Functional tests of battery backup device.

(i) Complete function tests on track machine, motor brake and control equipment.

(j) Floor levelling accuracy and re-levelling at different loads.

(k) Tests on Emergency Power and Fire operation. Temperature readings of Elevator controller and equipment shall be taken every fifteen minutes for at least 2 hours or the duration of test whichever is longer.

(l) Functional tests of all features and functions not included in the above but required in the Contract.

9.40.2. Twelve Hour Run

Each Elevator shall be subject to a 12-hour duty cycle test, during which the Elevator shall run continuously with the contract load for 12 hours and shall travel up and down with intermediate stops such that the number of starts complied with the specification.

9.41. Certificate of Taking Over

The final acceptance tests of each item of equipment shall be undertaken in the presence of the "Engineer/Engineer's Representative", in accordance with the test specification. Any defects and/or deviations discovered without prior written notice of no objection during the tests shall be rectified at the Contractor's own expenses. These shall be entered a defects list agreed between the Contractor and the "Engineer/Engineer's Representative". The Certificate of Taking Over will not be issued until these tests have been completed and the defect list substantially reduced to such an extent that the "Engineer/Engineer's Representative" considers that the equipment is safe for operation.

9.42. Certification

Upon completion of each Elevator the Contractor shall submit to the Employer, a Certificate of Supervision issued by the Contractor's Professional Employer / Employer's Representative, in a format acceptable to the "Engineer / Employer's Representative".

CHAPTER – 10

10. OUTLINE FIRE ALARM & DETECTION SYSTEM SPECIFICATIONS – BUILDING & BRIDGE

10.1. Fire Alarm System

10.1.1. General

This section specifies the scope of design, manufacturing, supply, installation, testing commissioning of as intelligent addressable Fire Alarm and Detection System, in compliance with NBC, NFPA and Indian standards as a guiding standard and the system shall be design in an integrated manner for various buildings of MTHL Project.

The contractor shall develop design for intelligent addressable Fire Alarm and Detection System in the buildings and tunnel in compliance with Codes and Standards mentioned in the specification and in coordination with Maharashtra Fire Service requirement.

Scope of work

The Scope of work is to design, manufacturing, supply, installation, testing commissioning of as intelligent addressable Fire Alarm and Detection System in compliance with Codes and Standards mentioned in the specification and in accordance with Outline design criteria and international best practices for all the three Building and Tunnel etc. as require for satisfactory operations.

The intelligent addressable Fire Alarm and Detection System shall comprise of the following:

- Micro-processor based Main Fire Alarm Panel
- Repeater Panel
- Analogue addressable Multisensory Detector, smoke detectors, heat detectors
- Addressable manual call points
- Addressable Hooter cum strobe
- Batteries and charger
- Electrical wiring, conduits and accessories

The Addressable Main Alarm Panel will be 4 Loops but expandable up to 10 loops with a Loop capacity of the number of detector and devices per loop varies from 128 per loop, 99 Smoke Detectors,99 Devices and 159 Detectors and 159 Devices (As per IS-2189). The panel will be in the control room or respective building and will have LCD alpha numeric display. PC based Workstation is required for event log of Main Fire alarm Panel. The location shall be decided during detail design.

The fire alarm panel will have the capability to process and evaluate incoming signals from addressable devices such as smoke detectors, heat detectors, combined optical and heat detectors, manual call point and I/O modules via Fire Survival Cables confirming to BS 7846:2009, BS 6387 CWZ, BS 8434-2 as applicable. Fault isolators will be provided after every 20 devices. (Fire rating hours meet the requirement of circuit integrity test for min 3HR at 750 Drg.C as per IEC 60331.)

The Fire Alarm System will be provided with input modules for interface with flow switches and Output Module to Hooter cum strobe.

Codes and Standards

- BS 4683 / BS EN 60079: Electrical Apparatus for Explosive Atmospheres
- BS 5445 : Components of Automatic Fire Detection Systems
- BS 5839 : Fire Detection and Alarm Systems for Buildings
- BS 6387: Performance Requirements for Cables required to Maintain Circuit Integrity under Fire Conditions

- BS EN 54-1 : Fire Detection and Fire Alarm Systems
- BS EN 55104 : Electromagnetic Compatibility
- BS EN ISO 9000 : Quality Management and Quality Assurance Standards
- BS EN ISO 9001 : Quality Systems Model for Quality Assurance in Design, Development, Production, Installation and Servicing
- BS EN ISO 9002 : Quality Systems Model for Quality Assurance in Production, Installation and Servicing
- BS EN ISO 9003 : Quality Systems Model for Quality Assurance in Final Inspection and Test
- BS EN ISO 9004 : Quality Management and Quality Assurance Standards
- BS 7846 / BS EN 60702-2: – Code for Fire Survival Cables.
- IS 2189 : 2008 Selection, Installation and Maintenance of Automatic Fire Detection and alarm system – Code of practice
- NFPA 72 : 2010 National Fire Alarm Code
- Codes and regulations of the jurisdictional authorities
- UL Listed & FM approved

