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TECHNICAL SPECIFICATIONS

PART A- ELECTRICAL-LT SYSTEM

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CHAPTER – 01 MV SWITCHGEAR

1.1 MV Switchgear

The scope of work shall cover the design, manufacture, supply, installation, testing and commissioning of all power panels, suitable for 415 volts $\pm 10\%$, 3-phase, 50 Hz, 4-wire system incorporating circuit breakers of various types, bus bars, interconnections, metering, protection, earthing etc., meeting the requirements shown in schematic diagrams, schedule of quantities and as specified.

1.1.1 Standards

1. All equipment's, components, materials and entire work shall be carried out in conformity with applicable and relevant Bureau of Indian Standards and Codes of Practice. In addition, relevant clauses of the Indian Electricity Act 2003 and Indian Electricity Rules 1956 as amended up to date shall also apply. Wherever appropriate Indian Standards are not available, relevant IEC Standards shall be applicable.
2. Equipment's certified by Bureau of Indian Standards shall be used in this contract in line with government regulations. Test certificates in support of this certification shall be submitted, as required.
3. It is to be noted that updated and current standards shall be applicable irrespective of dates mentioned with references/ standards in the tender documents.

Some of the applicable standards are listed below & latest version must be adopted: -

In case of any conflict between specifications & the standards, the instructions/ decision of 'The Engineer' or Engineer authorized representative shall be binding.

Sl. No	Code	Description of code
1	IEC 61439 / EN 61439 -part	Specification for low voltage switchgear and control gear assemblies for total type tested.
2	IEC 60947 / IS 13947: Part 1: 1993	Specification for Low-voltage Switchgear and Control gear - Part 1: General Rules
3	IEC 60947 / IS 13947: Part 2: 1993	Specification for Low-voltage Switchgear and Control gear - Part 2: Circuit Breakers
4	IEC 60947 / IS 13947: Part 3: 1993	Specification for Low-voltage Switchgear and Control gear - Part 3: Switches, Disconnectors, switch disconnectors and Fuse Combination Units
5	IEC 60947 / IS 13947: Part 4: Sec 1: 1993	Specification for Low-Voltage Switchgear and Control gear - Part 4: Contractors and Motor-Starters - Section 1: Electromechanical Contactors and Motor Starters.
6	IS 13947: Part 5: Sec 1: 2004	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 1: Electromechanical Control Circuit Devices.
7	IEC 60947 / IS 13947: Part 5: Sec 2: 2004	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 2: Proximity Switches.
8	IS: 3231 – 1986	Specification for Electrical Relays for Power System Protection.
9	IS: 11353 – 1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus terminals.
10	IS: 10118 (Parts 1 to 4) 1982	Code of practice for selection, installation and maintenance of switchgear and control-gear.

Sl. No	Code	Description of code
11	IS: 3043 – 1987, IEEE-80 standard – 2000	Code of Practice for earthing- Guide for safety in AC substation grounding.
12	IS: 732– 1989	Code of Practice for Electrical Wiring Installations.
13	IS: 5578 – 1984	Guide for marking of insulated conductors.
14	IS: 5216 Part I & II 1982	Recommendation on Safety Procedures and Practices in Electrical Work.
15	SP: 30: 1985	National Electrical code.
16	IS: 1646 – 1997	Code of practice for fire safety of buildings (general): Electrical installation.
17	IS: 2075 – 2000	Ready Mixed Paint, Staving, Red Oxide Zinc Chrome, Priming - Specification
18	IS: 1248 (All Parts) 2003	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories- Specification.
19	IS: 3618 – 1966	Specification for Phosphate Treatment of Iron and Steel for Protection Against Corrosion.
20	IS: 6005 – 1998	Code of practice for phosphating of iron and steel.
21	IS: 5 - 2004	Colour for Ready Mixed Paints and Enamels.
22	IS:8828 – 1996	Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations.
23	IS 11353.1985	Making switchgear bus bar guide for uniform system, identification of conductors, apparatus terminal.
24	IS 2147.-1962	Degree of protection of enclosures for low voltage switchgear.
25	IS 3231-1986	Electrical relays and power system protection
26	IS 10118.1982	Maintenance of switchgear& control gear
27	IS-2551-1982	Danger notice plates.
28	IEC 60529 / EN-60529	Specification for degree of protection provided by enclosures- IP code.
29	EN 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
30	IEC 60831	Shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1000 volts.
31	IEC 60871-1	Shunt power capacitors for AC power systems having rated voltage about-1000 volts.
32	IEC 60044-1	Instrument transformers.
33	IEC 60211	Maximum-demand-meters indicators, class-1.0.
34	IEC 60521	Class 0.5,1,2 alternating current watt-hour meters.

Sl. No	Code	Description of code
35	IEC-61643, 62305, 60364	Lightning and surge protection.
36	IEC 60255/EN EN-60255	Electrical protection relays.
37	ANSI	America National standard International Institute for Electrical protection relays.
38	IEC 60228 / BS BS-6360	Specification for conductors in insulated cables and cords.
39	IEC 1036,687,1286	Direct reading single / three phase meter – digital type.
40	BS 7211	Specification for thermosetting insulated cables, un-armoured for electric power and lighting with low emission of smoke and corrosive gases when affected by fire.
41	BS 381 C/ BS 4800	Specification of colours for identification, coding and special purpose.
42	BS 1432	Specification for copper for electrical purposes, high conductivity copper rectangular conductors with drawn or rolled edges
43	BS 5685	Electricity meters.
44	BS 1650	Specification for capacitors for connection to power frequency systems.
45	BS 2757	Method of determining the thermal classification.
46	SP-30-1985	National electric code.
47	IEC 60695	The insulation material conforming to Glow wire test.

1.1.2

Scope

1. The scope of this specification for the work of the Design, engineering, supply, installation, testing and commissioning of all power panels including three phase ACB, MCCBs, MCBs, Protective Relays in enclosures suitable for 415 volts $\pm 10\%$, 3-phase, 50 Hz, 4-wire system incorporating circuit breakers of various types, bus bars, interconnections, metering, protection, earthing etc., meeting the requirements shown in schematic diagrams, schedule of quantities and as specified. The main LT panels for Normal power, DG power and other panels are as per the standard design & requirement of employer.
2. The LV main switchboards shall be of **Totally Type Tested assemblies (TTA)** and Switchboard configuration with form **4b Type-6 construction as per IEC 61439 -1 or EN 61439 -1**. All type tests shall be as defined in IEC 61439 -1 or EN 61439 -1, built up from compartments housing circuit breakers, control gear, relays, bus bars, controls and other items of equipment.
3. Selection of ACB, MCCB and MCB shall be of same make. **Total Discrimination** up to the Icu value of down Breakers must be available between the various elements of switchgear (ACB, MCCB, MCB etc) selected. Supplier must provide test certificates from acceptable, reputed laboratories to prove the same, if so desired by Engineer. In view of standardization and Uniformity, mixing of two series of switchgear (even from the same manufacturer) for either MCCB or ACB will not be permitted. In case higher frame size is required to be provided to achieve the above requirement, due to selection of a particular make, the same shall be provided at no extra cost if other makes are able to achieve the same with the specified frame size.
4. Test certificates issued by reputable independent testing laboratories and authorized testing agencies in accordance to IEC/ISO 17065 shall be furnished as required to substantiate the quality and fulfilling

requirement of Totally Type tested Assemblies (TTA). The panel manufacturer should have in-house Fabrication, assembly, powder coating and testing facility.

5. Classification of the equipment shall be minimum **Class C** and the access to it should only be limited to authorized persons. In case an internal arc occurs, the assembly's ingress protection shall be retained so as to avoid any foreign element penetration inside the electrical assembly.
6. The LV main switchboards shall also pass the arc fault containment tests in accordance with IEC 61641 with minimum 65KA for 0.3 sec continuously. In this course of the test the breaker should carry the fault current for the complete test duration time or Voltage shall be maintained for the entire test. Internal arc test should comply with edition 3, Class C & complying to all the criterion 1 to 7 of IEC 61641.
7. All the TTA Panels must be supplied as per OEM type tested design as per 61439-1&2. In all the drawings Switchgear OEM has to evaluate the design and sign the Drawings. In Inspection report also switchgear manufacturer has to sign the Report. Apart from the switchgear, the OEM must to give the design, performance warranty undertaking letter and service undertaking letter. Inspection shall be conducted at OEMs / approved facility. The Inspection reports should be signed by OEM.
8. Switchgear OEM only responsible for Design, Project Management, Manufacturing, performance, warranty and service for all the panels.
9. All the ACB, MCCB, MCB, RCBO's the service / supply back up required for minimum 15 years.
10. Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work.

1.1.3

Air Circuit Breakers

1. Air Circuit breakers shall be air break, moulded case horizontal draw-out type fully interlocked and meeting the requirements of Indian /IEC standards. Breakers shall be rated for an operating voltage U_e of 690 V & insulation voltage U_i : 1000 V, Rated Impulse withstand-12KV for main circuit and rated full load amperes as indicated on drawings. Breaker shall be capable of making and breaking system short circuits as specified. Discrimination should be available among the breaker up to design fault level.
 2. 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 kept locked in any position. Breakers for remote operation shall be 240-volt ac motor operated spring charged accessory or 24 V dc operated shunt trip coil whichever specified. 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 should be capable of setting Neutral protection to N or N/2 to ensure precise neutral protection. Future upgradability for the circuit breaker with help of Digital Modules shall be possible.
 3. 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: 13947 with symmetrical rupturing capacity at 415 Volts as per BOQ and drawings. All circuit breakers shall be provided with over current/ short circuit, instantaneous & earth fault releases or as required. 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 24-volt dc / 240-volt ac shall be provided. The ACBs shall have $I_{cs} = I_{cu} = I_{cw}$ for 1 second. The circuit shall comply with the isolating function requirements of IEC 60947-2 section to facilitate the safety of person. ACB should inbuilt communication for cradle management.
1. **Constructional features**
 - i. 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.

- ii. 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.
- iii. 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.
- iv. The automatic shutters should be integral part of breaker & locking arrangement should be provided as per standards.
- v. Contacts should be self-aligning type requiring no special effort to align them.
- vi. The ACBs shall be fitted with arc chutes on each pole designed to permit rapid dispersion, cooling and extinction of the arc.
- vii. ACBs shall have separate main and arcing contacts. Arcing contacts shall be hard wearing material as per manufacture standard.
- viii. The insulation material shall confirm to Glow wire test as per IEC 60695.
- ix. ACBs shall be CE marked.
- x. ACB shall have minimum watt losses in order to restrict temperature rise inside the breaker.
- xi. All the ACB should have the following features.

Minimum features	Display from min 25 A onwards
Graphical Display	V, A, Hz, KW, KVA, PF, in all the phases and total with class 1 accuracy.
Protection	ANSI, 49, 51, 51TD, 50, 51 N, 51N TD, 51G, Zone Selectivity 68, under voltage – 27, Over Voltage 59, Residual Current 64, Phase unbalance-46
Feature	Embedded Ethernet with in release Redundancy port.
	Waveform capturing on trip event with magnitude of 20 events and time stamping
	Alarms-Unbalanced loads, under voltage, over voltage
	Thermal Memory.
	Counter –ON / Off operation
	Digital I/O – 10 No's
	Password protection for unauthorised access

2. Operating mechanism

- i. The Circuit Breaker shall be trip free with stored energy type operating mechanism, closing spring shall be able to manually charge 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 always 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.
- ii. 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.

- iii. "Service" -- Both main and secondary isolating contacts closed. LOTO key provided with two keys as minimum.
- iv. "Test" --Main isolating contacts open, and secondary isolating contacts closed.
- v. "Isolated" -- Both main and secondary

3. **Circuit breaker interlocking**

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

- i. It shall not be possible for the Breaker to be rack-in or rack-out 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 shall open only when ACB is in OFF position.
- ii. 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.
- iii. It shall not be possible for the Circuit Breaker to be plugged in unless it is in the OFF position.
- iv. 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. **Circuit Breaker auxiliary contacts**

The Circuit Breaker shall have minimum 6 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 auxiliary 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. Anti-pumping. Mechanical and electrical anti-pumping devices shall be incorporated in the circuit breakers as required.

5. **Mechanical & Electrical life.**

Mechanical & Electrical life. The Circuit Breaker shall have minimum Mechanical life of 20000 operations and electrical life of 8000 operations.

6. **Type Test Certificates**

The ACBs shall be type tested and certified for Combined sequence test in compliance to IEC: 60947/Equivalent IEC from Indian/International Testing Authorities. Supplier should submit certificates for the same. All ACB shall confirm to EMC & shall be immune to harmonics to avoid nuisance tripping.

ACBs shall be provided with embedded Modbus TCP over Ethernet for BMS (Building Management System) connectivity through Ethernet protocol. And should communicate the following parameters of ACB's: -

- On/Off/Trip Status Message.
- Spring Charge Storage (Charged or Discharged).
- ACB Position – Connected, test and disconnected position, removed.
- Event and trip log.
- No. of Tripping Operations L, S, I and G.
- Contact wear indication.
- No. of operating cycles under load & total no. of operating hours.
- Tripped signals with details of tripping current.
- All event signals with time stamp.

- Temperature in the circuit breaker with min/max values.
- Temperature in the control cabinet with min/max values
- Measuring 3 ph RMS voltages, Current, KW, KVAH, PF.

7. Protection

The true RMS sensing microprocessor-based communication upgradeable numerical release with intrinsic embedded Modbus TCP over Ethernet 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 LED / LCD display for showing the actual value 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), all energy & power parameters including Maximum demand. The release should have individual fault detection by LEDs for faster fault diagnosis and reduce down time. The release shall be self-diagnostic with indication. All the adjustment should be on line (password protected) and the circuit breaker need not be switched off 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 to reduce thermal stress on the system. The release should provide last 5 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 and any outside disturbances should not affect the trip unit of circuit breaker. The trip unit should be self-powered. Release shall be lockable either with password lock or mechanical lock & it shall be responsibility of vendor to interface with HT settings with LT settings for discrimination with $t=k/I^4$ curve for better co-ordination with upstream circuit breakers.

1.1.4

MCCB

1. Moulded Case Circuit Breakers shall be standard products of established manufacturers best suited to the application duty and shall conform to IEC 60947-2. / IS 13947-2, MCCBs shall be suitable for fault levels as required 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.
2. MCCBs shall be current limiting type with trip time of less than 10 milliseconds suitable for 3 phase, 415 Volts $\pm 10\%$, AC, 50 HZ supply with neutral 4P/3P/2P as required and rated for insulation voltage 750 V, Rated Impulse-8 KV and Rated operating voltage of 415V for 3 Phase, Service short circuit breaking capacity (Ics) shall be 50kA at MDB and marked with suitability for positive isolation as required. All Breakers/MCCBs shall incorporate front adjustable trip units with adjustable overload (40-100%) and adjustable short circuit faults. All the MCCBs shall have microprocessor-based releases. 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 minimum 15000 operations.
3. 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.
4. MCCBs shall be provided with suitably rated releases accessories as specified in the drawings and BOQ to avoid the burning due to sustained command. In addition, MCCBs shall be provided with following interlocking devices with the compartment door.
 - i. Door interlock to prevent door being opened when the breaker is in ON position (extendable rotary

- handle to be invariable provided).
- ii. Interlock to prevent the breaker being switch ON with the door open.
 5. 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'.
 6. 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.
 7. MCCBs to be used in conjunction with ASTS shall be motorized or motor operated to provide trouble free successful switch over of supplies to the safe side. The Motor mechanism of MCCB should be stored energy type.
 8. Each MCCB shall have a facility for padlocking in the off position. For this OEM has to supply LOTO kit for minimum 3 no's in each frame.
 9. MCCBs shall have Copper spreader links with phase barriers as standard feature.
 10. MCCBs protection releases should be shrouded to avoid unauthorized tampering.
 - i. In-built RMS sensing of current
 - ii. Central front from Overload 40-100% and short circuit with time delay adjustments.
 11. MCCBs shall have shrouded terminals
 12. MCCBs shall be CE marked.
 13. MCCBs shall not have any load line biasing.
 14. MCCBs shall be type tested and certified from local/International testing authorities for conformance to IEC/IS standards.
 15. All releases shall be tamper proof.
 16. There should be total discrimination between ACBs, MCCBs and MCB's. For this switchgear manufacturer has to give the discrimination chart before submitting the drawings.
 17. Earth fault protection shall be inbuilt feature of MCCB. For TP MCCBs external Neutral CT shall be provided to avoid nuisance tripping due to unbalance loads.
 18. MCCB for Motor back protection shall be dedicated Motor duty with only magnetic setting.
 19. All MCCBs which are incomers or provided in separate enclosures shall be provided with in-build RJ 45 ports for BMS (Building Management System) connectivity with MODBUS over TCP/IP protocol. And must communicate the following parameters: -
 - ON, OFF and Trip status.
 - Event and trip log.
 - Trip Counter after LSIG trips.
 - Operating hours' counter.
 - Switching cycle counter.
 - Trip History- 20 nos along with time stamping
 - THD-I & THD-V up to 40th.
 - Energy parameter (V, A, KW, KVA, etc with class 1 accuracy).
 - Temperature.

- wear of the contacts

1.1.5 Switch Fuse Units & Disconnects/Isolators (Where applicable)

1. Switch fuse units shall have quick-make, quick-break silver plated preferably double break contacts with operating mechanism suitable for rotary operation in the case of cubicle mounting. All switches shall be rated according to the equipment schedule or drawings and shall withstand the system prospective fault current let through. Cam operated rotary switches with adequate terminal adaptors up to 25A are acceptable but for all higher rating switch fuse units shall be heavy-duty type.
2. Fuses shall be HRC cartridge type conforming to IS: 13703 – 1993 with a breaking capacity corresponding to system fault level. Fuses shall be link type with visible indication. Screw type fuses are not acceptable for any ratings.
3. All disconnects shall consist of switch units quick-make, quick-break type with silver plated contacts. The switches shall preferably have double breaks. The switches shall preferably have sheet steel enclosure, which in turn is mounted on suitable angle iron frame work. In wet locations enclosures shall be IP56 rated. Disconnects shall have a minimum breaking capacity of 5 ka at 415 Volts.
4. Switch contacts shall be designed with arc repelling features to extinguish the arc quickly to provide long contact life.

1.1.6 MCCB/MCB Isolators

1. MCCB/MCB Isolators shall be fixed on wall, on self-supported galvanized angle iron frame work as required and mounted as near to the motor as possible. Where several motors are installed, isolators if required shall be provided at a central location on a common frame work with prior approval at site. The Isolator shall be provided in GI sheet IP 56 enclosures as required.
2. Painting, earthing and labels shall be provided as generally indicating for MV Switchgear and as shown on drawings.

1.1.7 General

Switchboards shall be suitable for operation at three phase 4 wire, 415-volt, 50 Hz, 12 KV for ACB's and 8 KV for MCCB's impulse withstand, neutral grounded at transformer system with a short circuit level withstand as per schedule of quantities and drawings. The enclosures shall be designed to take care of normal stress as well as abnormal electromechanical stress due to short circuit conditions. All covers and doors provided shall offer adequate safety to operating persons and provide ingress protection of IP54 with form 4b segregation unless otherwise stated. Ventilating openings and vent outlets, if provided, shall be arranged such that same ingress protection of IP54 is retained. Suitable pressure relief devices shall be provided to minimize danger to operator during internal fault conditions. Entire switchgear used in switchboards shall be completely fuse free. No fuses shall be used anywhere in the installation.

Switchboard panels along with ACBs shall be of TTA type (Total Type Tested) at CPRI / Independent test house accredited by NABL only. Further all the Type Test Reports shall be from the Switchgear Manufacturer only.

The Panels are generally named as follows: -

- Main LT Panel
- Main Emergency Panel
- Normal Distribution Board
- Emergency Distribution Board
- Main Lighting Distribution Panel (MLDP)
- Ventilation & Air Conditioning Panel (VACP)
- Fire Pump Panel (FPP)
- Domestic Pump Panel (DPP)
- Light Distribution Boards (LDB)
- Power Distribution Board (PDB)

➤ UPS Distribution Board -UPS

1.1.8 Switch Board Configuration

The switchboard shall be configured with Air Circuit Breakers, MCCBs and other equipment as called for in the schedule of quantities. The MCCBs shall be arranged in multi-tier formation whereas the Air Circuit Breakers shall be arranged in single or double tier formation only to facilitate operation and maintenance. The switchboards shall be of adequate size with a provision of 15% spare space to accommodate possible future additional switchgears.

1.1.9 Equipment Specification

All equipment's used to configure the switchboard shall comply to the relevant standards and codes of the Bureau of Indian Standards and to the detailed technical specifications as included in this tender document.

1.1.10 Constructional Features

1. The switchboard shall be metal clad totally enclosed; floor mounted freestanding type of modular extensible design suitable for indoor mounting.
2. Switchboards shall be either compartmentalized or non-compartmentalized as stipulated in schedule of quantities.
3. Switchboards shall be made up of requisite vertical sections, which when coupled together, shall form continuous dead front switchboards.
4. Switchboards shall be readily extensible on both sides by addition of vertical sections after removal of the end covers.
5. The switchboard shall be designed for use in high ambient temperature and humid tropical conditions as specified. Ease of inspections, cleaning and repair while maintaining continuity of operation shall be provided in the design.
6. Metal based fire retardant neoprene gaskets of high quality between all adjacent units and beneath all covers shall be provided to render the joints dust and vermin proof to provide a degree of protection of IP 54 or better as stipulated in schedule of quantities.
7. The Main distribution panels and sub-main distribution panels are floor standing, metal-clad in Form 4b type-6 construction with separation panels. These switchboards are designed and manufactured in accordance with IEC61439 standard with IP54 protection. All switchboards shall be 25% spare circuit breakers providing for future loads installation.
8. 'U' Channels forming switchboard frames shall be fabricated from 2.5mm thick electro galvanized MS sheet. All joints shall be neatly formed and finished flush with adjacent surfaces by grinding. No joints shall be in corners. Bare edges shall be lipped. Structural members and bracings wherever required shall be welded or bolted to the frame. The frame shall be of modular design and extensible. All doors and covers shall also be fully gasketed with metal-based neoprene gaskets with fasteners designed to ensure proper compression of the gaskets. The hinged door shall open a maximum of 150°. All hinged doors shall have earth braid connected to the cubicle. Good quality door handles fitted with toggles to operate rods to latch with suitable slots in both top and bottom of switchboards shall be provided. Latching rods and associated brackets shall be cadmium plated.
9. Each vertical section shall be provided with a rear side cable chamber housing the cable end connections and power / control cable terminations. There should be generous availability of space for ease of installation and maintenance with adequate safety for working in one vertical section without coming into contact with any live parts.
10. Switchboard panels and cubicles shall be fabricated with CRCA sheet steel of thickness not less than **1.6mm** in general and load bearing members with **2.0mm** and shall be folded and braced as necessary to provide a rigid support for all components. The doors and covers shall be fabricated from CRCA sheet steel of thickness not less than 2mm. 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.

11. All panels and covers shall be properly fitted and square with the frame. The holes in the panels shall be correctly positioned.
12. 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 switchboards.
13. Electrical Panel shall be tested IK-10 for mechanical impact in accordance with IEC 62262
14. Non-Magnetic gland plates of not less than **3 mm** thick of suitable size shall be provided at the top and bottom of the LV main switchboards for the termination of incoming and outgoing power cables or bus ways. Where armoured multi-core cables terminate inside the switchboard enclosure, glanding plates or glanding brackets shall be provided for securing the cables to the switchboard. When Securing of cables is arranged to avoid the cable weight coming on the gland plate.
15. The Electrical Panel shall operate without excessive vibration and with a minimum of notice as per best of engineering practice and shall also operate without excessive temperature rise at the rated load conditions. Panels should strictly be Seismic compliant to Zone 4 as per IEC 60068.

1.1.11 Switchboard Dimensional Limitations

1. A base channel 100mm x 50mm x 3mm thick shall be provided at the bottom.
2. A minimum of 275 mm blank space between the floor of switchboard and bottom most unit shall be provided.
3. The overall height of the switchboard shall be limited to 2300 mm unless otherwise stipulated.
4. The height of the operating handle push buttons etc. shall be restricted between 300 mm and 1900mm from finished floor level.

1.1.12 Switchboard Compartmentalization

1. For compartmentalized switchboards, separate totally enclosed compartments shall be provided for horizontal busbars, vertical busbars, ACBs, MCCBs and cable alleys.
2. Earthed metal or insulated shutters shall be provided between draw out and fixed portion of the switchgear such that no live parts are accessible with equipment drawn out. Degree of protection within compartments shall be at least IP54.
3. Sheet steel hinged lockable doors for each separate compartment shall be provided and duly interlocked with the breaker in "ON" and "OFF" position.
4. For all circuit breakers separate and adequate compartments shall be provided for accommodating instruments, indicating lamps, control contactors and control MCB 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.
5. The Main distribution panels and sub-main distribution panels are floor standing, meta- clad in Form 4b type with separation panels. These switchboards are designed and manufactured in accordance with IEC61439 standard with IP54 protection. All switchboards shall be 25% spare circuit breakers providing for future loads installation.
6. Each switchgear cubicles shall be fitted with label in front and back identifying the circuit, switchgear type, rating and duty. All operating device shall be in front of switchgear only. Minimum height from floor level for any device mounted on panel cover shall be 250 mm.
7. A horizontal wire way with screwed cover shall be provided at the top to take interconnecting control wiring between vertical sections.
8. Separate cable compartments running the height of the switchboard in the case of front access boards shall be provided for incoming and outgoing cables.
9. Cable compartments shall be of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top.
10. Adequate and proper support shall be provided in cable compartments to support cables.
11. 15% spare space shall be provided in all switchboards to cater for future use.

1.1.13 Switchboard Bus Bars

1. Bus bars shall be made of high conductivity, high strength Copper, complying with requirements of grade Cu ETP of IS 191. Design of bus bar system shall comply to IS 5578 and IS 11353. Bus bars shall be of rectangular cross sections suitable for full load current for phase bus bars and neutral bus bar or as stipulated in schedule of quantities. Bus bar shall be suitable to withstand the stresses of fault level as specified in schedule of quantities.
2. Bus bars shall be insulated with heat shrunk PVC sleeving of 1.1 kV grade and bus bar joints provided with clip-on shrouds.
3. The bus bars shall be extensible on either side of the switchboard.
4. The bus bars shall be supported on non-breakable, non-hygroscopic epoxy resin or glass fibre reinforced polymer insulated supports able to withstand operating temperature of 110° C at regular intervals, to withstand the forces arising from a fault level as stipulated in schedule of quantities.
5. All bus bars shall be colour coded.
6. Auxiliary buses for control power supply, space heater power supply or any other specified service shall be provided. These buses shall be insulated, adequately supported and sized to suit specific requirement. The material for auxiliary supply bus will be electrolytic copper.
7. The busbar shall be air insulated, solid rectangular bars of electro-tin plated, hard drawn, high conductivity, 99%, copper bars and shall be mechanically braced to withstand the maximum symmetrical short-circuit current rating of the main breaker in each assembly.
8. The bus bar shall have enough cross-sectional area to continuously conduct rated full load current for operation in 50-degree centigrade ambient temperature and for limit temperature rise within the requirements of IEC-61439- 1. The current carrying capacity of the bus bar shall be of the bare bus bar rating confirming to IEC-61439-1
9. Ground bus shall be of 50% size of phase bus and shall be furnished to the entire length of the switchboard.

1.1.14 Switchboard Interconnection

All connection and tap offs shall be through adequately sized connectors appropriate for fault level at location. This shall include tap off to feeders and instrument/ control transformers. Alternatively, current limiters of approved make any type shall be used.

For unit ratings up to 100 amps, FRLSZH insulated copper conductor wires of adequate size to carry full load current shall be used. The terminations of such interconnections shall be crimped. Solid connections shall be used for all ratings of 100 Amps and above.

All connections, tapping's, clamping, shall be made in an approved manner to ensure minimum contact resistance. All connections shall be firmly bolted and clamp with even tension. Before assembly joint surfaces shall be filed or finished to remove burrs, dents and oxides and silvered to maintain good continuity at all joints. All screws, bolts, washers shall be cadmium plated. Approved spring washers shall be used with cadmium plated high tensile steel bolts with BSF threads.

1.1.15 Draw out Features

Air circuit breakers shall be provided in fully draw out cubicles, unless otherwise stated. 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 interlocks shall be provided on the draw out cubicles to ensure safety and compliance to relevant standards. The MCCB's shall be provided in fixed type cubicles.

1.1.16 Instrument Accommodation

Instruments and indicating lamps shall not be mounted on the circuit breaker compartment door for which a separate and adequate compartment shall be provided, and the instrumentation shall be accessible for testing and maintenance without danger of accidental contact with live parts of the switchboard.

1.1.17 For MCCB's Instruments and Indicating Lamps

For MCCB's instruments and indicating lamps can be provided on the compartment doors. The current transformers for metering and for protection shall be mounted on the solid copper busbars with proper supports. AUXILIARY SUPPLY

1. AC supply: 230V, 1 phase, 50Hz for closing circuit
2. Suitable fuses and links shall be provided for individual circuits for protection and for isolation from bus wire without disturbing the other circuits. Bus wires from panel to panel shall be wired through necessary control terminals.
3. Panel heaters and thermostats shall be provided in all the panels
4. Control supply 240V AC shall be supplied at one point. A separate bus shall be provided for the AC supply required for closing circuit, for space heater and thermostat
5. 240V sensing relay with volt free contacts shall be provided for sensing the control supply for local and remote indication to BMS/SCADA.

NOTE:

In case of any requirement of DC Control supply, contractor to provide for battery charger & Battery for satisfactory operation of system. The rates to be quoted accordingly as no separate payments for the same shall be made.

1.1.18

Wiring

- All wiring for relays and meters shall be with FRLSZH insulated copper conductor wires. The wiring shall be coded and labelled with approved ferrules for identification. The minimum size of copper conductor control wires shall be 2.5 sq.mm.
- All internal wiring shall be neatly run and securely fixed in non-metallic cleats in such a manner that, wherever practicable, wiring can be checked against diagrams without removal of the cleats.
- All Control Circuits shall be protected by a MCB.
- Terminations for terminals shall be of the crimped-on ring type. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.
- All wires between the terminals of two equipment shall be given a unique printed number of sleeves according to an approved system. A wire number shall not change solely by virtue of passing through, say, a marshalling terminal block.

1.1.19

Cable Termination

1. Knockout holes of appropriate size and number shall be provided in the switchboard in conformity with the location of incoming and outgoing conduits / cables. In knockout place suitable rubber grommet to be provided.
2. The cable terminations of the circuit breakers shall be brought out to terminal cable sockets suitably located in the cable chamber.
3. The cable terminations for the MCCBs 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 switchboards.
4. The switchboards shall be complete with tinned brass cable sockets, tinned brass compression glands, gland plates, supporting clamps and brackets etc. for termination of
5. 1100-volt grade aluminium conductor XLPE cables.
6. Removable gland plates shall be provided for power and control cables. The gland plates shall be 3mm thick and for single core cables shall be of nonmagnetic material.
7. Both incoming and outgoing cable shall have top or bottom entry depending on site requirement.

1.1.20

Space Heaters

Anti- condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch suitable for electrical operation at 230 volts AC 50 Hz single phase of sufficient capacity to raise the internal ambient temperature by 5° C. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the switchboard is in operation. As a general rule, the heaters shall be placed at the bottom of the cubicle.

1.1.21 Ventilation Fans

The switchboard shall be provided with panel mounting type ventilation fans in each panels where ever required as per the design for proper ventilation. The fan shall be interlocked with switchgear operation.

1.1.22 Earthing

Continuous earth bus sized for prospective fault current to be provided with arrangement for connecting to station earth at two points. Hinged doors/ frames to be connected to earth through adequately sized flexible braids. Earthing arrangement should comply to IS: 3043.

1.1.23 Remote Monitoring

The following critical status and alarms for each LVSB shall be sent to BMS for remote monitoring via volt-free contacts rated at 240V AC/ 110 V DC, provided in the LVSB.

- Individual ACB/MCCB open/close and trip status.
- Common alarm for ACBs/MCCBs trip on fault/locks out.
- Common alarm for any local/remote or local/auto selector switch in local mode,
- Control supply failure,
- ACB ready to close indication.
- Emergency push button (EPB) operated, and
- L V S B under voltage alarm.

1.1.24 Sheet Steel Treatment and Painting

Sheet steel used in the fabrication of switchboards shall undergo a rigorous cleaning and surface treatment seven tank process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognized phosphating process after which a coat of primer paint comp actively with the final paint shall be applied over the treated surface. Final paint coat of oven baked powder coating, of minimum 50-micron thickness, of sheet approved by Engineer-in- Charge shall then be provided.

1.1.25 Name Plates and Labels

Suitable engraved white on black nameplates and identification labels of metal for all switchboards and circuits shall be provided. These shall indicate the feeder number and feeder designation.

1.1.26 General Requirements

The designated panels will be interfaced with BMS/ Fire Detection/ Firefighting systems. All necessary provision to be made in the panels for these interfaces. Designated panels will be provided with clean agent gas system, which must be taken care by the panel manufacturer at their works or for making the necessary provisions for accommodating the same inside the panels and conduct necessary tests at factory.

1.1.27 Relays, Ct's, Pt's, Meters, Indicating Lamps

This section covers specifications for protection and control relays for breakers, Instruments transformers, Measuring Instruments, push buttons, Indicating Lamps in LT switchboards.

1.1.27.1 Standards and Codes

Updated and current Indian Standard Specifications and Codes Practice will apply to the equipment and the work covered by the scope of this contract. In addition, the relevant clauses of the Indian Electricity Act 2003, Indian Electricity Rules 1956, National Building code 2016. National Electrical Code 2011, Code of Practice for Fire Safety of Building (general): General Principal and Fire Grading – IS 1641 as amended up to date shall also apply. Whenever appropriate Indian Standards are not available, relevant British and/or IEC Standards shall be applicable.

Application guide for Current transformers	IS 4201
Application guide for Voltage Transformers	IS 4140
Application guide for Relays Electromagnetic Relays	IS 3842
	IS 5051

1.1.27.2 Protection and Control Relays

The Circuit Breaker shall have protection and control relays as specified in the schedule of quantities. Relays shall be approved types complying to relevant IS. and having approved characteristic. Relays shall be flush mounted in dust proof cases. Relays shall be arranged so that adjustments, testing and replacement can be affected with minimum of time and labour. All relays shall be microprocessor based programmable (third generation) type relays. In case of C.T. operated thermal overload and magnetic instantaneous short circuit release, the overload release shall be such that each phase can be individually set depending on the phase unbalanced currents. The releases shall have inverse time current characteristics and the magnetic release shall be time delayed with a minimum setting of 25 ms varying up to 300 ms for discrimination without the breaking current capacity of the ACB.

1.1.27.3 Current Transformers

Separate sets of CTs shall be provided for metering and protection. CTs shall conform to 2705 (part –I, II and III) in all respects. All CTs used for medium voltage application shall be rated for 1 KV. CTs shall have rated primary current, rated burden and class of accuracy as specified in Schedule of Quantities/drawings. Rated secondary current shall be 5A unless otherwise stated. Minimum acceptable class for measurement shall be class 0.5 to 1 and for protection class 5P10. CTs shall be capable of withstanding magnetic and thermal stresses due to short circuit faults as applicable. Terminals of CTs shall be paired permanently for easy identification of poles. CTs shall be provided with earthing terminals for earthing chassis, frame work and fixed part of metal casing (if any). Each CT shall be provided with rating plate indicating:

- Name and make
- Serial number
- Transformation ratio
- Rated burden
- Rated voltage
- Accuracy class

CTs shall be mounted such that they are easily accessible for inspection, maintenance and replacement. Wiring for CT shall be copper conductor FRLSZH insulated wires with proper termination works and wiring shall be bunched with cable straps and fixed to the panel structure in a neat manner. Facilities for shorting terminal shall be provided.

1.1.27.4 Potential Transformers

PT's shall conform to IS 3156 (Part I, II and III) in all respect. Primary and secondary circuit wiring star connected, and voltage ratio shall be 33 KV / $\sqrt{3}$ / 110/ $\sqrt{3}$ or 415/ $\sqrt{3}$ / 110/ $\sqrt{3}$ as specified in Schedule of Quantities. Class of accuracy shall be 1.0. Over voltage factor shall be 1.2.

1.1.27.5 Measuring Instruments

Direct reading electrical instruments shall conform to IS 1248 or in all respects. Accuracy of direct reading shall be 1.0. Meters shall be suitable for continuous operation between 0°C and 50°C. Meters shall be flush mounting and shall be enclosed in dust tight housing. The housing shall be of steel or phenolic mould. Design and manufacture of meters shall ensure prevention of fogging of instruments glass. Display shall be LCD / TFT only. Suitable selector switches shall be provided for ammeters and voltmeters used in three phase system unless otherwise stipulated, 96 mm x 96 mm instrument shall be used. The meter shall be built- in selector switch. The rating type and quantity of meters, instruments and protective device shall be as per schedule of Quantities/drawings. Ammeter on motor circuit shall be provided with suppressed scales to take care of shorting surges.

1.1.27.6 Ammeters

Ammeters shall be of digital type. Ammeter shall be latest Micro controller-based technology, built in selector switch for phase selection, ultra-bright LED display.

1.1.27.7 Volt Meters

Voltmeters shall be digital type range of 3 phase 415-volt voltmeters shall be 0-500. Volt meters shall be provided with protection MCB.

1.1.27.8 Power quality Analysers

Power Quality analysers (PQA) shall be of 3 phase LCD /TFT display digital type and shall be provided with a maximum demand indicator if required equipped with Ethernet port & RJ-45 port and connection with BMS System. The PQA should be compulsorily positioned at all LT Incomer panels. The PQA shall be able to determine whether a disturbance event occurred upstream or downstream of the meter to help locate the fault origin. The PQA shall sample continuously at 128 / 256 samples per cycle with 512 MB non-volatile one-year data memory with disturbance direction detection.

The PQA shall provide with minimum the following values:

- Voltage L-L per-phase and average.
- Voltage L-N per-phase and average.
- Voltage unbalance (%).
- Current per phase, neutral, and average.
- Current unbalance (%).
- Active power (per phase, three-phase total).
- Reactive power (per phase, three-phase total).
- Apparent power (per phase, three-phase total).
- Power factor - fundamental (per phase, three-phase total).
- Power factor - displacement (per phase, three-phase total).
- Accumulated energy (active, reactive, and apparent).
- Incremental energy (active, reactive, and apparent).
- Demand, predicted demand, peak demand with date and time.
- THD up to 40th harmonic (total, even, odd) with magnitude and angle for individual harmonics.
- minimum/maximum value for measured parameters.
- Password protection for unauthorized access.