10.2. TECHNICAL AND FUNCTIONAL REQUIREMENTS

10.2.1. Control Panel

a) The automatic and manual Fire Alarm Control Panel (FACP) shall be multi-zone control panel of the intelligent analogue addressable type, complete with power supply, battery charger, batteries.

b) The main Fire Alarm Control Panel shall be located within the Control Room of building, with an interface to the Workstation for the Fire Detection & Suppression system. All the fire detectors, alarm devices and interfaces to other systems shall be connected via this panel.

c) The FACP shall be analogue addressable in a lockable housing with illuminated function keys and capable of full "stand-alone" operation.

d) The FACP shall be at least 4 loop control panel with loops expandable feature up to 10 loops for all buildings and of intelligent addressable type with a loop capacity of minimum 128 devices, complete with all alarm loop cards and input / output control interface, at least 600 character display or greater, easily operable with acknowledgement, reset and silence facility with 21 Inches LED monitor and appropriate with latest configuration printer with software. Intel core 17 Processor with 3.0 GHZ or higher, 4 GB RAM or above. 1 TB SATA HDD, Integrated Sound & Graphics Media Accelerator, optical scroll mouse, multimedia keyboard .52x CVO Read / Write, Dual LAN card, 2 Serial port, 1 parallel port. 4 USB Ports, all hardware driver as required for smooth operation, Windows 7/XP 32-bit Desktop preloaded operating system with standard MS Office package, & along with latest antivirus version with updated security pack and minimum 3-year product license validity. Auto recovery and auto archive software and suitable for operation on 230 volts A/C. 50 Hz. The panel should be compatible with SCADA/BMS system.

e) Detection devices shall be connected via loops with a maximum acceptable length of 1.2 to 2.0 km. The FACP shall have indicators for information, isolation (including device isolated), alarms and faults (including system fault, device fault, and external fault and processor fault).

f) Activation of manual call points or detectors shall be identified on the FACP identifying the loop number and detector address number including the associated Fire Alarm zone. This information shall be provided via a textual message on a separate screen integral to the FACP. Fire alarm panels shall be lockable with alarm/reset functions.

On/Off controls and alarm disable controls. A facility shall be provided to allow operating access to authorized person. This shall be via key or password access.

g) The FACP shall be self-checking and shall have the facility to identify faulty/ contaminated devices or system malfunction such that faulty status/condition shall not be confused with fire alarms. The loss or failure of any detector or alarm device shall be identified and displayed within 60 seconds.

h) FACP shall be equipped with monitoring/relay points to relay status and alarm messages to the SCADA system.

i) Relays points shall be provided for:
   - FAP healthy signal,
   - Fire alarm condition,
   - Fire zone of such alarm condition,
   - Fire condition link to PA automatic messaging,
   - Non-synchronizing clock.

j) These relay signals shall be connected to the building communications equipment.

k) The FACP should have degraded mode of operation in case of main CPU failure i.e. If communication is lost to the panel CPU, the system shall provide added survivability through the intelligent Loop Cards. Inputs from devices connected to the SLC and Loop Cards shall activate outputs on the same loop when the inputs and outputs have been set with point programming to participate in local mode or when the type codes are of the same type: that is, an input with a fire alarm type code shall activate an output with a fire alarm type code

l) The FACP, Graphical software & BMS integration card should be on true Peer to Peer Network technology & Data Regenerate at each node result in resulting in failure of one node doesn't affect other node

m) The FACP Central Processing Unit shall contain and execute all control-by-event (including Boolean functions including but not limited to AND, OR, NOT, ANYx, and CROSSZONE) programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory and shall not be lost with system primary and secondary power failure.

n) The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.

o) Sensitivity Adjust: The system shall provide Automatic Detector Sensitivity Adjust based on Occupancy schedules.

p) Environmental Drift Control: The system shall provide means for setting Environmental Drift Compensation by device. When a detector accumulates dust in the chamber and reaches an unacceptable level but still below the allowed limit, the control panel shall indicate a maintenance alert warning. When the detector accumulates dust in the chamber above the allowed limit, the control panel shall indicate a maintenance urgent warning.

q) One-Man Walk Test: The system shall provide both a basic and advanced walk test for testing the entire fire alarm system. The basic walk test shall allow a single operator to run audible tests on the panel. All logic equation automation shall be suspended during the test and while annunciators can be enabled for the test, all shall default to the disabled state. During an advanced walk test, field-supplied output point programming will react to input stimuli such as CBE and logic equations. When points are activated in advanced test mode, each initiating event shall latch the input. The advanced test shall be audible and shall be used for pulling station verification, magnet activated tests on input devices, input and output device and wiring operation/verification.

r) The control panel shall be housed in a UL-listed cabinet with key & lock suitable for surface or semi-flush mounting. The cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.

s) Two-way emergency telephone communication circuits shall be supervised for open and short circuit conditions.

t) Speaker circuits shall be arranged such that there is a minimum of one speaker circuit per smoke zone. Speaker circuits shall be electrically supervised for open and short circuit conditions. If a short circuit exists on a speaker circuit, it shall not be possible to activate that circuit.

u) The panel should communicate to all addressable field devices using 2 core 1.5 sqmm twisted pair cables. The SLC loop cabling should be only Class-A as per NFPA-72 2016 edition clause No. 12.3.1.

v) The SLC detectors can be changed without making the whole system offline & The panel firmware can be Upgraded without making whole System Offline.

w) The FACP shall interface with other systems including but not limited to:
   1) Sprinkler Systems. The system shall monitor water flow for wet standpipes etc. as required. The FACP shall receive signals from the sprinkler flow switches to identify activation,
   2) Gas Suppression System. The gas extinguishing control panel and monitor the release of gas. The FACP shall receive signals from the individual gas suppression system control to identify activation inert gas flooding system/panel flooding system.
   3) FACP shall also interface with Public address and voice alarm system, lifts, escalators, AFC gates, electrical rooms, fire pumps, SCADA/BMS system and all other systems as per requirement.

x) The response to alarms from various combinations of the detectors, flow switches, or manual call points shall, via the dedicated microprocessor, initiate performance of such other functions as required like:
   1) Alert staff,
   2) Alert Line controller,
   3) Initiate operation of Fire Suppression Equipment,
   4) On confirmation of Building Manager, initiate operation of Automatic Public Address System message,
   5) Release Smoke stop doors held open,
   6) Allow any emergency exit fastenings to open on transmission of the Evacuation signal,
   7) Initiate illumination of Station No Entry signs on transmission of the Evacuation signal (via control room),
   8) Initiate closure of Fire shutters,
   9) Initiate smoke extraction measures.

y) All detector and bell circuits shall be continuously monitored and a fault on any of these shall be indicated in the Main Fire Alarm Panel.

z) The FACP shall also control and monitor the flow switches for Fire sprinkler system and Gas suppression system.

aa) Each system shall provide at least 25 % spare capacity for future expansion as per UL 864 latest edition.

10.2.2. Battery **Charger and Batteries**

A 24 V DC trickle type battery charger and batteries shall be provided. The unit shall incorporate the following components: -

1) Trickle charger assembly.
2) Rotary type selector switch.
3) One incoming double pole control fuse holder with suitably rated fuse.
4) Sealed type Ni-Cd/SMF lead acid batteries
5) Rectifiers and DC output voltage stabilizer

The unit shall be suitable for use on a 240 V AC single phase power supply and shall

automatically maintain the 24 V DC batteries in a state approximate to full charge and at the same time to compensate for the standing load. The charger shall cater for re-charging the battery from fully-discharged condition to fully-charged condition in not more than 24 hours Batteries shall be of sealed Ni-Cd/SMF Laed Acid type requiring no maintenance throughout the normal life of the battery and shall be of capacity capable of maintaining the system in normal working condition for at least 24 hours without recharging and subsequently operating in the "alarm" condition continuously for at least one hour. 72 hours back up shall be provided to the indication lamp of the "sprinkler power loss". In selection of battery capacity, a deterioration factor of 0.9 minimum shall be applied. Monitoring integrality of battery charging equipment.

10.2.3. Manual Call Point

a) Manual call point shall comply with BS 5539: Part 2 or NFPA 72. The MCP shall be pull lever type instead of break glass panel push button type MCP. They shall be addressable type and shall be arranged to operate automatically upon pulling the lever. It shall be manufactured in bright red compliant material; Operation shall be via a plastic membrane (non-breakable) with wording on method of operation in white lettering. The cover shall be etched in black lettering in Hindi and English "FIRE", the letters measuring not less than 10mm high.

b) The surface of the Manual call point shall be provided with a LED indicator. It shall light up upon activation of the Manual call point. The operation of any call point connected to the system shall cause the station FACP to enter the alarm state within three seconds.

c) Contacts shall be of silver or approved non-deteriorating alloy, for normally close/open system. The voltage and current ratings of the contacts shall be marked within the unit.

d) The units shall be of the flush mounting type and suitable for direct connection to the type of wiring system therein specified without the addition of unsightly surface boxes, glands and adaptors. Special boxes compatible with the conduit system shall be provided where necessary for installation of the call points.

e) Manual call point shall be positioned at a height of 1.4m at strategic points throughout the station such that they are clearly visible from front and sides as practicable and Manual call point shall be located so that one is within 61 meters of any point in the station. Provide flush plates for the recess mounting units.

f) Each Manual call point shall be accompanied by an alarm bell except those installed in concourse and platform areas where no alarm bell is required. The alarm bells and flashing light units shall actuate upon receipt of a fire alarm signal from any of the Manual call points or detection systems.

g) Each Manual call point shall be complete with built-in testing slot, such that testing can be carried out by insertion of the test key without removing the glass front cover of the unit.