1.1.27.9

Multi-Function Meters

A. General Requirements

- The meter shall be suitable for operation in 3 - phase networks, balanced as well as unbalanced load, Four quadrant metering.
- It shall be possible to use the multifunction meter directly in 415V (LL) / 230V (LN) networks or 110V (L-L) / 63.5V (L-N) networks.
- The multifunction meters shall be suitable for operation up to 55 Deg C.
- The meters shall be self-powered. Size 96 mm square, panel cut out 92 mm square.
- The multifunction meters shall have backlit LCD / TFT display.
- The meter shall be tamper-proof (password protected) to avoid mishandling by unauthorized person.
- Accuracy of meter will be 0.5 for main panel & for remaining panel will be 1
- Standard: IS14697.
- Sampling rate: 64 samples per cycle.

B. Measured Values requirement

All metered values will be in "true RMS" values. The monitor shall include a keypad allowing for the viewing of different selected values. The monitor shall display the following values

- Voltages: Phase-phase / phase-neutral.
- Currents: Per phase / neutral.
- Apparent, active and reactive power: Three Phase total.

- Power factor: Individual Phase & Total Average.
- Frequency: 50 Hz \pm 5%.
- Max. / Min. Values: Max. Min. Voltage phase wise, Max. Line Current Phase Wise, Min Cap and Ind PF, Max Min Frequency, Max Active Reactive & Apparent Power.
- Active energy: Import / export.
- Reactive energy: Import / export.
- Energy demand per measuring period: Three phase average rating for active and apparent power: 30 min.
- Min. / max. rating values within the measuring period: Should be possible to be measured.
- THDI & THDV up to 40th.

C. Measurement Accuracy

The multifunction meters shall be of high accuracy type and shall have the following levels of accuracy. (Accuracy class in accordance with IS 14697).

D. Communication

The meters shall have inbuilt RJ-45 port with MODBUS over TCP/IP protocol. It shall be possible to provide meter ID / Baud Rate by the keys on the meter. Meter should easily communicate with SCADA system to take all required values of meter.

1.1.27.10 Energy and Reactive Power Meters

Trivector meters shall be two elements, integrating type, KWH, KVA, KVARH meters. Meters shall confirm to IEC 170 in all respects. Energy meters, KVA, and KVARH meters shall be provided with integrating registers. The registers shall be able to record energy consumption of 1000 hours corresponding to maximum current at rated voltage and unity power factor. Meters shall be suitable for operation with current and potential transformers available in the panel.

1.1.27.11 Indicating Lamps

Cluster LED type indicating lamps shall be provided for indication of phases and Breaker position as required in the Schedule of Quantities. Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

1.1.27.12 Push Buttons

Push buttons shall be of non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. Contacts shall be of adequate strength and have a positive whipping action when in operation.

1.1.28 Local Authorities Requirements

All requirements by the local authority including those listed below shall be complied with for floor - mounted switchboards as required.

- Danger Notice Plate.
- Rubber floor mat complying with relevant IS to be provided for the full length of the switchboard.

1.1.29 Test Certificate

Type test certificates of all standard component parts, e.g. contactors, breakers, switches, relays, CT's, PT's, Control wires etc. and for the standard factory-built assembly shall be submitted by the supplier.

If the type test certificate for any item is not available for the similar ratings, then the type tests must be conducted, and relevant documents shall be submitted.

1.1.30 Testing and Inspection

1. Certificate for all routine and type tests for circuit breakers in accordance with the IS: 2516 -1963 shall be furnished.
2. All panels shall be meggered phase to phase and phase to neutral using a 1000 / 500 V megger with all

outgoing feeders in closed position. The megger value should not be less than 200 mega ohms between phases and 200 mega ohms between phase and neutral.

3. All meters and relays shall be calibrated and tested through secondary injection tests.
4. Pre-commissioning tests as required and as per manufacturers recommendations shall be carried out in the presence of OEM manufacturer on each switchboard at site before energizing the switchboards including but not restricted to the following:
 - a) Physical checking of the switchboards including checking alignment of panels, interconnection of Bus bars, tightness of bolts / connections and evidence of damage / cracks in any components.
 - b) Physical checking and inspections of inter panel wiring
 - c) Checking of free movement of ACBs / MCCBs
 - d) Checking of operation of breakers
 - e) Insulation tests of bus bar supports and control wiring etc. with 1.1 kV megger.
 - f) Primary & secondary injection tests of relay and CTs.
 - g) Checking of interlocking function.

1.2 External Feeder Pillar

External Feeder Pillars for outdoor lighting with fixed canopy shall be provided for distribution to Mast and street lights, should be IP65 and shall be suitable for operation on 3 phase 4 wire/ single phase 2 wire, 415/ 240 Volts + 10%, 50 cycles, neutral solidly grounded at transformer and short circuit level not less than 10KA at 415 Volts. All external feeder pillars shall be as per relevant IS. The short circuit current rating including Bus sizing and bus bracing shall not be less than the specified rating.

1.2.1 Construction Features

The Feeder Pillars shall be sheet cabinet for outdoor installation, dead front, floor mounted. The Distribution Panel shall be totally enclosed, completely dust and vermin proof and shall be with hinged doors, Neoprene gasket and padlocking arrangement shall be made. Steel sheets used in the construction of Feeder pillar shall be 3mm thick for structural members and 2mm thick for doors & covers and shall be folded and braced as necessary to provide a rigid support for all components. Ingress rating protection of feeder pillars shall be not less than IP-65.

All Feeder Pillars and covers shall be properly fitted and square with frame, and holes in the panel correctly positioned. Fixing screw shall enter into holes tapped into an adequate thickness of metal or provided with wing nuts. Self-threading screws shall not be used in the construction of Distribution Boards. A base channel of 75mm x 40mm x 5mm thick shall be provided at the bottom of feeder pillars. Minimum clearances of 200mm shall be provided between the floor of Feeder Pillars and the lowest units.

Feeder Pillars shall be of adequate size with a provision of spare switchgear as indicated on the single line diagram & bill of quantities. Breakers shall be arranged in multi-tier. Knockout holes of appropriate size and number shall be provided in the Feeder pillars in conformity with the location of cable connection. Removable sheet steel plates shall be provided at the bottom with knockouts for additional cable entry at site if required.

Every cabinet shall be provided with Trifoliate or engraved metal plates. All panels shall be provided with circuit diagram engraved on PVC sheet. All live accessible connections shall be shrouded and minimum clearance between phase and earth shall be 20mm and phase shall be 25.4mm.

1.2.2 Bus Bar Connection

The bus bar and interconnections shall be of Copper and of rectangular cross section suitable for full load current for phase bus bars and neutral bus bars. The bus bars and interconnections shall be insulated with heat shrinkable sleeve and shall be colour coded. The bus bars shall be supported on glass fibre reinforced thermosetting plastic insulated supports at regular intervals to withstand the forces arising in case of short circuit in the system. All bus bars shall be provided in a separate chamber and all connection shall be done by bolting, additional cross sectional area to be provided to compensate for the holes. All connections between bus bars and breakers shall be through solid copper strips of proper size to carry full rated current and insulated with heat shrinkable sleeves. Bus bars and connections shall be sized, braced and supported to withstand the mechanical forces and thermal effects resulting from short

circuit current.

1.2.3 **Cable Compartments**

Cable compartment of adequate size shall be provided in Feeder pillars for easy clamping of all incoming and outgoing cables entering from the bottom. Adequate supports shall be provided in cable compartments to support cable.

1.2.4 **Miniature Circuit Breaker**

Miniature Circuit Breaker shall comply with IEC/IS 60898-1, IS-8828-1996/IEC898-1995. Miniature Circuit Breakers shall be quick make and break type for 230/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity shall not be less than 10 KA at 415 V AC. MCBs shall be DIN mounted. The MCB shall be Current Limiting type (Class-3). MCBs shall be classified (B, C, D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer. The MCB shall have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer shall publish the values.

The housing shall be heat resistant and having a high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP and FP miniature circuit breakers shall have a common trip bar independent to the external operating handle.

1.2.5 **Earthing**

Earth bus bar shall be provided at bottom inside of the Feeder pillar and clamp shall be provided for external earthing.

Earth bus bar shall be of sufficient cross section to carry momentary short circuit and short time fault current to earth.

All non-current carrying metal parts shall be effectively bonded to earth bus.

1.2.6 **Painting**

All sheet work shall undergo a process of degreasing, pickling in acid, cold rinsing, and phosphating, passivating and then painted with two coats of Zinc Chromate primer paint and then baked in an oven. The finishing treatment shall be by application of two coats of powder coating paint shade of colour of panel inside/ outside shall be 631 of IS code.

1.2.7 **BMS Interface**

Electrical Contractor shall cross reference the requirement of BMS remote control and monitoring interface as required for electrical equipment's and shall provide the necessary volt free contact and remote-control interface for BMS.

Serial interface as applicable for ACB/MCCB and digital meters or MFMs shall be strictly on standard protocol communication (preferable with MODBUS-TCP over Ethernet) Necessary interface detail and drawing shall be provided to BMS contractor during commissioning.

All terminals and BMS interface terminal and ports shall be wired to a separate chamber with adequate number of ITBs and with proper marking as per interface document.

No such change in contact or pseudo signal shall be provided for critical alarms control interface.

BMS and PLC interface for control command shall be pulse type close contacts for single command output / double command output or a variable voltage/current (i.e.0V- 10V or 4mA - 20 mA) for analogy output command.

There shall be one interface for control open and one for control close operations. The Contractor shall provide appropriate equipment to sense and latch the remote control signal for performing the open/close control function. The BMS digital output (DO) & analogy output (AO) signal shall be as stipulated.

Contacts shall be rated to adequately make and break and carry continuously not less than 5A at 250V AC or 2A at 110 V AC –Potential free contacts for sequence of event (SOE) and alarms shall firmly close and seat in position once activated. The contacts shall not bounce or vibrate due to internal or external causes.

Required data point as per BMS requirement shall be configured in respective controller or equipment by panel manufactures as required with necessary hardware and software for above said serial link communication.

1.3 **Integrated Hybrid Solution panel for PF improvement including static VAR Generator.**

Manufacturer of the Integrated Hybrid Solution Panel shall be the manufacturer of the Principal Power Quality Solution Equipment, viz., Capacitor, Reactor, Capacitor duty Contactor, Thyristor Switching Module, Power Factor Controller, APFC panels, Static VAR Generator.The Manufacturer shall also have at least 25 years of experience in the field of

Manufacturing of capacitors. The components and assemblies should have Type tested in an external NABL accredited laboratory. Manufacturer shall have in-house facility for demonstrating the functional testing of the Integrated Hybrid panel including that of harmonic filtering and that of thermal mapping. There must be one enclosure with common incomer, master intelligent controller for both APFC and SVG.

Hybrid integrated solution hereafter will be referred as single hybrid panel consisting of APFC with step configuration and Static VAR Generator with combination of one or more filter modules which provides stepless power factor correction system.

1.3.1 **Scope**

Design, manufacture, supply, erection, testing and commissioning of Indoor Type Automatic Power Factor correction capacitor Panel for power factor improvement as per specification given below:

1.3.2 **Standard**

Unless otherwise stated below, the capacitor shall comply with the following standards (and their latest amendments): IS 13340-1993, IS16636:2017 "applicable for 'Low-Voltage APFC capacitor panel' (Voltages up to 1000V). The Panel Manufacturer must have the following type test certificates and possess the Routine test at the factory premise:

- Verification of effectiveness of automatic PF correction (Type test).
- Measurement of transient over-currents due to capacitor switching (Type Test).
- Temperature rise test (Type test).
- Test for checking functional operation (Routine test).
- Guidelines about electrical environment.

1.3.3 **Capacitor panel**

BOQ shall be used to form a bank of capacitors of desired capacity. In Order to ascertain highest reliability of the system the Capacitor Panel shall be of single make only (Capacitor/Capacitor duty contactor/Series Reactor). The APFC panel must be of OEM make only.

Each power factor correction equipment shall consist of capacitors, switchgears, cables, cable gland, control relays, step controllers, sensing apparatus, CTs and contactors etc. Capacitor bank with rating as shown on the drawings shall be provided and connected to the designated switchgear in the LV main switchboard to improve the overall power factor to not less than 0.95 lagging. The Contractor shall ensure that the power factor correction equipment shall not cause harmonic resonance in the LV electrical network. The system shall ensure that a leading PF does not occur.

1.3.4 **Construction:**

Each basic unit of Metallized Polypropylene (MPP) Heavy Duty capacitor shall be built with several elements. These elements shall be combination of capacitor tissue paper and Film Foil capacitor manufactured using Poly propylene film placed between 2 layers of metal foil and winding. The elements shall be connected to the external bus bars through these leads in a series parallel connection to form a three-phase unit.

The capacitor units shall be Stud Mounting Cylindrical Construction having high Inrush current capability (Up to 500xIr) and Over current capability (Up to 2.0 x Ir) with using minimum floor space. The container of capacitors shall be made from 2 mm thick M S sheet steel of polyester paint coated finish. Each standard unit shall be provided with internal fuses (operation coordinated with case-rupture characteristics to avoid rusting).

The capacitor bank shall be of floor standing type built up from static primary capacitor units. The primary capacitor unit shall be of the dry type without impregnation liquid, self- healing and with losses not greater than 0.5 W / KVA_r.

The primary capacitor unit shall comply with the requirement of IEC 60871-1 or BS 1650. Each capacitor bank shall be fitted with an automatic discharge assembly which shall discharge the entire capacitor bank from the peak alternating voltage to a voltage not exceeding 50 V measured at the capacitor bank terminals one minute after-disconnection-from-the-supply.

The capacitors shall be controlled by an automatic multi-step capacitor control relay switching the appropriate

bank of capacitors in stages minimum to achieve the best average power factor. A no-volt and single phasing protection shall be provided. All capacitors involved shall be disconnected instantaneously, and reconnected step by step at intervals after the supply is restored.

The power factor correction equipment shall be a self-contained integral unit. The control relays, fuses and contactors etc. shall be housed in a cubicle complete with an isolation switch interlocked with cubicle door. Local/off/auto selector switch and visual indication of energized capacitor with red lamps, etc. shall be provided. The following alarms shall be provided.

Local Alarms:

- Out of Steps
- Over-compensation
- Over current
- Overvoltage
- Capacitor Bank Failure
- Capacitor Bank On/Off.

Remote Alarms:

- Capacitor Bank General Failure
- Capacitor Bank Off (Out of Service).

1.3.5

Capacitor Features

- Conformance to Standards IEC 60831-1 & 2, EN60831-1 & 2
- General specifications: 3 phases, delta connected, 50 Hz.
- Capacitors must be ISI marked as per updated according to Energy efficiency act 2001.
- Self-healing property.
- Life Expectancy up to 2, 00,000 Operating Hours (-40/D).
- Switching capacity shall be 15000 Switching per year to handle dynamic load.
- Voltage: Must be designed to withstand system over voltage, increased voltage due to series reactor and harmonics.
- Capacitor type: Super heavy duty, Resin filled type, with 2.2. KV PIV Dry Type.
- Overvoltage +10% (12h / 24h), + 15% (30m / 24h), + 20% (5m), +30% (1m) as per Clause 6.1 of IS 13340-1993.
- Overcurrent: $2.0 \times I_n$
- Peak Inrush current withstand: $500 \times I_n$
- Total watt-losses (excluding) discharge resistors: $< 0.45 \text{ W / k V Ar}$.
- Temperature category: -40 deg. To 60 deg. or at D class.
- Capacitor shall be self-heating type and oil impregnated for longer life. The impregnant shall be inert gas, biodegradable type, must be properly treated and de-gasified, so as not to have any degeneration properties and shall be non-oxidizing.

The design shall be modular for simple mechanical assembly, no extra accessories metal parts to be required. Unit must be free standing with an IP 54 protection level.

The automatic control shall be accomplished using an automatic multi-stage kVAr sensitive, solid state relay having several stage switches, which shall operate the capacitor contactors.

Capacitor banks shall comprise single phase units with sheet steel case and terminals suitable for connection with copper bars in delta connection and shall be built from modular units preferably of identical rating. Impregnates

used in capacitors shall be non-harmful and shall not have been condemned-by-any-Environmental-protection-agencies.

1.3.6 Series Reactor

1. Application

LV Harmonic Filters shall be used with harmonic filter duty power capacitors to mitigate harmonics in APFC System, improve power factor and avoid electrical resonance in LV electrical networks.

2. Construction, Testing & Protection

The low voltage filter reactor shall be series type having a three phase, iron core construction suitable for indoor use (IP 00). The reactor shall be air cooled and the layout shall be in accordance with IEC 60076.

The complete unit shall be impregnated under vacuum and over-pressure in impregnation resin and shall be suitable for temperature Class H (T60/H) operation.

The reactor shall be tested using a separate source voltage test of 3.0kV (coil to core) for 1 minute as per IEC 60076/3.

The permitted tolerance of inductance shall be $\pm(5\%)$ of rated inductance value.

Reactor tuning factor shall be (7%) and the current rating of the reactor shall include the effects of harmonics and other possible over-currents.

The reactor shall be fitted with a temperature sensitive micro-switch in the centre coil (normally open) for connection to trip circuits in case of high operating temperatures.

1.3.7 Discharge Resistance

Capacitors shall be provided with permanently connected discharge resistors so that residual voltage of capacitors is reduced to 50 volts or less within one minute after the capacitors are disconnected from the source of supply.

1.3.8 Terminal

Each capacitor bank shall be provided with a SIGUT terminals shall be preferable

Terminal chamber and cable glands suitable for PVC insulated aluminium conductor armoured cables as specified.

1.3.9 Earthing

Two separate earthing terminals shall be provided for earth connection of each bank.

1.3.10 Switchgear & protection

Incomer switchgear shall be TP&N breaker of appropriate rating. Suitable contactor for each step shall be used and must be capable of capacitor switching duty at each step for short circuit protection.

Busbars shall be suitably colour coded and must be mounted on appropriate insulator supports.

Power cables used shall have superior mechanical, electrical and thermal properties, and shall have the capability to continuously operate at very high temperatures up to 125 degC.

Internal wiring between main bus-bars, breaker, contactor and capacitors shall be made with 1100 V grade, FRLSZH insulated, copper conductor cable of appropriate size, by using suitable copper crimping terminal ends etc.

Suitable bus links for input supply cable termination shall be provided.

1.3.11 Control circuit & General protection

The control circuit shall be duly protected by using suitable rating MCB.

An emergency stop push button shall be provided to trip the entire system (22.5 mm dia, mushroom type, press to stop and turn to reset). Wiring of the control circuit shall be done by using 1.5 sq.mm, 1100 V grade, FRLSZH insulated, multi-stranded copper control wire. Inspection terminal strip, number ferruling, labelling etc. shall be provided.

440 V caution board on the panel shall be provided.

1.3.12 APFC relay/ controller

Microprocessor based APFC relay (Intelligent VAR controller) should have dual sensing so that on Transformer supply it can suitably switch to desired power factor shall sense the PF in the system and automatically switch ON / OFF the capacitor unit or stage to achieve the preset target PF. The controller shall have the following features:

- Digital settings of parameters like PF, Switching time delay, Step limit etc.
- LCD Display displaying P.F./V/I/KVA/KW/KVAR temp./Harmonics (THD and Individual for Voltage and current)
- Indication of PF, preset parameters, Contactors switching operation, and Capacitors operating Life
- Minimum threshold setting of 1% of CT current.
- No-volt release.
- Unique External Temperature Sensing by PT100.
- EMI/EMC Type Tested.
- Protective shut down in case of harmonic overload.
- Shall be compatible of HT single CT sensing from HT and LT (BR5008/BR6000) relay.
- Indication for Failure to achieve the target PF, Harmonic overloading, Step failure etc.

1.3.13 Static VAR Generator cum load balancer

The Static VAR Generator is intended to compensate the reactive power requirement in a 3-phase, 3/4-wire electrical system stepless manner. The Static VAR Generator shall in co-ordination with advanced multilevel controller will perform below actions

- Sense the existing power factor.
- Offer reactive power compensation exactly as per requirement.
- Will be able to switch-ON/OFF the conventional LC banks used in Hybrid panel.
- Automatically transfers the reactive load to the LC bank.
- Able to offer leading compensation.
- a) Electrical system data:
 1. System Voltage: 400V/415V/440V for a 3 phase, 3/4 wire system.
 2. Supply voltage tolerance: +/- 10%.
 3. System Frequency: 50 Hz, +/- 3Hz.
- b) Basic product requirements
 1. The Static VAR Generator shall meet the following basic requirements:
 - a) The Static VAR Generator shall be based on 3 level topologies
- c) The Static VAR Generator shall have a Switching frequency of 20kHz
- d) The Static VAR Generator shall have a minimum immediate load change Reaction time within a span of 5ms (millisecond).
- e) The Static VAR Generator shall have a TFT Colour Control with LED Backlit Display touch screen unit shall be a minimum of 7" for display of parameters as also for setting.
- f) The Static VAR Generator shall be suitable for operation within an ambient temperature between -10 to + 40 °C without deration.
- g) The details of advanced multilevel controller should be as below

Technical data and specifications of PQvar Advanced Multi Controller (AMC) unit	
External ports	
Control output contact	Control outputs, up to 18 at most Contact support: 120 V AC / 10 A, 220 V AC / 8 A, 400 V AC / 3 A, 110 V DC / 0.2 A, 60 V DC / 0.6 A, 24 V DC / 5 A Level signal: 12 V DC / 30 mA
Reserved dry contact	One input and one output
Communication protocol	MODBUS
Protection functions	Under-voltage, over-voltage, under-frequency, over-frequency, phase failure, high harmonic voltage, SVG over-load, SVG over-temperature and others
Display	7-inch touch screen
Installation requirements	
Power consumption	< 25 W
Protection class	IP41 for the front panel, and IP20 for the rear panel
Operating environment	
Operating temperature	-20 °C to +60 °C
Altitude	≤ 2500 m
Humidity	≤ 95%
Storage temperature	-40 °C to +70 °C
CT ratio	150/5 ~ 10000/5

1.3.14 Testing & commissioning

After installation of the capacitor the following pre-commissioning test shall be carried out at site.

- Insulation resistance shall be tested with a 1000 volts' megger between phases and phase to earth.
- Residual voltage shall be measured after switching of the capacitors and the same shall not be more than 50 volts after one minute.
- Each discharge resistor shall be tested for its working.
- Voltage Test
 - Between terminals - 2.15Xrated voltage at rated 10 frequency applied for 10seconds Between terminals and containers - 3kV applied for 10 seconds.
- Type tests for the equipment shall include 1.4 x operating voltage, temperature cycling and repeated-switching.
- The capacitor bank shall be subject to test as specified in relevant Indian standards at the factory and the test certificate shall be furnished in quadruplicate.

1.4 Active Harmonic Filter

1.4.1 Scope

This specification covers design, manufacture, supply, testing and commissioning of Harmonic Filter Equipment intended for indoor installation for the reduction of harmonics within specified limits. It shall be capable of load balancing in all the 3phases.

1.4.2 General Technical Specifications

- The Active Harmonic Filter is intended to eliminate harmonic distortion from the line conductors in a 3-phase, 3/4-wire electrical system resulting in reduced line current, reduced current distortion and reduced upstream electrical system harmonic voltage distortion.
- The active harmonic filter shall mitigate harmonics from the 2nd harmonic up to the 50th harmonic and limit harmonic distortion at its point of connection to within the harmonic limits specified herein.
- The active harmonic filter shall be designed to connect in parallel with each of three phase conductors of a 3-phase, 3-wire or 3-phase, 4-wire electrical power system.
- The active harmonic filter shall be suitable for connection at the LV side of the transformer, at the electrical power distribution panel or at a specified individual load.
- The equipment shall provide harmonic mitigation, dynamic power factor correction and load balancing on individual phases.
- The equipment shall be suitable for operation on an electrical system being fed by a generator as its input

power source.

- The equipment shall be modular in nature to facilitate ease of maintenance and minimal inventory of spares.

1.4.3

Electrical System data

- System Voltage: 200V – 480V \pm 10%, for a 3 phase, 3 wire system, and 200 V- 400 V \pm 10% for a 3 phase, 4 wire system.
- Supply voltage tolerance: +/- 10%
- System Frequency: 50 / 60 Hz, +/- 3Hz.
- Harmonic Cancellation Current per Phase: 35A, 60A, 75A, 150A harmonic Cancellation Current for the Neutral for a 3 Phase, 4 wire equipment: It must be modular design of 35A, 60A, 75A, 150A.
- The design shall comprise of multiple filter units in parallel connection to achieve the total current requirements for harmonic mitigation.

1.4.4

Basic product Requirement

The active harmonic filter shall meet the following basic requirements:

- The Active Harmonic Filter shall be based on 3 level topologies. The Active Harmonic Filter shall have very low Power losses.
- The Active Harmonic Filter shall have a rate of harmonic reduction > 98%.
- The Active Harmonic Filter shall have Under voltage and Overvoltage protection.
- The Active Harmonic Filter shall have integrated overload protection.
- The Active Harmonic Filter shall have Internal short circuit protection.
- The Active Harmonic Filter shall have Overheating protection.
- The Active Harmonic Filter shall have Inverter bridge protection.
- The Active Harmonic Filter shall have Grid Resonance detection and protection.
- The Active Harmonic Filter shall have Fan fault alarm.
- The Active Harmonic Filter shall have Overheating protection.
- The Active Harmonic Filter shall have facility to select and compensate individual Harmonics up to 50th order. The degree of compensation on each individual harmonic shall be adjustable from 0% to 100% and also it is possible to set a maximum current in Ampere for each Harmonic.
- The Active Harmonic Filter shall be controlled by a minimum of 32 bit DSP.
- 14 The Active Harmonic Filter shall have a Switching frequency of 24kHz and Control frequency of 48kHz.
- The Active Harmonic Filter shall have a minimum immediate load change reaction time of 50 microseconds.
- The Active Harmonic Filter shall have a steady state response time to full steady state compensation of < 300 μ s.
- The Active Harmonic Filter shall have a TFT Colour Control with LED Backlit. Display touch screen unit shall be a minimum of 7" for display of parameters as also for setting. The IP class for the display shall be IP65. The brightness Intensity shall be not less than 450cd/m² for convenience of visibility from a reasonably long distance. Optionally 12.1" size display screen shall be available for better viewing.
- The Active Harmonic Filter shall have the option of using only one portable display touch screen unit which can be connected individual AHF separately for parameter setting. This facility can be of use where many AHFs are installed. This facility shall serve as a parameter setting tamper proofing arrangement.

1.4.5 Standards for Active Harmonic Filter:

Code	Description
ANSI/IEEE 519 - 2014	Guide for Harmonic Control and Reactive Compensation of Static Power Converters.
ASCE 7	Minimum Design Loads for Buildings and Other Structures
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
EN 61000-6-4 Class A, EN 61000-6-2	EMS
ASTM E 329	Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
UL 508	Standard for Industrial Control Equipment
UL 1449	Standard for Transient Voltage Surge Suppressors

1.4.6 System Description:**1.4.6.1 Performance Requirements:**

1.4.6.2 Active harmonic filter (AHF) shall be defined as a power electronic device consisting of power semiconductors known as insulated gate bipolar transistors (IGBT) that switch into the AC lines to modulate its output to mitigate detrimental harmonic current; correct the displaced reactive current (leading or lagging); and balance the current (also known as negative sequence current) for the power source.

1.4.6.3 THD(v) shall be limited to not more than 5 percent as contributed by the loads at the location of each AHF.

1.4.6.4 *THD(i) shall be limited to 3% or less as long as AHF is 50% or more loaded and all nonlinear loads have 3% or larger input impedance. A THD(i) set point may be set to optimize THD(i) performance.

1.4.6.5 *Displacement power factor (PF) shall be corrected to 0.99 or better at the location of each AHF.

1.4.6.6 Displacement PF shall never go leading due to AHF performance or design.

1.4.6.7 *Source current imbalance shall not exceed 2% phase-to-phase after correction. (*Sizing should be done accordingly)

1.4.6.8 Service Conditions:

Active harmonic filter shall be suitable for the following conditions:

1.4.6.9 **Operating Ambient Temperature Range:** Up to 100A shall have an operating temperature range of 0 °C to 45 °C.

1.4.6.10 **Maximum Altitude:** 3300 feet (1000 m) with derating at 1% per 100 meters.

1.4.6.11 **Humidity:** to 95 percent, non-condensing.

1.4.7 EQUIPMENT SIZE / RATINGS

1.4.7.1 Active harmonic filter (AHF) shall be designed to operate from an input voltage of 380 V AC to 480 V AC, plus 10 percent, minus 15 percent at each nominal voltage. AHF shall be designed to operate with an AC supply frequency of 50 Hz or 60 Hz, +/- 3 Hz. AHF heat losses shall not exceed more than 3 percent of the unit kVAR rating.

1.4.7.2 An energy saving feature shall be provided to permit stopping AHF when load goes below a desired set point (10% factory setting) and turn on at some higher set point (15% factory setting)

1.4.7.3 Safety features include a dead front design where upon opening the enclosure door on floor standing units. Extreme measures must be taken to bypass this safety dead front design. To perform service, the enclosure door should never be opened without locking out the upstream feeder breaker.

1.4.8 Active Harmonic Filter Unit**1.4.8.1 Enclosure:**

AHF shall be provided in IP 42 enclosure.

1.4.9 Function of AHF:

1.4.9.1 AHF shall have automatic restart capability upon power loss return and fault resets.

1.4.9.2 Fault trip limit shall occur after five restarts within a 5-minute period and provide positive shut down and noticed. Upon occurrence of the fault trip limit, AHF shall stop output current production and lock out restart until the fault is manually cleared. AHF shall incorporate an over-temperature output roll back that shall reduce the total output current to reduce power component heating in order to maintain maximum current correction at the elevated temperatures within the electrical system.

1.4.9.3 AHF shall monitor the incoming air temperature and invoke a hard trip of the unit at 124°F (51°C), before it must give the alarm at the temp of 48°C.

1.4.9.4 AHF shall be compatible with SPD, EMC filters, SCR (thyristor) snubber circuits, and switched mode power supplies (SMPS).

1.4.10 Operator Interface:

1.4.10.1 AHF shall have a door-mounted human machine interface (HMI) with touch screen control rated NEMA 4-12 (IP65), dust-tight and liquid-resistant.

Note: HMI is not suitable for outdoor use.

1.4.10.2 HMI shall provide run/stop control from every screen. HMI shall provide an oscilloscope feature to display specific parameters.

- a. Three sets of data may be monitored at a time. Up to twenty predefined parameters can be chosen for each curve.
- b. Performance trend curves shall be displayed for load total RMS current, load RMA harmonic current per phase, AHF harmonic current output per phase, AC mains voltage per phase, THDi, TDD, load RMS reactive current, and AHF RMS reactive current output.
- c. Bar graphs shall be provided for display of the mains and load harmonic current amplitudes per harmonic order.
- d. Selected internal curves shall be provided for diagnostic and performance checks

1.4.10.3 HMI shall provide external communications via an RJ45 connectors. Modbus TCP/IP shall provide remote run/stop and display of operating parameters, set-up parameters and diagnostic functions.

1.5 MPCB (Motor Protection Circuit Breaker)

1.5.1 Motor protection circuit breakers shall comply with the general recommendations of standard IEC 60947, Part - 1, 2 and 4 (Section-1).

- a) The devices will be in utilization category A, conforming to IEC 60947-2 and AC3 conforming to IEC 60947, Part - 4 (Section-1).
- b) Rated operational voltage of 690V AC (50/60 Hz)
- c) Rated insulation voltage of 690V AC (50/60 Hz)
- d) Isolation conforming to standard IEC 60947-2,
- e) Rated impulse withstands voltage (U_{imp}) of 6 kV.

1.5.2 MPCB shall meet following requirement: -

1.5.3 Mounting

The motor circuit breakers will be designed to be mounted vertically or horizontally without de-rating.

1.5.4 Contacts

In order to ensure maximum safety, the contacts will be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc., by high performance thermoplastic chambers.

1.5.5 Operating mechanism

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 will close, open, and trip simultaneously.

1.5.6 Button

The motor circuit breakers will be actuated by a rotary operator clearly indicating the position ON (I), OFF (O), trip

1.5.7 Isolation:

- a) The mechanism will be designated so that the different types of operator will only be in position (O) if the main contacts are physically separated.
- b) In position (O) the operating devices will indicate the isolated position.
- c) Isolation is enhanced by the double break of the main circuit.

1.5.8 Padlocking

Motor circuit breakers will accept a padlocking device in the "isolated" position.

1.5.9 Trip

The motor circuit breakers will be equipped with a "PUSH TO TRIP" device on the front enabling the correct operation of the mechanism and poles opening to be checked.

1.5.10 Limitation and Durability

- a) The motor circuit breakers will be current limiting for a mains voltage of 400 V, the maximum let-through energy (I^2t) on short circuit being extremely low.
- b) The motor circuit breakers will have a high electrical and mechanism durability of at least 5 times that required by the standard.

1.5.11 Protection functions

The motor circuit breakers will be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection.

1.5.12 In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) will be factory set to an average value of 12 Ir.

- a) All the elements of the motor circuit breakers will be designated to enable operation at an ambient temperature as per IEC without derating.
- b) The thermal trips will be adjustable on the front by a rotary selector.
- c) The adjustment of the protection will be simultaneous for all poles.

1.5.13 All MCBs and Residual current breaker shall be referred to technical specification part-2 Distribution Board, clause no. 3 & 4.

1.5.14 Selection of ACB, MCCB, MCB and MPCB shall be of same make. Total Discrimination up to the Icu value of Downstream Breakers must be available between the various elements of switchgear (ACB, MCCB, MCB, etc.) selected. Supplier must provide required supporting documents along with calculations for the same. In case higher frame size (than those specified

in the BOQ) is required to be provided to achieve the above requirement, due to selection of particular make, the same shall be provided at no extra cost if other makes are available to achieve the same with specified frame size.

Note: -

Chapter-1 shall be read in conjunction with Chapter-2 of ERTS and BOQ sub head no A.02 and A.04.

CHAPTER – 02**DISTRIBUTION BOARDS****2.1 DISTRIBUTION BOARDS**

This section covers the detailed requirement for supply, installation, testing and commissioning of DB's suitable for 415 Volts, 3 Phase, 50 HZ, 4 wire system.

2.1.1 MCCB Distribution Boards

- a) Distribution boards of 3 phase, 415 V, 50 HZ, 63 A & above shall be moulded-case circuit breakers assembled in enclosed steel box which have electrical characteristics as specified/required.
- b) The circuit breakers shall comply with IEC 60947-1, IEC 60947-2 or IS 13947 standards.

2.1.2 MCB Distribution Boards.

- a) Distribution Boards shall be suitable for operation on 3 phase/single phase 415/230 Volts, 50 Hz.
- b) The Distribution Boards shall comply with the relevant Indian Standards and Indian Electricity Rules and Regulations.

2.1.3 Fabrication Details and Components

- a) The Distribution Boards shall be metal enclosed, CRCA sheet steel cubical, indoor, dead front, wall mounting type. The Distribution board shall be totally enclosed, completely dust and vermin proof. Gaskets between all adjacent units and beneath all covers shall be used to render the joints dust proof. Doors and covers shall be fully gasketed with foam rubber and/or rubber strips and shall be lockable. Sheet steel used in the construction of Distribution Boards shall be 1.6mm thickness CRCA sheets and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal.
- b) The distribution boards shall be mounted at height of 1200 mm from floor to bottom of panel unless otherwise specified. All the panels and covers shall be properly fitted square with the frame, and holes in the panel correctly positioned. 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 Distribution boards.
- c) Knockout holes of appropriate size and number shall be provided at top and bottom to drill holes for cables/conduit entry as required, as per site conditions.
- d) Removable sheet steel gland plates shall be provided at top and bottom to drill holes for cables/conduit entry as required, as per site conditions.
- e) Indicating lamps need to be provided for each phases, ON, OFF and Trip status of the incomer breaker.
- f) The distribution boards shall be installed recessed or surface mounted on walls by fastening to suitably grouted studs of not less than 12 mm diameter.
- g) The distribution boards shall be provided with 3 pole neutral miniature circuit breaker with neutral link (TPN MCB) or double pole miniature circuit breakers (DP MCB) of appropriate capacity as incoming as per the Schedule of Quantities. The distribution boards shall be provided with 3 numbers double pole earth leakage circuit breakers (DP ELCB) one for each phase or four pole residual current circuit breaker on the incomer as per Schedule of Quantity. The distribution board shall be provided with single pole miniature circuit breakers (SP MCB) or TP MCB as outgoing, as per Schedule of Quantity.
- h) MCB's shall be provided on the phases of each circuit. The individual banks of MCB's shall be detachable. There shall be ample space behind the banks of MCB's to accommodate all the wiring. All the distribution boards shall be completely factory wired, ready for connections. All the terminals shall have adequate current rating and size to suit individual feeder requirements. Each circuit shall be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits shall be distinctly marked with a small description of the service installed.

2.1.4 Miniature Circuit Breakers

The breaking capacity of the MCBs shall be 10 kA in accordance with IEC 60947 & IS 13947 / 8828 - 1996 and with

tripping characteristics to suit the type of load it is feeding. They shall be suitable for 35mm DIN rail mounting in any plane without derating. The terminals should be protected against finger contact to IP 20 degree of protection with no restriction for line and load.

- Number of poles: single-pole, double-pole, triple-pole or four-pole as specified in the BOQ or Drawings
- Protection against external influences: Enclosed-type,
- Method of connection: Bolted type or clip-on type,
- Rated operational voltage and frequency 240 / 415 V AC and 50 Hz.
- Rated current: 6 A, 10 A, 16 A, 20 A, 25 A, 32 A, 40 A, 50 A, as shown on the Drawings. Above 50A, MCCB as specified above must be used.
- Range of instantaneous tripping current: MCB's shall be current limiting Type Class 3 with range of instantaneous tripping current B, C or D type as appropriate or as specified,
- Rated short-circuit breaking capacity: not less than 10 kA (M3) unless otherwise specified in BOQ
- I_{2t} characteristic: suitable for load and circuit being protected,
- Degree of protection: IP-20 for MCB's.
- Reference ambient temperature: as per IEC 60898.