10.2.4. Detectors

a) Smoke detectors shall be of multisensory type.

b) Detectors shall comply with NFPA 72, BS 5445: Part 1, UL listed or equivalent standard, multisensory. The internal circuits shall be of solid-state device and shall be sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock.

c) There shall be a built-in magnetic test switch in each intelligent device.

d) Built-in testing facility shall be provided based on NFPA 72 requirements.

e) Detector base shall be compatible for connection of all types of analogue addressable detectors and shall have the facility to drive a remote visual alarm indicator which shall be provided for all concealed detectors. Remote indicator shall be compatible with the detector so that the operation of the indicator will not impair or affect the brightness of the detector's built-in LED.

f) There shall be 360-degree view LEDs on the detector head so that alarm condition of the detector can be seen clearly from any direction or angle.
g) Detector shall be low profile, no more than 60mm in height including the base to minimize dust accumulation at detector head, resulting from the pattern of airflow.
h) Labels shall be provided adjacent to all detectors with appropriate letters indicating the corresponding address and letters shall be of not less than 20mm high.

10.2.5. Multi Sensor Detectors

a) The detector shall be a microprocessor based analog addressable smoke detector, which uses a combination of smoke and heat sensing technologies.
b) The detector should have the ability to adapt to its environment by utilizing a built-in microprocessor to determine its environment and choose the appropriate sensing settings. The detector design shall allow a wide sensitivity window, no less than 1 to 4% per foot obscuration. This detector shall utilize advanced electronics that react to slow smoldering fires and thermal properties all within a single sensing device.
c) The detector shall utilize advanced algorithms to provide early warning and an accurate analysis of alarm situations.
d) The detector should be programmed for min 5 sensitivity level.
e) Contaminated multisensory detectors can be programmed in heat only mode.

10.2.6. Heat Detectors

Heat detector shall be an analogue addressable type designed to raise an alarm when the temperature is at a rate-of-rise of 8 °C per minute or higher or at a fixed alarm temperature of 58°C. It shall comply with BS 5445: Part 5 Grade 1 or UL listed and equal, and Maharashtra fire service approved. The detector shall be self-restoring type.

10.2.7. Hooter cum Strobe

a) All the areas of Elevated stations shall be provided with sounder cum visual strobe units rather than public movement area. Public movement area shall be provided with strobe unit.
b) The unit shall be wall mounted, approved color, suitable for operation on 12V/24V with following features.
c) Visual Characteristics: The visual strobe shall consist of Xenon flash tube with associated lens / reflector. The feature selectable candela outputs (15, 15/75, 30, 75 or 110). The flash rate shall not exceed two flashes per second (2Hz) and nor less than one flash per second (1 Hz) throughout the listed operating range of appliances.
d) The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90-degree angle on both sides of the strobe.
e) Sounder pulse rate and decibel level above the ambient shall comply with NFPA standards.
f) Strobe shall be placed wall mounted in corridors no more than 4570 mm (15 feet) from the end of a corridor with 30.5 m (100 feet) maximum distance between strobes. Where there is an obstruction to the viewing path in the corridors, such as a cross-corridor door or ceiling elevation change, consider the obstruction as defining a new corridor.

10.2.8. Flashing Light Units

a) Alarm flashing light units shall be of flush mounted pattern complete with red indicating lights.
b) Each unit shall consist of one tungsten bulb and shall be fitted with all necessary flashing and control provisions. The unit shall be suitable for 24 V DC operation.
c) The dimensions, construction and design details of the unit shall be in accordance with section 6-4 of NFPA 72 or other standards acceptable to Maharashtra fire service.

d) Flashing light unit installed outdoor shall be of weatherproof type and shall be designed to IP55 or better.

10.2.9. Communication Cables

a) Detector cable loops shall be based on Class A wiring as per NFPA 72.
b) All detection loops/network wiring shall be minimum size of 1.5mm2 twisted pair, screened, fire survival cables complying with BS 7846, category CWZ.
c) All 24V DC power supply lines shall be minimum size of 2.5mm2 fire survival screened cables complying with BS 7846 category CWZ.

10.2.10. Interfacing Relay

Signals to control other systems by means of dry contacts shall be equipped with a 24V DC relay, with dry contact rated at not less than 2A 240 VAC. The relay and terminal block shall be housed in a covered galvanized steel or stove enamel steel box with adequate size to house all relays but in no case smaller than 110mm by 100mm by 50mm. Terminals shall be labelled clearly by means of silk screened or engraved lettering in metal or plastic plate.

10.2.11. Printers

The fire alarm control panel shall comprise a system printer which shall have a 96 ASCII character set. The printer shall have an indicator to alert the operator that paper has run out. The printer shall have a self-test feature to verify printer operability even when offline.
Monitor Modules
Addressable contact monitoring module shall communicate via the detection cable loop with the FS control panel for continuous monitoring of any NO or NC dry contacts connected including break glass, flow switch and repeating dry contact signals from gas flooding system and gas detection system. LED indication shall be provided to show the status of the module.
Control Modules
Control module shall provide an addressable output for a separately powered alarm indicating circuit or for a control relay and housed in a covered galvanized steel or stove enamel steel box with enough size to house all modules.
The control module shall provide a supervised indicating circuit where indicated on the Drawings. Any open/short circuit fault shall be detected/highlighted/displayed at the FS control panel. Subsequent fire alarm signals shall activate the appropriate controls and signaling devices despite of the fault conditions.
The control module shall act as a control relay where required.
The control module shall contain a LED which blinks upon being scanned by the FS control panel. Upon activation of the module, the LED shall be latched on.
Status of control module shall be fed back to FS control panel and print out automatically once it is activated.

10.2.12. Fault Isolator Modules

Fault isolator modules shall detect and isolate a short-circuited segment of a fault-tolerant loop. The module shall automatically detect a return-to-normal condition of the loop and restore the isolated segment.
Modules shall be provided for every 20 field addressable devices to limit the extent of devices affected in the event of a short-circuit. A minimum of two fault isolator modules shall be provided for one detection line loop.

10.2.13. Repeater Panels

Remote repeater panels for repeating all alarm status indication with LCD display shall be provided at the specified location and shall be Maharashtra fire service approved.
The repeater panel shall have identical zoning and Colour display for all alarms and shall fully correspond to those in the FS control panel.
The repeater panel shall be provided with warning buzzer which shall activate when an alarm occurs in the fire control room and a push switch shall be provided for silencing the warning signal. Lamp test control switch shall also be provided in the panel.
The panel shall contain an integral backlit LCD display of minimum 600 characters and built-in printer port as per this Specification. LCD display shall be viewable through the panel door.
The repeater panel enclosure shall be flush mounted, and all electronics shall be contained in the enclosure. Access to the repeater panel switches shall be protected by key-switch.
The panel construction shall be as per Specification.

10.3. Fiber Optic Linear Heat Detector (LHD) & Linear Heat Sensing Cable (LHSC)

10.3.1. Objectives

The main electrical infrastructures viz. Cable Wires, Feeder Pillar and Lighting / Power Distribution system HT & LT etc. shall be planned to install in the Void of Box Girder. Therefore, the Box Girder shall have adequate protection in case of Fire etc. The Linear Heat Detection System shall provide such protection under such exigencies.

10.3.2. Technical Specification

The Linear Heat Detection System shall use Raman based OTDR technology that includes the Optical Fiber LHSC and an LHD Control Unit that houses the electronics.
The optical fiber shall be connected to the Control Unit in a single continuous loop or shall be connected on either end to a single Control Unit to ensure redundancy and full coverage of the protected fire zones even if the cable is broken / cut / damaged at one point. FRNC coated Stainless Steel wire armored fiber optic cable shall be used for coal conveyors and thermoplastic fiber optic sensor shall be used for other applications.

The sensor cables shall be tested and approved for functional integrity for 2 hours at temperatures up to 750 °C according to IEC 60331-25.
The system shall provide continuous heat detection / temperature monitoring over the entire length of 10 km. A cable break or fire / alarm condition shall be indicated / located / identified within 40 seconds and to within 1-6 meter.
The Control Unit shall provide a minimum of 1, 2, 4 (one, two, four) measurement channels. The system shall be fully programmable with respect to zone lengths and alarm thresholds. Alarm set-points may be set to fixed temperature, deviation from average and/or rate-of-rise temperature, which should further be adjustable in terms of fixed temperature, rate of time and number of iterative counts to eliminate false alarms.
The Control Unit shall have a min. 44-volt free non-latching, certified relay outputs. (1 contact is for fault signals and remaining 43 contacts are programmable zonal relay contacts).
The control unit should have 4 opto-decoupled programmable input relays to enable remote alarm to reset and other functions.
The Control Unit shall have the capability to be interfaced via an Ethernet link or USB port for

interface to a PC and Modbus over Ethernet (Modbus TCP) for a site control system. The PC shall include programs / licensed software for displaying real time zone temperatures.

A real time temperature trace of the sensor cable shall be displayed on the PC and alarm messages highlighted and acknowledged, including identification of the actual position of a cable break / fire condition.

All accessories such as Control Units, fittings, fastenings, sleeves, straps, staples, clips (mountings), rings, test terminals, junction boxes, etc. which are required for interconnection with the fire annunciation system shall be provided.