2.1.5 Residual current Circuit Breakers

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 (I_n): as shown on the Drawings,
- Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on drawings or as per approval of the Engineer.
- Rated voltage: 240/415 V AC,
- Rated frequency: 50 Hz,
- Rated insulation voltage U_i acc. to IEC/EN 60664-1 = 500 V AC
- Rated impulse withstand voltage (1.2/50) U_{imp} = 4 KV
- Surge current resistance (wave 8/20) = 250 A
- Rated short-circuit capacity: not less than 1.5 kA unless otherwise specified in BOQ
- 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 ferruling for circuit identification,
- I_{2t} characteristic: suitable for equipment and circuit being protected
- Degree of protection: IP 3X to IEC 60529 or EN 60529, and
- Reference ambient temperature: As per IEC.
- The tripping mechanism shall be of trip-free so that the unit cannot be held closed against earth fault. Tripping devices utilizing electronic amplifiers or rectifiers are not acceptable.
- Rated conditional short-circuit current I_{nc}=I_{dc} = 10KA (with a SCPD)
- And all the RCCB must be able to connect the auxiliary contact at any time.

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.

2.1.6 Residual current Circuit Breakers with over-current protection(RCBO)

RCBOs shall be double pole or four-pole current-operated, housed in a totally enclosed moulded case, manufactured and tested in compliance with IEC 61009 -1, IS 12640(part 2) 2008 and ISI marked.

RCBOs shall meet the following requirements:

- Number of poles: two pole two module 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 drawings or as per approval of the Engineer.
- Rated voltage: 230/415 V AC,
- Rated frequency: 50 Hz,
- Rated short-circuit capacity: 10kA [Icu]
- 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 ferruling for circuit identification,
- I2t characteristic: suitable for equipment and circuit being protected
- Degree of protection: IP 2X, and
- Reference ambient temperature: As per IS 12640-1
- 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.
- Auxiliary contact mounting must be possible for Any time like – Under voltage, Overvoltage, shunt trip and remote Trip indication.
- 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
- A mechanical flag indicator on RCBO for faster identification of fault trip condition i.e. in case of earth leakage current flag appears on the toggles thus immediate showing the cause of the trip of the device it's for preventive measures.

2.1.7

Testing and Commissioning

Commissioning checks and tests shall include all wiring checks and checking up of connections.

- a) Operation checks and lubrication of all moving parts.
- b) Continuity checks of wiring etc. as required.
- c) Insulation test: When measured with 500 V meggar, the insulation resistance shall not be less than 100mega ohms.

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CHAPTER – 03**DISTRIBUTION CABLING****3.1 DISTRIBUTION CABLING****3.1.1 General**

Technical specifications in this section cover supplying and laying of MV cabling.

3.1.2 Standards and Codes

Updated and current Indian Standard & IEC standards Specifications and codes of practice as stipulated below shall apply to the equipment's and the work covered in this section. In addition, the relevant clauses of the Indian Electricity Act 1910, Indian Electricity Rules 1956(with latest amendment), National Building Code 2016 (with latest amendment), National Electrical Code 2011, Code of Practice for Fire Safety of Building (general): General Principle and Fire grading – IS 1641 as amended up to date shall also apply. Wherever appropriate Indian standards are not available, relevant British and/or IEC Standards shall be applicable.

- a) PVC Insulated heavy duty cables: IS 1554 – 1988
- b) Cross Link Polyethylene insulated PVC (sheathed XLPE cables): IS 7098 – 1985
- c) Code of Practice for installation and maintenance of power cables: IS 1255 – 1983
- d) Conductors for insulated electrical cables: IS 8130– 1984
- e) Drums for Electrical cable: IS 10418-1982
- f) Method of test of Cables: IS 10810-1988.
- g) Recommended current rating: IS 3961-1987
- h) Recommended short circuit current rating of high voltage PVC Cables: IS 5891-1970
- i) Flammability Characteristics of cables: IEC-332
- j) Flammability Characteristics of cables as per Swedish standard: SS4241475 class F3
- k) Determination of smoke generation of outer sheath under fire: ASTM-D-2843
- l) Performance of mechanical and Compression join in electrical cable – BS 4579
- m) Mechanical Cable glands – BS 6121.
- n) PVC insulation and sheath of electrical cables – IS 5831.
- o) **BS / EN 60754- Part 1 & 2**
- p) **ASTM D 2863-13**
- q) **BS EN – 61034: 2015**
- r) **IEC – 61537**
- s) **IS-2629/2623/4759**
- t) **IS-2062/ E250A**

3.1.3 Abbreviations

S. No	Abbreviation	Description
1.	PVC	Poly-vinyl Chloride
2.	XLPE	Cross-Linked Polyethylene
3.	FRLSH	Flame Retardant Low Smoke and Halogen
4.	LV	Low Voltage
5.	MV	Medium Voltage
6.	HV	High Voltage
7.	HT	High Tension

S. No	Abbreviation	Description
8.	MS	Mild Steel
9.	GI	Galvanized Iron
10.	RCC	Reinforced Cement Concrete
11.	UPVC	Unplasticised Poly Vinyl Chloride
12.	FRLSZH	Flame Retardant Low Smoke Zero Halogen

3.1.4 LV Cables

LV Cables below and up to 16sqmm shall be copper and for sizes above 16sqmm shall be Aluminium conductor FRLSZH, XLPE, insulated, FRLSZH sheathed steel armoured with an outer protective sheath of flame-retardant low smoke zero low halogen (FRLSZH) generally conforming to IS 7098(part-1) & IEC-60502-1. Cables shall be rated for 1100 Volts. The conductor of cable from 16 sq. mm. to 50 sq. mm. shall be stranded. Sector shape stranded conductors shall be used for cables of 50 sq. mm. and above. Conductors shall be made of electrical purity Aluminium ¾ H or H temper Conductors shall be insulated with high quality **XLPE** base compound. A common covering (bedding) shall be applied over the laid-up cores by extruded sheath of unvulcanised compound. Armouring shall be applied over outer sheath of FRLSZH sheathing. The outer sheath shall bear the manufacturer's name and trade mark at every meter length. Cores shall be provided with following colour scheme of **XLPE** insulation.

- i. 1 Core : Red/Yellow/Blue/Black
- ii. 2 Core : Red & Black
- iii. 3 Core : Red, Yellow and Blue
- iv. 3.5 and 4 Core : Red, Yellow, Blue and Black.

3.1.5 Fire Survival Cables:

Fire survival cables shall be used for emergency circuits. All cables used for fire & safety system systems shall have a 3-hour fire survival capacity. These cables shall be ethylene propylene rubber (EPR) insulated with mica rapping. Cables shall be tested and stamped for fire survival duty and necessary certificates shall be furnished with each lot of supply.

3.1.6 Current rating shall be based on the following conditions.

- i. Maximum conductor temperature : 70 °C for PVC and 90 °C for XLPE
- ii. Ambient air temperature : 45 °C
- iii. Ground temperature : 30 °C
- iv. Depth of laying : 1000 mm.

3.1.7 Short circuit rating of cables shall be as specified in IS 1554 Part – I.

Cables have been selected considering conditions of maximum connected loads, ambient temperature grouping of cables and allowable voltage drop. However, the contractor shall recheck the size before cables are fixed and connected to service.

3.1.8 Delivery, Storage and Handling

Cable drum shall be stored on a well-drained, hard surface, preferably of concrete, so that the drums do not sink in ground causing rot and damage to the cable drum. The cable drum shall conform to IS 10418. During storage, periodical rolling of drums, in the direction of the arrow marked on the drum, shall be done once in 3 months. Both ends of cables shall be properly sealed to prevent moisture ingress. Drums shall be stored in well ventilated area protected from sun and rain. Drums shall always be rested on the flanges and not on flat sides. Dropping of drum even from a small height or the drum falling from one side shall be replaced. Movement of drums shall always be in the direction of arrow marked on the drum. For the transportation over long distance, the drum shall either be mounted on drum wheel and pulled by ropes or they shall be mounted on trailers etc. Drums shall be unloaded preferably by crane otherwise they shall be rolled down carefully on suitable ramps. While transferring cable from 1 drum to another, the barrel of the new drum shall have diameter not less than the original drum. Cables with kinks or similar visible defects

like defective armouring etc. shall be rejected.

3.1.9 Laying of Cables

Cables shall be so laid that the maximum bending radius is 12 times the overall diameter of the cable for LT cables and 15 times the overall diameter of HT cables. Cables shall be laid in masonry trenches, directly on walls/cable trays, directly buried in ground or in pipes/ducts as elaborated below. Cables of different voltages and power and control cables shall be laid in different trenches with adequate separation. Wherever available space is restricted such that this requirement cannot be met, LT cables shall be laid above HT cables. Where more than one cable is laid side by side, cable marker tags of approved type inscribed with cable identification details shall be permanently attached to cables at entry points to the building, at specified intervals for cables laid direct in ground and in locations like manholes, pull pits etc.

3.1.9.1 In Masonry Trenches

Wherever so specified, cables shall be laid in indoor / outdoor masonry / RCC trenches to be provided by Engineer-in-charge. Cables shall be laid on Painted MS supports fabricated from minimum 38mm x 38 mm x 6mm painted/galvanized angle iron supports grouted in trench walls at intervals not exceeding 600 mm. If required, cables shall be arranged in tier formation inside the trench. Suitable clamps, hooks and saddles shall be used for securing the cables in position and dressing properly so that the clear spacing between the cables shall not be less than the diameter of the cable. Trenches shall be provided with chequered plate/RCC covers. After laying and dressing of cables, trenches shall be filled with fine sand as directed.

3.1.9.2 On Tray / Walls

Wherever so specified, cables shall be laid along walls/ceiling or on cable trays. Cable shall be secured in position and dressed properly by means of suitable clamps, hooks, saddles etc. such that minimum clear spacing between cables, is diameter of cable. Clamping of cables shall be at minimum intervals as mentioned in table below.

TYPE OF CABLES	SIZE	CLAMPING BY	FIXING INTERVALS
MV	Up to and including 25 sq.mm	Saddles 1mm thick	45cm
MV	35Sq.mm to 120 sq.mm	Clamps 3mm thick 25mm wide	60cm
MV	150Sq.mm and above	Clamps 3mm thick 40mm wide	60cm

Note: The fixing intervals specified apply to straight runs. In the case bends, additional clamping shall be provided at 30 cm from the centre of the bend on both sides.

3.1.9.3 Buried Directly in Ground

a) General

Cables shall be so laid that they will not interfere with underground structures. All water pipes, sewage lines or other structures which become exposed by excavation shall be properly supported and protected from injury until the filling has been rammed solidly in places under and around them. Any telephone or other cables coming in the way are to be properly shielded as directed by Engineer- in-Charge. Surface of the ground shall be made good to conform in all respect to the surrounding ground to the satisfaction of Engineer-in-Charge.

b) Routing of Cables

Before cable laying work is undertaken, the route of the cables shall be decided with the Engineer-in-Charge. While shortest practicable route shall be preferred. Cable runs shall follow fixed development such as roads, footpaths etc. with proper off sets so that future maintenance and identification are rendered easy. Whenever cables are laid along well demarcated or establishes roads, the LV/MV cables shall be laid further from kerb line than HV cables. Cables of different voltages and power and control cables shall be kept in different

trenches with adequate separation. Where available space is restricted, LV/MV cables shall be laid above HV cables. Where cables cross one another, the cables of higher voltage shall be laid at a lower level than the cables of lower voltage. Power and communication cables shall as far as possible cross at right angles. Where power cables are laid in proximity to communication cables the horizontal and vertical clearances shall not normally be less than 60 cm.

c) Width of Trench

The width of trench shall be determined on the following basis as per interface with Civil. The minimum width of trench for laying single cables shall be 350 mm. Where more than one cable is to be laid in the same trench in horizontal formation, the width of trench shall be increased such that the inter axial spacing between the cables except where otherwise specified shall be at least 200 mm. There shall be a clearance of at least 150 mm between axis of the end cables and the sides of the trench.

d) Depth of Trench

- i. The depth of trench shall be determined on the following basis as per interface with Civil. Where cables are laid in single tier formation, the total depth of the trench shall not be less than 750 mm for cables up to 1.1 KV and 1250 mm for cables above 1.1 KV.
- ii. When more than one tier of cables is unavoidable and vertical formation of laying is adopted, the depth of trench shall be increased by 300 mm for each additional tier to be formed

e) Excavation of Trenches

The trenches design details shall be advised to civil contractor and be excavated in reasonably straight lines. Wherever there is a change in direction suitable curvature of 12 times the overall diameter of the largest cable shall be provided.

Where gradient and changes in depth are unavoidable these shall be gradual. Excavation should be done by any suitable manual or mechanical means. Excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. Adequate precautions shall be taken not to damage any existing cables pipes or other such installations during excavation. Wherever bricks, tiles or protected covers or bare cables are encountered, further excavation shall not be carried out without approval of the Engineer-in-Charge. Existing property exposed during trenching shall be temporarily supported or propped adequately as directed by the Engineer-in-Charge. The trenching in such cases shall be done in short lengths, necessary pipes laid for passing cables therein and the trench refill as required. If there is any danger of trench collapsing or endangering adjacent structure the sides shall be well shored up with timbering and/or sheathing as an excavation proceeds. Where necessary these may even be left in place when back filling the trench. Excavation through lawns shall be done in consultation with the Engineer-in-Charge. Bottom of the trench shall be level and free from stone, brick etc. The trench shall then be provided with a layer of clean dry sand cushion of not less than 80 mm in depth.

f) Laying of Cable in Trenches

The cable drum shall be properly mounted on jacks or on a cable wheel at a suitable location. It should be ensured that the spindle, Jack etc. are strong enough to carry the weight of the drum without failure and that the spindle is horizontal in the bearing to prevent the drum creeping to one side while rotating. The cable shall be pulled over rollers in the trench steadily and uniformly without jerks or strains. The entire cable length shall, as far as possible, be laid in one stretch. However, when this is not possible the remainder of the cable shall be removed by flaking i.e. making one long loop in the reverse direction. After the cable is uncoiled and laid over the rollers, the cables shall be lifted slightly over the rollers beginning from one end by helpers standing about 10 meters apart and drawn straight.

The cable should then be taken off the rollers by additional helpers lifting the cables and then laid in the trench in a reasonably straight line. For short runs and cable sizes up to 50 sq mm 1.1 KV grade the alternate method of direct handling can be adopted with the prior approval of the Engineer-in-Charge. If two or more cables are laid in the same trench care should be taken to preserve relative position. All the cables following the same routes shall be laid in the same trench. Cables shall not cross each other as far as

possible. When the cable has been properly straightened the cores shall be tested from continuity and insulation resistance. The cable shall be measured thereafter. Suitable moisture sealing compound/tape shall be used for sealing of the ends.

Cables laid in trenches in a single tier formation shall have a covering of clean dry sand of not less than 170 mm above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. If additional tiers are formed each of the subsequent tiers also shall have a sand cushion of 300 mm. The top most cable shall have a final sand covering not less than 170 mm before the protective cover is laid. A final protection to cables shall be laid to provide warning to future excavators of the presence of the cable and to protect the cables against accidental mechanical damage. Such protection shall be with second class bricks of not less than 200mm x 100 mm x 100 mm (normal size) laid breadth wise the full length of the cable to the satisfaction of the Engineer-in- Charge. Where more than one cable is to be laid in the same trench this protective covering shall cover all the cables and project at least 50 mm over the sides of the end cables. In addition, bricks on edge shall be placed along the entire run on either side of the cable run. The trenches shall than be back filled with excavated earth free from stones or other sharp-edged debris and shall be rammed and watered in successive layers not exceeding 300 mm. Unless otherwise specified a crown of earth not less than 50 mm in the centre and tapering towards the side of the trench shall be left to allow for subsidence. The crown of earth should however not exceed 100 mm so as not to be a hazard to vehicular traffic. Where road berms or lawns have been cut or kerb stones displaced the same shall be repaired and made good to the satisfaction of the Engineer-in-Charge and all surplus earth and rocks removed to places as specified.

g) Laying of Pipes / Closed Ducts

In locations such as road crossings, entry to buildings/poles in paved areas etc., cables shall be laid in pipes or closed ducts. Spun reinforcement concrete pipes shall be used for such purpose and the pipe shall not be less than 100 mm in Diameter for a single cable and not less than 150 mm diameter for more than one cable. These pipes shall be laid directly in ground without any special bed. Sand cushioning and /or brick tiles need not be used in such installations. Unless otherwise specified the top surface of piped shall be at a minimum depth of 1000 mm from the ground level when laid under roads, pavements etc.

The pipes for road crossings shall preferably be on the skew to reduce the angle of bend as the cable enters and leaves the crossing. Pipes shall be continuous and clear of debris or concrete before cable is drawn. Sharp edges at ends shall be smoothened to prevent injury to cable insulation or sheathing. No deduction shall be made for sand and bricks not used for cables passing through RCC Hume Pipes or for parts of vertical cables at the lighting poles. Wherever so required, cables shall be laid at the bed of the lake through existing PVC pipe as itemized in Schedule of Quantities.

h) Route Markers

Route Markers made from 100 mm x 5 mm GI plates bolted to 35 mm x 35 mm x 6 mm and 60 cm long angle shall be provided along the cable route at intervals not exceeding 100 m in straight runs and at every bend.

i) Laying of Cables in Floors

Laying of cables directly in floors shall be avoided and GI Pipes of adequate size shall be used whenever necessary. However, if the cables must be laid direct in the floor specific written approval of Engineer-in-Charge shall be obtained and the contractor shall cut chases, lay the cables and make good the chases to original finish.

j) Cable Entry into Buildings

Cable entry into buildings shall be made through RCC pipes recessed in the floor. RCC Hume pipes shall be provided well in advance for service cable entries. The pipe shall be filled with sand and sealed at both ends with bitumen mastic to avoid entry of water. Suitable size manholes shall be provided wherever required to facilitate drawing of cables as per requirements.

k) Cable Identification Tags

Wherever more than one cable is laid/run side by side, marker tags as approved by the Engineer- in-Charge, inscribed with cable identification details shall be permanently attached to all the cables in manholes/pull pits/joint pits/ entry points in buildings/open ducts/trenches etc. These shall also be attached to cables laid directly in ground at specified intervals, before the trenches are back-filled.

l) Wall / Floor Crossing

Adequately sized sleeves shall be provided for all wall and floor crossings. The annular space around the cables at either end shall be sealed with fire resistance packing material which shall be made available by Engineer-in-Charge. The sealing shall be done as per manufacturer's instructions.

m) Termination / Jointing of Cables

Soldered jointing/termination shall be totally avoided. Solder less terminations by using Dowel crimping tools and suitable lugs shall be adopted for all cable terminations. Any terminations may without use of proper crimping tool is liable to be rejected. In the case of Aluminum conductors, it is to be ensured that the conductor oxidation is cleaned by means of emery paper and then a thin coat of tin is applied before pinching into any equipment. Heat shrinkable Raychem type terminations shall be provided for high voltage cables and Brass double compression glands shall be provided for LT cable terminations. Straight through jointing of LT or high voltage cable shall normally be totally avoided. If unavoidable, such jointing shall be carried out as per procedure to be got specifically approved from Engineer-in-Charge and without cost.

n) Measurement of Cable Runs

The cable runs shall be measured up to the outer end of the boxes without any allowance for overlap joints. The rate shall include all the above-mentioned material, labour etc. for laying as required.

3.1.9.4 Cable Joints

Cable joints shall be resorted to and permitted only if length of cable route is more than standard cable drum length. Cable joints shall not be permitted in any other circumstances. Wherever unavoidable these joints shall be made with specific approval of Engineer and shall from a part of cable run /laying. Cable Jointing shall be done only of approved make cable joints. No extra cost shall be paid for jointing of cables.

The joints shall be resorted to and permitted only if length of cable route is more than standard cable drum length. Cable joints shall not be permitted in any other circumstances. Wherever unavoidable these joints shall be made with specific approval of Engineer and shall from a part of cable run /laying. Cable Jointing shall be done only of approved make cable joints. No extra cost shall be paid for jointing of cables.

The jointing kits shall match the cable specifications. Joints shall not be permitted in the fire survival cables in case the joint does not meet the fire survival conditions.

Every connection at a cable joint shall be mechanically and electrically sound, be protected against mechanical damage and any vibration, shall not impose mechanical stress on the fixings of the connection and shall not cause any mechanical damage to the cable conductor.

The appropriate tools specified by the joint manufacturer shall be used when jointing cables.

3.1.9.5 Cable Loops

At the time of the installation approximately 3 meters of surplus cable shall be left

- a) at each end of the cable
- b) on each side of underground straight through /tee/ termination joints.
- c) at entries to buildings
- d) and such other places as may be decided by the Engineer-in-Charge This cable shall be left in the form of a loop.

Wherever long runs of cable length are installed cable loops shall be left at suitable intervals as specified by the Engineer-in-Charge.

3.1.9.6 Bonding of Cables

Where a cable enters any piece of apparatus it shall be connected to the casting by means of an approved type of armoured clamp or gland. The clamps must grip the armouring firmly to the gland or casting, so that in the event of ground movement no undue stress is placed on to the cable conductors.

3.1.9.7**Cable Glands & Accessories**

a) Non-Armoured Cable

All cable glands and accessories shall be approved to BS 6121 or equivalent Indian standard.

The Cable gland shall have a watertight seal when fitted to a cable.

Each cable gland shall be supplied with a brass gland locknut and a flame-retardant low smoke halogen free outer gland shroud. The shroud shall totally enclose the gland body and form an effective seal against the cable sheathing.

The Gland shall be **weatherproof**.

a) Armoured Cable

All cable glands and accessories shall be approved to BS 6121 or equivalent Indian standard.

The Cable gland shall have a watertight seal when fitted to a cable.

Cables shall be terminated in a gland fitted with an armour clamp and an earth tag. The gland body shall be provided with an internal conical seal to receive the armour clamping cone, and a clamp nut, which shall secure the armour-clamping cone, and conical armour seal. The spigot of the gland body shall be threaded to suit standard conduit accessories. A flame-retardant low smoke halogen free shroud shall be fitted to cover the gland body.

b) Cable Ties

Cable ties shall be made from corrosion resistant, flame retardant and ultra violet stabilised materials. At locations where cables are installed above tracks or in areas subjected to significant and constant vibration, cable ties shall be of metal construction type and coated with a corrosion resistant, low smoke halogen free and flame-retardant insulation material.

3.1.9.8**Penetration in Walls**

Where proprietary cable transits are required, they shall be installed strictly in accordance with the manufacturer's recommended procedures. Where cables pass through walls, floors, or fire partitions, sleeves shall be installed to facilitate installation and subsequent withdrawal of the cable.

After installation of the cables, the hole(s) through which the cables pass shall be sealed with fire resisting material to achieve the fire rating as the structure through which they pass. Details of the proposed sealing method shall be submitted for approval prior to implementation. Cables passing through external walls shall additionally be sealed with appropriate additional weather protection to prevent the ingress of water.

3.1.9.9

The fire resisting material shall intumesce to form a hard char that tightly seals penetrations against flame spread, smoke and toxic fumes. The fire resisting material shall be tested according to ASTM E119, ASTM E814 and ASTM E84. Test certification and test report shall be submitted.

The materials shall not emit toxic gases on exposure to fire. The materials shall be easy to dismantle and replace in case of rearrangement and also withstand vibration due to rail operation and seismic tremor.

3.1.10**Testing**

a) Tests at Manufacturer's Work

The cables shall be subjected to shop test in accordance with relevant standards to prove the design and general qualities to the cables as below (as per IS 10810):

- i. Routine test on each drum of cables
- ii. Acceptance tests on drums chosen at random for acceptance of the lot.
- iii. Type test on each type of cables, inclusive of measurement of armour DC resistance of power cables.

b) Site Testing

- i. All cables before laying shall be tested with a 500 V Megger for 1.1 KV grade or with a 2500/5000 V Megger for cables of higher voltages. The cables cores shall be tested for continuity, absence of cross phasing, insulation resistance to earth /sheath / armour and insulation resistance between conductors.
 - ii. All cables shall be subject to above mentioned test during laying, before covering the cables by protective covers and back filling and before the jointing operations.
 - iii. After laying and jointing, the cable shall be subjected to a 15 minutes AC/DC pressure test. In the absence of facilities for pressure testing, it is enough to test for one minute with 1000 V Megger for cables of 1.1 KV grade and with 2500/5000 V Megger for cables of higher voltages.
- c) Test Witness
- Tests shall be performed in presence of representative of Engineer-in-Charge. The contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

3.2 Cable Trays

Cable trays shall be galvanized, and factory fabricated out of MS channels, angle iron tee, bends sections, flats and perforated sheet for different loads and number and size of cables as given below.

3.2.1 Ladder Type Cable Trays

Ladder type cable trays shall be hot dip galvanized as per specification given elsewhere.

- a) 1200 mm wide
Runners 25 x 100 x 25 x 3 mm
Rungs 20 x 40 x 20 x 3 mm 250 mm C/C.
- b) 1000 mm wide
Runners 25 x 100 x 25 x 3 mm
Rungs 20 x 40 x 20 x 3 mm 250 mm C/C
- c) 750 mm wide
Runners 20 x 75 x 20 x 2.5 mm
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
- d) 600 mm wide
Runners 20 x 75 x 20 x 2.5 mm
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C.
- e) 450 mm wide
Runners 20 x 75 x 20 x 2.5 mm
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C.
- f) 300 mm wide
Runners 20 x 75 x 20 x 2.5 mm
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C.
- g) 150 mm wide
Runners 20 x 75 x 20 x 2.5 mm
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C.

3.2.2 Perforated Type Cable Trays

Perforated type cable tray shall be hot dip galvanized and factory fabricated out of 2 mm thick MS perforated sheet for different sizes as given below. Perforated type cable tray shall be galvanized as per specification given elsewhere.

- a) 50 x 600 x 50 mm
- b) 50 x 450 x 50 mm
- c) 50 x 300 x 50 mm

d) 50 x 150 x 50 mm

e) 50 x 100 x 50 mm

1. Trays shall have suitable strength and rigidity to provide proper support for all the contained cables. Trays shall not have sharp edges, burrs or projections injurious to cable insulation. Trays shall include fitting for changes in direction and elevation.
2. Cable trays shall be mounted as per enclosed drawing by means of required size of angle support and suitable fasteners. Spacing of the support structure shall be such the cable trays shall remain perfectly horizontal without buckling when fully loaded with cable runs. The support structure shall be suspended from ceiling slab or grouted to walls in an approved manner. Width of the horizontal arms of the support structure shall be same as the tray width plus length required for threading/bolting /welding to the vertical supports. The length of vertical supporting members for horizontal tray runs shall be to suite the number of tray tiers required. Cable trays shall be bolted / welded to support structure. Minimum clearance between the top most tray tier and the ceiling shall be 300 mm. Trays shall be erected properly to present a neat and clear appearance. Trays shall be installed as a complete system. The entire cable tray system shall be rigid. Each run of cable tray shall be completed before laying of cables. Cable trays shall be erected so as to be exposed and accessible. Cables shall be fixed to the tray by clamp fabricated from minimum 3 mm thick GI sheets. Cables shall be dressed properly to provide minimum one diameter clearance between adjacent cables and from tray ends. Cable trays shall be earthed by 25mm x 6 mm GI strips as required.

Cable trays, of sizes as per schedule of quantities and drawing shall be of perforated doubled bend channel or of ladder design as specified in BOQ. Cable trays shall be fabricated from sheet steel of thickness as per BOQ and shall be complete with tees, elbows, risers and all necessary hardware.

Trays shall have suitable strength and rigidity to provide proper support for all the contained cables. Trays shall not have sharp edges, burrs or projection injurious to cable insulation. Trays shall include fittings for changes in direction and elevation. Cable trays and accessories shall be painted with two coats of iron oxide zinc chromate primer after proper surface preparation and two finishing coats of synthetic enamel paint of approved make or as specified in BOQ. Cable trays shall have side rails.

3.2.3 Specification for hot dip galvanizing process for mild steel used for earthing, cable trays or junction boxes for electrical installation

General requirements

i. Quality of Zinc

Zinc to be used shall confirm to minimum Zn 98 grade as per requirement of IS: 209-1992.

ii. Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness up to 6 mm in accordance with IS:6745-1972 shall be 400g / sqm.

The weight of coating expressed in grams per square meter shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs, rust strains bulky white deposit, blisters.

Mild steel flats/wires shall undergo a process of degreasing, pickling in acid, cold rinsing and then galvanizing.

3.2.4 Raceways

Raceways shall be fabricated from minimum 2 mm thick pre-galvanized sheets finished with cover. GI Earth Link Bars shall be provided at every joint to ensure earth continuity of GI cover. Removable covers shall be provided with Neoprene gaskets and shall be fixed to the raceways by counter sunk cadmium plated screws at intervals of maximum 450 mm. Cross sectional area of the raceways shall be such that total overall cross-sectional area (after insulation) of all the wiring conductors is not more than 50 % of the cross sectional area of the raceway. Contractor shall furnish details of the basis of raceway sizes adopted in all areas along with shop drawings of conduit, raceway and wiring layouts for approval.

3.2.5 Installation of Raceways

Raceways shall be fixed either overhead in surface or shall be recessed in floor as indicated in drawings. Overhead raceways shall be installed over the false ceilings on structural supports fixed to the structural ceiling by dash fasteners. Raceways recessed in floor shall be fixed such that 2 mm thick removable cover protrudes over the finished floor surface by around 6 mm on either side of raceway.

CHAPTER – 04**SWITCH, SOCKETS, FANS, WIRE AND CONDUITS****4.1 Switch, Sockets, Fans, Wire and Conduits****4.1.1 General**

Technical Specifications in this section cover the Internal Wiring Installation in concealed/ surface conduit/ raceways pertaining to:

- Lights and fans
- Convenience socket outlets
- Control wiring
- Sub main wiring

Prior to laying and fixing of conduits, the contractor shall carefully examine the working drawings prepared by him and approved by the Engineer's representative indicating the Layout, satisfy himself about the sufficiency of number and size of conduits, location of junction boxes, sizes and location of switch boxes and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of the Engineer's Representative. Any modifications suggested by the contractor shall be got approved 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 and as far as possible no junction box shall be provided in the entire length of conduit run for drawing of wires. Only switch outlets lighting fixtures outlets, equipment power outlets and socket outlets shall be considered for drawing of wires.

4.1.2 Governing Specification

Electrical wiring along with other related items shall conform to the latest standard or harmonize as per the respective standard as given below or specified along with the equipment in the specification.

In case of any conflict between specifications & the standards, the instructions/ decision of the Engineer' or Employer's authorized representative shall be binding.

4.1.3 Standards and Codes

Updated and current Indian Standard Specifications and Codes of Practice as stipulated below shall apply to the equipment's and the work covered in this section. In addition, the relevant clauses of the Indian Electricity Act 1910, Indian Electricity Rules 1956, National building Code.2016 (with latest amendment), National Electrical Code 2011, Code of Practice for Fire Safety of Building (general): General Principal and Fire Grading - IS 1641 and IEE wiring regulation 16th edition as amended up to date shall also apply. Wherever appropriate Indian Standards are not available, relevant British and/or IEC Standards shall be applicable.

Sl no	Standard Codes	Description
1	IS: 1554 Part-1	660/1100V grade FR PVC insulated wires.
2	IS: 9537: Part I, 1980	GI conduits for electrical wiring.
3	IS: 9537: Part I, 1981	IS: 9537: Part I, 1980.
4	IS: 3837: 1990	Accessories for rigid steel conduits
5	IS: 3480: 1990	Flexible Steel conduits for electrical wiring
6	IS: 4615: 1990	Switch socket outlets.
7	IS: 1293: 1988	3 pin plugs and socket outlets up to 250 volts.

8	IS: 1885: 1971	Glossary of items for electrical cables and conductors
10	IS: 8130: 1984	Conductors for insulated electrical cable
11	IS: 1913: 1978	General and safety requirements for fluorescent lamps Luminaries
12	IS: 3854: 1997	Switches for domestic and similar purposes.
13	IS: 5133: Part I & II 1969	Boxes for the enclosure of electrical accessories
14	IS: 2551: 1982	Danger notice plates
15	IS: 1644: 1998	Code of practice for personal hazard fire safety of buildings
16	IS: 1646: 1997	Code of practice for electrical installation fire safety of buildings
17	IS: 732: 1989	Code of practice for electrical wiring installations
18		
19	IS: 1646: 1982	Code of practice of fire safety buildings (General- Electrical installations).
20	IS: 5216: 1982	Guide for safety procedure and practices in Electrical works
21	IS: 694:2010	Polyvinyl chloride insulated sheathed and unsheathed cables with rigid and flexible conductor for rated voltage up to and including 450/740V.
22	IS: 2309:1989	Code of practice for protection of building and allied structure against lighting.
23	IS: 5831	PVC insulation and sheath of electric cables and flexible cords
24	BS EN 50525-3-31	
25	BS EN 60228	
26	ASTM D 2863-13	
27	NES 713	
28	BS/EN-60754 Part (1&2)	

Abbreviations

Sl. No.	Abbreviation	Description
1	PVC	Poly-vinyl Chloride
2	XLPE	Cross-Linked Polyethylene
3	FR	Fire Retardant
4	FRLSZH	Flame Retardant Low Smoke Zero Halogen
5	MS	Mild Steel
6	GI	Galvanised Iron

**Technical
Requirement**

- a) FRLSZH Cables/Wires for rated voltages up to 660/1100 V.
- b) Electrical Wires shall confirm to IS 694-2010. Generally, there are three types of electrical wires used in system described at SI No. 17, 19 and 20 of the specification IS 694-2010.
- c) Single core non-sheathed cables with flexible conductors for general purpose with maximum temperature of 70°C, 660/1100V grade.
- d) FRLSZH insulated (Type A vide clause 5.1 of IS 694:2010). PVC shall confirm to IS 5831.
- e) Stranded Copper conductors' class 5 as per IS 8130.
- f) Size and purpose
- g) Lights and Fans: 2.5mm² multi-strand copper conductors or as specified in BOQ 6/16 socket and group wiring of lighting and fan circuits: 4/6 mm² multi- strand copper conductors or as specified in BOQ.
- h) Multi core sheathed cables with flexible conductors for general purpose with maximum temperature of 70°C, 660/1100V grade.
- i) FR -PVC insulated (Type A vide clause 5.1 of IS 694:2010). PVC shall confirm to IS 5831.
- j) Stranded copper conductors' class 5 as per IS 8130
- k) Sheath shall be PVC of type ST1 with 70°C PVC compound confirming to IS 5831

4.1.4

Material Specifications

- a) Rigid GI Conduit

These shall be galvanized iron 16 gauge up to 32mm and 14 gauge for sizes above 32mm, electric resistance welded (ERW), electric threaded type, with both ends screwed having perfectly circular tubing. Conduits shall show no appreciable unevenness and shall be free from burrs, fins and the like which may cause damage to cable insulation. These rough internal edges shall be removed by means of a proper reamer. Conduits shall be precision welded and shall be fabricated from tested steel strips of required thickness by high frequency induction weld process. Welds shall be smooth and consistently of high quality to ensure crack proof bending. The conduit shall be galvanized to IS 209- 1992 and IS 6745-1972. All conduits used in this work shall be ISI embossed.

- b) Flexible Conduit

The usage shall be restricted to only those areas where it is not possible to use Rigid GI Conduits. All final connections specially to vibrating equipment's shall be made through steel flexible conduits **with PVC coated (Halogen free) with required accessories. Flexible steel conduits shall be as per IS: 3480-1990 and IEC- 61386.** Where flexible steel conduit is employed, the length shall not exceed 2.5 meters and shall be provided with an earth continuity conductor of copper size not less than 2.5mm².

- c) GI Bends

Large right-angle bends (more than 75mm radius) or non-right-angle bends in conduits runs shall be made by means of conduits bending machines carefully so as not to cause any crack in the conduit. Small right-angle bends in conduits runs can be made by standard conduit accessories (solid/inspection bends/ elbows). No run of conduit shall have more than four right angle bends from outlet to outlet. Bends in multi runs of conduits shall be parallel to each other and neat in appearance, maintaining the same distance as between straight runs of conduits.

4.1.5

Conduit Accessories

a. Standard Accessories

Heavy duty black Enamel painted/ Galvanized standard conduit fittings and accessories like standard/ extra-deep circular boxes, looping in boxes, junction boxes, solid/ inspection elbows, solid/inspection tees, couplers, nipples, saddles, check nuts, earth clips, ball socket joints, bushes etc. shall be of superior quality and of approved makes. Heavy duty covers screwed with approved quality screws shall be used. Samples of all conduits fittings and accessories shall be got approved by Engineer-in- Charge before use.

b. Fabricated Accessories

Wherever required, outlet/ junction boxes of required sizes shall be fabricated from 1.6mm thick MS sheets excepting ceiling fan outlet boxes which shall be fabricated from minimum 3mm thick sheets. The outlet boxes shall be of approved quality, finish and manufacture. Suitable means of fixing connectors etc., if required, shall be provided in the boxes. The boxes shall be protected from rust by zinc phosphate primer process. Boxes shall be finished with minimum 2 coats of enamel paint of approved colour. A screwed brass stud shall be provided in all boxes as earthing terminal.

c. Outlet Boxes for Light Fittings

These shall be minimum 75mm x 75mm x 50mm deep and provided with required number of threaded collars for conduit entry. For ceiling mounted fluorescent fittings, the boxes shall be provided 300mm off centre for a 1200mm fitting and 150mm off centre for a 600mm fitting so that the wiring is taken directly to the down rod. 3mm thick Perspex/hilum sheet cover of matching colour shall be provided.

d. Outlet Boxes for Ceiling Fans

Outlet boxes for ceiling fans shall be fabricated from minimum 3mm thick MS sheet steel. The boxes shall be hexagonal in shape of minimum 100 mm depth and 60mm sides. Each box shall be provided with a recessed fan hook in the form of one 'u' shaped 15 mm dia rod welded to the box and securely tied to the top reinforcement of the concrete slab for a length of minimum 150 mm on either side. 3mm thick Perspex / hylam sheet cover of matching colour shall be provided.

e. Boxes for Modular Wiring Accessories

Boxes for housing modular wiring accessories (switches, switched socket outlets, telephone / computer / TV outlets, bell pushes, electronic fan regulators etc.) shall be fabricated from minimum 1.6mm thick MS sheets provided with rust inhibiting zinc phosphating treatment. The MS boxes shall be suitable for a grid plate being fixed over it for mounting wiring accessories leaving ample space at the back and on the sides for accommodating wiring conductors, MS boxes shall be provided with a brass earth terminal. The MS boxes shall have knockout holes for conduit entry which shall be secured in position by check nuts and provided with bushes. No timber shall be used for any supports. Switch and outlet boxes shall be located as shown in the drawings.

In case the number of switches in one box is not tallying with that available in standard manufacturer range, the box accommodating the next higher number of switches shall be provided without any extra cost.

4.1.6

Wiring Capacity of Conduits

Conduits shall be of ample sectional area to facilitate simultaneous drawing of wires and permit future provision also. Total cross section of wires measured overall shall not normally be more than half the area of the conduit. Maximum number of wires which could be drawn in

Various sizes of conduits shall be as

Nominal cross sectional area of conductor in sq.mm	20 mm		25 mm		32 mm		38 mm		51 mm		64 mm	
	S	B	S	B	S	B	S	B	S	B	S	B
1	2	3	4	5	6	7	8	9	10	11	12	13
1.50	5	4	10	8	18	12	—	—	—	—	—	—
2.50	5	3	8	6	12	10	—	—	—	—	—	—
4	3	2	6	5	10	8	—	—	—	—	—	—
6	2	—	5	4	8	7	—	—	—	—	—	—
10	2	—	4	3	6	5	8	6	—	—	—	—
16	—	—	2	2	3	3	6	5	10	7	12	8
25	—	—	—	—	3	2	5	3	8	6	9	7
35	—	—	—	—	—	—	3	2	6	5	8	6
50	—	—	—	—	—	—	—	—	5	3	6	5
70	—	—	—	—	—	—	—	—	4	3	5	4

Note:

1. *The above table shows that maximum capacity of conduits for a simultaneous drawing in of cables.*
2. *The columns headed 'S' apply to runs of conduits which have distance not exceeding 4.25 m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed 'B' apply to runs of conduit, which deflect from the straight by an angle of more than 15 degrees.*

4.1.7 FRLSZH Insulated Wires

Flame retardant FRLSZH insulated wires shall be single core unsheathed in voltage grade 1100V conforming to relevant IS with 99.97% pure electrolytic grade bright annealed stranded bare copper conductors. Special parameters of FRLSZH insulation like critical oxygen index, temperature index, smoke density and flammability test shall conform to relevant IEC and ASTM Standards. Coil packing shall be ISI marked as stipulated in IS 694.

4.1.8 Modular Cover Plate Mounted Wiring Accessories**a) Switches**

All 6- and 16-Amps switches shall be of the modular enclosed type flush mounted 220-volt AC of the best quality and standard. The switch moving and fixed contacts shall be of silver nickel and silver graphite alloy and contact tips coated with silver. The housing of switches shall be made from high impact resistant, flame retarding and ultra violet stabilized engineering plastic material. The switch controlling the light point shall be connected on to the phase wire of the circuit.

b) Modular Cover Plates

Switches, receptacles and telephone system outlets in wall shall be provided with moulded cover plates of shape, size and colour approved by the Engineer in Charge made from high impact resistant, flame retarding and ultra violet stabilized engineering plastic material, and secured to the box with counter sunk round head chromium plated brass screws. Where two or more switches are installed together, they shall be provided with one common switch cover plate as described above with notches to accommodate all switches either in one, two or three rows.

One and two gang switch cover plate, telephone outlet cover plate, 6 and 16 amps switched / unswitched plates, shall have the same shape and size. Three and four gang switch cover plates shall have the same shape and size. Six and eight gang switch cover plates shall have the same shape and size. Nine and twelve gang switch cover plates shall have the same shape and size. Wherever five switches, seven switches, ten switches and eleven switches are to be fixed the next higher sizes of gang switch cover plate to be used and openings shall be provided with blank-off covers at no extra cost.

c) Wall Socket Outlets

All 6/16 amps wall sockets outlets unless otherwise mentioned on the drawings shall be switched, with round with 6 pins and fitted with automatic linear safety shutters to ensure safety from prying fingers. Unswitched 6/16 amps wall socket outlets where called for in the drawings shall be of six pin type. The socket outlets shall be made from high impact resistant, flame retarding and ultra violet stabilized engineering plastic material. The switch and sockets shall be in the same plate. The plates for 6 amp switched / unswitched plugs and telephone outlets shall be of the same size and shape. All the switched and unswitched outlets shall be of the best standard. The switch controlling the socket outlet shall be on the phase wire of the circuit. An earth wire shall be provided along the cables feeding socket outlets for electrical appliances. The earth wire shall be connected to the earthing terminal screw inside the box. The earth terminal of the socket shall be connected to the earth terminal provided inside the box.

d) Industrial Socket Outlets

Polycarbonate type Industrial plugs, connectors, socket outlets and appliance inlets shall be provided to meet IS60309-2. Heavy-duty single phase socket shall be 20A & three phase socket outlet shall be 32A, 63A complying with IS 60309-2. For interior use such as plant room unit shall be rated to IP56. Externally or in wet environments shall be IP65.

4.1.9 Conduit Installation**a) System**

The whole conduit system shall be installed to comply fully with relevant provision in Indian Standard Specifications, Indian Electricity Rules and IE wiring regulations. Conduits shall be laid either recessed in walls and ceilings or on surface on walls and ceilings or partly recessed and partly on surface, as required. Same rate shall apply for recessed and surface conduiting in this contract. Stranded copper conductor insulated wire of size as per schedule of quantities shall be provided in entire conduiting for loop earthing. Steel wire of suitable size to serve as a fish wire shall be left in all conduits runs to facilitate drawing of wires after completion of conduiting.

b) Layout

Conduits layout and routes shall be submitted for Engineer-in-Charge's approval prior to execution. Allowance for adjustments due to site conditions shall be provided with no extra cost.

Conduit routes shall be chosen for easy, straight runs with a minimum of bends and crossing. Generally, they shall follow the structure of building, running at right angles or in parallels to floors and ceiling. Conduit shall be kept within 300mm of floors and ceiling when running parallel to them.

Outlets boxes for housing accessories shall be used as draw boxes. The total number of draw boxes shall be kept to a minimum and shall be provided so that conduits runs do not exceed 12m or have more than two right angle bends.

All conduits shall be kept clear of gas and water pipes. In, conduits shall be at least 150mm away from gas pipe. Where proximity to these pipes is unavoidable, they shall be effectually segregated e.g. Using rubber or other insulating material to prevent appreciable voltage difference at possible points of contact. Segregation from extra low voltage circuits and telecommunication circuits shall also apply unless these are wired to that same voltage requirements as lighting and power circuits.

Conduits from different distribution boards shall not be connected to the same junction box. Each run of conduit shall be assembled complete with draw in wires

c) Joints and Terminations

Electrical and mechanical continuity shall be maintained throughout all conduit's joints and terminations. Conduit threads shall be thoroughly cleaned, and the conduits tightly screwed. The conduit system shall be watertight after installation.

Conduits shall be connected using couplers or via boxes. With a coupler, the ends of the conduit shall be butted close together and the running coupler is screwed tightly on and tightened by a locknut.

Conduits terminating into boxes provided with spouts shall be threaded so that there are no exposed threads. For boxes with no spouts, the termination shall be made using a brass bush and a coupler. The conduit is pushed through the knockout or drilled entry and the bush is screwed tightly onto its end. The coupler is screwed to butt firmly against the exterior wall of the box.

Where conduits are not jointed or terminated in boxes, they shall be terminated in a screwed brass bush.

In all joints and terminations, conduits threads shall not be exposed. Where this cannot be avoided as in a running coupler, the exposed threads shall be coated with red lead paint to seal against the ingress of water.

d) Bends

Conduits shall be bent cold with an approved type of bending block or bending machine, without altering the dimensions of their sections.

All conduit bends shall be such as to permit compliance to the requirements for bends in the IEE /IS regulations. Bends shall be made with as large a radius as the position of the conduit within the building permits. Where the bend is more than 90 degrees, circular or rectangular junction boxes shall be used for connecting conduits.

e) Recessed Conduiting

Conduits recessed in concrete members shall be laid before casting, in the upper portion of slabs or otherwise

as may be instructed, to embed the entire run of conduits and ceiling outlet boxes with a cover of minimum 12mm concrete. Conduits shall be adequately tied to the reinforcement to prevent displacement during casting at intervals of maximum 1 meter. No reinforcement bars shall be cut to fix the conduits. Suitable flexible joints shall be provided at all locations where conduits cross expansion joints in the building.

Conduits recessed in brick work shall be laid in chases to be cut by electrical contractor in brick work before plastering. The chases shall be cut by a chase cutting electric machine. The chases shall be of enough width (minimum 10mm spacing between adjacent conduit) to accommodate the required number of conduits and of sufficient depth to permit full thickness of plaster (minimum 6mm) over conduits. The conduits shall be secured in the chase by means of heavy-duty pressed steel clamps screwed to MS flat strip saddles at intervals of maximum 1 meter. The chases shall then be filled with cement and coarse sand mortar (1:3) and properly cured by watering. For chases more than 75mm width, a wire mesh shall be provided for the full length and width of the chase in the plaster to prevent cracking.

Junction boxes intended for facilitating drawing of wires in conduiting system shall be in accessible locations to permit redrawing of wires in future. Open ends of conduits laid in slabs and walls shall be suitably plugged before pouring concrete/plastering to prevent ingress of water / debris in to the conduits.

Entire recessed conduit work in concrete member and in brick work shall be carried out in close coordination with progress of civil works. Conduits in concrete member shall be laid before casting and conduits in brick work shall be laid before plastering. If it became necessary to embed conduits in already cast concrete members, suitable chase shall be cut in concrete for the purpose. For minimizing this cutting, conduits of lesser diameter than 25mm and outlet boxes of lesser depth than 50mm could be used by the contractor for such extensions only after obtaining specific approval from Engineer-in-Charge. For embedding conduits in finished and plastered brick work, the chase would have to be made in the finished brick work. After fixing conduit in chases, chases shall be made good in most workmanlike manner to match with the original finish.

Cutting chases in finished concrete or finished plastered brick work for recessing conduits and outlet boxes etc. shall be done by the Contractors without any extra cost.

In the concealed GI conduit system, all boxes for accessories & draw/junction boxes shall be installed such that outer rim is flush with the finished surface of the wall. Sockets near skirting level shall be fed from the floor above rather than the floor below, because in the latter case it would be difficult to avoid traps in the conduit.

f) Surface Conduiting

Where surface mounted distribution boards are used with a sunk conduit, a flush adaptable box shall be fitted in the wall behind the distribution board and to take the flush conduits directly into it. Holes can be drilled in the back of the distribution board and bushed. Spare holes should be provided for future conduits. Distribution boards must be bonded to the adaptable boxes and unused holes should be sealed.

Wherever so desired, conduit shall be laid in surface over finished concrete and / or plastered brickwork. Suitable spacer saddles of approved make and finish shall be fixed to the finished structural surface along the conduit route at intervals not exceeding 600mm. Holes in concrete or brick work for fixing the saddles shall be made neatly by electric drills using masonry drill bits. Conduits shall be fixed on the saddles by means of good quality heavy duty GI clamps screwed to the saddles by counter sunk screws. Neat appearance and good workmanship of surface conduiting work is of importance. The entire conduit work shall be in absolute line and plumb. Conduits above false ceiling shall be fixed on suitable hangers supported from structural ceiling.

All surface conduits shall be run in a vertical or horizontal direction. Diagonal runs shall not be permitted.

g) Fixing of Conduit Fittings and Accessories

For concealed conduiting work, the fittings and accessories shall be completely embedded in walls/ceilings leaving top surface flush with finished wall/ceiling surface in a workman like manner.

Loop earthing wire shall be connected to a screwed earth stud inside outlet boxes to make an effective contact with the metal body.

h) Painting and Colour Coding of Conduits

Before laying, conduits shall be painted specially at such places where paint has been damaged due to vice or wrench grip or any other reason.

If so specified, surface conduits shall be provided with 20 mm wide and 100 mm long colour coding strips as below.

Use	Code Color
Low Voltage	Grey
Telephone	Black
Earthing system	Green
Control system Lighting	Purple
Security Conduit	Blue
Fire Alarm Conduit	Red

Conduit Feeder schedule shall include the following information:

- Conduit identification- Conduit Size
 - Circuit identification- Conduit Type
 - Conduit from- Conductor Description
 - Conduit to- Conductor Quantity
 - Identification of multiple runs
- i) Drawing reference Protection of Conduits
- To safeguard against filling up with mortar / plaster etc. all the outlet and switch boxes shall be provided with temporary covers and plugs, which shall be replaced by sheet/plate covers as required. All screwed and socketed joints shall be made fully water tight with white lead paste.
- j) Cleaning Of Conduit Runs
- The entire conduit system including outlets and boxes shall be thoroughly cleaned after completion of erection and before drawing in of cables.
- k) Protection Against Dampness
- All outlets in conduit system shall be properly drained and ventilated to minimize chances of condensation and sweating.
- l) Expansion Joints
- When crossing through expansion joints in building, the conduit sections across the joint shall be through approved quality heavy duty metal flexible conduits of the same size as the rigid conduit.
- m) Loop Earthing
- Loop earthing shall be provided by means of insulated stranded copper conductor wires of sizes as per schedule of quantities laid along with wiring inside conduits for all wiring outlets and sub mains. Earthing terminals shall be provided inside all switch boxes, outlet boxes and draw boxes etc.

4.1.10

Laying and Drawing of Wires

- a) Bunching of Wires
- Wires carrying current shall be so bunched in conduits that the outgoing and return wires are drawn into the same conduit. Wires originating from two different phases shall not be run in the same conduit. No joint shall be permitted in the run of wires.
- b) Drawing of Wires
- The drawing of wires shall be done with due regard to the following precautions: -
- No wire shall be drawn into any conduit, until all work of any nature, that may cause injury to wire is completed. Burrs in cut conduits shall be smoothened before erection of conduits. Care shall be taken in

pulling the wires so that no damage occurs to the insulation of the wire. Approved type bushes shall be provided at conduit terminations.

- i. Before the wires are drawn into the conduits, conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction by forcing compressed air through the conduits if necessary.
- ii. While drawing insulated wires into the conduits, care shall be taken to avoid scratches and kinks which cause breakage of conductors.
- iii. There shall be no sharp bends.
- iv. The contractor shall, after wiring is completed, provide a blank metal/sun mica plate on all switch/outlet /junction boxes for security and to ensure that wires are not stolen till switches / outlets etc. are fixed at no extra cost. The contractor shall be responsible to ensure that wires and loop earthing conductors are not broken and stolen. In the event of the wire being partly/fully stolen, the contractor shall replace the entire wiring along with loop earthing at no extra cost. No joint of any nature whatsoever shall be permitted in wiring and loop earthing.

c) Termination / Jointing of Wires

- i. Sub-circuit wiring shall be carried out in looping system. Joints shall be made only at distribution board terminals, switches / buzzers and at ceiling roses/connectors/lamp holders' terminals for lights/fans/socket outlets. No joints shall be made inside. Conduits or junction/draw/inspection boxes.
- ii. Switches controlling lights, fans or socket outlets shall be connected in the phase wire of the final sub circuit only. Switches shall never be connected in the neutral wire.
- iii. Wiring conductors shall be continuous from outlet to outlet. Joints where unavoidable due to any special reason shall be made by approved connectors. Specific prior permission from Engineer-in-Charge in writing shall be obtained before making such joint.
- iv. Insulation shall be shaved off for a length of 15mm at the end of wire like sharpening of a pencil and it shall not be removed by cutting it square or wringing.
- v. Strands of wires shall not be cut for connecting terminals. All strands of wires shall be twisted round at the end before connection.
- vi. Conductors having nominal cross-sectional area exceeding 1.5 Sq.mm shall always be provided with crimping sockets. Tinning of the strands shall be done wherever crimping sockets are not available as per instructions of the Engineer-in-Charge.
- vii. All wiring shall be labelled with appropriate plastic ferrules for identification.
- viii. At all bolted terminals, brass flat washer of large area and approved steel spring washers shall be used.
- ix. The pressure applied to tighten terminal screws shall be just adequate, neither too much nor too less.
- x. Switches controlling lights, fans, socket outlets etc. shall be connected to the phase wire of circuits only.
- xi. Only certified valid licensed wireman shall be employed to do the wiring/jointing work.

d) Load Balancing

The contractor shall plan the load balancing of circuits in 3 phase installation and get the same approved by the Engineer-in-Charge before commencement of the work.

e) Colour Code of Conductors

Colour Code for normal supply - Red, Yellow, Blue for three phases, black for neutral and Green for Earth - Shall be maintained for the electrical wiring installation.

Colour code for UPS supply - Red/white, Yellow/white, Blue/white for three phases, white for neutral and Green/yellow for Earth.

4.1.11

Wiring for Lighting Fixtures

- a) The Light fixtures and fittings shall be assembled and installed complete and ready for service in accordance with details, drawings, manufacturer's instructions and to the satisfaction of Engineer-in-Charge.

- b) Wires brought out from junction boxes shall be encased in GI Flexible pipes for connecting to fixtures concealed in suspended ceiling. The flexible pipes shall be provided with a check nut at the fixture end.
- c) Pendant fixtures specified with overall lengths are subjected to change and shall be checked with conditions of the job and installed as directed.
- d) All suspended fixtures shall be mounted rigid and fixed in position in accordance with drawings, instructions and to the approval of Engineer-in-Charge.
- e) Fixtures shall be suspended true to alignment, plumb, level and capable of resisting all lateral and vertical forces and shall be fixed as required.
- f) All suspended light fixtures etc. shall be provided with concealed suspension arrangement in the concrete slab / roof members. It is the duty of contractor to make these provisions at the appropriate stage of construction.
- g) All switches and outlet boxes shall be bonded to earth with installed stranded copper wire as specified.
- h) Wires shall be connected to all fixtures through connector blocks.
- i) Flexible pipes, where ever used, shall be of make and quality approved by the Engineer-in- Charge. Ease of maintenance / replacement shall be kept in view.

4.1.12 Measurement and Payment of Wirings

Wiring for lights, fans and convenience socket outlets shall be measured and paid for on Point Basis as itemized schedule of quantities and as elaborated as below (unless otherwise stated).

4.1.13 Average Wiring Length

The point wiring basis for wiring for lights, fans and convenience socket outlets shall assume average wiring length and average conduiting length per point based on parameters stipulated below. The average wiring length and average conduiting length forming the basis of point wiring payment, shall take the electrical layouts of the entire project into consideration. Tenderers are advised to seek clarifications, if they so desire, on this aspect before submitting their tenders. No claim for extra payment on account of electrical layouts in part or whole of the project requiring larger average wiring and conduiting length per point, whether specifically shown in tender drawings or not, shall be entertained after the award of contract.

4.1.13.1 Point wiring for lights – primary and secondary light points

In respect of group control of light (more than one light controlled by one switch or MCB), wiring up to the first light in the group shall be measured and paid for as a primary light point. Wiring for other lights looped in one group for switch controlled as also MCB controlled lights shall be measured and paid for as secondary light points. The cost of MCB controlling such lights shall not be included in the primary light point rate since the MCB shall be paid for in the item of DB. Primary light points shall include the cost of wiring from switch control to the first light fixture.

4.1.13.2 Design Parameters

Wiring shall be carried out as per following design parameters in recessed/surface conduit/ conduit cum raceway system.

- a) Only looping system of wiring shall be adopted throughout. No joints excepting at wiring terminals shall be permitted.
- b) All accessories shall be flush type unless otherwise stated.
- c) For estimation of load, following loads per point shall be assumed.
 - i. Light Points - As per load of fixture.
 - ii. 6A socket outlet points - 100 Watts.
 - iii. Fan points - 60 Watts.
 - iv. Exhaust Fan points - 100 Watts unless otherwise specified.
 - v. 16A socket outlet points - 1000 Watts unless otherwise specified.
- d) Light and fan points shall be wired on a common final sub-circuit. Each sub circuit shall not have more than a

total of 10 nos. lights and fans or a load of 800 watts whichever is lesser unless specifically stipulated otherwise. Wiring shall be carried out in rigid GI conduiting system.

- e) Each sub circuit for power socket should not have more than a total of 2 Nos. or not greater than 2000 W. Separate circuit shall be run for each geyser, Kitchen equipment, window Air conditioners and similar appliances.

4.1.13.3

Scope of Point Wiring

a) Wiring for Lights

Primary Light Points

Wiring for primary light points, as defined above, shall commence at the switch terminals and shall terminate at the ceiling rose/connector in ceiling box/lamp holder via the control switch (for switch-controlled lights). Rates for primary light point wiring shall be deemed to be inclusive of the cost of entire material and labour required for completion of primary light point thus defined including.

- Recessed/surface conduiting system with all accessories, junction/draw/inspection boxes, bushes, check nuts etc. complete as required.
- Wiring with stranded copper conductor FRLSZH insulated 660/1100-volt grade wires including terminations etc. complete as required.
- Loop earthing with insulated copper wires.

Secondary Light Points

Secondary light points, as defined above, shall cover the cost of interconnection wiring between group controlled light fittings and shall be deemed to be inclusive of the cost of entire materials and labour required for completion of the secondary light point thus defined including: -

- Recessed/surface conduiting system with all accessories, junction/draw/inspection boxes, bushes, check nuts etc. complete as required.
- Wiring with stranded copper conductor FRLSZH insulated 660/1100-volt grade wires including terminations etc. complete as required.
- Loop earthing with insulated copper wires.

b) Wiring for Ceiling Fans

Wiring for ceiling fan points shall be same as for primary light points.

c) Wiring for Exhaust Fans

Wiring for exhaust fan points shall be same as for primary light.

d) Wiring for Convenience Socket Outlets

Wiring for 6 Amps socket outlets on work tables shall be partly in GI Conduit and partly in GI raceways as indicated in electrical layout drawings. Wiring for socket outlets (6 amps as well as 16 amps) in locations other than workstations shall be carried out in GI conduit only.

e) Point Wiring for 5 pin 6A Convenience Socket Outlets

Point wiring for 5 pin 6 Amps socket outlets on point wiring basis shall be the same as primary light points defined in Para 2.14.2, including loop earthing of the third pin complete as required and as itemized in scheduled of quantities.

f) Point Wiring for 5 pin 16A Convenience Socket Outlets

Point wiring for 5 pin 16 Amps socket outlets on point wiring basis shall be the same as primary light points defined in Para 2.14.2, including loop earthing of the third pin complete as required and as itemized in scheduled of quantities.

g) Sub Main Wiring

Sub mains wiring shall be measured and paid for on linear basis as per the length of conduit installed between terminations. This shall include separate conduit system with all accessories, separate wires and

insulated loop earthing conductors as itemized in schedule of quantities. The quoted rates shall include termination of wiring at either end. Cost of wires only without conduits at either end required for end terminations and taken inside switchboards etc. shall be deemed to be included in the liner running meter rate of sub main wiring in conduit and no extra shall be paid for such additional wiring without conduit.

h) Cabling for Lighting/Power sockets in Sheds

Cabling for lighting/Power sockets shall be measured and paid for on linear basis as per the length of cable installed between terminations as per schedule of quantity.

4.1.13.4

Routine and Completion Tests

a) Installation Completion Tests

At the completion of the work, the entire installation shall be subject to the following tests:

- i. Wiring continuity test
- ii. Insulation resistance test
- iii. Earth continuity test
- iv. Earth resistivity test

b) Polarity test

Besides the above, any other test specified by the local authority shall also be carried out. All tested and calibrated instruments for testing, labour, materials and incidentals necessary to conduct the above tests shall be provided by the contractor at his own cost.

c) Wiring Continuity Test

All wiring systems shall be tested for continuity of circuits, short circuits, and earthing after wiring is completed and before installation is energized

d) Insulation Resistance Test

The insulation resistance shall be measured between earth and the whole system conductors, or any section thereof with all protection in place and all switches closed and except in concentric wiring, all lamps in position of both poles of the installation otherwise electrically connected together, a direct current pressure of not less than twice the working pressure provided that it does not exceed 1100 V for LT circuits. Where the supply is derived from AC three phase system, the neutral pole of which is connected to earth, either direct or through added resistance, pressure shall be deemed to be that which is maintained between the phase conductor and the neutral. The insulation resistance measured as above shall not be less than 200 Mega ohms divided by the number of points provided on the circuit. The whole installation shall not have an insulation resistance lower than one mega ohm.

The insulation resistance shall also be measured between all conductors connected to one phase conductor of the supply and shall be carried out after removing all metallic connections between the two poles of the installation and in those circumstances the insulation shall not be less than that specified above.

The insulation resistance between the frame work of housing of power equipment's / appliances and all live parts of each equipment / appliance shall not be less than that specified in the relevant standard specification or where there is no such specification, shall not be less than half a Mega ohm or when PVC insulated cables are used for wiring 12.5 Mega ohms divided by the number of outlets. Where a whole installation is being tested at a lower value than that given by the above formula, a minimum of 1 Mega ohm is acceptable.

e) Testing of Earth Continuity Path

The earth continuity conductor including metal conduits and metallic envelopes of cable in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance of earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

f) Testing of Polarity of Non – Linked Single Pole Switches

In a two-wire installation a test shall be made to verify that all non-linked single pole switches have been connected to the same conductor throughout, and such conductor shall be labelled or marked for connection to an outer or phase conductor or to the non- earthed conductor of the supply. In the three or four-wire installation, a test shall be made to verify that every non-linked single pole switch is fitted to one of the outer or phase conductor of the supply. The entire electrical installation shall be subject to the final acceptance of the Engineer-in-Charge as well as the local authorities.

g) Earth Resistivity Test

Earth resistivity test shall be carried in accordance with IS Code of practice for earthing IS – 3043

h) Performance

Should the above tests not comply with the limits and requirements as above the contractor shall rectify the faults until the required results are obtained. The contractor shall be responsible for providing the necessary instruments and subsidiary earths for carrying out the tests. The above tests are to be carried out by the contractor without any extra charge.

i) Tests and Test Reports

The contractor shall furnish test reports and preliminary drawings for the equipment to the Engineer-in-Charge for approval before commencing supply of the equipment. The Contractor should intimate with the tender the equipment intended to be supplied with its technical. Any test certificates/ reports required by Employers/ Statutory Authority would be supplied by the Contractor without any extra charge. All test reports shall be approved by the Engineer-in-Charge prior to energizing of installations.

4.1.14

Wall Mounted Industrial Fan

The Contractor shall supply and install wall / column mounting cooling fan at Depot workshop (Man working area), warehouses manufacturing facilities and garages where humid and demanding conditions exist. All circulator heads shall have high efficiency corrosion resistant propellers with aluminium blades. Circulator heads utilize a vertical tilt/locking adjustment for directional flow. Wire guards shall be grey polyester powder-coated and comply with OSHA Standard 1910.212 (1/2" max opening). Fans shall be complied to IS 6272 or UL/CUL Listed Standard 507. All circulator heads are no oscillating except 1VCF2 thru 1VCF5, 13F046 and 13F047 which sweep through a 45° or 90° arc. Permanent split capacitor motors are totally enclosed air over. The rubber sheet shall be inserted between fan casing and wall, for vibration isolator.

The preferred rated voltages for the industrial cooling fans shall be 240 V for single- phase induction type motor and sweep 450mm.

Each fan shall be indelibly marked with at least the following information:

- a) Manufacturer's name, trade-mark of fan (if any) and number;
- b) Rated voltage(s) or voltage range and number of phases;
- c) Input in watts;
- d) Size of fan;
- e) Rated speed of fan in rev/min;
- f) Rated frequency;
- g) Country of manufacture;
- h) Rated current;
- i) Direction of rotation.

In the case of a fan provided with an earthing terminal or contact, it shall be indelibly marked with the symbol.

4.1.15

Testing of fans

Type test: - The tests specified below shall constitute type tests and shall be carried out on three samples of same type and rating selected, preferably, at random from a regular production lot as per IS 6272

- a) High voltage
- b) Insulation resistance
- c) Earthing continuity
- d) Electrical input
- e) Fan speed
- f) Power factor
- g) Leakage current
- h) Cord grip
- i) Starting
- j) Air delivery
- k) Temperature-rise

Acceptance Tests - The following shall constitute the acceptance tests:

- a) High voltage
- b) Insulation resistance
- c) Earthing continuity
- d) Electrical input
- e) Fan speed.

Annexure A:

Acceptance Test Report			Section VI-B- Electrical		
Customer Name:					
P.O.No.& Date:					
Description:					
Specification :IS 694:2010 & Data Sheet			Specified Values	Type Test Values	Observed Values
S.I No	Test Descriptions	Unit	(Specified Values shall be as per IS 694:2010 and the Cable selected)	Type test Values shall be the same as submitted at the time of Vendor	DRUM/COIL No.:
	Core Identification				
	Colour of Outer Sheath		Black	Black	Black
1	Maximum size of Conductor	mm			
2	Conductor Resistance (ohms/km corrected at °C)				
3	Annealing Test (for copper Wires After stranding)				
4	Thickness of Insulation	mm			
5	Thickness of Outer sheath	mm			
6	Overall dia of core	mm			
7	Test on Insulation (As per IS-5831-				
	Type of compound				
	i) a) Volume resistivity (at 27 DC)	Ohm cm			
	b) Volume resistivity (at 90 DC)	Ohm cm			
	ii) a) Tensile strength (Before ageing)	N/mm ²			
	b) Elongation at break (Before ageing)	%			
	Test on Outer Sheath (as per IS- 5831-1984)				

8	Type of compound					
	i)	a) Tensile strength (Before ageing)	N/mm ²			
		b) Elongation at break (Before ageing)	%			
9	Routine High Voltage test at R.temp.					
10	FRTest					
	i)	Oxygen Index Test				
	ii)	Temperature Index Test				
11	Flammability test					
	i)	As per IS 10810 (Pt 53)				
	ii)	Time of burning after removal the flame				

Annexure B:

Sr. No.	Checks to be done before Drawing of Wire in Conduits as per the Specification for supply & installation of conduits, associated fittings & accessories	Remarks
1	Steel wire of 1.6 sqmm size shall be left in all conduit runs to facilitate drawing of wires	
2	Check for any mechanical stress on the conduit.	
3	Check for use of approved quality metallic flexible conduits at expansion joints of the building	
4	Check allowance for running earthing wire as per Specification	
5	Conduit should be kept within 300mm of floors and ceiling when running parallel to them	
6	Ensure conduit runs must not exceed 8 m or have more than two right angle bends.	
7	Check conduits from different Distribution Boards must not be connected to same junction box	
8	Check the water tightness of the Conduit system as per the 'Method Statement including Tests' submitted by the contractor. As per the specification of conduit.	
9	Check the coupling used in conduit system, conduits must be coupled using couplers	
10	Check the joints and terminations of the conduits, conduit-threads must not be exposed and if	

Sr. No.	Checks to be done before Drawing of Wire in Conduits as per the Specification for supply & installation of conduits, associated fittings & accessories	Remarks
	unavoidable then must be treated	
11	Check the conduit bends as per approval given by the Engineer at site.	
	In Recessed Conduit and Outlet Boxes	
12	Ensure minimum of 12mm of concrete must cover the conduit and outlet box.	
13	Ensure that the conduit must be tied to the reinforcement with steel wire (dia 1.5 mm) at an interval of maximum 1 m.	
14	Check the space between the concealed conduits entering the draw-in box must be minimum 25mm In Case of Conduit Recessed In Brick	
15	Ensure 10 mm space must be available between conduits and depth must be sufficient so that minimum thickness of plaster over conduit is 6 mm Ensure Galvanised Chicken wire mesh of 0.6 mm thick	
16	with 10 to 15 mm aperture must be provided for full length of the chase in the plaster	
17	Ensure that all boxes for accessories and draw/junction boxes must have outer rim flushed in the finished surface, in case of concealed conduits	
	In Case of Surface Conduiting	
18	Check for approved make spacer saddle at an interval not exceeding 600 mm and 300 mm from the fittings.	
19	Good quality of workmanship must be ensured in case of surface conduiting	
20	Check that the loop earthing wire must be connected to a screwed earth stud inside outlet boxes to make an effective contact with the metal body. Ensure that all outlets and switch boxes shall be provided with temporary covers and plugs before plaster and concreting work to safeguard against filling up with mortar/plaster etc.	
22	Check entire conduit system including outlets and boxes must be thoroughly cleaned after completion of erection and before drawing of wires. Check loop earthing is provided by means of insulated	
23	stranded copper conductor wires of sizes as per BOQ laid along with wiring inside the conduits for all wiring outlets.	
	Checks to be done after Drawing of Wire in Conduits as per the Specification for Conduit Wiring of Depot Specification.	
24	Check the phase and neutral must be drawn in the same conduit.	
25	Ensure two different phases must not run in same conduit.	
26	Check the wiring, no joint must be present in the conduits or junction/draw/inspection boxes, except with prior written approval from Engineer at site.	

Sr. No.	Checks to be done before Drawing of Wire in Conduits as per the Specification for supply & installation of conduits, associated fittings & accessories	Remarks
27	Check all bolted terminals, brass approved flat washer of large area must be used.	
28	Check that good quality heat shrinkable sleeves are used at the terminations.	
29	Check the switches controlling lights, fans, socket outlets etc. must be connected to the phase wire of circuit only.	
30	Ensure bushes must be provided at the conduit edges and proper care must be taken so that no damage occurs to the insulation of the wire.	
31	Insulation resistance must be tested. This must not be less than 50 divided by the number of points in the circuit in mega ohms. (50/no. of circuits). Check the earth continuity of various equipment installed.	
34	Measure current and voltage of all the lighting circuits at the sub-distribution board with all the lamps switched on to ensure that these are within design values, in case of 3phase the load must be balanced reasonably.	
35	Measure the minimum and maximum illumination levels after installation of all the lamps along with the supplier of lamp/luminaries and shall and shall comply with the designed value	
36	Check the phase sequence to ensure correct phase sequence.	
*Note: The test for insulation resistance must be carried out when all the equipment is disconnected from the circuit.		
Date & Sign		

CHAPTER – 05

LIGHT FIXTURES (INDOOR AND OUTDOOR AREA)

5.1 Scope

Scope of work under this section shall include inspection at supplier's /manufacturer's premises at site, receiving at site, safe storage, transportation from point of storage to point of erection, erection and commissioning of **INDOOR & OUTDOOR LED** light fittings, fixtures and accessories including all necessary supports, brackets, down rods and painting etc. as required.

5.1.1 Objective

The main lighting objectives are:

a) Safety and health

The lighting should enable the occupant to see sufficiently well to work and move about in safety, both under normal condition and in the event of emergency involving a power failure. The lighting must not create conditions which are injurious to health, requiring for example, the elimination of harmful radiation, the prevention of eye strain and prevention of glare.

b) Performance

Visual performance is the term used to describe both the speed at which the eyes function and the accuracy with which the visual task can be carried out.

c) Appearance and comfort

The way in which a space is illuminated can affect its character and the object with in it

Where the creation of mood or atmosphere is predominant this must be the prime lighting objective, but some consideration should be given to this factor in all the designs

d) Energy and cost effectiveness

Significant saving in energy consumption, and therefore cost of providing lighting without reducing standards can be achieved by applying an energy-effective-design approach to lighting installation, the cost of owning and installation can be divided as follows:

i. Investment Cost

The investment cost for an installation can be split up as follows:

- i. Luminaries cost, including control gear and very often the initial lamp costs
- ii. Lighting control system
- iii. Mounting accessories
- iv. Electrical wiring
- v. Installation cost

Where several alternative lighting solutions based upon similar luminaries' arrangement have been proposed, all of them satisfy the quality criteria, the difference in the cost of electric wiring and the installation is considerably less as compared to total system cost whereas, use of different luminaries and mounting accessory would make substantial difference in investment costs. Different luminaires choice has direct implication on the running cost either in the energy cost or the cost of maintenance. Also, the luminaries chosen and the way these are arranged and mounted can affect the cost of wiring.

ii. Running Costs

The most important running costs are those involving

- i. Energy
- ii. Lamp replacement
- iii. Maintenance of system

Maintenance costs represent a relatively small part of the total annual costs. This is particularly important in environments where disturbance to the work routine should be avoided. The major running cost factor is the cost of energy. This means that the lighting, apart from meeting all the other demands likely to be placed upon it, must also be as efficient as possible to keep electricity consumption to a minimum

5.1.2

Standards and Codes

The scope of work shall cover the supply, installation, testing, and commissioning of lighting system comprising light fittings (LED, chokes, control gear, lamps, fixing arrangement etc. as specified standard.

The LED lighting and their associated accessories such as lamps, reflectors, housings, control modules etc., shall comply with the latest applicable standards, more specifically the following:

IS 3646 (All 3 parts)	Code of practice for interior Illumination
IS 16102 Part-2	Self-ballasted LED lamps for general lighting services. (Part2-Performance Requirements).
IS 16103 Part-2	Self-ballasted LED lamps for general lighting services. (Part2-Performance Requirements).
IS 16104	Method of measurement of lumen maintenance of solid-state light (LED) sources.
IS 16105	Method of measurement of lumen maintenance of solid-state light (LED) sources.
IS 16106	Method of electrical & photometric measurements of solid-state lighting products.
IS 16107 Part-1	LED Luminaries performance general Requirements.
IS 16107 Part-2	LED Luminaries performance particular Requirements.
IEC 55015/EN 55015	Limits and method of Measurements of radio disturbance characteristics of electrical lighting and similar equipment.
IEC 60529/EN 60529	Specification of degrees of protection provided by enclosures (IP code).
IEC 60555/EN 60555	Disturbances in supply systems caused by household appliances and similar electrical equipment.
IEC 60947-4-1/EN 60947 – 4- 1	Specification for low – voltage switchgear and control – gear, Contractors, motor starters, electromechanical contractor and motor-starters.
IEC 60555, EN 55015	Electromagnetic Compatibility: Emission
IS 16108	Photo-biological safety of lamps & lamps system.
BS 646	Cartridge fuse- links (rated up to 5 amperes) for AC/DC service.
IEC 60742 / EN 60742/BS 3535	Isolating transformers and safety isolation transformers.
IS 3646 Part 1 & 2	Code of Practice for Interior Illumination.
IS 1777 – 1978	Industrial luminaire with metal reflectors
IS 10322 (All Parts)	Specification for Luminaires
NBC 2016	National Building Code India

NLC 2010	National Lighting Code
IE Rules	Indian Electricity Act and Rules issued there under
IS 16101	General lighting - LED's and LED modules – Terms and condition
IS 15885:(Part-2 Section-13	Safety of Lamp, Control Gear Part2 Particular requirements section-13. DC supplied IE electronic control gear for LED module.

A All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard Codes of Practice or the relevant British Standard Codes of Practice in the absence of Standard.