The control unit should be able to operate in temperatures between -10 and +60 °C on a continual basis without loss of performance.

The system should not be able to produce a source of ignition under any circumstance (inherently safe operation) and should be internationally approved as such. (ATEX or equivalent.)

The system should be internationally approved for fire detection by UL and FM according to US standards and approved by VdS according to EN 54-22.

Safety function meets the requirement of SIL2

Typical power consumption shall be less than 20 W (room temperature / 25 °C)

Laser Source shall be based on a Laser Diode according Class 1M, as specified by EN60825-1 (2000). The Laser output power shall be less than 20mW.

CHAPTER – 11

11. OUTLINE CLEAN GAS BASED FLOODING SYSTEM SPECIFICATIONS – BUILDING

11.1. CLEAN GAS BASED FIRE TRACE TUBE SYSTEM FOR ELECTRIC PANEL

11.1.1. General

The contractor shall develop design for Clean Gas based Room Gas Flooding / Fire trace tube Gas suppression system for electric room, switch room, IT Room, Electrical Panel etc. in the buildings and tunnel in compliance with Codes and Standards mentioned in the specification and in coordination with Maharashtra Fire Service requirement.

11.2. Scope

The scope covers Design, Supply, Installation, Testing and Commissioning of Automatic Clean Agent Flooding System complete for electric room, switch room, IT Room, Electrical Panel etc. in the buildings and tunnel including fire trace tube, cylinder, valves, integration with Main Fire Alarm Control Panel for status monitoring etc. The work to be executed by authorized & certified Fire Trace installer shall cover:

1) Providing Direct Panel Gas Flooding System and with linear Fire trace tube inside the panels.
2) Arrangement of Clean Gas Agent for flooding inside the panels.
3) Audio-visual annunciation devices for indicating incidence of fire.
4) Any other item required to the successful commissioning of the system.
5) Provision of manual arrangement for discharge of gas inside the above panels if required.

The electrical panel fire suppression system shall be complete with Direct Clean Gas storage cylinders for required capacities, extinguishing agent as specified, linear fire trace tubing, filling and end-of-line adaptors, pressure switches, control equipment and all necessary accessories and push in fittings to form a complete and working installation to protect the Electrical panel in case of fire.

The panels to be protected shall be determined as per the approval of the engineer-in-charge.

The system will have an interface with Main Fire Alarm and Control Panel (The capacity shall be as per the approved manufacturer standard). In case of fire in the concerned Panel, indication of Fire Trace discharge status should come in Main Fire Alarm and Control Panel.

11.3. Regulatory Requirements

a. All the detecting devices, alarm, indicating devices, containers and other related equipment shall be UL Listed and/or FM approved

b. All installations shall conform to NFPA requirements.

c. Clean Agent used should be FM-200 The design and installation of the Clean Agent gas based High Temperature Polymer tube system is based on the latest applicable codes and also as per the manufacturer's recommendations, the required Clean Agent gas quantity is arrived as per the volume of the respective panels to be protected. In addition, the following standards and rules and regulations shall be applicable:

- Fire Protection Manual of Tariff Advisory Committee, Fire Insurance Association of India.
- NFPA 2001 : Standard on Clean Agent Fire Extinguishing Systems.
- UL 2166 : Mono Carbon Clean Agent Extinguishing Systems.
- NBC 2016 Part IV : National Building Code Part IV: Fire Safety System.
- Local Fire Brigade Authority.

11.3.1. UL Listed & FM approved system Description

a. The Clean Agent Pre-Engineered automatic direct fire suppression system shall be approved by Underwriters Laboratories/Factory Mutual

b. Each clean agent pre-engineered automatic system is equipped with its own detection/discharge Fire trace tubing. The pre-engineered concept minimizes the amount of engineering involved in system design. When the detection/Discharge tubing is installed within the limitations stated in the manufacturer manual, no hydraulic calculations are required to determine the pressure drop, agent flow or discharge time.

c. Each Clean Agent extinguishing unit, when installed, is a self-contained system, meaning that it is equipped with its own automatic (non-electric) detection system, which when actuated, automatically releases the suppression agent into the Electric panel.

d. The Clean Agent Automatic Direct System consists of the following major components:

- Clean Agent Cylinder/Valve Assembly.
- Cylinder Mounting Bracket.
- Fire trace Detector, Actuation and Discharge Fire trace Tubing and Fittings (No Substitute).
- Pressure Switch

e. The Clean Agent Automatic Direct System utilizes unique Fire trace flexible tubing that is attached to the top of the cylinder valve. This Fire trace tubing is pressurized with dry nitrogen, is temperature sensitive and acts as a continuous linear thermal detector that ruptures upon Flame impingement. Once the detector tubing is ruptured forming a nozzle at the rupture point, it allows the Clean Agent to flow through, distributing the extinguishing agent into the protected area. Upon system actuation, the pressure switch can be used to indicate system discharge, shutdown ventilation, shut-off electrical power etc. may be required.