5.1.3

Light Fitting General Requirements

- a) All fixtures shall be complete with accessories necessary for installation whether so detailed under fixture description or not.
- b) Fixture housing frame or canopy shall provide a suitable cover for the fixture outlet box or fixture opening.
- c) Fixture shall be installed at mounting heights as detailed on the drawings or instruction on site by the Employers representative.
- d) Fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the fixture highly secured to a fixture stud in the outlet box. Extension pieces shall be installed where required to facilitate proper installation. Design of hangers and method of fastening other than shown on the drawings or here in specified shall be submitted to the Engineer for approval.
- e) Pendant fixture within the same room or area shall be installed plumb and at a uniform height from the finished floor. Adjustments of height shall be made during installation as per instructions of Engineer.
- f) Flush mounted and recessed fixtures shall be installed to completely eliminate light leakage within the fixture and between the fixture and adjacent finished surface.
- g) Fixture shall be completely wired and constructed to comply with the regulations and standards for Electric light fixtures, unless otherwise specified. Fixture shall bear manufactures name and the factory inspection label unless otherwise approved.
- h) Fixture with visible frames shall have concealed hinged and catches. Pendant fixtures and lamp holder shall be provided with ball type aligners or similar approved means. Recessed fixtures shall be constructed to fit into an acoustic tile ceiling or plaster ceiling. Flanges shall be provided for plaster ceiling. Fixtures with hinged diffuser doors shall be provided with spring clips or another retaining device to prevent the diffuser from moving.
- i) Detailed catalogue cuts for all fixtures or if so, required by the Engineer sample fixtures shall be submitted for approval to the Engineer before orders for the fixture are placed. Shop drawings for non-standard fixture types shall be submitted for approval to the Engineer.
- j) Recessed fixtures shall be constructed so that all components are replace-able without removing housing from the ceiling.
- k) Lamp shall be supplied and installed in all lighting fixtures furnished under this contract. All lamps shall be rated for 250 volts. Lamps for temporary lighting services shall not be used in the final lamping of fixture units. Lamp shall be wattage and type as shown on the drawings and schedule. Where not shown the details shall be ascertained from the Engineer before procurement.
- l) Lamps for permanent installation shall not be placed in the fixtures until so directed by the Engineer and this shall be accomplished directly before building portions are ready for occupation
- m) Each fitting shall have a terminal block suitable of loop out connection by 1100V PVC Insulated copper conductors' wires/cables. The internal wiring should be completed by manufacturer by means of standard FRLSZH copper wire and terminated on the terminal block.

- n) Each light fitting shall be provided with an Earthing terminal. All metal or metal enclosed parts of the earthing terminal to ensure satisfactory earthing continuity throughout the fixture.

5.1.4 LED Lights Technical Requirement

a) LED Luminaries

This specification covers for supply of Light Emitting Diode (LED) lighting that shall be used as general lighting in system. The product should be latest state of art and compliant to relevant IEC 60598-1, 2, 3, IEC 62031 and IEC/PAS 62612 or their latest edition depending on the type of luminaries. In addition to the above luminaries shall adhere to relevant BIS standards IS 15885, 16101, 16102, 16103, 16104, 16105, 16106, 16107 (Part I & II) as per the application.

The supplier shall have proven design capabilities and should provide type test certificate / performance certificate from an NABL accredited laboratory. The manufacturer shall have at least five years' experience of design and manufacturing of similar products. The proposed products from the proposed manufacturing unit shall have established their satisfactory performance and reliability for three years in minimum. The product and its major components shall be state of art and of proven design.

b) Fixture

- i. The fixture shall be suitable to work under following ambient conditions.
 - Maximum ambient temperature of 50° C.
 - Atmosphere - The product shall be designed to work in coastal, humid, salt laden and corrosive atmosphere.
- ii. Housing, if not used as a heat sink shall be made of at least 0.5 mm thick sheet Steel/ extruded Aluminium (minimum 2 mm thickness) or pressure die cast (minimum 2 mm thickness), conforming to relevant standards, polyester powder coated of at least 40 microns) and high U.V. & corrosion resistance.
- iii. Heat sink used should be extruded Aluminium or Pressure Die-Cast Aluminium having high conductivity preferably ADC 12 or LM 6.

Luminaries should be covered with suitable Glass or diffuser with High Transitivity. Outdoor luminaries shall be with clear toughened glass or clear polycarbonate cover.

Lighting fixtures and accessories shall be designed for continuous trouble-free operation under diverse atmospheric conditions without deterioration of materials. Degree of protection of enclosure shall be at least IP-65 for outdoor fixtures. However, down lighter and other internal fixture shall be provided with at least IP-54/20 protection.

The fixture should conform to applicable IS 10322 / IEC 60598 (All parts & amendments) and should have the associated LM-79 and LM-80 report from accredited lab. Test report shall be submitted along with relevant catalogues.

c) LED Approved Make Compliances shall be as below but not limited to

IS certified. High lumen efficacy LEDs suitable for the application along with following features shall be used:

- i. LED Efficacy at the chip level shall > 120 lumen/watt (For High power LED)
 - a. The efficiency of the LED at 85 Degree C junction temperatures shall be more than 85%.
 - b. The system luminous efficacy of LED luminaires shall be as under
 - Efficacy > 75 lumen/Watt for low wattage luminaries (<45W); and
 - Efficacy > 85 lumen/watt for high wattage luminaries (>45W)
- ii. Adequate heat sink with proper thermal management shall be provided.
- iii. Minimum view angle of the LED shall not be less than 120°.
- iv. Power factor of complete fitting shall be more than 0.9.

- v. LED shall be surface mounted type duly soldered to PCB by Reflow system or COB type. The Solder used shall be ROHS compatible for environment friendliness.
- vi. Input frequency range shall be between 50Hz \pm 3%.
- vii. Minimum Colour rendering index CRI \geq 70 unless specified in item description.
- viii. Correlated Colour Temperature shall be in the range of 3000 K - 6500 K.

d) LED Driver

LED driver shall have following features:

- i. Input voltage Range within 160V (RMS) to 270V (RMS) o Driver shall be designed to withstand surges of at least 1.5 KV.
- ii. Output voltage of the driver shall be designed to meet the Power Requirement of the system.
- iii. Output voltage ripple should be within 3%
- iv. Output over voltage protection 125 V DC
- v. Full Load Efficiency \geq 85%
- vi. Total Harmonic Distortion
 - For 0- 50 W for shall be less than 25%
 - Above 50 W rating shall be less than 15%.
- vii. Current waveform should meet EN 61000-3-2
- viii. LED Driver shall withstand voltage of 350V for 2 hours and restore normal working when normal voltage is applied
- ix. The driver should comply with CISPR 15 for limits and methods of measurement of Radio disturbance characteristics.
- x. The equipment should comply with IEC 61547 for EMC immunity requirements.
- xi. The control gear should be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384.

e) General

The lumen maintenance of the LED lightings shall not be less than 70% after 50,000 hours. The supplier shall provide evidence that the LED chipset manufacturer has the patent right to produce the supplied LED chipset to avoid infringement of white LED patent. Free warranty shall commence after delivery and end at 60 months after delivery. The warranty of replaced item shall re-start from date of attending defect / replaced.

Test reports for various parameters i.e. flux, power, efficacy, chromaticity, temperature, protection etc. issued by an NABL accredited laboratory shall be furnished. Estimation on product's life and performance shall also be furnished.

Client reserves the right of testing of products for its conformity in accordance with above specifications.

5.1.5

Indoor Light Fitting

a) Surface Mounted Light Fitting

- i. Only single and/or two LED tube lamps with accessories shall be used in any one fixture.
- ii. Surface mounted fixtures longer than two feet shall have one additional point of support besides the outlet box fixture stud when installed individually. Pendant individually fixtures four feet long and smaller shall be provided with twin stem/conduit hangers. Stems shall have ball aligners or similar devices and provided for a minimum of 25 mm vertically adjustment. Stems shall be of appropriate length to suspend fixtures at require mounting height.
- iii. Light fitting housing shall be CRCA sheet steel, powder coated, and minimum IP 20 protection required
- iv. Lamps shall maximum energy savings and a minimum guaranteed of 50000 burning hours and a lumen output of 4000 lm. colour shall be approved from employer representative.
- v. The surface mounted light fitting shall be using without false ceiling area like pump room, ASS, Electrical

room, stair case, stores, workshop, stabling shed etc.,

b) Recess Mounted Light Fitting

- i. Where ever false ceiling will come like office area, supervisor room, staff room, canteen, toilet etc., using that recess mounting LED light fitting with supporting arrangement.
- ii. Light fixtures lamps shall be maximum energy savings and a required maximum guaranteed of life burning hours and fitting selection, lumen output based on the lux level requirement
- iii. Light fitting housing shall be CRCA sheet steel, powder coated.
- iv. Decorative LED fitting shall be provided with mounting/housing channel cum reflectors of CRCA sheet steel. Stove enamelled diffusers or louvers shall be translucent white polystyrene, as specified.

c) Shed Light Fixtures

- i. High bay and low bay industrial type LED light fixtures shall be used in the shed area.
- ii. Light fitting out let box shall be provided with hanging arrangements, adequate support the complete light fixtures weight.
- iii. Shed light fitting shall be provided the High pressure die cast aluminium housing arrangement with tempered glass cover.

5.1.6 Installation of Light Fixtures

The light fixtures and fittings shall be assembled and installed in position complete and ready for service, in accordance with details, drawings, manufacturer's instructions and to the satisfaction of the Engineer. Pendant fixtures specified with overall stem lengths are subject to change and shall be checked with conditions on the job and installed as directed. All suspended fixtures shall be mounted rigid and fixed in position in accordance with drawings, instructions and to the approval of the engineer.

5.1.7 Lighting Lux Levels Requirements

The Contractor shall Design, supply, install and commission a high efficiency lighting system for all area and buildings of the Depot including emergency lighting system Light fittings for all areas shall be selected to suit various architectural design and finishes and the Contractor shall allow for the design co-ordination process that this shall entail. The light fittings and all associated accessories shall be subject to the Notice of No objection of the Employer.

Lighting fixtures shall be manufactured locally by approved factory or imported.

The design of mounting details of the light fitting shall take into consideration the ease of maintenance. Where light fittings are mounted at high levels, the Contractor shall provide suitable means to enable the light fittings to be maintained without the use of portable ladders or other portable equipment with minimum interruption to the railway operation.

The Contractor shall design, supply, install and commission of light fittings for all areas.

Emergency lighting in the escape corridors and staircases shall be un-switched.

The lighting on escape route shall be connected to dedicate UPS serving Very Essential Loads. Selected lighting loads of other areas shall be connected to DG serving Essential load remaining lighting shall be on normal supply.

Lighting levels shall be uniformly distributed throughout the whole depot, and shall be designed such that glare, dark recesses and areas of poor lighting levels are avoided. Highlight of 2 times the general illumination level shall be provided by down lighting for main entrance, lift front doors, tops and bottoms of stairs.

All offices, plant rooms, workshop, stabling yard and stores shall have local switches to control the lighting in that area apart from BMS control. Where six or more luminaries are provided in a single room, circuits shall be split, and the multi-gang switches shall be provided. Manual override switch at relay panel shall be provided in case of BMS is failed.

The street lighting shall consist of luminaries on galvanized steel pole, for road lighting. Illumination levels

The lux levels to be achieved in various areas of station buildings, both in normal and emergency conditions are indicted in the table below. Contractor shall verify and demonstrate the achieving of the light level as per the table below: -

Sr. No	Activity Areas for Depot	Recommendations		UPS Lighting
		Normal (Lux)	DG Set (Lux)	Essential (Lux)
1	Workshop Bay	300	100	-
2	Inspection Bay	300	100	-
3	Interior Cleaning Bay, ETU Workshop	300	100	-
4	Stabling Shed	100	50	-
5	Entrance, Reception Areas	250	125	5- 10
6	Workshop Repair Section	300	100	-
7	Workshop Offices	250	125	-
8	Circulating areas, Corridors etc.	200	100	5- 10
9	Store Rooms	150	50-75	-
10	System wide Equipment Rooms	250	125-150	5- 10
12	General Offices	300	100	5- 10
13	Toilets	100	25	5- 10
14	Outdoor Lighting (Street Lighting)	25	10	5- 10
15	Outdoor Parking	30	15	5- 10
16	ASS, LT Panel Room, DG Set Room, Traction Equipment Rooms	300	100	5- 10
17	Technical Rooms	300	100	5- 10
18	Pump Room	150-200	25-50	5- 10
19	Transformer Room (ASS Room)	200 – 250	25-50	5- 10
20	Signalling Equipment Room	300 – 500	50	5- 10
21	Telecommunication Equipment Room	300 – 500	50	5- 10
22	Signalling Control Panel Room	300 -500	50	5- 10
23	Communication Equipment Room	300 – 500	50	5- 10
24	Communication Maintenance Room	300 -500	50	5- 10
25	Security Room	200 – 300	25-50	5- 10
26	Lift Lobby	200 -300	50	5- 10
27	Refuse Room or Spare Room	100 - 150	25-50	-

Sr. No	Activity Areas for Depot	Recommendations		UPS Lighting
Operation areas				
1	Control room	300	150	05-10
2	Equipment rooms and Other operation areas	200	100	05-10

Note: If any areas or rooms are not specified in above table, consider suitable illumination levels for the same should be followed as per LED lighting standards and references mentioned in technical specifications.

CHAPTER – 06**OUTDOOR LIGHT FITTING (HIGH MAST AND STREET LIGHT)****6.1 Outdoor Light Fitting (High mast and Street light)****6.1.1 Scope**

The scope of work covers the design, manufacture, supply, installation and testing of lighting poles, weather proof light fixtures, wiring to the fixtures, cable laying, earthing as specified and shown on the drawing.

6.1.2 Standards

The following standards shall be applicable:

IS: 3528 – 1966	Water proof electric lighting fitting
IS 1239: Part 1: 2004	Steel Tubes, Tubular and Other Wrought Steel Fittings - Specification - Part 1: Steel Tubes
IS 1239: Part 2: 1992	Mild steel tubes, tubular and DG other wrought steel fittings, Part 2 Mild steel tubular and other wrought steel pipe fittings
IS 10322: Part 5 Sec 3: 1987	Luminaries: Part 5 Particular requirements, Section 3 Luminaries for road and street lighting (superseding IS:2149)
IS 2713: Parts 1 to 3: 1980	Specification for Tubular Steel Poles for Overhead Power Lines
IS 1646: 1997	Code of practice for fire safety of buildings (general): Electrical installations
IS 1255: 1983	Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
	Indian Electricity Act, 2003 and IE Rules, 1956 as amended
	Regulations laid down by the Chief Electrical Inspector
	Any other regulations laid down by the Local Authorities
Note: All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard Codes of Practice or the British Standard Codes of Practice in the absence of Indian Standards.	

6.1.3 High Mast**a) Scope**

This specification deals with the design, fabrication/manufacture, testing, supply and erection of outdoor high mast lighting equipment including 20.0 mtr / 30.0 mtr high mast with mobile lantern carriage, luminaries and associated accessories, fittings, etc. to be installed for lighting of yard. High mast lighting shall be designed such that columns and fittings can be maintained without the need to close sections of the depot.

High mast lighting shall be designed such that photocells and drivers are installed at low level. Where used, high lighting masts shall allow for lowering of hoisted light rings for ease of maintenance.

b) Codes and Standards

- i. Design, manufacture and performance of the mast shall comply with all currently applicable statutory regularities and safety codes and standards in the locality where the equipment will be installed and generally in accordance to the following:
 - British Code of Practice CP3: Chapter V Part 2: 1972
 - Technical Report No.7: Second Edition, Section 2:1996 by the Institute of Lighting Engineers.
- ii. The work shall be done to a high degree of workmanship in accordance with approved drawings and in

conformity with this specification and the relevant specifications and code of practice of the bureau of Indian Standards, including the following:

- Indian Electricity Rules.
- IS: 1646-1982: - Code of Practice for fire safety of buildings (general); Electrical Installations.
- IS: 1255-1983: - Code of Practice for installation and maintenance of power cables up to and including 33 kV rating
- Regulations laid down by the Chief Electrical Inspector.
- Any other regulations laid down by the Local Authorities.

c) Design

30mtrs high mast suitable for fixing 12/16 luminaries, in two sections, with confirm carriage and all accessories required to complete the supply and erection of High Masts at designated locations high mast shall be manufactured as for Technical Report No. 7 (latest edition) by the institution of lighting engineers and as per specification of high masts given in this document

d) General Constructional Features

- i. The mast shaft shall be made with the best steel grade, in compliance with BS EN 10025 FE 510C, having the following guaranteed characteristics:
 - Minimum Yield Strength = 355 N/ sq. mm for thickness less than 30 mm Tensile Strength ranging from 490 to 630 N/sq. mm
 - Minimum elongation for thickness between 3mm and 30 mm: 22%
- ii. The steel grade for accessories shall be BS EN 10025 Fe 430A or equivalent, having followed guaranteed characteristics:
 - Minimum Yield Strength = 225 N/sq. mm for thickness less than 30 mm Tensile Strength ranging from 340 to 470 N/ sq mm
 - Minimum elongation for thickness between 3 mm and 30 mm: 26%
- iii. All holding bolts are hot dip galvanized to BS: 729.

e) Mast Design Criteria

- i. The high mast and the lowering system with the required number of floodlights and lamp control gears etc. in place shall be capable of withstanding a sustained basic wind speed of 180 km/h with 3 seconds gust.
- ii. The design shall be in such a manner that it is capable of withstanding external forces exerted by wind pressure and should have a minimum wind load factor of 1.25 and material factor of 1.115. Design life of mast should be at least 25 years.

The mast shall be designed in accordance to the table below: (Contractor need to provide the technical data for high mast asked below by contractor) & below data shall be submitted for further approval from the employer representative.

Maximum Loading	20m High Mast	30m High Mast
Foundation		
Shear Force		
Overturning Moment		
Torsion Moment		
Axial Load		
Max. Deflection		
Max. Base Flange O.		

D.		
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f) Mast structure and construction

- i. Each mast section to be delivered to site shall have a minimum length of 9.0 m. the sections shall not be circumferential welded through slip joint of multiple short sections. Detailed instructions relating to site assembly shall be provided by contractor to engineer.
- ii. The top section shall have a flange plate for bolted connection to the head frame. The base shall have a flange plate for fixing the high mast onto the concrete foundation by GI anchor bolts.
- iii. The mast shall be fabricated as per technical report no.7 of institution of lighting engineers. It will be butt welded longitudinally to form a tapered section with (one) longitudinal seam weld is permissible. All welding shall be to BS 5135 having the following basic requirements:
- iv. Mast sections to base flange and longitudinal weld within 150 mm of the female slip joints areas shall have:
 - Full penetration between plates of all thickness.
 - No fissures.
 - No undercutting.
 - No blow holes, porosity or spherical beyond 5% on the minimum thickness. No detectable angular inclusion.
- v. Longitudinal welds along the mast shaft shall have: - 60% minimum penetration between plates. No fissure on the inside and outside surface. No undercutting on the outside surface. No blow holes.
- vi. Ultrasonic testing procedures shall be considered as minimum permissible testing method.
- vii. The wall thickness of each section shall be designed to withstand the loads to which the high mast will be subjected to but shall not be less than 3 mm.
- viii. Unless otherwise specified connection between the various station shall be achieved by telescopic slip joints, the overlapping length being at least equal to 2.0 times the inside diameter of the female section. Slip joint assembly shall be performed at site. Shaft section shall not be joint by circumferential weld or bolting.
- ix. The base plate shall be free from lamination and shall be single flange constructed with holes' jig drilled for anchor bolt passage. The bottom of the base mast section shall be securely welded to the base plate by complete penetration butt welding or fillet welding. The welded connection of the base plate to the mast section shall fully develop the strength of the section.
- x. The base section shall be equipped with a hinged service door. The service door opening shall be completed with a close fitting weatherproof and equipped with a vandal resistant lock. The service door shall not be smaller than 1400 mm X 300 mm. The opening shall be reinforced by a thick steel door frame.
- xi. Base plate dimensions and thickness and the no. diameter, size and the placement of anchor bolts shall be determined by calculation and indicated in the drawings.
- xii. Anchor bolts shall be deformed steel reinforcement bars having the following minimum guaranteed characteristics: Specified characteristic strength = 460 N / sqmm Tensile strength = 480 N / sqmm
- xiii. Welding of two or more anchor rods of shorter lengths to achieve the design length shall not be permitted. No welding shall be allowed on the anchor rod body.
- xiv. Adequate earthing and earthing terminal shall be provided within the access door area of each high mast. Details shall be submitted to the engineer for approval.
- xv. All high mast shall be hot dip galvanized, in accordance with British Standard 729/1971(1986).
- xvi. All mast component shall be hot dip galvanized after completion of fabrication. The galvanized of sections having overall length of up to 14m shall be achieved in a single dip operation. Double dipping of any mast section is strictly prohibited. Galvanising shall be inspected for adhesion, mass of zinc

coating and uniformity of coating.

g) Lantern Carriage

- i. The mobile luminaries ring shall be of steel construction and manufactured in three segments. Bolted flanges shall join the unit. All mobile components of the system shall be located on the mobile part in order to allow visual inspection during each operation. Proper luminary's carriage ring support arms shall be provided for supporting the luminaires carriage ring when the lantern is lowered for maintenance of luminaries.
- ii. The mobile luminary's carriage shall be designed to carry the assigned no. of luminaries and control gears and shall be evenly balanced. Nylon Paddle Guide Ring shall be incorporated as a buffer arrangement between mobile luminaries' carriage and mast shaft. This is to prevent damaged to mast surface during raising and lowering operation of mobile luminaries' carriage.
- iii. The complete mobile components shall be hot dip galvanised in accordance to BS 729.
- iv. The steel grades used for construction of the head frame assembly and mobile part shall follow BS EN 10025.

h) Raising and Lowering Mechanism:

For installation and maintenance of luminaries and lamps, it shall be necessary to lower and raise the mobile luminary carriage by means of a suitable winching arrangement at the base of the mast. The speed of the rising and lowering of lantern carriage ring shall be at least 3.0 m per minute.

i) Winch: -

- i. The winching system except for the drive unit shall remain permanently inside the mast. Each mast shall be provided with a double drum winch suitable for raising and lowering the luminary carriage ring.
- ii. The winch must be robust design and completely self-sustaining type without the brake - shoe, springs or clutches. It can be removed from the mast for maintenance if the need arises in future. The reduction gear of the winch shall be of endless worm gear. Operating in an oil bath. The minimum safe working limit of the winch shall be not less than 750 Kg.
- iii. The capacity and operating speed of the winch shall be clearly marked on an indelible label together with the specification of the recommended lubricant.
- iv. A minimum 6 turns of wire rope shall be on the grooved drum when the mobile luminary ring is fully lowered to rest on the supporting arms.
- v. The winch is entirely self-sustaining under all normal circumstances and it will not depend on the brake or restarting of device. The uncontrolled or dangerous speeds will occur in the event of the total failure and concern reports to be submitted to engineer on request.

j) Test certificates in support of the safe working limit shall be provided upon request. Head Frame:

The head frame duly hot dip galvanized shall include a pulley system accommodate 3 stainless steel hoisting wire rope at any one time and separate pulley for the passage of flat electrical cables. The pulleys shall be of non-corrosive material and shall run on self- lubricating bearing with stainless steel axles.

k) Hoisting and Suspension Wire Ropes:

- i. The high mast shall be fitted with flexible stranded stainless-steel hoisting wire ropes of 7 x 19 constructions with a minimum breaking strength of 2350 Kgs. The combine lifting capacity of the hoisting wire rope shall have a factor of safety not less than 5 times the safe working load (SWL) of the winch and shall be entirely suitable for the design application.
- ii. A transition plate shall be incorporated to connect the suspension wire ropes to the two stainless steel winching wire ropes ensuring ensure even distribution of loads between the two stainless winching-wires by means of an equalizer with a provision to fix electrical cables.

l) Electrical Cables:

Electrical cable shall be anti-twisting flat flexible 2.5 sqmm cable suitable for small bending radius. One

standard 8 core flexible electrical cable with 2.5 sqmm conducting area shall be provide for connecting of power supply to the light source and shall terminate at the stationary connecting board in the base compartment with a multiple 10-pin weather proof plug and socket coupler fitted with locking levers.

m) Winch driving Power Tool:

- i. The winch drive unit shall be complete with a 415V, 3-Phase, 50 Hz squirrel cage, reversible weather resistance, IP 55 protection, min. class B insulation induction motor, a coupling flange for winch to facilitate detachment and attachment on several masts in succession.
- ii. For safety reasons and final precision docking of lantern carriage ring to the head frame, the drive motor must have a provision to operate manually by using external crank device without removing the drive motor from the winch unit.

n) Control Panel:

Control of raising and lowering operation shall be carried out a distance away the mast base by means of a portable pendant type control panel complete with power supply and control cable of appx.5m length. The control panel shall be usable on all masts and shall be equipped with Emergency stop button and Push button for raising and lowering of the mobile part. The push buttons shall operate on the 'dead man' principle i.e. action shall have ceased as soon as the button is released. Portable control panel shall also include a portable panel for housing control switch and relays. The portable panel shall be equipped with safety devices such as electronic torque control in case of overload or overheating of the hoist motor.

o) Luminaries

- i. Flood light luminaries, suitable for LED floodlight 200 - 250 W.
- ii. Flood high luminaries, suitable for use with LED lamp 200 - 250 W watts for rotationally symmetric & asymmetric distribution. Complete with accessories including appropriate control gear and fixing arrangements, conforming to IS: 10322 1987. It should be complying with relevant LED luminaires standards as mentioned in technical specifications clause no. 2.14.3
- iii. The luminaries shall be sturdy, having die-cast aluminium housing and back plate, corrosion resistant, high purity aluminium reflector, electrochemically brightened and anodised heat resistant and toughened glass cover, high resistant silicon rubber market appropriate disc facilitating proper aiming of the luminary, stainless steel toggles and conforming to IP-65 protection. The luminaries shall be suitable for fixing on lantern carriage of high masts.

p) Testing and Commissioning

The lighting installation shall be tested as per approved schedule and the instructions of Engineer and shall include but not be limited to the following:

- Insulation resistance of each circuit shall be measured without the lamps being in place. It should not be less than 5 Mega ohms to earth.
- Current and voltage of all the outdoor lighting circuits shall be measured at the Main Distribution Board with all the lamps switched on to ensure that these are within designed values and in the case of 3-phase circuits, the load shall be balanced, preferably.
- Earth continuity shall be checked for all the circuits.
- After inserting all the lamps and switching on all the circuits, minimum and maximum illumination levels shall be measured in all areas and their conformity with designed levels established. The test results shall be entered in the approved pre-commissioning Proforma and submitted to the Engineer for approval before final commissioning.

6.1.4 Street Lighting

a) General

The steel tubular/ octagonal street lighting poles used for lighting of approach roads, traffic lanes and walkways in the circulating area, shall be erected at 300 mm from the edge of the road/walkway. The foundation for the poles shall be of 1:2:4 concrete. This shall be done by the Contractor as a part of the

contract work as per the approved drawing. The pole with its base plate shall be grouted in the foundation which shall be provided with muffing. HDPE pipes/sleeves of suitable diameter shall be embedded in the concrete for the incoming and outgoing feeder cables. The MCBs shall be mounted suitably as per relevant IS specifications and as per drawings approved by engineer.

b) Lighting Fixture

- i. The light fixture construction shall be of die-cast/extruded aluminium with a separate compartment for drivers and as suitable for external LED Light fixture or LED lamp as required. The reflector shall be pre-anodized polished /high purity electrochemically brightened anodized aluminium.
- ii. The luminaries glass reflector /acrylic cover shall be heat-resistant suitably sealed with neoprene/PU seal gasket as specified and required. Lamp holder shall be of porcelain and shall comprise of a terminal block of non-hygroscopic material.
- iii. The luminaries shall have integral ballasts housed in water tight and dust tight metal cases. Drivers suitable for LED lamp as specified and required shall be energy efficient and pre-wired to the lamp socket and terminal block, requiring only power supply leads to the ballast primary terminals. Outdoor luminaries shall conform to IP55 protection or above as required.
- iv. High Mast lighting luminaries Suitable for external use with high performance LED lamp for symmetric/asymmetric distribution. Complete with accessories including appropriate gear and fixing arrangements, confirming to IS 10322-1987. The luminaries shall be sturdy, having die-cast/extruded aluminium housing and black plate, corrosion resistant high purity aluminium reflector, electromechanically brightened and anodized heat resistant and toughened glass cover, high resistant silicon rubber marked appropriate disc facilitating proper aiming of the luminaries, suitable stainless-steel toggled confirming to IP -55 or above as required protection as specified as required. The luminaries shall be suitable for fixing on lantern carriage of high mast.

c) Street Lighting Poles

- i. The lighting poles shall be octagonal / round type poles as per IS 2713 (PART 2) – 1980, hot dip galvanized (9.0 m height) as per drawings and as specified. The pole shall have a base plate, a large access panel, and necessary fixture mounting bracket at top and 2 Nos. 1.5m length of 40mm diameter bent GI/HDPE pipes for cable loop-in loop-out to be provided. The access panel shall provide easy access to a multi-way porcelain connector and fuse board, to be mounted inside the pole. The access shall be specially fabricated with adequate reinforcement and weather gasket to prevent ingress of moisture and vandal proofed. Poles shall have large diameter entries for incoming and outgoing cable and two earth studs. The pole fabrication shall conform to the drawings and where such drawing is not available; the contractor shall make drawing, and have it approved from engineer before fabrication.
- ii. The octagonal / round poles shall be made from steel of minimum tensile strength 490 N/ sq.mm.
- iii. Grade of foundation bolts shall be 6.8 & confirming to IS: 1367 (Part-III) – 2002.
- iv. Foundation – adequate size M30 grade RCC foundation with 100 mm raft including excavation are included in the rates of street light poles. Contractor shall submit design calculation in support of size of RCC foundation for external lighting poles for approval to engineer and work shall be commenced after approval.
- v. The pole shall be provided with a 20 mm hole for wiring of street light pole and two nos. 20 mm studs are to be welded for earthing.

d) Junction Boxes and Connecting Cable

- i. Each pole shall be complete with an MS junction box of pole-mounting type, manufactured from MS sheet of 14 sheet gauge painted with oil paint over red oxide zinc chromate primer. The junction box shall have a water proof lockable cover (IP65) of size 300 x 100 mm. It shall be fitted with 6A MCB and 6-way, 20A connector strip, a neutral link, earthing studs and suitable down pipes for the incoming and outgoing cable-lead. The junction box shall generally comply with the requirements of IS: 2675-1983. The supply of pole shall be complete with 2 x 2.5 sqmm copper wire/cable, PVC insulated, FRLS XLPE

insulated drawn from the junction box to the luminaires terminal.

- ii. Pole shall have a concrete coping of 200 mm height and 300 mm diameter in M30.

e) Cable Laying

- i. Cabling shall be generally as specified in the section distribution 'CABLING.'
- ii. Cables shall be terminated in a 6-way terminal block inside the pole or attached there with as required.
- iii. Cable route shall be as shown on the drawings or the contractor shall mark out the route and lay the cables only upon approval of the route by engineer.

f) Earthing

All street light fixtures and poles shall be earthed as specified under section 'EARTHING.' In each pole, a through hole of 14 mm diameter shall be provided at a height of 300 mm for earthing. Every lighting pole shall be earthed by connecting it to the continuity earth of the feeder cable from the feeder pillar. In addition, every 5th pole shall be connected to locally provided earth electrode pit.

g) Street Light Feeder Pillars

Suitable feeder pillars, 3-phase 415 V outdoor type, with a fixed canopy shall be provided for power distribution to masts & street lights. The feeder pillar shall have IP 65 degree of protection & will be housed in stainless steel enclosure. It shall be provided with weather- proof lockable door, incoming and outgoing cable glands, earthing studs and other accessories.

h) Testing and commissioning

The lighting installation shall be tested as per approved schedule and the instructions of Engineer and shall include but not be limited to the following:

- i. Insulation resistance of each circuit shall be measured without the lamps being in place. It should not be less than 0.5 Mega ohms to earth.
- ii. Current and voltage of all the outdoor lighting circuits shall be measured at the Main Street Light Panel, with all the lamps switched on to ensure that these are within designed values and in the case of 3-phase circuits, the load shall be balanced if required.
- iii. Earth continuity shall be checked for all the circuits.

After inserting all the lamps and switching on all the circuits, minimum and maximum illumination levels shall be measured in all areas and their conformity with designed levels established. The test results shall be entered in the approved pre-commissioning Proforma and submitted to the Engineer for approval before final commissioning.

6.1.5 Depot & Yard Lighting Requirements

a) Depot & Yard Lighting

- i. General Depot lighting shall provide safe and efficient levels of lighting in order to maintain 24- hour operations. Only administration area and Depot entrances shall have public street quality lighting standards. All other areas of Depot shall have industrial type lighting with uniform lighting level. Ultimate care to be taken to avoid glare or light pollution from inside the Depot boundaries to outlying areas, other than what is necessary for perimeter security.
- ii. The entire Depot site shall be illuminated to provide for secure and safe operation, 24 hours a day and during inclement weather.
- iii. Heavy-duty, protected fixtures shall be used to light pits, bridges and gangways.

CHAPTER – 07**CONVENTIONAL & MAINTENANCE FREE EARTHING****7.1 Conventional & Maintenance Free Earthing.****7.1.1 General**

This section covers specifications for earthing of earth electrodes, earth leads and loop earthing conductors.

Separate earthing system shall be provided for neutral earthing (of transformers and generators) and body earthing.

All the non-current carrying metal parts of electrical installations including metal conduits, trunkings, cable armour, switchboards, DBs, light fittings and all current carrying parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system.

Earthing of Transformer, DG set, Equipment body earthing, BMS-DCC-SCADA equipment, OHE, other items shall be carried out as per drawings. The Contractor shall lay an earth mesh of not more than 1.00-ohm resistance at each location using copper flats/rods.

The clean or special earthing system required by Signalling/AFC/Telecom/SCADA equipment shall be supplied and installed by the Contractor. The clean earth mesh shall give minimum 0.5-ohm resistance on each location.

All the earthing strips shall be buried in floor or wall as required and all the fastening (by nut bolts) of earthing strips shall be tag welded as well.

All three-phase equipment shall have two separate and distinct body earths and single phase equipment shall have a single body earth.

Separate earth leads of appropriate size shall be provide for.

- a) Main switchboards
- b) UPS system earth bus
- c) Computer system earth bus
- d) Telephone system earth bus

Wherever so specified the earth lead shall be PVC sheathed to provide a “clean” earth. And all the earth strip buried in ground shall be PVC sheathed.

All metallic components and pipes within bathrooms, toilets and kitchens shall be connected to the earthing system by means of minimum 4 sq. mm PVC insulated (green) copper conductor wires.

7.1.2 Standards

The earthing system shall be TN-S and carried out in conformity with the updated current edition of IS 3043: 1987. In addition, relevant clauses of Indian Electricity Act 2003, India Electricity Rules 1956 and IEE Wiring Regulations (16th editions), IEEE - 80, as amended up-to date, shall also be applicable.

Materials used for earthing shall be as mentioned in table below.

Area	Material	Earth Value
Auxiliary Sub Station building (Complete)	GI strip	$\leq 1 \text{ ohm}$
Clean earth requirements.	Copper Insulated Stranded Conductor (as per design)	$\leq 0.5 \text{ ohm}$
Other Building	GI or Copper as per design	$\leq 1 \text{ ohm}$

Earth Electrodes**a) Plate Earth Electrodes**

The plate electrodes shall be of copper or GI as called for in the schedule of quantities. Minimum dimensions of the electrodes shall be 600 mm x 600 mm. Thickness of copper electrodes shall not be less than 3.18 mm and of

GI electrodes not less than 6.35 mm.

b) Pipe Earth Electrodes

Pipe electrode shall be fabricated from a 40 mm dia 4500 mm long class B (medium) GI pipe. The GI pipe shall be tapered at the bottom and shall be provided with 12 mm dia holes drilled at every 75 mm.

c) Galvanizing

Galvanizing of Earth Electrodes and Earthing Conductors shall conform to class-IV of IS 4736: 1986.

7.1.3

Earthing Station

a) Earth Mats

Earth mat shall be constructed as per IEEE 80 – 2000 and IS 3043-1987. Copper round/ flats shall be used for constructing earth mat of adequate size (horizontal and vertical conductors) and at depth of 700 – 1000 mm from ground or as shown on the drawings. Adequate number of risers shall be brought from earth mat for further connection to ASS equipment and downstream equipment. Main earth terminals shall be provided in ASS, DG and pump room as required. The resistance of the earth mat shall not be more than 1 Ohm

b) For Plate Electrodes

Plate electrode shall be buried in ground with its face vertical and top not less than 3 m below ground level. In case the permanent moist soil is not available at 3 m depth, the plate electrode shall be buried at the increased depth beyond 3 m level till permanent moist soil is available and nothing extra shall be paid. The electrode shall be surrounded by alternate layers of charcoal and salt. A 20 mm dia class B GI pipe shall be provided for watering of the soil surrounding the electrode. The watering pipe shall have a watering funnel attachment with a wire mesh which shall be housed in the masonry inspection chamber. Main earth lead shall be securely terminated at the electrode by means of 2 bolts, nuts, check nuts and spring washers the earth lead from the electrode up to the test link in masonry chamber shall be drawn in a suitable diameter class B GI pipe for mechanical protection. The GI pipe shall be provided with a coat of bituminous paint or bituminized jute wrapping for additional corrosion protection. The lead shall terminate in a Test link provided in the inspection chamber to enable the earth electrode to be isolated for measuring earth resistance.

c) For Pipe Electrodes

Pipe electrode shall be installed with its top not less than 200 mm and the bottom end not less than 4.5 m below ground level. In case the permanent moist soil is not available, the length of the pipe electrode shall be increased till the depth where permanent moist soil is available, and no extra payment shall be made on this account. The top shall be provided with a 40 mm x 20 mm reducer to fix watering funnel with mesh in top. The entire length of pipe below the inspection chamber shall be surrounded by alternate layers of charcoal and salt. Earth lead shall be provided as for plate electrode and shall be terminated using a through bolt, nuts, check nuts, spring washers etc.

d) Masonry Inspection Chamber

The watering funnel arrangement as also earth test links shall be accessible and shall be housed in a 400 mm x 400 mm x 400 mm deep masonry inspection chamber having a lockable 10 mm thick cast iron hinged cover plate attached to a galvanized steel frame work embedded in the chamber walls. The hinged cover shall be suitably marked on top so that it is conspicuously identifiable as an earth station.

e) Location of Earth Electrode

Location of earth electrodes shall be based on following guidelines. Minimum distance between any electrode and building structure shall be 1.5 m.

Minimum distance between two adjacent electrodes shall be 2 m.

Electrodes shall be in accessible locations. Entrances, pavements and roads shall not be used for locating earth electrodes.