f. The Clean Agent Automatic Direct System is designed and listed as an Automatic unit. No manual or electric means is provided for simultaneous actuation of multiple systems. Only one (1) unit can be used to protect one hazard. These extinguishing units cannot be combined to protect a larger size hazard, since they are not designed to provide for simultaneous actuation of two or more units.

g. The Clean Agent is stored in DOT steel cylinders as a liquefied compressed gas, super-pressurized with Dry Nitrogen to 150 psig at 70oF. The ambient operating temperature range for all system components is: +32oF to 130 oF (0oC to 54.4oC).

MMRDA

h. Each container is equipped with a nickel–plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the Detection Tubing. The ball valve must be kept closed always when the container is not in service. In addition, the container valve is equipped with a pressure relief (rupture disc) device in compliance with DOT requirements.

i. A wall-mounted painted steel bracket is used to mount the container/valve assembly in a vertical (upright) position. Each bracket is equipped with two integral quick-clamp straps.

j. For the direct Clean Agent systems, the tubing performs three functions: Heat Detection, System Activation, and Clean Agent discharge. The tubing is installed throughout the Electrical Panel volume, with one end connected to the top of the Clean Agent container valve. The tubing is pressurized with Dry Nitrogen to 150 psig and maintains the system in the "OFF" position. An optional pressure gauge or pressure switch can be connected to the other end of the detector/discharge tube to monitor system pressure and/or signal of system actuation, etc. The detector/discharge tubing is heat sensitive and, in a fire, situation is designed to rupture at any point upon flame impingement. The rupture of the tube results in a formation of a discharge nozzle that will perform a complete discharge of the Clean Agent. Location and spacing of the tubing should be placed above the hazard areas being protected.

k. A pressure switch is connected at the end of line of the Detection Tubing to monitor system pressure, system actuation or to energize/de energize electrically operated equipment. Manufacturer recommends that all systems use a pressure switch coupled with some other devices to alert personnel in the event of a system discharge.

11.4. Design Requirements

a. Provide enough Clean Agent FM -200 liquid to convert into Clean Agent vapor. Considering the following when computing volume to verify suitability and to establish design limitations:

- Volume of hazard area.
- Specific volume of Clean Agent.
- Discharge time and flow rates.
- Design concentration and design factors.
- Detector/discharge tubing placement.

b. Locate Clean Agent supply near each hazard area.

c. Interface system with main control fire alarm system and BMS

d. Provide total flooding of 7 percent Clean Agent concentration by volume as per NFPA-2001.

e. The pre-engineered automatic system concept minimizes the amount of engineering required when evaluation is design for a specific application.

f. No calculations are required for pressure drop, flow rates or discharge time if the discharge/detection tubing is installed within the limits as specified by this manufacturer.

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g. When the additional limitations of hazard volume, area coverage, maximum height, design concentration, agent quantity, detection tubing arrangement etc. are also met, the system installation shall be understood to comply with the design requirements, NFPA-2001, and FMRC approval.

h. Therefore, no discharge tests or concentration measurements shall be required.

i. All doors and holes in the enclosed/equipment should be closed or sealed to maintain the tightness of enclosure.

j. The system should have means to close the exhaust fans if installed in the panel at the time of system activation.

k. As desired by the engineer-in-charge the main supply of panel can be shut off with the system.

11.5. Technical Specifications of Fire Trace Tube

a. The High Temperature Polymer tube should be a flexible tube made of special polymer.

b. The High Temperature Polymer tube should be red in color to indicate it is part of fire protection system.

c. The tube should be non – conductive, non- corrosive and flexible.

d. The automatic system shall become a self-contained; self-actuating unit does not require an external source of power or electricity.

e. The System shall utilize unique flexible tubing that shall be attached to the top of the container valve. The tubing shall be pressurized with Dry Nitrogen to 150 psig at 70°F (1.034 KPA @21°C) is temperature sensitive and shall act as a continuous linear thermal detector that shall rupture upon flame impingement.

f. Once the detection tubing is ruptured, forming a nozzle at the rupture point, it shall allow the Clean Agent through the Nozzle into the protected area.

11.6. Clean Agent Containers

a. Fill containers with required Clean Agent. Pressurize with dry nitrogen to 1.034 kPa (150 psig) at 21°C (70 ° Fahrenheit).

b. Each storage container is equipped with a nickel–plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the detection tubing. The quarter-turn ball valve shall be kept closed always when the container is not in service.

c. All container valves shall be equipped with a pressure relief valve (rupture disc) device in compliance with DOT requirements.

d. The containers shall be located as close as possible to be protected enclosure. In some cases, the containers shall be mounted inside the protected enclosures. The container assemblies shall be in a ready accessible location to allow for ease of inspection service and maintenance.

e. Each container shall be equipped with a straight siphon tube. Each container can only be mounted in a vertical upright position. The container discharge valve shall be capable of releasing the Clean Agent in a vertical direction, so that the discharge force is perpendicular to the floor.

f. The pressure gauge shall permit a quick visual inspection of the container pressure.