7.1.4

Earthing Conductor

a) Main Earth Lead

Interconnections between earth bus provided on the main switchboard inside the building for body earthing / neutral earthing terminals of transformers/generators for neutral earthing and test link provided in the earth electrode inspection chamber shall be laid at minimum 300 mm depth below ground (minimum 600 mm below road crossings and paved pavements) For small installations where this lead is by means of GI copper wire, the earth lead shall be drawn in a 15 mm dia class B GI pipe. For larger installations the GI pipe size shall be suitable for drawing the earth strip. GI pipe shall be provided with a coat of Bituminous paint on the outside for minimizing corrosion. In locations where GI protection cannot be provided, the earth conductor shall be wrapped with bituminous jute wrapping.

b) Earthing Conductors

Earthing conductors shall be connected to form the earthing network throughout the installation for earthing of all non-current carrying metal parts as below. Materials and sizes shall be as per schedule of quantities:

Main earthing conductors shall be taken from the earth connections at the main switchboards to all other switchboards in the network.

Sub-mains earthing conductors shall run from the main switchboard to the sub distribution boards and to the final distribution boards.

Loop earthing conductors shall run from the distribution boards and shall be connected to any point on the main/sub-main earthing conductor, or its distribution board or to an earth leakage circuit breaker.

Conducting systems and cable armouring shall be earthed at the ends adjacent to switchboards at which they originate, or otherwise at the commencement of the run by separate loop earthing conductors in effective electrical contact with cable armour, switch boxes, accessories, lighting fitting etc.

c) Installation and Jointing Conductors

Earthing conductors shall be provided in longest possible unbroken length to minimize jointing of the conductors in between terminations.

- i. Strip conductors shall be secured to the building walls etc. with appropriate size of saddles at intervals not exceeding 900 mm. The saddle shall be gun metal for copper and GI for GI strips.
- ii. Copper earth strips shall be joined by butt welding/brazing or the mating surfaces shall be tinned, riveted and soldered.
- iii. GI earth strips shall be joined by GI bolts, nuts, check nuts and spring washers of appropriate size.
- iv. All exposed joints shall be provided with 2 coats of anti-corrosive paint.
- v. Wires shall be joined by means of lugs of appropriate size connected by bolts, nuts, check nuts and washers. If the connection is on a painted surface, the paint shall be thoroughly removed, and the metal exposed for making effective electrical contact. Lugs and bolts shall be of brass for copper wires and GI for GI wires.

d) Prohibited Connections

Neutral conductor, sprinkler pipes conveying gas, water, or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lightning protection system shall not be used as a means of earthing system an installation or even as a link in an Earthing system.

e) Resistance to Earth

The earth resistance at each electrode shall be measure. No earth electrode shall have a greater ohmic resistance than 1 ohm for main earth and 0.5 ohms for clean earth as measured by an approved earth testing apparatus. In rocky soil the resistance may be up to 8 ohms Where the above stated earth resistance is not achieved, necessary improvement shall be made by additional provisions, such as additional electrode (S), different type of electrode, or artificial chemical treatment of soil etc, as may be directed by the Engineer-in-charge. The requirements of chemical earth or maintenance free earth is mentioned in clause 6.2.6 for necessary compliance.

7.1.5

Testing at Site

a) Testing of Earth Continuity Path

The Earth continuity conductor including metal conduits and metallic envelopes of cable in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance of earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

b) **Earth Resistivity Test**

Earth resistivity test shall be carried out in accordance with IS Code of Practice for earthing IS:3043.

7.1.6

Maintenance Free Earthing

a) **Scope**

This specification covers components, enhancing material & jointing used and procedure for constructing of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus earth pit for maintenance free earthing system to ensure that the resistance to earth is near zero consistent throughout the year.

b) **Standards**

This specification requires the reference to the following documents:

Sl.No	Code	Description of code
1	IS – 3043	Code of practice for earthing
2	ANSI / IEEE-standard-80-2000 IEEE-81-standard	Guide for safety in AC sub-station grounding
3	IEC-60364	Electrical installations of buildings
4	IEEE-1100	Recommended practice for powering and grounding of sensitive electronic equipment's
5	IEEE-1100, NEPA 780, IEC-1024	Clean earth system.

Wherever, reference to any specification appears in this document, it shall be taken as a reference to the latest version of that specification unless the year of issue of the specification is specifically stated.

c) **Applications**

Earthing systems covered in this document shall be for

- i. Providing effective grounds for Sub stations (ASS - Transformer and Generator neutral earths).
- ii. Traction, S&T and Telecommunication equipment.

d) **Type of Soil**

Soil can be classified in to various types, though based on the size of the particles it contains:

i. **Normal soil**

Black cotton soil, vegetable soil, garden soil, loamy garden, soil shallow black, soil medium black soil, deep black soil and marshy soil etc having low soil resistivity value (up to 50-ohm meter).

ii. **Sandy Soil**

This type has the big particles and the size of the particles does determine the degree of aeration and drainage that the soil allows. It is granular and consists of rock and mineral particles that are very small. Therefore, the texture is gritty and sandy soil is formed by the disintegration and weathering of rocks such as limestone, granite, quartz and shale, thus resulting in over-drainage. It warms very fast in the spring season. Coastal area, silt soil, red sandy soil, sandy clay and coastal alluvium etc. having soil resistivity up to 2000 ohm- meter are considered as sandy soil.

iii. **Rocky Soil**

The area containing rocks, pebbles, uneven hard surface laterite soil, lime stone, sand stone, gravel, granite and chalk etc. having soil resistivity more than 2000 ohm-meter is considered as rocky soil. This type of soil does not absorb moisture and are extremely poor conductor.

e) Location of Earth Electrode

Where there is option, site should be chosen in one of the following types of soil in the order of preference given: -

- i. Wet marshy ground.
- ii. Clay, loamy soil, arable land.
- iii. Clay and loam mixed with varying proportions of sand, gravel and stones.
- iv. Damp and wet sand, peat.

Dry sand, gravel chalk, limestone, granite, very stony ground and all locations where virgin rock is very close to the surface should be avoided,

f) Measurement of Earth Electrode Resistance

The earth resistance shall be measured using fall of potential method as per para 37 of IS: 3043.

g) Earth Electrode

The earth electrode is the main component of the earthing system which is in direct contact with the ground and thus provides a means of releasing or collecting any earth leakage currents. The material should have good electrical conductivity and should not corrode in a wide range of soil conditions. For an effective earthing system, two types of earth electrodes can be used as described here:

i. Rod earth electrode

High tensile-low carbon steel rod having diameter not less than 17mm complying with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more, Length 3000 mm (minimum). Length of the electrode may be increased in multiple of 1 meter to reduce earth resistance if required. To increase the length, pieces of similar rod shall be either exothermally welded to basic 3-meter electrode or connected using socket of suitable size. These sockets shall also be molecularly bonded by 99.99% pure high conductivity copper on inner & outer surface with copper coating thickness 250 micron or more.

Copper bus bar of size 250 mm x 50mm x 6 mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall be exothermally welded to rod with 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.

The design of the electrode should be such as to have more than 15kA current carrying capacity for 1 second.

ii. Pipe earth electrode

Primary Conductor

MS pipe with 25 - 50 mm diameter, class B, ISI mark as per IS-1239,

Secondary Conductor

MS pipe with 40-100 mm diameter, class B, ISI mark as per IS-1239,

Conductive Mixture

For hermetically filling inside the cavity i.e. between secondary conductor & primary conductor, crystalline compound is to be injected in the electrode assembly. It is a combination of high conductivity metal alloys, copper & aluminium powder, conductive carbon/cement and bonding material etc. mixed in different proportion. The mixture is forced (pressurized) filled inside the earth electrode in the paste form and after solidification of the same, the end caps are welded. The metal alloys shall help in conducting the current and conductive carbon gives anti corrosive property. Bonding material should provide strength to the mixture. Resistivity of the mixture shall be less than 0.2 ohm-meter. Resistivity shall be

tested by making a 20cm cube of the material and checking resistance across the opposite face of the cube.

Complete electrode shall be molecularly bonded by 99.99% pure, high conductivity copper on outer surface with copper coating thickness 300 micron or more.

Its surface shall be clean and free from any visible oxide layer or foreign material.

Copper bus bar of size 250 mm x 50mm x 6 mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall preferably be exothermically welded to earth electrode or connected with the help of two number stainless steel nut bolts of appropriate size having 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.

h) Current carrying capacity

The design of the electrode should be such as to have more than following current carrying capacity in kA (for 1 second):

Sl.No	Current Capacity	Primary conductor diameter	Electrode dimensions (Dia. X Length)
1	3 kA	25 mm	40 mm x 2000 mm
2	5kA	25 mm	40 mm x 3000 mm
3	15kA	25 mm	50 mm x 3000 mm
4	40kA	40 mm	80 mm x 3000 mm
5	50kA	50 mm	100 mm x 3000 mm

Note: - For more than 50KA applications, multiple electrodes of 50KA capacity shall be installed and connected.

i) Earth Enhancement material

Earth enhancement material is a superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It may contain conductive cement, graphite, hydrous aluminium silicate, sodium montmorillonite etc and shall not contain betonies. It improves conductivity of the earth electrode and ground contact area. It shall have following characteristics-

- It should have low resistivity preferably below 0.2 Ohm-meters. Resistivity shall be tested by making a 20cm. cube of the material and checking resistance across the opposite face of the cube.
- It shall not depend on the continuous presence of water to maintain its conductivity.
- It should be a little alkaline in nature with pH value >7 but <9, test certificate from NABL approved laboratory to be provided for the composition so designed.
- It should have better hygroscopic properties to absorb moisture. It should absorb and release the moisture in dry weather condition and help in maintaining the moisture around the earth electrode.
- It should have capacity to retain >10% moisture at 105°C. Test certificate from NABL approved lab to be submitted for the composition so designed.
- It should have water solubility < 5%. Test certificate from NABL approved lab be submitted for the composition sodesigned.
- It should be granular with granule size 0.1 mm to 3 mm.
- It should be nontoxic, non-reactive, non-explosive & non corrosive.
- It shall be thermally stable between -10 degree centigrade to +60-degree centigrade ambient temperature.
- It shall not decompose or leach out with time

- It shall not pollute the soil or local water table and meets environmentally friendly requirement for landfill.
- It should expand & swell considerably and removes entrapped air to create strong connection between earth electrode and soil.
- It should be diffusing into soil pores and creates conductive roots enlarging conductive zone of earth pit.
- It shall be permanent & maintenance free and in its “set form”, maintains constant earth resistance with time.
- It shall not require periodic charging treatment or replacement.
- It shall be suitable for any kind of electrode and all kinds of soils of different resistivity.
- It shall not cause burns, irritation to eye, skin etc.
- Minimum quantity of earth enhancement material to be supplied for 5' x5'x 10' earth pit – Min. 75 kgs per pit 300mm bore type earth pit – Min 50 kgs per pit.
- The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity, batch no & date of manufacture.

j) Backfill Material

Normally the excavated soil shall be used if it is free from sand, gravel and stones. In case the excavated soil contains sand, gravel and stones these shall be removed by appropriate methods such as hand picking, sieving etc. Small proportion of sand in the soil may be permissible. Material like sand, salt, coke breeze, cinders and ash shall not be used because of its acidic and corrosive nature. If the excavated soil contains sand, gravel and stone in large proportion and it is not feasible to remove these economically, good quality soil from other place may be used for backfilling.

While backfilling the soil shall be thoroughly compacted with at least 5 kg compactor. In case the soil is dry, small quantity of water may be sprinkled only to make it moist enough suitable for compacting. Large quantity of water may make the soil muddy which is not suitable for compacting and after drying the soil may contain voids which may permanently increase earth resistance.

k) Equipotential bus & Earthing Conductor

A copper bus bar of size 300mm x 25mm x 6mm to be installed in the equipment room as equipotential bus and must be connected with preferably copper strip of 25mm x 3mm (suitable length) from instrument to the bus bar. The connecting terminal of the earth electrode to the bus bar must be connected by copper strip of 25mm x 3mm (suitable length) buried inside a trench of 300mm width x 600mm depth (from the earth pit to the nearest wall). It shall be duplicated. However, it shall be ensured that only minimum required length is used, and any extra length is cut away to keep the earth impedance minimum. It shall be high conductivity copper having electrical conductivity of 101% IACS i.e. minimum 99.9% copper content the maximum specific resistance of the copper strip earthing conductor shall be 17.241×10^{-7} -ohm cm at 20°C. At a temperature of 20°C, its density shall be 8.89 gm/c. Its surface shall be clean and free from any visible oxide layer or foreign materials.

It shall preferably be connected to earth electrode and earth bus bar with the help of exothermic welding or at least two number stainless steel nut bolts of appropriate size. Normally a single length of copper strip shall be used for each duplicate copper strip earthing conductor and no joint should be used. However, in situation requiring greater length one joint in each copper strip shall be permitted. The joints shall be made by exothermic welding of at least 10mm overlapping portion of the strips.

l) Construction of unit earth

Make 5ft x 5ft x 10ft earth pit. If it is not possible to make such a pit due to non- availability of clear space at locations like ATM, High mast lighting tower, Passenger information systems, PRS etc. or in rocky soil, min. 300 mm bore up to 10 ft deep can be made using earth auger or any other method.

Earth pit larger than specified size can be made, if required. Sleeve the soil digged and remove the gravels and stones. If soil quality is good (without Murum and rocks) then add some quantity of earth enhancement material in the soil for using as backfill. If the soil seems unusable (containing large quantity of gravel, stones, murum, sad etc.) then replace the soil with black cottonsoil. If the soil seems unusable (containing large quantity of gravel, stones, murum, sad etc.) then replace the soil with black cottonsoil. Insert the electrode at the centre of the earth pit and arrange to keep it vertical in the pit. Arrange for adequate quantity of water supply for the earth pit. (Approx. 600 litres). Fill the pit with the backfill and keep on adding the earth enhancement material surrounding the electrode and simultaneously watering the pit. With a steel bar or pipe, keep on poking the soil gel and stirring intermittently for removing the air pockets and proper settlement of the pit.

The procedure to be repeated till completion of the filling of the earth pit along with the packing material and enough watering adequate ramming. The pit should be very compactly rammed and watering for 2-3 days and addition of soil if required be done. Make trench of 600 mm (depth) x 300 mm (wide) from the earth pit to the nearest point of connection. Construct inspection chamber with cover for the installation. Measure the earth resistance as per IS 3043:1987 code of practice. Earth resistance value shall be less than 1 ohm in non-rocky/non-sandy surface by single electrode Installation and in rocky surface by multiple electrode installation (not more than three electrodes & its individual earth pits). For earthing purpose, if solid rocky layer is found within 10 feet from ground level while digging the earth pit then it is considered rocky surface. Coastal area, silt soil, red sandy soil and sandy clay are considered as sandy surface. If required resistance is lower than the resistance of single earth electrode, then multiple earths can be constructed and interconnected.

- m) Construction of ring earth by providing multiple earth pits.
 - i. Wherever it is not possible to achieve required earth resistance with one earth electrode/pit due to difficult/rocky soil conditions, provision of ring earth consisting of more than one earth pit shall be done. The number of pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one earth pit shall be repeated for other earth pits.
 - ii. The distance between two successive earth electrodes shall be min. 3mtrs / length of electrode whichever is higher. and max. up to twice the length of the earth electrode.
 - iii. These earth pits shall then be inter linked using 25X3 mm copper strip to form a loop preferably using exothermic welding or with the help of at least two number of stainless-steel nut bolts of appropriate size.
 - iv. The interconnecting strip shall be buried no less than 600mm (0.6m) below the ground level. This interconnecting strip shall also be covered with earth enhancing compound.

n) Inspection chamber

A 450X450X450 mm (inside dimension) concrete box (wall thickness min. 50 mm) with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid of 50 mm. thick, with pulling hooks, painted black shall be provided to cover the earth pit. PVC sleeve of appropriate size shall be provided in concrete wall to take out earthing connections. The masonry work shall be white washed inside and outside. Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it. On backside of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.

o) Marking

The marking shall be clear, distinct and visible to the naked eye from about 1 meter; the size of marking shall be of minimum 25 mm. Following information shall be legibly and indelibly marked on the packed sets.

- Specification no.
- Name of the manufacturer

- Batch no. & Date of manufacturer
- Current carrying capacity

p) Tests.

Following tests shall be done on one sample.

- Testing of copper coating shall be done as described below: -

The copper coating shall not be less than the prescribed thickness at any point and shall comply with the adherence requirement in para (ii) & (iii) below.

Length of the electrode with one end cut to a 45-degree point shall be driven between two steel clamping plates or the jaws of a vise set 0.04 in (1.02 mm). less than the diameter of the electrode, to shear off sufficient metal to expose the bond between the copper coating and electrode. Peeling of the coating by the steel plates or the jaws of the vise is acceptable, but there shall be no other evidence of separation of the coating from the metal core.

At room temperature, a length of the electrode is rigidly held in a clamp or vise and the free end is bent by applying a force normal to the electrode at a distance from the clamping device equal to 40 times the diameter. The magnitude of the force and the direction of application of force shall be such that the electrode is permanently bent through a 30-degree angle. While bending of the electrode there shall be no evidence of cracking of the copper coating.

- Material composition of Rod & MS pipe shall be tested as per standard
- Copper bus bars shall be tested for percentage of copper as per IS: 14644.
- Corrosion Test: As per IS: 2119, salt spray test for analysis of effect of corrosion for the specific electrode shall be done through NABL approved testing lab, preferably for 500 hrs. or more.
- Exothermic weld material shall be tested as per provisions of IEEE 837.
- Electrical properties test on conductive mixture as per clause no. 1.8.2.3.
- Physical, chemical & electrical properties test on earth enhancement material as per clause no. 1.8.3
- Toxic polybrominated biphenyls (PBBs) & polybrominated biphenyl ethers (PBDEs) on conductive mixture & earth enhancement material. content tests for cadmium, lead, mercury, hexavalent chromium,
- Certificates from NABL approved laboratories shall be submitted with test results of above tests. Test certificates shall not be more than three years old.
- For dimension, weight and specific resistance average of 3 readings shall be taken. Average value shall be within specified limits and individual values shall not go beyond double of tolerances.

q) Acceptance Tests

Following shall constitute acceptance tests and shall be done on 100% sample basis for all the tests mentioned below except where otherwise indicated—

- Physical check for earth electrode as per clause no. 1.8.1 for rod type electrode and as per clause no. 1.8.2.4 for concentric pipe type electrode.
- Physical check for copper bus bar as per clause no.1.8.1 para-2 for rod type electrode and as per clause no. 1.8.2.3 Para 4 for concentric pipe type electrode.
- Dimensional and construction feature tests of inspection chamber Cl. no.2.9.7.7.8
- Earth enhancement material as per clause no. 2.9.7.7.3
- Earth resistance measurements as per clause no. 2.9.7.6.

r) Rejection

In case the any component tested and inspected in accordance with this specification, fail to pass the tests

or comply with the requirement of the specification, another two components from the same lot shall be inspected in accordance with the specification and if one of them also fail to pass the test, the whole lot of that component shall be rejected subject to the discretion of the purchaser or his nominee.

s) Inspection

All the gauges/ test & measuring instruments shall be under calibration control at the time of inspection and proof to this office shall be produced.

Inspection and testing shall be carried out by the inspecting authority nominated by the purchaser to ensure that all the requirements of this specification are complied with for the acceptance of the materials offered by the supplier for inspection.

The purchaser or his nominee shall have right of free access to the works of the manufacturer and to be present at all reasonable times and shall be given facilities by the manufacturer to inspect the manufacturing process at any stage of manufacture. He shall have the right to reject whole or part of any work or material that does not conform to the terms of this specification or any other specification or requirement applicable and may order the same to be removed / replaced or altered at the expense of the manufacturer. All reasonable/complete facilities considered necessary by the inspecting authorities for the inspection shall be supplied by the manufacturer free of cost.

The manufacturer shall at his own cost prepare and furnish the necessary test pieces and appliances for such testing as may be carried out at his own premises in accordance with the specification. Failing the existence of facilities at his own premises for the prescribed tests, the manufacturer shall bear the cost of carrying out the tests in an approved laboratory, workshop or test house.

t) Completion Report & Certification

The last documents for the completion of the procedure will be submission of the work completion report to the concern Railway authority. After testing the earth values of the pits and proper recording in presence of Railway authority, certified grounding self- adhesive certificate shall be provided for all installations and the same will be displayed / pasted at the place of installation.

The complete layout with dimensions of the earthing & bonding system shall be submitted by the supplier in appropriate size (in three copies) after commissioning showing commissioning date, earth resistance, specification no. and manufacturer's name.

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CHAPTER-8

LIGHTNING PROTECTION SYSTEM

8.1 Lightning Protection System.

8.1.1 Standards & codes

Sl. No	Code number	Description of codes.
1	IS/IEC 62305 -1 to 5	Codes for practice for protection against lightning
2	NBC-2016	National building code of India -2016
3	IS 3043-2018	Codes practice of Earthing
4	IS-2309-1989	Protection of building and allied structures against lightning-Code of practice.

Wherever, reference to any specification appears in this document, it shall be taken as a reference to the latest version of that specification unless the year of issue of the specification is specifically stated.

8.1.2 Scope

This section covers Protection of buildings against lightning in accordance with IEC 62305 and shall include the provision of a parallel path lightning system complete with air terminal conductors, ground terminals inter connecting conductors and other fittings required for the complete system.

8.1.3 Materials, Dimensions and Testing Points

The materials of lightning conductors, down conductors, earth termination etc. of the protective system shall be reliably resistant to corrosion or be adequately protected against corrosion by galvanising. No combination of materials shall be used that may form electrolytic couples.

All Air Terminations shall be of Copper and all down conductors shall be of hot dip galvanized.

8.1.4 Testing Points

Each down conductor shall be provided with a testing point in a position convenient for testing but inaccessible for interference. No connection, other than one direct to an earth electrode, shall be made below a testing point. Testing points shall be Copper.

8.1.5 Design Considerations

- i. The entire lightning protective system shall be mechanically strong to withstand the mechanical forces produced in case of a lightning stroke.
- ii. The lightning protective system shall be so installed that it does not spoil the architectural or aesthetic beauty of the buildings.
- iii. A vertical air termination where provided need not have more than one point and shall project at least 30 cms. Above the project, salient point or network on which it is fixed.
- iv. Horizontal air terminations shall be so interconnected that no part of the roof is more than 9 m away from the nearest horizontal termination along the outer perimeter of the roof is used. For a roof of larger area, a network of parallel horizontal conductors shall be installed.
- v. Horizontal air terminations shall be coursed along contours such as ridges, parapets and edges of flat roof, and where necessary over flat surfaces in such a way as to join each air termination to the rest and should themselves form a closed network.
- vi. All metallic finials, chimneys, ducts, vent pipes, railings, gutters, metallic flag staff etc. on or above the main surface of the roof of the structure shall be bonded to, and form part of, the air termination network. If portions of a structure vary considerably in height, any necessary air termination or air termination network of the lower portions shall be in addition to their own conductors, be bonded to the down conductors of the taller portions.
- vii. All air terminals shall be effectively secured against overturning either by attachment to the object to be

protected or by means of substantial braces and fixings which shall be permanently and rigidly attached to the building. The method and nature of the fixings should be simple, solid and permanent, due attention being given to climatic conditions and possible corrosion.

8.1.6 Joints and Bonds

The lightning protective system shall have as few joints in it as possible. Wherever joints in the down conductor above ground level are necessary they shall be mechanically and electrically effective. In the down conductor below ground level there shall be no joints. The joints shall be welded. The bonding of the drain water pipe shall have a cross sectional area not less than that employed for the main conductors. Gas pipe, however, in no case shall be bonded to the earth termination system.

8.1.7 Fasteners

Conductors shall be securely attached to the building or other object to be protected by fasteners as may be approved by the Engineer-in-Charge and shall be of Stainless steel or other suitable materials with suitable precautions to avoid corrosion. The lightning conductors shall be secured at not more than 1.0 m apart for horizontal run and 0.75 m for vertical run.

8.1.8 Earth Terminations

Each down conductor shall have an independent earth pit. The interconnection of all the earth termination shall be preferable. It should be capable of isolation for testing purposes by 'testing joints' of GI provided in suitable enclosures.

8.1.9 Earth Electrode

Earth electrodes shall be constructed and installed as specified in Clause

The whole of the lightning protective system shall have a combined resistance to earth not exceeding 5 ohms before any bonding has been affected to metal in or on a structure or to surface below ground.

CHAPTER-9**UNINTERRUPTED POWER SUPPLY SYSTEM (UPS)****9.1 Uninterrupted Power Supply System (UPS)****9.1.1 Scope**

The scope of work shall cover design, supply, erection, testing and commissioning of a static Uninterrupted Power System meeting the performance criteria under equipment schedule.

9.1.2 Detailed Description

This section specifies the manufacture, supply, testing, and installation and commissioning of Uninterruptible Power Supply System, hereafter referred to as UPS. The UPS system shall consist of the UPS unit, Input and Output switch gear and Battery. The UPS systems shall maintain a continuous AC Power supply to the loads classified as of Emergency category loads for the Depot Buildings in all possible power failure scenarios.

The UPS system in general shall consist of the following.

- a) Input/ Output power supply panel
- b) Rectifier/Charger.
- c) Battery System.
- d) Battery Circuit Breaker.
- e) Inverter.
- f) Static Bypass Switch.
- g) Built In / External Manual Bypass Switch.
- h) Control Units and Interconnections between different UPS Elements.
- i) Data logger, Digital Display and annunciation.

This is only for guidance and may vary with technological advancements.

9.1.3 Governing Specifications

STANDARDS	DESCRIPTION
IEC 62040 – 1,2 and 3 or Latest	Specification for Uninterruptible power systems (UPS)
IEC 61643-1 or latest	Surge Protective Devices
EN 61000-4-3 or latest	EMC - Immunity
IEC 61000-3-2/ 61000-3-3 or latest	EMC - Emission
IEC 61000-4 or latest	Electromagnetic compatibility Testing and Measurement Techniques
Source ISO 3746-2010 or Latest	Sound Level of Noise
IEC 60695-11-20 or latest	Flammability Tests
BS 55014-1 or latest	Radio frequency interference (RFI) levels
IEC 61439 or latest	Low Voltage Switchgear and Panels
IEC 60947 or latest	Low-voltage Switchgear and Control gear Assemblies
BS 7671 or latest	IEE Wiring Regulations
BS 7430 or latest	Code of practice for Earthing

The UPS and their constituent parts will comply with the relevant latest version of British Standards, Europeans Standards (EN), International Electromechanical Commission (IEC) Standards, and International Organization for Specification (ISO) Standards as specified above.

9.1.4

Requirements

a) Functional Requirements

Features: The UPS shall be a true parallel redundant, (Clause 3.1.35 of IEC 62040-3) Double Conversion (Clause 3.2.16 of IEC 62040-3) (VFI technology Online type.) and shall configure to A.3.2.2 of the IEC 62040-3 as Parallel Redundant with bypass. The UPS system shall consist of the components as defined under clause 3.1 of IEC 62040-3.

The loads are generally linear to clause 3.2.6 of IEC 62040-3 but shall cater to nonlinear loads to clause 3.2.7 of IEC 62040-3. UPS shall be compatible to take non-linear loads and capable to handle high crest load. The UPS shall be suitable for taking unbalanced load vide clause 3.5.22 of IEC 62040-3. UPS shall be provided with input power factor correction features.

Capacity: The capacity of the UPS shall be as per the BOQ. However, in general the Ratings of UPS standardized for DEPOT applications is part of detailed design on obtaining the interfacing with respective contractors and fulfil the UPS capacity requirements.

b) Mode of Operation

The UPS shall operate in the following modes: -

- Normal mode (Mains Up) Clause No. 3.2.13 of IEC 62040-3
- Stored Energy mode (Mains Down) Clause No. 3.2.14 of IEC 62040-3
- Battery Recharge (Mains Restored)

When mains supply is restored from failure or restored via automatic supply changeover switch, the rectifier / charger shall resume the supply of DC power to the Inverter and batteries. During this period, no interruption or disturbance shall be caused to the inverter output.

When the battery system is fully charged, the rectifier / charger shall automatically adjust the output voltage to float charge the battery system.

c) Automatic By-pass mode (Static By-pass Switch) as defined vide clause 3.2.15 of IEC 62040-3 and as following:

In the event of overloads exceeding system capabilities (short-circuits, heavy inrush current or battery capacity being exhausted upon rectifier / charger supply down) or the detection of internal faults, the static by-pass switch shall instantaneously synchronize with the inverter output and transfer the loads to the bypass supply source without load interruption.

Retransfer of the load to the UPS shall be accomplished, after the restoration and stabilization of the output power modules to the specified tolerances, without disturbance to the load. In both these transfers, UPS output voltage and frequency tolerances must remain within the specified limits.

d) Built in / Manual By-pass mode (Maintenance) as defined vide clause 3.2.15 of IEC 62040- 3 and also as following:

The external independent manual bypass switch shall be manually operated to Perform, make- before-break switching of the UPS load to either the UPS or the Mains supply source without load interruption, for UPS maintenance purposes. On UPS load being connected to by-pass supply, full access to the UPS input / output Equipment shall be possible.

e) Maintenance of Batteries

For maintenance purposes, it shall be possible to isolate the battery system from the rectifier / charger and the Inverter by means of a circuit breaker. In such a case, the UPS shall continue to supply the load as specified herein, except in the event of mains supply outage.

9.1.5

Sub Components of UPS System Rectifier /Charger

The input of the rectifier / charger shall be protected by a circuit breaker with adjustable settings. A walk-in circuit shall

be provided at the rectifier / charger input to eliminate sudden inrush current from the mains supply or changeover of supply source. The current walk-in shall take place to allow a gradual increase in the loading in the mains supply source.

The UPS shall have IGBT rectifiers to remove harmonics. The converter should be solid state PWM converter with IGBT rectifiers. The converter should have the following important features.

- Power Conversion
- Battery Charging
- Power Factor Improvement
- Current Harmonic Reduction
- Voltage Regulation
- Transient Recovery
- Automatic Synchronization
- Over-current Protection
- Over Temperature Protection
- Control Power Failure Protection
- Short Circuit Protection
- Current limiting function of battery charging to prevent the battery from being damaged.

The rectifier/ battery charger shall provide a regulated DC output for the inverter and the battery. The rectifier/charger regulation shall ensure that the DC output voltage fluctuations are less than 1% of rated value, irrespective of load and mains supply voltage variations.

The rectifier /charger shall be equipped with a filter limiting the DC ripple voltage to a values ess than 1% of the DC Voltage.

The rectifier / charger shall have sufficient capacity to enable simultaneous supplying of full load to the inverter and recharging a fully discharged battery to 100% rated value within 10 hours.

A protective circuit shall be provided to prevent battery overcharge. After the rectifier/ charger has recharged the battery to 100% capacity, the rectifier / charger shall float charge the battery. Provision shall be made to prevent the battery from over-charging due to battery charger rectifier fault. An adjustable battery current limiting device shall limit the battery recharge current to the maximum value recommended by the battery manufacturer. The rectifier/charger shall be electronically current limited to protect the connections to the Inverter input and to prevent damage to the battery.

The battery low-volt cut-off shall be set to suit the battery manufacturer's recommendation to ensure the battery is not damaged by a deep discharge.

The rectifier/charger unit shall be equipped with an over-voltage protection device.

9.1.6

Inverter

The inverter shall be a solid-state device with proven Pulse Width Modulation technique utilizing Insulated Gate Bipolar Transistors and microprocessor controls, capable of

accepting the output of the rectifier / charger or the battery system and provide a 3-phase alternating current output complying with the performance requirements.

The inverter shall utilize the latest and reliable technology to achieve high efficiency and reliability, and to cope with non-linear loads. The inverter should incorporate following essential features.

- Voltage Regulation
- Transient Recovery
- Automatic Synchronization
- Over-current Protection
- Over Temperature Protection

- Short Circuit Power Protection
- High Speed switching
- Frequency Control
- Inverter Output Voltage Harmonic distortion
- Inverter Overload protection

Each inverter leg shall be protected from over-current to prevent damage to the solid-state devices in the inverter bridges.

9.1.7 Automatic Static by pass switch

The UPS shall be provided with a static by-pass switch (make before break type) which is synchronized with the UPS. In the case of inverter failure, sub-circuit failure, load start-up inrush or battery capacity being exhausted upon rectifier / charger supply down, the static bypass switch shall transfer the load to the mains automatically within 4 milli-seconds. The UPS shall withstand the switching transient or fault energy produced during operation of the static bypass switch parallels two different supply sources. Full protection discrimination shall be achieved on the bypass circuit. In case of a single sub-circuit fault, the capacity of the static by- pass switch shall withstand the fault energy until the protective device of the sub-circuit clear the fault. The continuous capacity of the Static bypass switch shall be equal to the 100% continuous rating of the inverter. The overload capacity shall be equivalent to the overload characteristics of the UPS. The current handling capacity of switch shall be 10 times for 20 milliseconds.

The means of operation shall ensure an uninterrupted transfer of load to or from the by-pass supply source under both automatic and manual mode of operation.

Transfer conditions

The static bypass switch shall transfer from the inverter to the by-pass supply source under the following conditions.

- Inverter under voltage (less than 90 % of nominal),
- Inverter over voltage (greater than 110 % of nominal),
- Inverter overload,
- Inverter shut down for any reason (including failure)
- Manual signal.
- DC circuit under voltage or over voltage. Final end voltage of the system battery is reached.

At the same time, the inverter output shall be isolated to prevent the bypass supply source from back feeding power to the inverter.

9.1.8 Retransfer to inverter

The static by-pass switch shall be capable of automatically retransferring the load back to the Inverter after the Inverter has returned to normal voltage and stabilized for a period or the overload due to short-circuit or high inrush current has disappeared. The system shall only retransfer the load to the inverter provided all the following conditions are met.

- a) The inverter and the bypass supply source are synchronized.
- b) Inverter voltage is within $\pm 5\%$ of nominal for 2 to 30 seconds (adjustable).
- c) Manual transfer signal off.
- d) The overload current disappears within 1 to 10 minutes (adjustable).

9.1.9 Independent Manual By-Pass switch

A manually operated mechanical manual bypass switch shall be provided for the for maintenance on UPS and battery. The transfer scheme shall be make-before breaking uninterrupted transfer of the load from the static bypass switch output to the external manual bypass supply source or vice versa. The switching arrangement shall be designed to electrically isolate the UPS from the distribution board. The current switching capacity of the manual bypass switch shall be at least four times the UPS rated output current. Key interlock between external manual bypass switch and the inverter switch shall be provided such that the inverter output cannot be changed over with the external manual bypass

supply source directly.

In addition, the manual bypass switch shall be pad – lockable

9.1.10 **VRLA Battery System**

Twin Battery banks supplying 100% rated load suitable for half hour back up with each UPS i.e. two banks of 30 minutes backup for a set of UPS over its full-service life complete with heavy duty, high discharge valve regulated lead-acid type batteries, battery racks and interconnecting cables shall be provided.

The battery capacity shall be designed for long life (Design life of 10 years) for 2V SMF VRLA with uniform charging and discharging rates. Recombination cells, thus obviating the specific need for flameproof equipment in the UPS room.

The overall capacity of the battery system shall be such as to meet the specified performance and technical requirements throughout the life of the battery. The battery capacity shall be designed for long life with uniform charging and discharging rates. In calculating the battery capacity, an ageing and de-rating factor, advised by the supplier shall be taken into account, this factor shall not be more than 0.8. Battery sizing calculations shall assume an ambient temperature of up to 40°C and room temperature of 25°C. The battery cell shall be heavy duty, rechargeable, valve regulated lead acid and maintenance free type and the performance shall comply Battery shall be in conforms to IEC 60896-21&22 having an intended design life of at least 10 years.

The Charging of the battery to be done by the supplier at site. All equipment like charger and material required for charging should be provided by the supplier.

Contractor shall provide design calculations for selection of battery sizing & capacity in VAH duly considering ageing factor of 0.8, end cell voltage 1.75 and, load power factor of 0.8, & 10% design margin.

On restoration of grid power, the converter should automatically reactivate and provide DC power to the inverter, simultaneously recharging the system battery in boost mode and automatically switch to float mode after full charge recovery of the battery.

VRLA Battery shall be fitted in mild steel rack module as VRLA Cells require to maintain compression. The rack shall be designed to provide easy access to all components for maintenance and to minimize floor space requirements.

The battery shall have sufficient capacity and discharge characteristic to meet the requirement listed. The battery shall be suitable for the following charging duties: A fully discharged battery shall be charged to 75 % of its rated capacity within 8 hours under float charge conditions.

A fully discharged battery shall be charged to 100 % of its rated capacity within 10 hours under boost charge conditions.

VRLA battery container shall be flame retardant polypropylene opaque type and shrouded terminals shall be provided.

VRLA batteries come with sleeved connectors and terminal shrouds on the terminals, so that no base metal is exposed. Hence no isolation is required and can be in operation with complete safety. As stated, isolation is not required in VRLA batteries which comes in modules and fully protected from any exposure to electricity. Further a fully enclosed cabinet with doors will not allow air circulation which will affect the thermal management of the VRLA batteries thereby affecting life.

Racks shall be made of mild steel and a coating of non-conductive and fire-retardant material for ex- paint is required.

9.1.11 **Battery Rack**

The battery racks shall be constructed from good quality of high strength good quality mild steel sections. These battery racks shall be painted with two coats of acid/ alkali resistant paint of approved make. The racks shall be of Single tier/ two tier construction depending on the final layout based on space availability.

➤ **Marking**

Each cell shall be marked to meet the requirements of relevant Indian standards. In addition, each cell shall be legibly numbered serially to identify the cell during manufacture, testing, installation and operation of battery to identify after having assembled into battery bank in battery racks.

The marking shall be provided as per IS 13369. A set of loose stickers shall be provided to mark the cells position in the assembled battery bank at site so that a cell removed for maintenance can be put back in

original position.

The bidder should Provide onsite replacement warranty for 60 months including Free Preventive & corrective Maintenance for the warranty period.

9.1.12 Safety

Battery protection and charge controller

The Battery bank shall be protected from internal fault by a circuit breaker. The battery circuit breaker installed at the battery room should be complete with a metal enclosure conforming to an Ingress Protection Classification of IP 54.

The UPS shall be automatically disconnected from the battery bank when the discharge limits of volts per cell are reached, or when signalled by other control functions.

Temperature monitoring equipment shall be incorporated in the UPS system to optimize the charger voltage as a function of battery room temperature, to generate alarm in case of room temperature exceeding the pre-set permissible temperature and to predict the battery backup time. System efficiency shall be as per IS 13369.

9.1.13 Reliability

The service life of batteries shall be 10 years. The manufacturer shall submit details of maintenance required by batteries to ensure long service life.

➤ Special Condition

A representative from the side of battery manufacturer should be present during commissioning of UPS and battery bank to ensure that the DC link voltage set by the UPS manufacturer is as per the requirement of battery bank. The battery manufacturer shall also certify that whether commissioning done at site is satisfactory.

9.1.14 Testing

The Manufacture of the batteries must have type test certificates, from an accredited third party, for all the tests specified IS 13369 and shall not be more than five years old.

In case these are not available, manufacturer will be required to get these tests executed from an accredited third party.

The factory acceptance tests shall be done in accordance with IS 13369. The equipment shall be dispatched after testing in presence of authorized representative of purchaser.

The manufacture representative shall be available at the time of commissioning of batteries at site. The manufacture shall issue a certificate to the effect that the batteries have been installed and commissioned as per his approved scheme for the purpose.

9.1.15 Environmental Conditions

All equipment shall be capable of withstanding any combination of the following external environmental conditions without any mechanical or electrical damage or degradation / deterioration in performance.

- Operating ambient temperature: 0°C to 45°C
- Relative humidity: Up to 95 %
- Storage temperature 0°C to 50°C
- Operating altitude: As per IEC 62040-3

The equipment shall be designed to provide rated output at the extreme environmental conditions specified above.

9.1.16 Performance Requirements Input Parameters

- a) Input Voltage: - 415 V (AC) / 240 V (AC) (As per requirement). Each with input voltage tolerance of (–10% to + 10%).
- b) Wiring: - 3-phase, 4 wire and earth for Three Phase input/ Single phase and Neutral for Single Phase input.
- c) Input Frequency: - 50 Hz ± 5%
- d) Input Power Factor: - The total power factor of UPS as a load shall be from 0.99 lagging to unity, with rated load, fully charged battery, and input voltage within (10% to + 10%) of the nominal value.

- e) Harmonics on Input Voltage: - Input voltage distortion factor shall not exceed 0.08 and harmonic components shall not exceed values given in IEC 62040-3, Clause 5.2.1.d.
- f) Reflected Input Current Harmonics: - The rms value of all harmonics in the input current waveform contributed by UPS shall be less than 5%.
- g) Current Limiting: -The system shall be provided with inrush current limiting to 125% of the rated UPS load current.

9.1.17**Output Parameters**

- a) Rated voltage: 415 / 240V, 3 Phase 4 wire / single phase respectively.
- b) Steady state voltage regulation: $\pm 1\%$ for a load between 0 and 100% of full
- c) Rated value, irrespective of value of the normal mains supply voltage and DC Voltage, provided these voltages are within the limits specified.
- d) Transient voltage regulation: Should be less than 3%.
- e) Output Voltage harmonic distortion: An output filter to be provided to limit total distortion to less than 5% with no single harmonic greater than 3%, irrespective of load and normal mains supply, provided these are within the limits specified.
- f) Steady state voltage unbalance (difference between phase voltage and the arithmetic average of the three-phase voltage): $\pm 1\%$ maximum for balance load,
- g) $\pm 3\%$ maximum for 50% unbalance load.
- h) Phase displacement: $120^\circ \pm 1/2^\circ$ for balanced load; $120^\circ \pm 1^\circ$ for 50% unbalanced load.
- i) The output voltage shall not dip more than 20% in case of any fault on the load side of UPS.
- j) Output Frequency shall be as following
 - i. Rated frequency: 50 Hz.
 - ii. In normal operation, the output frequency of the inverter shall be synchronized to that of the bypass supply source within the limits of 3% (settable)
 - iii. For frequency variations exceeding these limits, the inverter shall switch over to free running mode, with regulation, providing an output frequency to within 1Hz of the rated value without switching to batteries.
 - iv. Frequency slew rate: 2Hz / second minimum maximum.
- k) Load Current Crest Factor: A crest factor up to 3:1 for the load current shall be anticipated
- l) Load Unbalance Capacity: -The UPS shall have the capability to accept up to 50% load unbalance with the ratio of current in the most loaded phase to the current in the least loaded phase not exceeding 2, provided that the most loaded phase current does not exceed the rated line current.
- m) Overload Capability: -The UPS shall be able to supply 110% for 60 minutes, 125% rated load for at least 10 minutes and 150% rated load for at least 1 minute
- n) Output power factor: - 0.9 and above.

9.1.18**Noise Level**

Notice emanating from the UPS during operation shall not exceed at a distance of 1.5 m from the enclosure, over a load range of 10% to 100% of the rated full load and measured as per the standard. It should be possible to change the internal parameters of the UPS (initially set by the manufacturer) in order to vary the output parameters, if required. The UPS shall automatically analyse the condition of the battery string on a programmable period. It shall detect and enunciate the battery failure condition locally and remotely. The periodic test shall not impair the battery readiness in case of normal supply outage.

- 70 dBA for 80KVA UPS
- 65 dBA for 60KVA & 30KVA UPS
- 55 dBA for 20KVA and below UPS.

9.1.19**Additional Requirements Diagnostics**

The UPS shall be fitted with a Microprocessor based Supervision and Diagnostic System, which monitors all aspects of the UPS operation. The system shall aid in the rapid identification of internal faults.

UPS shall be provided with RS 485 compatibility for remote monitoring and to extend alarm & status indications, annunciation and metering to BMS System located in Station Control Room. It shall be provided to communicate with an external computer for remote monitoring and diagnostics. The communication protocol shall be clearly documented and submitted for approval by the Engineer. Contractor must interface with the BMS Contractor regarding this.

All the necessary software and hardware accessories shall be provided at the Depot for the monitoring and diagnostics of the UPS via the RS 485 data interface.

9.1.20 Display

All the modules and accessories shall be integral part of the main cubical and provide controls, metering & monitoring system and self-fault diagnostic / annunciation system for healthy/faulty status through LEDs, data logger with LCD display suitable display and power monitoring software for operational status locally. The UPS shall be fitted with an integral control and indication panel.

9.1.21 Instrumentation

The UPS shall be provided with, digital instrumentation to indicate, as a minimum, the following information. All readings shall have an accuracy of at least $\pm 0.5\%$ of true value and the settling time shall be less than 1 second. If certain meter is used to display more than one parameter, a manual selector switch shall be provided for reading selection.

- A) True RMS voltage
 - UPS input voltage with phase selection
 - Rectifier output voltage
 - DC battery voltage
 - UPS output voltage with phase selection
- B) True RMS current (crest factor – 3:1)
 - UPS input current with phase selection
 - DC battery charge/discharge currents
 - UPS output current with phase selection and
 - By-pass source current with phase selection.
- C) Frequency
 - Mains frequency
 - UPS output frequency.
- D) Power (kW)
 - UPS output power with phase selection
- E) Power Factor
 - Inverter output power factor
 - Elapsed operating time.

9.1.22 Indications and alarms

The UPS shall include a mimic diagram with LED suitable display indication for the UPS equipment status and audible and visual alarm alerting annunciation. The status indication and alarm annunciation with the associated protection and control circuits shall include, but not be limited to, the following status and alarms.

- a) **Equipment Status Alarms**
 - UPS Input Voltage
 - UPS Output Voltage
 - Dual Supply, Healthy Status

b) Rectifier/Charger

- Rectifier Normal/Failure
- Rectifier Failure
- Boost / Float Charge

c) Battery

- Battery Charging / Discharging
- Circuit Breaker Open
- Battery Test Run
- Battery Discharging
- Battery Low Voltage
- Battery Earth Fault
- Battery Test Fail
- DC Over voltage

d) Inverter

- Inverter Normal/Failure
- Inverter Failure
- Inverter Overloaded
- Output over voltage / under voltage.

e) Static By-pass

- By-pass Normal / Failure
- Load on Inverter / Bypass
- By-pass Failure
- Synchronous Failure
- Static switch on manual

f) Manual Bypass

- Load on UPS / Bypass
- Manual Bypass Off / On
- Transfer Inhibited

g) Ventilation

- Fan Normal / Failure, or
- Over temperature alarm / shutdown (two stages)
- Fan Failure, or
- Over temperature alarm (adjustable)
- Over temperature shutdown (adjustable)

h) Emergency Pushbutton

- UPS On/Emergency Shutdown
- Emergency Shut Down with protective cover.

i) Common Alarm

- Alarm triggered - Common Alarm

Also, the following control should be present:

- i. Alarm test/reset push buttons
- ii. Lamp test/reset push buttons,

iii. Alarm silence push button.

There should be an alarm upon the occurrence of any faults or failures as mentioned above, along with an indication at the remote BMS panel. Audible and visual annunciation shall be activated at the indication panel when an alarm has occurred. Such annunciation shall be latched on alarm occurrence and shall be such that it can only be cleared by pressing a manual reset button.

The alarm state indications on mimic diagram shall remain until a manual reset switch is operated and the alarm state has been cleared.

Remote monitoring status: - The following critical status and alarms of UPS shall report to Station Building Management System (BMS) controller for remote monitoring via volt-free contacts rated 24 V DC, 1A provided in the UPS modules:

- Supply A normal / failure
- Supply B normal / failure
- Load on inverter / bypass
- Battery charging / discharging
- Manual bypass off / on
- UPS (rectifier / charger / inverter / bypass switches) common alarm
- Battery common alarm
- Fan normal / failure or Over temperature alarm / shutdown
- UPS on / emergency shutdown.

Remote Control: - There will be no remote control for the UPS except Emergency shutdown push buttons in readily accessible locations, fitted with non-lockable covers or shrouds.

There should be a system of communication provided with the UPS for transferring the Battery run test and inverter failure data to mobile telephone of OCC in the elevated stations.

9.1.23

Safety

UPS shall be designed for low impedance, less than 50V touch voltage and limited ripple content. Two independent and distinct earth electrodes connections shall be provided for earthing of UPS connections comprising 50 x 4 mm Copper strips / 50 x 6 mm GI strips or as required / approved. Surge protective devices shall be provided at the inputs and output of the UPS to protect the UPS and the load equipment against any power surge due to lightning, switching, etc.

The UPS system shall be equipped with an interlocking system to prevent parallel operation of any non-synchronized sources activated either by any manual switches or automatic switches. The UPS output shall be supplied via means of isolation with suitable protection, sufficient to supply the full rated output load. The module shall be designed such that if there is a single fan failure or over temperature, an alarm shall sound, but it will in no way produce degradation of performance. In case of unavoidable shutdown due to excessive temperature rise, a warning alarm shall be given out before the shutdown. All cabinets shall be solidly bonded to earth in accordance with BS 7430 using adequate section of cable or bus bar. The earth connection at the cabinets/enclosures shall be made to the frame earth provided or alternatively to a substantial part of the basic frame rather than a bolted - on panel.

9.1.24

Circuit Protection

Means of isolation with suitable protection shall be provided at both input and output within the UPS, which fully discriminate with upstream and downstream circuit breakers. The system shall be provided with component protection, to minimize damage and downtime in the event of component failure, against:

- AC Supply voltage transients and transfers.
- Internal faults.
- Sustained overload.
- Load switching transients.
- Current surges.

The system shall be provided with interlocks to prevent accidental damage to the UPS during maintenance or normal operation.

UPS system shall be designed with protection & annunciation system for monitoring the following:

- Phase sequence.
- Overload and short circuit trip.
- Earth fault.
- Reverse Power Flow.
- Low battery voltage.
- Fault indication alarm through suitably designed hooter.
- Self-diagnostic annunciation system.
- Ventilation Failure
- Temperature monitoring

The manufacturer shall provide the scheme of operation of various protective devices for the above-mentioned conditions.

9.1.25 Emissions in case of fire

The equipment shall produce low smoke and no toxic emissions in case of internal or external fire/over-heating. The equipment shall not have any component which bursts with smoke or toxic emission. The AC and DC capacitors used shall have over pressure safety device or disconnect or. Cables, wires & insulating materials used, shall be fire retardant, low smoke and zero halogen material.

9.1.26 System Efficiency

The efficiency of the proposed UPS shall be at least 90% and above from 25% load to full load. The life and efficiency are of prime importance. The manufacture may offer UPS with any new proven technology having advantage of life and energy efficiency without compromising on other parameters of specification.

9.1.27 Reliability, Maintenance, Spares & Life

The system shall have high operating efficiency, front access and self-diagnostic features. There shall be enough redundancy in all vital parts to achieve a breakdown free operation of the system. The reliability shall be greater than 99.9%. The manufacturer shall provide data confirming to the required reliability.

The UPS shall be designed for maintenance free working. The conditioning monitoring system through sensing of all parameters of working equipment's shall be designed to take care of incipient faults to undertake any unscheduled repairs without causing consequential damages.

Equipment shall be designed and manufactured in modular manner to facilitate the fault diagnosis and replacement of each modular part. Each module shall be capable of being interchanged with other modules of the same type without affecting the rest of modules in place.

The service life of the UPS system shall be at least 20 years. The manufacturer shall submit the list of those items whose life does not match with the service life of UPS. The life of such spares shall be advised with a certificate from the manufacturer of the spares. The firm shall provide purchase specification of these items.

The manufacturer shall submit a list of all the spare parts with price list to be kept after the expiry of defect liability period. The vendor shall provide the Annual Maintenance cost of UPS system (including batteries) for their full service life, in blocks of 5 years or year wise.

9.1.28 Material and Manufacturing

Quality Assurance and Controls the Contractor's Management Systems shall emphasize quality assurance and controls. The programme shall be adequate to ensure an acceptable level of quality of the equipment supplied. The concept of total quality assurance shall be based on the principle that quality is a basic responsibility of the Contractor's organization, and shall be visible by:

- a) Firm procurement and job performance specifications.

- b) Firm procedures for transmission of information and data to their Subcontractors and ensuring their compliance. Adequate testing to ensure repetitive product conformity to design requirements and Total programme of surveillance and verification of physical performance and configuration accountability.
- c) Adequate records shall be kept by the Contractor to provide evidence of quality and accountability. These records shall include results of inspections, tests,
- d) process controls, certification of processes and personnel, discrepant material, and other quality control requirements.
- e) Complaint handling and commitment towards customer satisfaction.

ISO certifications to which the quality standards are compiled Materials and Workmanship requirements

All materials and processes to be used, whether incorporated in equipment at the manufacturer's works or used for installation at site, shall comply with the requirements of this M&W Specification and shall conform to good modern practice. The following requirements shall be the minimum requirements and they shall not relieve the Supplier from ensuring that his designs are fit for purpose, and that all materials and processes are suited to their intended purposes and environments. The basic workmanship and manufacturing principles shall be visible during visual inspection such as no sharp corners, sizing of screws/bolts, cable layout and identification, bedding and rubbing of parts, clearances, user friendly switches and indication panel etc.

All equipment and components supplied under the Contract shall have proven reliability and shall be designed, manufactured and installed to meet the specified and / or relevant international or national standards. The Contractor shall submit to the Engineer for approval, a list of all supplied equipment and components with a declaration of conformance to standards.

The manufacture shall supply information about the bill of material used in the manufacturing of the product if the Engineer so desire to satisfy himself about the use of quality material.

9.1.29

Mounting and Enclosure

UPS shall be free standing and mounted as a whole on a heavy-duty fabricated steel base frame constructed from folded channel sections with suitable mounting pads. All air entries shall be protected with cleanable filters. The cabinets shall be vermin and dust proof with IP 20-degree protection.

The Cabinet shall be constructed with material of thickness 1.6 mm for non-load bearing members and 2.5 mm for load bearing members and suitably braced to form a rigid structure. Full substantiation of mechanical strength shall be provided for approval to demonstrate that the cabinet is free from distortion when equipment is mounted and support on floor. All metallic cabinets shall have treatment for corrosion protection and painted with epoxy polyester paint.

The dimensions of the cabinets shall be optimally sized without requiring excessive floor space.

The equipment shall be constructed in modular units, which shall be installed in metal enclosures designed for floor mounting. Each module shall be constructed on a rigid base frame. Sub-assemblies and components shall be mounted on pull out and/or swing out trays. Cable connections to the cable ladder and trays shall be of sufficient length to allow for easy access to all components.

The UPS cabinet shall have a clear area of at least 900 mm in front to allow the doors to be opened fully and maintenance to take place. Doors shall be fitted with lockable handles or other approved means of fastening and shall be provided with locking bars and guides to prevent distortion. Cabinet shall be arranged so that access doors or panels into compartment can only be opened when the locking device is in the unlocked position. Two sets of keys shall be provided for each lock.

Each Cabinet shall be fitted with metallic gland plates for entry of cables and an earth terminal. Foundation bolts and lifting hooks or eyes shall be provided as necessary for handling purposes. It shall be fitted internally with a nameplate, which shall state the manufacturer's name, address, telephone and e-mail address, serial number, rating and year of supply.

Danger warning notices with red letters on a white background shall be fitted to covers, which give access to live terminals or conductors at and above 110 volts. The danger board should be provided as per Indian Electricity Rules.

Circuit and function labels shall be provided. All labels shall be in one language as approved by Engineer. All switches or control unit provided for operation by Operating Staff shall be labelled with prominent display by letter size of minimum 6 mm.

The modules shall be designed to be transported in a horizontal and/or vertical mode as may be necessary to enable installation of the modules in the positions designated on Site.

Each of the items shall be adequately packed and protected against damage in transit from the manufacturer's work area to the Site. Similarly, after delivery to Site, each cubicle shall be properly protected from damage until work is completed.

The mechanical and electrical design of all cabinets shall be submitted for approval by the Engineer.

Each cubicle shall be provided a space for keeping operating manual along with other documents related to the UPS with suitable labelling.

Electronic Components and Sub-Assemblies: Each plug-in module or printed circuit board shall be securely plugged into the main unit with guiding construct to hold the module in place. Printed edge connector shall not be used.

Printed circuit boards shall have sufficient thickness to ensure its mechanical rigidity and to eliminate the risk of damage during installation and maintenance. Dip switches shall be avoided as far as possible. Jumper wire is not allowed.

Printed circuit boards shall be designed and manufactured to the accepted standards, which shall include standards for conductor thickness, width and spacing. Different standards shall be applied to equipment operated under different conditions if applicable.

All plug-in modules shall be clearly and unmistakably identified. Labelling with module name, part number, serial number and revision number shall be provided.

LED shall be provided with each plug-in module or printed circuit board to indicate the power supply and component fault status. They shall be easily visible without any obstructions.

The rated voltage of insulated terminal blocks shall be 415 V between terminals, 240V to earth. Insulated terminal blocks shall comprise brass tubular connectors with screw connections contained within a moulded block suitable for working temperature up to 100°C.

Terminals shall be designed to clamp the conductor between metal surfaces with Sufficient contact pressure but without causing damage to the conductor. With the largest recommended conductor in position, and tightly clamped, there shall be at least two full thread pitches of the screw engaging in the connector.

All materials and parts comprising the module system shall be new and of current manufacture of a high grade and free from all known defects and imperfections.

All active electronic devices shall be solid state. All semi-conductor devices shall be hermetically sealed. Vacuum tubes shall not be used for any purposes.

Terminals shall be supplied suitable for the cables being used to make the power connections. Terminals shall be provided for connecting the remote alarm contacts.

All power semi-conductors shall be fused in a manner to prevent cascaded or sequential semi-conductor failures. Indicator lamps denoting blown fuse conditions shall be located such as to be readily observable without removing panels or opening of the cabinet doors.

Isolating switches shall be of the load type with ON/OFF indication and lock attachment. Critical isolating switches essential for continuity of the load power shall be pad-lockable.

Contactors if any shall have Contactor coils suitable for use on direct current. Rectifiers shall be of the selenium type and terminals shall be provided to external control of the contactors on the AC side of the rectifier.

Relays shall be of the plug-in type and shall be housed in dust tight enclosures.

9.1.30

Electrical Works and Accessories

All electrical equipment in the UPS, including MCCB, MCB, cable connector, trunking, conduit and other electrical accessories, shall comply with, the sections and clauses of the M & W Specifications, relevant to these items. All the

cables and wires used must be of Low Smoke Zero halogen type.

9.1.31 Testing & Commissioning

The manufacturer of the UPS must have type test certificates, from an accredited/ reputed third party, for all the tests specified IEC 62040 – 3 and shall not be more than five years old.

In case, these are not available, manufacturer shall arrange to get these tests executed in their factory as per clause 6.6 of IEC 62040-3 in the presence of third party NABL certified body. The ENGINEER official may call for repeat of all or some of the tests during factory acceptance test.

Manufacturer will be required to carry out the routine and optional tests as specified in IEC 62040 – 3.

The UPS shall be thoroughly checked for correct operation and load tested in supplier works before dispatch. All faults created for check on satisfactory function of protection system, control functions, workmanship and site load conditions shall be simulated, checked and proved. The equipment shall be dispatched after testing in presence of authorized representative of purchaser.

The manufacture representative shall be available at the time of commissioning and testing of UPS at site. The manufacture shall issue a certificate to the affect that the UPS has been installed and commissioned as per his approved scheme for the purpose.

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CHAPTER- 10
DIESEL GENERATOR SET (DG- SET)

10.1 Diesel Generator Set (DG-SET)**10.1.1 Standards & codes.**

Sl. No	Code	Description
1	BS 60529, IEC 529	Degrees of protection provided by enclosures
2	BS 6667, IES 801	Electromagnetic Compatibility
3	BS 88	Fuses
4	BS 3535	Isolating transformers
5	BS 171, IES 76	Power transformers
6	BS 6290	Sealed lead acid rechargeable single cells
7	BS 60146, IES 146	Semi-Conductor converters
8	BS 4196-6, ISO 3746	Sound level of Noise Source
9	BS 800, VDE 875	Radio Interference Limits
10	BS 5514	Reciprocating internal combustion Engines
11	BS 4552	Fuel-filters, strainers & sedimentary for compression-ignition engines
12	BS 2594	Storage Tanks
13	BS 799 Part 5	Tanks and Fittings
14	BS 5486	Fuse-boards
15	IS 1460	Diesel Fuel
16	IEC 60034	Alternator
17	ANSI S12.34	Survey Methods for Determination of Sound, Sources, Power Levels of Noise
18	ANSI S12.36	Survey Methods for Determination of SPL of Noise Sources
19	IEEE S 85	Standard Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
20	IEEE S 112	Test Procedure for Poly-phase Induction Motors and Generators
21	IEEE S 519	Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
22	NEMAICS-1	General Standards for Industrial Control
23	BS 7226	Performance Tests
24	BS-2613 / IS 13364-Part-II-1992	Specification-for-AC-Generators-driven-by-reciprocating internal combustion engine Part 2 - Rated above 20 kVA and up to 1250 kVA

Sl. No	Code	Description
25	BS: 5000	Specification for rotating electrical machines of particular types or for particular applications
26	IS- 4722, BS 5000	Brushless alternator with automatic voltage regulator
27	BS: 4999 / IS: 4722 -2001	General requirements for rotating electrical machines
28	IS 6362: 1995	Designation of Methods of Cooling of Rotating Electrical Machines
29	IS-1460	Automotive diesel fuels - Specification
30	IS 3169 – 1991	Internal combustion engine –two stage, one liter diesel fuel filters.
31	IS-3351	Internal combustion engines- diesel fuel filters. Method of tests
32	BS-4999	General requirement for electrical rotating equipment's
33	IS- 6362	Designation of methods of cooling of rotating machines
34	IS-8183	Bonded mineral wool.
35	CPCB	Rules & regulations of Central pollution control board
36	ISS 3231-1965(IEC pub.255 with amendment No 1 & 2 (1967, 1969)	Protection system for D.G.- relays for protection of system
37	IS- 3842 1966,1967&1968	Do-
39	IS- 5216 -1969	Do -
40	IS: 8183 - 1993	Bonded mineral wool for sound isolation.
41	ISO 8528-1:2005 Part- 1,2,3,4,5	Reciprocating internal combustion engine driven alternating current generating sets -- Part 1: Application, ratings and performance

- The equipment offered shall conform to the latest revision of relevant Indian or British Standard (BSS.) and Codes together with the requirements of the Local Supply Authority and Department of Explosive etc.
- The equipment shall be as per latest relevant standards / codes of IS/BS/IEC/IEEE/EN.
- Equipment offered shall comply with latest pollution norms at the time of delivery of the equipment.
- In addition to the above, all relevant Central Pollution Control Board (CPCB) notifications shall be complied and certificates of approval are mandatory and shall be submitted by contractor to employer.

10.1.2

Specification for DG set:

General:

Technical specification shall conform to latest CPCB norms effective from July 1, 2004 include design, supply, installation, testing and commissioning of automatic start direct coupled Diesel Generator Sets suitable for continuous round the clock operation at up to rated output with permissible overload along with associated works. Items included (but not limited to) in the contract are abstracted as below.

- Diesel engines directly coupled with alternators mounted on a rigid fabricated steel base frame with resilient anti vibration mountings.

- Exhaust piping with silencer to provide 75 dBA insertion loss
- Electric starting equipment including batteries and battery chargers.
- Acoustic and weather proof enclosure with arrangement for fresh air intake and hot air extraction
- Statutory approvals including permission from Electric Supply Authority for operation of DG sets., clearance from Electrical Inspector, approval from pollution control board and necessary approvals from department of explosive for bulk oil-diesel storage.
- The equipment offered shall conform to the latest revision of relevant Indian or British Standard (BSS.) and Codes together with the requirements of the Local Supply Authority and Department of Explosive etc.
- The equipment shall be as per standard relevant standards / codes.

Capacity of DG set shall be such that total connected emergency electrical load of depot shall be within 70 percent rated full load capacity of D.G. / Name plate rated capacity of engine & alternator.

D.G. Set shall be loaded up to 70 percent and 30 percent shall be cushion for future connected loads

Design, supply, including all transportation, storage, loading / unloading, insurance and safe custody till handing over, installation, testing and commissioning of the sound attenuated Diesel Generator set. The DG set shall be complete with the following:

- Sound attenuated weatherproof enclosures.
- Ventilation and illumination system for acoustic enclosure
- Skid mounted Engine with Radiator assembled with Alternator, satisfying all requisite parameters
- Brush less alternator provided with suitable automatic voltage regulator conforming to IS 4722, BS 5000. The alternator shall be self-excited, self-regulated, self-ventilated type
- Residential type of silencer
- Bank of SMF VRLA starting batteries with battery charger for trickle boost and charging.
- AMF Panel with load switches as per standard design to suit for auto operation of D.G.set
- Anti-vibration mounting pads
- All piping system between engine and radiator
- Piping system for fuel line from engine to the day tank (internal and external tanks both). The pipes shall be MS pipes of 25 mm diameter or braided flexible.
- External fuel tank of 990 litres capacity. The tank shall be made out of 14 SWG thick MS sheets with all accessories such as oil level indicator, drain plugs, manhole and painting etc. complete as required by Indian Explosive Rules and Regulations
- Provision of necessary signals for Lighting Management System (LMS) and Building Management System (BMS).
- Provision of facility for incorporating linear fire gas tracing system at site.
- Miscellaneous safety and other items viz. rubber mat in front of AMF Panel, maintenance schedule board, cabinet for spares, danger sign boards, first aid box etc.
- Provision of facility for incorporating linear fire gas tracing system at site.
- Miscellaneous safety and other items viz. rubber mat in front of AMF Panel, maintenance schedule board, cabinet for spares, danger sign boards, first aid box etc.
- Exhaust piping system including MS pipes, specials, bends, flanges, reducers, etc. connection to silencers and lagging the exhaust pipe as per specifications.
- Radio interference-All equipment provided under this specification shall be so designed that it will not cause interference with radio equipment. In the event of the inherent characteristics of the equipment being such that radio interference is possible, efficient devices to nullify the same shall be provided. Suppressers shall be as per the relevant I.S./B.S. Standards.

10.1.3 Specification for AMF Panel:

1. Confirm to relevant standards and spec. Main Breaker with 4-pole MCCB of 50 KA. The AMF panel will have special provision of feeding to two feeders, simultaneously, one for M.V.S.B (FPP) at Fire Water Pump Room and other one for the MDB 2.0 (Essential) at ASS.
2. The DG Room is located down to the auxiliary sub-station (ASS) and close to the Fire pump room. Sensing of normal source power supply is extended from MDB 1.0 to the AMF panel. Starting of DG set is controlled through automatic mains failure panel (AMF). The supply from the DG set is received at MV switch board, MDB 2.0(Essential), installed at ASS. DG supply is extended to FPP panel through parallel feeder cable.
3. The DG set will start automatically even in cold conditions so as to take full load within 10 to 30 seconds (wake up time) from failure of normal supply.
4. The AMF panel shall be connected & provided with suitable interlocking arrangements to ensure automatic starting of the DG set in case of failure of supply from both the sources and interlocking arrangement to avoid any incident of paralleling of normal power supply with DG set supply. There shall be provision of Manual Transfer of source and ASTS.

10.1.4 Engine starting system:

- Engine starting system with electrical start motor and battery system.
- Battery capacity selected suitable for minimum 10 cranking attempts
- Auto start, minimum three repeat start attempts as per pre-set intervals for cranking / rest time etc.
- Battery re-charging facility by engine driven alternator as well as through mains powered Battery charger, including battery charging circuit isolation facility during starting attempts or while engine running.

All wiring / cabling and connections including trenching, resurfacing as required between the following:

- Engine Control Panel and AMF Panel.
- starting battery bank and engine control
- Engine mounted alternator to battery and static battery charger to battery.
- Electrical Panel and Fuel pumps, etc.
- Battery charger to batteries.
- Any other cabling required to complete the work.
- All the cables (power and control) will be FRLSZH type. Contractor shall submit cable schedule and plan to Employer before executing the work. The cables sizing and laying shall be as per manufacture's recommendation. For AMF application, 8/10-core 2.5-sqmm flexible armoured copper cables shall be used. All the cable should be crimped, marked & tagged and routed through proper cable glands in the control panel.

10.1.5 Protection for D.G set:**a. Electrical protection:**

- Over current.
- Earth fault.
- Short circuit
- Reverse Power.
- Single phasing protection.

b. Prime mover / Engine protection.

- High temperature of engine cooling water.
- Low Lube oil pressure of engine

- Engine over-speed.
- Engine-fuel tank low level.

c. Earthing.

- Earthing of DG-set
- AMF panel
- Alternator neutral earthing etc.

All the requirements of IE Rules, NBC etc. shall be complied for earthing and safety system.

10.1.6 Gas Flooding

Automatic Gas flooding of AMF panel, using linear heat sensing tubes Fire trace or equivalent Climatic Conditions -- Ambient Temperature-

- a. Max. + 50 °C RH 90%).
- b. Min. + 8°C.

10.1.7 BMS system

BMS system for D.G. Set and AMF panel. Following signals shall be required from the DG set and AMF panel for the building Management system within depot.

a) D.G.set

- DG run ON/OFF status.
- DG set trip alarm.
- Day Tank Fuel (External tank) Graduated Level.
- Day tank low level alarm
- DG room exhaust fan ON / OFF status.
- Auto / Manual switch status.
- Lube, Oil pressure low alarm.
- DG set engine water temp high alarm.
- Battery voltage low alarm.
- DG room fresh air fan ON / OFF status.
- DG start/stop command

b) AMF Panel:

- Voltage Monitoring.
- Current Monitoring.
- Frequency Monitoring.
- Power Factor Monitoring.
- Energy Metering.

- c) The AMF Panel shall be provided with a PLC (Programmable Logic Controller) unit, along with I/O modules (with 30% spares) to achieve the above requirements. Transducers as required for the above signals shall also be provided by the contractor. These signals shall be accessible to BMS working on MODBUS through TCP/IP protocol through a RS 485 port provided in the AMF panel.
- d) The power circuit, breaker requirement for input / output from the AMF shall be followed as per standard design / approved drawings. There shall be two output feeder breakers including one incoming breaker. All the breakers shall be of motor operated, microprocessor based 36 KA, 4 pole MCCBs with RS 485 compatibility.
- e) The all necessary arrangements for monitoring of the fuel consumption, specific energy / fuel consumption through BMS shall be provided

- f) There shall be alarms for non-operation of DG sets for long periods in the BMS system.
- g) The contractor shall provide at least four signals corresponding to 10 %, 25%, 50% and 75% loading of DG sets, accessible through RS 485 port provided in the AMF panel.

10.1.8**D.G Set Operation:**

- DG sets are expected to run at light load / No load. The DG set offered, should be suitable for operation under light load /No load, without any adverse impact on the service performance or life of the equipment.
- Depot with independent reliable sources of power supply and DG sets would be required to operate for a very small duration and after large period of idling. DG set should be designed to work satisfactorily even after prolonged idling period.
- Approximately 60 percent of the load shall be non-linear. DG set should be designed to operate under non-linear load environment. DG set should be so designed that the ripples are not created in the energy generated and EMI and RFI are within acceptable limit, specified by standards.
- Lubrication system shall be complete with necessary gear pump, piping and drilled oil passage strainer, oil cooler etc. and relief valve.
- DG set shall be able to start automatically even in cold condition without any adverse effect on its performance and capable to take full load within 10 seconds (wake up time) of failure of normal supply.
- DG set shall be designed for low specific fuel consumption.
- The DG set shall be suitable for working in parallel with another DG set by installation of an auto-synchronizing panel at a later stage (not included in this tender.)
- The DG set shall be suitable for continuous operation under the ambient conditions without any adverse effect on its performance.
- The DG set should be such as to start the Fire Fighting Pumps direct on-Line starters.

10.1.9**Diesel Engine**

The engine shall have the characteristics as indicated in the following table.

Sl. No	Details / parameter.	Description
1	Type	Suitable for generating set application, turbo charged, multi-cylinder, cold starting. The engines shall be provided with electronic fuel injection system
2	Cycle	Four strokes
3	Speed	1,500 r.p.m
4	Speed Variation	Within 2% for operation between 10% and 100% load
5	Method of Starting	by Battery
6	Output	The engine shall be suitable to deliver the stipulated rating under ambient conditions.
7	Engine rating	The engine rating shall be stated in accordance with the latest revision of relevant I.S. or B.S. Adequate precautions shall be taken to safeguard the sets against low lubricating oil pressure, high water temperature, over speed and over current.

a. Construction

- The Engine shall be internal combustion type direct injection, cold start suitable for diesel fuel, 1500 rpm, turbocharged, with electronic governor suitable for auto synchronization, 4-stroke of suitable rating with

provision of 10% overload for 1 hour in every 12 hours of running. Engine shall be multi-cylinder of in-line or V configuration and complete with basic accessories.

- Engine shall be built to comply with BS 5514 and shall be capable of sustaining a 10% overload for one hour in a 12-hour running period. The engine shall be complete with cooling fan drive, lubricating oil filters, air cleaners, starter motor/exciter, battery charging, regulator, fuel injector, fuel control solenoid, fuel lift pump, engine speed adjustment, other standard / operational accessories and protective devices.
- The Diesel Engine shall be designed for operation on High Speed Diesel (HSD) Fuel conforming to IS: 1460 – 2005.
- The engine shall be fitted with a heavy, dynamically balanced flywheel suitable for constant speed generator duty to meet the cycle variation requirements as per relevant standard. An electronic speed governor shall be fitted to maintain engine speed at all conditions of load in lines with the requirements of BS: 5514.
- Cylinder housing and crankcase shall be of high-grade cast iron with overhead valves. Housing and heads shall be provided with necessary cooling fins.
- Crankshaft shall be manufactured from solid forging with hardened crank pin and main bearing journals. The entire shaft shall be truly balanced.
- Pistons shall be of aluminium alloy and provided with necessary compression and scrapper rings and a fully floating gudgeon pin.
- Connecting rods shall be H-section steel stampings. Camshaft shall be gear driven (fly-wheel end) and easily removable.
- Lubrication system shall be complete with necessary gear pump, piping and drilled oil passage strainer, oil cooler etc. and relief valve.

b. Cooling:

- The engine shall be complete with suitable radiator for cooling the machine in tropical ambient temperatures, with engine-driven blower type heavy-duty cooling fan and radiator core.
- Water-cooled with fan and radiator, with engine driven circulating water pump, thermostat, temperature gauge with high temperature alarm / trip. Cooling water circuit shall be fitted with corrosion inhibitors.
- A thermostatic valve should by-pass the coolant in the primary circuit until a pre-set operating temperature is reached.
- The design shall consider compensation for possible ingress of dirt, which may normally clog the fins. The choice shall consider the place of installation and the flexibility available for locating cooling system, air circulation and smoke exhaust.

c. Filtration

- The engine shall have replaceable fuel oil filters. Lube oil filtration, air filtration shall be through replaceable filters.
- Fuel Filters - A supply line fuel filters shall be fitted and shall be of twin replaceable elements type complying with BS 4552 and relevant IS.
- Air filters - The engine shall be fitted with dry type air filters with replaceable elements. The engine shall be complete with fuel and lubricating oil filters with replaceable elements.

Twin heavy-duty air intake filters in accordance with BS 7226 and relevant IS suitable for operating in dust-laden atmospheres shall be fitted. Breathers shall be fitted with washable filters, which are easily accessible for maintenance.

d. Other items for engine.

Lubricating Oil Consumption

The Contractors shall state the guaranteed lubricating oil consumption in liters per hour.

- Air Filters

The engine air intake shall be fitted with a substantial air cleaner of oil bath/ paper element type. The filter shall be suitable for operation under dusty conditions.

➤ Crank Case Breather

The crankcase breather outlet of the engine shall be fitted with a filter cap capable of preventing entry of dust.

➤ Fuel and Lubricating Oil Filters

Filter for fuel and lubricating oil systems shall be of simplex type. Lubricating oil filters shall be of an efficient full flow type of ample capacity and suitable for use with detergent oils. They shall be capable of removing all foreign matter above a particle size of 5 microns.

➤ Lubricating Oil System

The engine shall be of the totally enclosed type and fitted with a positive pressure system of lubrication to all working parts. Lubricating oil shall be circulated in the engine by an engine driven pump. There shall be no moving part requiring lubrication by hand prior to the starting of the engine or while in operation.

➤ Safety Controls

The engine shall be complete with all controls to render the operation of the engine reliable and totally safe including but not restricted to the following.

➤ Low Lubricating Oil Pressure

Pressure sensors shall be fitted such that in the event of a fall in the lube oil pressure, an alarm and indication shall be actuated. In addition, the engine shall be automatically shut down in the event of lube oil pressure dropping to a predetermined low value. Potential free contacts for conveying the signal to BMS shall be provided

➤ High Water Temperature

An alarm shall be given if the close loop engine jacket cooling water temperature exceeds safe limits stipulated by the engine manufacturer due to any reason (including low level of water in secondary cooling system cooling tower). The engine shall be shut down when a pre-determined set water temperature is reached. Potential free contacts for conveying the signal to BG. I shall be provided.