11.7. CLEAN GAS BASED TOTAL ROOM FLOODING SYTEM

11.7.1. Scope of Tender

Fire suppression system is fire detection and quenching system. This is proposed for flooding entire room with FM - 200. The Cylinder Valve Assembly must be UL/FM approved with Seamless CCOE (PESO) approved cylinder and an undertaking from manufacturer must be submitted with the tender to comply the same.

11.7.2. System Details

The amount of agent to be provided shall be the amount required to obtain

a. uniform (minimum) design concentration Class C required to extinguish the fire at minimum anticipated temperature with the risk and as required by NFPA 2001, 2012 Edition with a hold time for 10 minutes. The system design shall not exceed 10% for normally occupied areas, adjusted for maximum area temperature anticipated with provision for room evacuation before agent release.

b. Necessary warning signs shall be displayed in and near such risk (entry and exit) envisaged for clean agent Gas suppression.

c. The Pipe used should be MS, ASTM Schedule 40.

d. The Cylinder to be pressurized at 34.5 Bar and Cylinder Valve Assembly must be UL/FM Listed.

e. Each cylinder shall have pressure gauze and low-pressure switch to provide visual and electrical supervision of the cylinder pressure. The low-pressure switch shall be wired to the control panel to provide audible and visual trouble alarm in the event of drop of pressure at 20 Bars and below. The pressure gauze shall be color coded to provide an easy, visual indication of cylinder pressure.

f. Furnish a welded steel bracket with each cylinder assembly for holding the cylinders in a saddle with a front bracket place that secures the cylinders depending on installation requirements.

g. The cylinder shall have pressure relief provisions that automatically operate before the internal nominal pressure exceeds 60 Bars.

h. Extinguishing Agent:

i. Comply with requirements of the authorities having jurisdiction.

j. Filling facility should be UL Listed / PESO approved.

k. Design Criteria

1) Standard Code: NFPA-2001 (Latest Addition)
2) Temperature of Risk: 20 °C to 27 °C
3) Design Concentration: 6.4 % -9 %
4) Flooding Factor: As per Manufacturer
5) Discharge Time: 10 Seconds
6) Design Pressure: Upstream of pressure reducer 34.5 Bars
7) Design Pressure: Downstream of pressure reducer as per calculation
8) Cylinder Capacity: 34 Ltr., 80 Ltr., 120 Ltr., 150 Ltr.
9) Nozzle Type: 360° / 180°
10) Altiue correction factor: As per Manufacturer Hold Period: 10 Minutes

11.7.3. Submittals

The Contractor must submit mechanical Working Drawing showing Pipe, Pipe Size, Bends, Reducer, Splits, Tee Connection, Valves, Fittings, supports etc. which should be supported with Hydraulic Flow Calculation. The Hydraulic Flow Calculation Software must be UL/FM approved.

11.7.4. Sequence of Operation

Aspiration system/ VESDA is to be used as detection system for total gas flooding system. a)

1) Activation of the First Smoke Detector (Air Sampling Smoke detection).
   a) Illuminate the respective circuit lamp on the control unit.
   b) Energize a pre-alarm audible alarm bell.
   c) Treatment remote alarm to the building Fire Alarm Panel.
   d) Activation of the Second Smoke Detector (Air Sampling Smoke detection).
   e) Illuminate the respective circuit lamp on the control unit.
   f) Energize an evacuation audible alarm horn device.
   g) Shut down the stand-alone air conditioning units serving the protecting area.
   h) Closes the supply and exhaust / return dampers serving the protected area.
   i) Activates a time delay mechanism which delays release of the clean agent for up to 20 seconds from the time the 2nd loop is activated. The Fire Suppression clean agent is released at the end of the time delay interval unless a "dead man" type abort switch is operated between the 1st and 2nd detection loops. A timed-out system discharges upon abort disengagement unless the system is cleared and reset.
2) Discharge of the Fire Suppression Clean Agent.
   I. Operates strobe light outside the protected area.
   II. The system may be activated by manual discharge switches located in the protected area. Operation of a manual discharge switch causes immediate discharge of the fire suppression agent and causes alarm and shut-down devices to operate the same as if the system had pirated automatically operation of a manual discharge switch overrides all time delay and abort system devices in the system.

11.8. Safety Equipment

The Contractor shall supply and install all the safety equipment at strategic location as laid down under Indian Electricity Rule and in conformation with Local Fire Authority of Maharashtra in complete without any additional Cost.

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