➤ Over Speed

Speed control shall be so arranged that a 12-1/2% increase over normal rated speed shall cut off fuel supply, thus stopping the engine. Potential free contacts for conveying the signal to BG. I shall be provided.

➤ Overload Protection

The engine shall be adequately protected against operating under overload conditions. The requirements shall be met by the provision of a fixed overload limit stop on the fuel pump rack control rod to prevent the set being subject to a load exceeding the rating plus 10%. Potential free contacts for conveying the signal to BG. I shall be provided

e. Accessories, Instruments and Safety Controls for Engine

Accessories, instruments and safety controls to be provided with the engine shall be (but not limited to) as below. All accessories shall be of design compatible with the design and /or operation of the engine.

Following Accessories are as part of engine.

- Flywheel.
- Coupling with guard
- Mechanical guarding of all moving parts
- Air cleaner oil bath / paper element type
- Corrosion resistor

- Heat exchanger.
- Governor – electronic
- Fuel injection.
- Fuel filter.
- Lube oil filter.
- SMF batteries with leads and float cum boost battery charger along with battery stand
- Stainless steel bellows
- Exhaust silencer
- Interconnection wiring, cabling and piping as required
- Set of standard tools
- Anti-vibration mounting pads

f. Instruments and Gauges:

- Lube oil pressure gauge.
- Battery charging ammeter
- Hour meter(mechanical) to show total engine run hours 10,000 hr capacity
- R.P.M. indicator of the tachometer type
- Starting switch with key.

g. Safety controls for

- Low lube oil pressure
- High water temperature
- Over speed.

h. Piping Materials

- Unless otherwise specified, pipes shall be 'C' heavy class G.I (black steel) as per IS 1239 (Class C) up to 150 mm and above as per IS 3589 of 4.85 mm thick suitable for welded joints. Wherever so specified, class C GI pipes with screwed joints could be used for pipes up to 50 mm dia. G.I / GI pipes shall be of makes as per approved list. Pipes shall be given one primary coat of rust inhibiting paint before being installed.
- Fittings shall be new and from approved manufacturers, Fittings shall be of pressure ratings suitable for the piping system. Flanges shall conform to ISS. Supply of flanges shall include bolts, nuts, washers, gaskets etc., as required. All equipment and valve connections shall be through welded flanges.
- Gate valves and check valves shall conform to IS:780/1969. Gate valves shall have non-rising spindles unless otherwise specified. Valves up to 40 mm dia shall have gun metal body and valves of more than 40 mm dia. cast iron body unless otherwise specified. Valves shall be suitable for test pressures as per piping system requirements and as per ISS.
- Butterfly valves shall conform to BS:5155, G.IS SP 67 & API 609. The valves shall be suitable for flow in either direction and seal in both directions. The valve shall be of integral moulded design.
- Strainers shall be Y type or Pot type as per schedule of quantities and /or as required with CI or fabricated steel bodies. Strainers shall have removable bronze screen with 3mm perforations. All strainers shall be provided with equal size isolating valves so that the strainer may be cleaned without draining the system.
- Pressure gauge shall be not less than 100 mm dia dial and of appropriate range and be complete with shut off gauge cocks etc. and shall be duly calibrated before installation.
- Pressure gauges shall be provided at the following locations:
 - Suction and discharge of pumps.

- Inlet and outlet of heat exchangers.
- Care shall be taken to protect pressure gauges during pressure testing.
- Thermometers shall be either 100 mm dia dial or direct reading industrial type of appropriate range duly calibrated before installation.
- Thermometers shall be installed in separable wells.
- Dial type thermometers on supply and return of heat exchangers.

Engine auxiliaries and wiring.

All engine auxiliaries shall be checked and tested for proper operation. Wiring between the engine auxiliaries and the DG control logic panel shall be provided with copper conductor FRLSZH insulated 1100 V grade armoured cables. Loop earthing as required shall be provided.

10.1.10 Fuel Tanks

- a) Fuel tank of capacity 990 liters or capacity as per capacity of D.G. set and as per manufacturer shall be provided. The tank shall be constructed from Mild Steel of not less than 14 SWG thickness in accordance with relevant IS standards. It shall be complete with filter breather unit and drain plug. The associated fittings shall be constructed from materials which are suitable for long terms contact with diesel fuel and shall not include yellow brass, low grade of copper and zinc, lead, and galvanized metals. The fuel piping and tanks shall be designed to free from leakage and airlocks. The fuel tank shall be supplied with a level gauge to indicate the fuel level in the tank in liters. The following fittings shall be included:
 - Direct reading level indicated (hydrostatic gauge).
 - Drain pipe situated at lowest point in tank complete with isolating value,
 - Outlet pipe complete with manually operated isolation value and mechanically operated isolation valve (for fire shut-down),
 - Fuel inlet pipe from the filling point at the top of the tank.
 - Fuel return inlet pipe connection (from the generator set),
 - A Fuel Day Tank storing capacity of 990 liters shall be as per rated capacity of D.G. - complete with mechanical fuel oil level indicator to indicate 'High 'and 'Low' levels and with isolation valves shall be supplied for storing diesel. The tank shall be mounted and raised from ground level for flow of diesel by gravity to D.G. Further a fuel pump / hand operated pump shall be supplied / provided to transfer fuel from barrels to this tank.
 - The tank shall be constructed from mild steel in accordance with BS 2594. The associated fittings shall be constructed from materials which are suitable for long term contact with diesel fuel and shall not include yellow brass, low grade of copper and zinc, lead, and galvanized metals. The following fittings shall be included:
 - a. Direct reading level indication (hydrostatic gauge),
 - b. Level switches for high and low alarm purposes
 - c. Drain pipe situated at lowest point in tank complete with isolating valve
 - d. Outlet pipe complete with manually operated isolation valve and mechanically operated isolation valve (for fire shut-down),
 - e. Fuel inlet pipe from the filling point at the top of the tank
 - f. Fuel return inlet pipe connection (from the generator set),
 - g. Vent pipe connected at high level to the tank. The pipe shall rise continuously from the tank to a position outside the Generator Building at high level and shall terminate with an inverted "U" bend and vermin screen
- b) Fuel Filters

A supply line fuel filter shall be fitted and shall be of the twin replaceable element type complying with -

BS 4552.

c) Fuel pipe work and valves

The generator package shall include the supply, installation, connection, testing and commissioning of all pipes and valves for the fuel system including, but not limited to the following:

- Service tank filling pipe,
- Bulk fuel tank to services tank pipe work,
- Service tank vent pipe
- Generator fuel supply and return pipes.
- Generator fuel supply and return pipes.
- All pipes, valves, fittings and connection materials shall be designed for use in conjunction with diesel fuel oil. All fuel piping shall be suitably corrosion protected.
- The fuel pipe-work shall be connected to the DG through flexible pipe for a short distance for isolation of vibrations

d) Fuel Consumption

The engine shall be suitable for satisfactory operation on high speed diesel oil as locally available. The fuel consumption of engine - in liters per / hour shall be within specific value and shall be in accordance with relevant I.S. or B.S. at 50%, 75% and 100% of rated load at 0.8 pf. Fuel consumption shall be low to deliver minimum 4 units per liter at 75% load.

Such guaranteed fuel consumption is also to be expressed in liters per unit (after supplying the requirements of auxiliaries) at 50%, 75% and 100% of rated load at 0.8 pf.

If guaranteed fuel consumption is exceeded, the Contractor shall make such modifications or alterations as are necessary to bring the consumption to within the guaranteed figures.

Tolerance of + 5% as defined in BSS-649-1958 shall be allowed.

e) Fuel pump and fuel system

- The capacity of the engine driven fuel pump shall be provided.
- Fuel control shall be of electronic type.
- Engine fuel system shall be suitable to operate on High-Speed Diesel Oil as per IS 1460.
- Engine fuel system shall include Two-Stage fuel filtration through primary and secondary fuel filters. The fuel filter elements shall be replaceable type.
- Engine driven fuel pump shall be provided to ensure enough flow and pressure of fuel inlet to the engine from the day fuel tank with suitable injection system with fast response characteristics to handle application and withdrawal of step loads on the engine.
- Low-pressure fuel lines to the fuel injector shall be preferred in view of safety requirements.
- Fuel injection pump shall ensure development of required fuel pressure and measured quantity required to develop full power with overload capacity of the engine.
- Fuel injection control shall be with electronic actuators with fuel injection timing control mechanism, which should be fast acting to respond to variable, jerk and step loads.
- The fuel system is integrated to the engine speed governor, which shall be electronic type.
- Enough quantity of diesel fuel shall be supplied by the engine driven pump to the fuel injectors / pumps to ensure that more than adequate quantity is available for injection to the cylinders to handle the applied load. Extra fuel supplied shall be returned to the fuel day tank after necessary cooling etc. so that the diesel fuel temperature in the tank is kept low for better fuel performance.

10.1.11

Exhaust System

a) **Engine Exhaust system:**

- The engine exhaust piping shall be amply sized for minimum backpressure and connected to the engine manifold through flexible connection or an expansion joint on one side and to a silencer on the other side along with pipe. The silencer shall be package type with adequate attenuation for urban use, constructed from heavy gauge galvanized steel. The sound absorbent infill shall be non-hygroscopic, vermin proof, non-combustible material. Engine shall be provided with residential type silencers so as to reduce the sound level **75 dBA** distance of 1 meter from the DG set as per norms.
- Silencer - The engine shall be fitted with Critical Silencers of design approved by manufacturer to provide minimum **25 dBA** insertion loss through the Silencer.

a) Exhaust piping

- Silencer outlets shall be connected to exhaust piping carried to the top of the building through shafts provided for the purpose. Exhaust piping shall be fabricated from class 'B' G.I pipes of size suitable to limit back pressure to within permissible limit. Contractor shall submit design calculation in support of the back pressure being within limits along with the tender.
- It is important to ensure that the surface temperature of the exhaust piping does not exceed 50°C. For this purpose, the entire length of exhaust piping shall be insulated with minimum 75 mm thick layer of mineral wool (96 kg /m³ density) held with chicken wire mesh covered with 24 SWG GI sheet cladding as required. Flanged joints in the exhaust piping shall be covered with removable insulation at suitable intervals for permitting access to the joint when required.
- Exhaust piping shall be connected to the engine by means of flexible section or an expansion joint and shall also be graded to a drain pocket inside the building. The pocket shall be fitted with a drain cock
- Provision of testing port shall be provided on exhaust pipe line.
- The exhaust piping from the silencer onward shall be led up to the specified/approved level and discharged through a rain cowl. Entire exhaust piping and silencer shall be Class 'B' MS pipe and shall be glass wool insulated with 75mm thick 48Kg/cum density fiberglass, white wool. The insulation shall be held in position with 0.63 mm diameter, 20 mesh, galvanized steel wire mesh and finished neatly with 24SWG Aluminium cladding.
- The generator set shall be provided with an exhaust system incorporating residential silencers and in case there is chance of noise not getting abated as desired, special silencers arrangements shall be carried out for noise abatement. Care shall be taken when locating the exhaust to ensure the exhaust gases are not drawn back into the air inlets of either the generator room or the pump room.
- Exhaust pipes within the building shall be lagged and guarded to prevent accidental contact up to a height of 2.5 m. No part of any exhaust system installed outside the building shall be less than 3 m from ground level. Passage of exhaust pipes through walls or the roof shall be sleeved and shall be shrouded to prevent ingress of rain or vermin. Exhaust emission control shall be as per Central Pollution Control Board and Karnataka /Bangalore Pollution Control Board regulations and all other statutes
- Flanged connection to the silencer and between pipe sections shall be made. Minimum wall thickness of pipes and the silencer shall be 3 mm. A stainless-steel bellows unit shall be provided for connection onto the engine.
- Exhaust piping shall be fabricated from class 'B' MS pipes conforming to IS 1239 of size suitable to limit backpressure to within permissible limit. The insulation thickness stipulated in the approved schedule of quantities shall be checked by the contractor to achieve a maximum temperature of 600 C on the outside surface of the insulated pipe and supporting calculations for back pressure shall be furnished. Flanged joints in the exhaust piping shall be covered with removable insulation at suitable intervals for permitting access to the joint, as and when required. All flanged joints shall have spice jet high temperature gasket. The piping shall be installed with necessary thermal expansion facility as required. Exhaust piping shall be connected to the engine by means of flexible section or an expansion joint and shall also be graded to a drain pocket inside the building. The pocket shall be fitted with a drain cock.

b) Hot air exhaust:

Hot air duct from DG engine radiator (top of the acoustic enclosure) to atmosphere shall be provided for routing the hot air generated by engine operation to keep the temperature rise of DG room within limits. The duct shall be constructed from GI sheet duct 1.0 mm (20SWG) thick including duct flanges, supports etc as per site layout requirement for radiator hot air outlet. In case the length of the duct is more than 3 meters (as constrained by site condition), an exhaust fan at the atmosphere end of the duct shall be provided.

10.1.12 Sound Attenuating Acoustic Enclosure:

- Sound Attenuating Acoustic Enclosure should have pleasant and aesthetical looks and should be able to bring the sound noise to tolerable limits of 75 decibels when measured at 1 meter away from the set.
- D.G. Set shall be provided with acoustic enclosure as per capacity of D.G.set, as per manufacturer of D.G.set & as per norms-rules & regulation of Central pollution control board to keep noise level within permissible range. Contractor shall submit necessary certificate of Central pollution control board in this regard.
- The DG set should be supported on a base frame in an MS Sheet enclosure with suitable ducting for air inlet and outlet. The door and enclosure should be given corrosion resistant treatment and painted to be weatherproof and long lasting. Resin bonded Glass / Mineral / Rock wool of high density (greater than 45 Kg / Cu. M) with minimum thickness of 75 mm covered with perforated MS Sheet should be provided and covered with tissue paper. Enclosures should be provided with durable locking system with doors duly gasketed with neoprene rubber.
- Exhaust gases should be taken out from the DG Set by means of MS Pipe and a noise suppressor.
- Proper care should be taken for engine heat rejection in order to have safe working temperature inside the enclosure by provision of fans etc, as required. The design aspect should ensure free and uninterrupted flow of suction and exhaust air in order that the temperature rise of the enclosure with respect to the ambient is less than 7°C.
- **Noise and emission levels:** Noise from DG sets as also emission levels of pollutants in exhaust shall comply with the requirements of and Environmental (Protection) Second Amendment Rules 2002 notified as per Central Government Notification dated May 17, 2002 as implemented by Central Pollution Control Board.
- Acoustic damping-The design of the Generator building shall be with the following:
 - a) Roof mounted inlet damper
 - b) Internally located exhaust air damper
 - c) The noise level generated while the generator set in running shall be controlled to 75 dB or less at 1 meter from the acoustic enclosure / external walls and / or roof of the generator building.
 - d) For maintaining noise level within limits, the sound reduction shall be by incorporating air inlet and outlet acoustic damping units together with other techniques as necessary. (e.g. installation of integral acoustic enclosure / acoustic lining for the generator room).

10.1.13 Safety systems:

- a) Governor - The performance of the governor under load conditions shall be to Class A1 in accordance with BS 5514: Part 4 (ISO 3046). The governor shall meet the following performance requirements:
 - Steady state speed band: + 1% or + 0.25% of nominal speed,
 - Transient frequency changes on application or rejection of 60% load: $\pm 8\%$,
 - Recovery time to steady state speed band on application of 60% load: 10 seconds,
 - Maximum speed drop: 5%
 - The electrical over speed trip provided shall operate at 120% of the rated speed.
 - Other safety controls and indicating instruments shall be as shown in Data Sheet.

- The governor shall be of electronic type with governing class A direct. The governor shall be capable of regulating the speed of the engine within the limits approx. 10% of the rated speed within 4 secs due to the sudden application or removal of full load
- The range of manual adjustment shall not be less than $\pm 5\%$ of rated speed. The governor control should be isochronous type and thus maintain constant speed of the engine at different load up to the maximum rating of the engine. The governor shall be suitable for isochronous paralleling and load sharing with another generator.
- The governor shall meet the following performance requirements
 - i. Steady state speed band: $\pm 1\%$ of nominal speed,
 - ii. Transient frequency changes on application or rejection of 60% load: $\pm 8\%$,
 - iii. Recovery time to steady state speed band on application of 60% load: 10 seconds,
 - iv. Maximum speed drop: 8%.
 - v. The automatic electrical over speed trip shall operate at 120% of the rated speed.
 - vi. Resetting of the over speed trip shall be possible by hand only.
 - vii. The performance of the governor under all the load conditions shall be to Class A1 in accordance with BS 5514: Part 4 (ISO 3046). The governor and associated fuel injection system with solenoid controls to be provided.
 - viii. The engine fuel and speed governing system shall allow large step load applications and fastest possible recovery to accept the load and operate. The transient speed drop on applications and rejection of 60% load should be limited to 8% as per BS 5514.

10.1.14**Engine starting: Battery and battery charger****a) 24 Volt DC Batteries**

There shall be a 12/24V lead acid stationary battery with an AH capacity suitable for 10 (ten) cranking attempts of (10 seconds each) plus all indicating lamps and alarm before each cell voltage falls to 1.8V. Battery shall be complete with necessary angle iron stand and multi strand flexible copper leads. The battery charger in the AMF Panel shall be capable of floating the battery with quick and trickle charging facility to maintain a cell voltage of 2 Volts.

24-volt batteries for each set shall comprise of standard lead acid stationary batteries consisting of required no. of cells, each of 2 volts, to build up AH capacity as required for satisfactory starting of diesel engines. One-hour rate of discharge to attain voltage of 1.85 volt per cell to 2 volts shall be provided. Battery shall be complete with inter cell connectors and acid level indicating floats. Battery cells shall conform to IS 1651 with up to date amendments. The electric start battery shall be of adequate capacity for 10 successive starts. Time delay relay shall be incorporated to provide a rest period of 1 – 5 sec (adjustable) before each successive start and a time by period of 19 -100 sec. (adjustable) before the system lock out due to failure of the 5th start to crank up the engine. The battery bank shall be provided with the following accessories.

- Battery stand
- Set of connectors with ends take off suitable for connections.
- Cell insulator and stand insulators
- Spring type hydrometer
- Thermometer with specific gravity correction scale
- Cell testing voltmeter
- Set of tools consisting of spanners, rubber syringe, acid resisting funnel and acid resisting tube of 2 liters capacity – one set
- Potential free contacts for conveying signals to BG. I

b) Battery Charging Equipment (Trickle and Boost Charging)

Battery trickle and boost charge required capacity designed to operate on single phase 230 volts, so cycles supply system and suitable for charging through charger / convertor as part of AMF panel or through separate battery charger. The battery charger shall be provided with the following accessories.

- AC and DC "ON" and "OFF" switches with HRC fuses
- Indicating lamps for indicating mains "ON" and battery charging
- Ballast to give charging
- Single phase double wound (copper-conductor) impregnated natural air-cooled mains transformer for rectifier stack.
- Rotary switch to give step control.
- Single phase full wave bridge connected silicon rectifier stack
- Moving coil ammeter to indicated charging current
- Moving coil voltmeters with a selector switch to measure the battery /charger voltage.
- Silicon blocking diodes connected to a suitable tap to maintain continuity of DC supply.
- AC and DC contactors of suitable rating as required.

All the components for battery charger shall be adequately rated and housed in a well-ventilated sheet steel cubicle with input and output terminals. Proper cable glands shall be provided for incoming and outgoing cables

- c) The starting system shall comprise a 24 V heavy-duty suitable capacity maintenance free high discharge lead acid battery, as required, and electric starting motor. The battery shall be sized to give not less than ten consecutive starts of the engine at 0°C. The starting system shall be complete with necessary relays, solenoid valves for fuel control and indicating panels as specified and required.
- d) An engine driven alternator and charging system shall be provided. A main powered battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfil the starting requirements. Automatic changeover shall be provided such that battery charging is always carried out by the engine driven alternator when the generator set is running.
- e) The mains powered charger shall be suitable for operation on a 240 V single phase supply and shall complete with the following indications and features:
 - Battery charge / discharge current,
 - Boost charge / trickle charge selector,
 - On / Off switch,
 - Fault indication.
- f) The battery charge shall have a selector switch by which the rate of charging the batteries can be selected.
- g) If the equipment does not start within three starting cycles with appropriate interval between each attempt, the starting attempt shall be aborted, and audio-visual alarm shall be raised.

10.1.15 Foundations mounting and installation

- The engine shall be complete with suitable radiator for cooling the machine in tropical ambient temperatures, with engine-driven blower type heavy-duty cooling fan and radiator core.
- A common rigid bedplate shall be provided for the engine and alternator, which shall be directly coupled. The coupling must be done after ensuring proper alignment of generator and engine shafts.
- The entire set shall be housed in soundproof enclosure mounted on suitable Rubber-in-shear type vibration mounts with 6mm static deflection for isolating the building floor. A nominal base concrete pad (if required) shall be provided over which the engine set with its own base frame and vibration mounts shall be mounted.
- DG Set in soundproof enclosure shall be housed in DG room.

- Radio Interference - All equipment's, provided under the scope, shall be so designed that they shall not cause interference with radio equipment. In the event of the inherent characteristics of the equipment being such that radio interference is possible, efficient devices to nullify the same shall be provided.
- The installation of DG set shall be strictly in compliance with the manufacturer's recommendations.
- The engine and direct coupled alternator shall be rigidly secured to a common rigid base frame fabricated from G.I sections. The DG set shall be placed on the RCC Floor with GERB make anti vibration mountings. A lifting hook of required capacity shall be provided above the finalized location of the DG set to facilitate installation and subsequent maintenance of the DG sets. The design of mounting arrangements with anti-vibration mountings shall be as recommended by the DG manufacturers and shall be such that a maximum of 5% vibrations are transmitted to the building structure. The Contractor shall confirm the type and make of mountings offered and the vibration isolation efficiency in the tender. All rigid pipe / bus bar connections to the DG set shall be made through flexible couplings.
- The combined Engine Alternator unit shall be mounted on a common rigid fabricated base frame. The alternator shall have its windings star connected with the neutral connection brought out to a separate terminal. The alternator shall fully comply with the latest Standard BS 2613 and BS 269 in respect of winding insulation and fast response to maintain steady voltage.

10.1.16

Alternator**a) Type & rating**

- Alternator shall be 3 phase, 4 wire 50 cycles 415-volt, brush-less screen protected drip proof with self-contained excitation system and self-regulating and conforming to BS 4999/5000, IS 13364 Part-2 and continuously rated in accordance with IS: 4722 and IS: 13364 Part-2. The alternator should have the rated capacity at 0.8 PF. The alternator shall be designed to suppress radio interference in conformity with BS 800. It shall be of heavy-duty single / double bearing design, adaptable for direct coupling with diesel engine including excitation system, automatic voltage regulator, voltage adjusting potentiometer and low speed protection.
- **Construction** -The alternator shall be of air ventilated screen protected drip proof design with IP 23 protection having adequate air intake / outlet areas to enable designed air quantity to flow within permissible pressure drop. The dynamic balancing of the rotor assembly shall be carried out as per IS.12075 -1987 and BS 6861 Part-I Grade-II to ensure vibration limit to be within as per IS 12075 or BS 4999. Double bearing alternator shall be provided with substantial bed plate with engine / generator mounting pads to ensure a good base for accurate alignment. A flexible coupling designed to suit the specific engine – generator combination shall be provided to minimize torsional effects. The alternator shaft and coupling shall be designed to withstand torsional vibrations even at certain critical speed. The terminal arrangement of the of D.G shall be suitable for receiving a bus duct with flexible interconnection with rubber bellows. All alternator neutral shall be solidly earthed and each neutral shall be connected to 2 no's copper plate earth stations by means of 50 mm x 6 mm copper strip. The body earthing shall be with GI strips and GI plate earth stations.
- **Rating** - The alternator shall be continuously rated to deliver the rated output at 0.8 pf lagging on a 3 phase 4 wire 415 volts 50 cycle system with neutral solidly earthed. The earthing system conforming to Indian TNS.
- **Alternator Insulation** --The alternator should be with class H insulation suitable to withstand tropical conditions
- The supply interlocks shall be provided to supply the electricity after stabilization only. The excitation system shall provide an exceptionally rapid response to load change and alternator shall be designed for high motor starting capabilities.
- **Temperature rise** -The maximum temperature rises of the various components of the alternator shall not exceed those permitted under I.S. with full output and under the ambient temperature conditions.

- The alternator shall be tropically insulated with H class insulation and windings shall be impregnated with thermosetting insulated varnish to use in tropical climates. Ample ventilation shall be provided by shaft mounting fan as per manufacturer design.
 - a. The neutral point shall be brought out separately and earthed permanently.
 - b. The band of voltage regulation shall be $\pm 1\%$ from no load to full load and under varying load conditions.
 - c. The overload capacity shall be 150-300 % for 10 seconds. Limitation, if any, shall be highlighted by the manufacturer.
 - d. The Alternator shall be suitable for taking unbalanced load as per IS 13364 Part-2.
- The alternator shall be of fabricated steel construction conforming to IP class specified, dynamically balanced rotor with single / two bearings and damper windings. The unit shall be with a large terminal box for outgoing cable connections specified. Necessary adapter box shall be provided if the terminal box is not adequate to receive the cables.
- Alternator rotor shall be salient pole type with a damper cage and dynamically balanced. Insulation shall be to class 'H'. All winding shall be fully impregnated for tropical climates with high quality of epoxy varnish.
- Ventilation to the alternators shall be by means of fans fitted on the rotor.
- It shall handle 10% overload in one hour in every 12 hrs of operation without exceeding the permissible possible temperature rise for the class of insulation provided.
- The Alternator shall have the following characteristics in indicated in the following table.

Sl.no	Details/Parameter	Description.
1	Type	Brushless, rotating field design alternator rated for 660 volt / 50 Hz complying to IS 4722-1992, BS 5000 Part-III and IEC 34
2	Excitation system	Permanent magnet generator (PMG) powered excitation system
3	Speed	1500 RPM
4	Net Site Output	Rated continuous at ambient conditions and as per schedule of quantities
5	Voltage Regulation	Within 0.5% of the rated voltage
6	Overload	More than 10% of the nominal for 1 hour every 12 hours without exceeding permissible temperature rise
7	Harmonics	Maximum 1% between phase and neutral and total maximum 3%

10.1.17**Excitation system**

- The main exciter shall receive power from a permanent magnet generator through separate auxiliary windings on stator via Automatic Voltage regulator. The AVR shall be of solid-state circuitry and shall provide regulated voltage to the exciter compensating for all normal variations. The main exciter output is fed to the main motor windings via a rotating 3-ph bridge rectifier assembly, which shall be protected, from voltage surges, short circuit, over load and diode failures. The AVR and control gear shall be mounted in a component box on the side of the machine. Electrical connections to the AVR shall be taken through a multi way plug and socket.
- Voltage regulation shall be within one percent under all conditions of load, power factor and temperature including cold to hot variation. There shall be no radio or television interference. Line voltage waveform shall be as true as possible with a total harmonic distortion not exceeding 3% on 3-Phase load.

- The excitation system and engine governor should be such that the alternator is capable of starting up induction motors having a starting kVA of not less than 1.8 times the alternator rated kVA. Manufacturer should indicate the voltage dip and duration under such conditions as required under equipment data.
- The neutral of each generating set shall be earthed solidly to ground with facility for isolation through a fully rated contactor or manual switch as shown.

10.1.18 **AMF panel & Automatic Mains Failure (AMF) operation**

- a) The AMF panel shall be capable of starting the DG set automatically in the event of unhealthy conditions of the main power supply including power (mains) failure, single phasing or voltage going below 85% or 360 V at the bus bar of MDB or Essential power panel and shall switchover essential load from the main supply to DG set. The voltage on both the incoming mains shall be continuously monitored through adjustable voltage monitor on all the three phases. To avoid unnecessary frequent starting and stopping of the DG set caused by momentary unhealthy condition, an adjustable timer with setting 1 to 10 seconds shall be incorporated in the control system. The DG set shall start automatically within 10 seconds of main supply failure. It shall be idle for three minutes after making change over from DG set supply to main supply, to ensure that the main supply has stabilized. The manufacturer shall specify the adjustable range in both the cases.
- b) The AMF logic must be achieved through a microprocessor-based circuitry to monitor engine controls with an on-line mimic giving status of Engine running, voltage built up & other status as required & specified. AMF shall have 3 modes of operations viz. automatic, manual & test. The set shall be capable of starting and taking up the load within the time stipulated in the data sheets.
- c) The sequence of Automatic Mains Failure (AMF) operation shall be as follows:
 - Upon main power failure, the generator shall receive 3 kick-starts and the generator breaker shall close only after building up of requisite voltage.
 - Hold the Mains Contactor or Breaker open.
 - On restoration of power, AMF logic should make change over from DG set to main supply and trip the engine after a preset time delay.
- d) The AMF Panel shall comprise of following
 - Circuit Breakers and MCCBs as per approved design / drawings.
 - Battery charger with normal and trickle charging facility and an isolating switch.
 - Over load and earth fault protection for the generator set.
- e) Logic
 - 1 no. of Control Panel having microprocessor-based DG Logic suitable for Auto Mains Failure, Auto Changeover / Interlocking, Auto Synchronizing, Auto Load Searching and Auto Load Management functions for adequate capacity of DG Set with manual over-facility shall be provided.
 - The above control panels shall be complete with all controls, protection, instruments and indication required for fully satisfactory automatic operation of the sets as per the stipulated logic. These shall include (but not restricted to) the controls, protection, instruments and indications as approved design drawings & approved schedule of quantities.
- f) Construction

The DG Control Panels shall be totally enclosed floor cum wall mountings front access panel suitable for indoor mounting. The main cubical of the panel shall be fabricated from minimum 2 mm thick CRCA steel sheets which shall be folded/braced as required to provide rigid support for all components. Doors and covers shall be fabricated from minimum 1.6 mm thick CRCA steel sheets. Joints in the steel metal work shall be seam welded and all welding slags grounded off and welding pits wiped smooth. Unless otherwise specified, the metal work shall be provided with powder coating of approved colour of minimum 50 Microns thickness applied over metal surface cleaned and treated with 7 tank process provided with primer coat. Doors / covers shall be provided with neoprene gaskets to ensure an ingress protection of IP 42. Main bus bars shall be of electrolytic aluminium alloy grade E91E sized for current density of maximum 1 amp/sq mm. Bus bars shall be

provided with heat shrinkable sleeves. DMC/SMC Bus bar supports shall be provided suitably designed to withstand the thermal and magnetic stress. Interconnections cabling shall be of appropriate size. Control wiring shall be with minimum 2.5 sq mm copper conductor wires. Interconnection cabling and control wiring shall be laid neatly and shall be secured adequately to be panel.

g) Operation

➤ **Auto mode**

A line voltage monitor shall monitor supply voltage on each phase. When the mains supply fails completely or falls below set value (variable between 80% to 95% of the nominal value) on any phase, the monitor module shall initiate start-up of diesel engine. To avoid initiation due to momentary dips or system disturbance, a time delay adjustable between 0.5 to 5 seconds shall be incorporated in the start-up initiation.

A three-attempt starting facility shall be provided with the sequence 6 seconds ON 5 seconds OFF-6 seconds ON 5 seconds OFF and 6 seconds ON. At the end of the third attempt if the engine has not been already started and built up Voltage, engine shall be locked out for start. A master timer shall be provided for the function.

The diesel alternator set reverts to standby for next automatic operation.

➤ **Manual Mode**

Under manual mode it shall be possible for the operator to start up the generator set by pressing the (START) push button.

Three attempt starting facility shall also be operative for the start-up function.

Alternator and mains Circuit Breaker 'CLOSE' and 'TRIP' operations shall be manual by pressing the appropriate button on the panel. Closure shall be feasible only after alternator has built up full voltage. If the load is already on 'MAINS' pressure on 'CLOSE' button shall be ineffective.

When running under manual mode, if the mains supply has failed, the load shall automatically get transferred to the alternator immediately over riding the stipulation of pressure on 'CLOSE' button.

Engine shut down, other than due to faults shall be manual by pressing a 'STOP' button.

➤ **Test Mode**

When under 'TEST' mode pressure of 'TEST' button shall complete the start-up sequence simulation and start the engine. The simulation will be that of mains failure.

Engine shall build up voltage, but the set shall not close alternator circuit breaker when the load is on the mains. Monitoring performance for voltage/frequency etc. should be feasible without supply to load. If during TEST run the power supply has failed, the load shall automatically get transferred to alternator.

10.1.19 Protection / Annunciation

Protection and annunciation system conforming to latest standards like BS/IEC or IS with soft control and touch resets shall be designed and provided comprising of following but not limited to:

- Overload and short circuit trip for main in-comers 1 & 2.
- Overload and short circuit trip for the DG set
- High temperature for cooling water trip
- Alarm in case the DG set is not run for one week at a stretch
- Earth fault
- Reverse power relay
- Low battery voltage
- Fault indication alarm through suitably designed
- Annunciation within built hooter Fuel low level alarm

➤ Fuel low level alarm

10.1.20 Meters and Indicators as Follows

a.	Meter		
	Generator	As in data sheets (Annexure-A)	
	Battery	0 - 24V Voltmeter 0 - 10A Ammeter for charge 0 – 500 mili amp ammeter for trickle charge	
b.	Indication and Alarm annunciation		
	Engine side	As in data sheets (Annexure-A)	
	Additional	Indication	Alarm
	Charger on	Yes	-
	Failed to start	Yes	Yes
	Low oil press	Yes	Yes
	Gen. on	Yes	-
	Mains on	Yes	-
c.	Auto-Manual change over switch		
	Start-Stop Reset	Buttons	
	Alarm Reset	Buttons	
	Lamp testing	Buttons	

10.1.21 Control system:

The control system shall work on suitably supplied DC / AC operated system with provision of alarm and operation status available on auxiliary terminal board to enable to extend alarm and operation status to operation control centre & station control centre. The metering system shall be based on digital indication with status on auxiliary contacts. The control system and metering panel shall provide for the following.

Sl no	Details
1	Metering / Indication
1	<ul style="list-style-type: none"> • Voltmeter • Phase-sequence indication • Ammeter • KW Meter • Frequency Meter • Battery Voltmeter • Common Fault Alarm Signal • KWH meter • Power factor meter
2	Counters
	<ul style="list-style-type: none"> • Hours Run Counter

Sl no	Details
1	Metering / Indication
3	Controls <ul style="list-style-type: none"> • Emergency Stop Button • Run/Off-Reset/Auto-Control switch • Lamp-Test / Reset Push Button • Attempt Start Timer • Terminals for Remote / Emergency stop • Interface-to-Remote Annunciation • Voltmeter-Phase Selector Switch • Ammeter-Selector Switch

Note -- Above or equivalent system shall be designed & provided as industrial standards. The annunciation alarm shall be repeated to the station control room through Building Management System (BMS).

10.1.22 Finish

The generator shall be thoroughly cleaned and primed with two coats of industrial primer and finished in two coats of industrial high gloss paint.

10.1.23 Performance tests and type tests - Testing & Commissioning:

a) Factory acceptance test – FAT

The generator shall be thoroughly checked for correct operation and load tested in manufacturer / factor before dispatch. All fluid seals, faults, control functions and site load conditions shall be simulated, checked and proved. The equipment shall be dispatched after testing in presence of Engineer-Employer.

b) Site Acceptance tests – SAT

After installation, the set shall be run for a minimum period of 0.5 hours continuously on no load. On satisfactory completion of the no-load run the set shall be run for a period of one day at 6 hours a day at 100% full load. All consumables including fuel, lube oil and load banks required for commissioning the set shall be supplied by the contractor. Test readings together with an hourly log of the running test shall be furnished.

- The trial shall be conducted in the presence of the Employer - Engineer and the test results shall be recorded in an approved format. Any abnormal condition occurring during trial run of the DG set shall also be recorded. Test results shall be recorded at 30 minutes intervals. All facilities, instruments, materials and consumables including fuel and lubricating oil required for the test shall be provided by the contractor at his cost.
- Test proving the satisfactory performance of all operating gear, safety functions and controls shall be carried out.
- Performance test at site shall include (but not limited to) the following test acceptance criteria:

1.	Voltage variation	±1%
2.	Voltage regulation	±1%
3.	Frequency regulation	±1%
4.	Maximum water temperature	±5% of guaranteed performance
5.	Minimum lube oil pressure	±5% of guaranteed performance

The Contractor shall be required to carry out any further tests / trials that the Employers Representative may desire to satisfy themselves that the Generator Sets and Associated equipment's fully comply with the conditions as set out in these Specifications.

c) Performance Testing –

DG sets shall be tested at varying loads at manufacturers works prior to dispatch of the sets to site. The performance tests at the works shall be carried out in presence of authorized representative from the employer. Due notice for the programme of performance testing at works shall be given to the Engineer-in-Charge to enable them to arrange for their representatives for this inspection to be at manufacturers works for this inspection and testing. The costs for the arrangement shall be borne by the Contractor.

- The performance test on each DG sets shall be of minimum 8 hours duration
- All instruments, materials, consumables (fuel oil, lube oil etc.) required for carrying out of the test shall be provided by the Contractor

Following test acceptance criteria shall be applicable.

1	Fuel consumption at 50%, 75%, and 100% load.	± 5% of guaranteed performance. Actual alternator efficiencies as determined in the manufacturer's factories. These tests shall be used as the basis of calculation of specific fuel consumption ratio.
2.	Voltage regulation from no load to full load	0.50%
3	Frequency regulation from no load to full load	0.50%
4	Maximum water temperature	+ 5% of guaranteed performance
5.	Maximum lube oil temperature	+ 5% of guaranteed performance
6.	Minimum lube oil pressure	+ 5% of guaranteed performance

d) Test Certificates

Copies of all documents of routine and type test certificates of the equipment's carried out at the manufacturer premises shall be furnished to the department along with the supply of equipment's and these are as below.

1. Routine tests

- Engine separately
- Alternator Separately

2. Type Test Certificates

- Engine
- Alternator
- Pumps
- Meters
- Governors
- All major components.

e) Pre-commissioning checks.

All standards check including the ones elaborated in the specifications to ensure that the installation of the DG sets and associated systems has been carried out satisfactorily shall be done on completion of installation. These shall include.

i. DG set

- Checking of insulation resistance

- Checking of earthing
- Checking of instruments and controls.
- Checking of alignment
- Checking of vibration transmission to building a structure.
- Checking of expansion joints.

ii. Exhaust system

- Checking of silencer operation
- Checking of surface temperature of exhaust piping

iii. Fuel system

- Checking of automatic operation of fuel transfer pumps.

iv. Testing of piping system

- a) Entire piping system after installation shall be flushed with clean water to ensure thorough inside cleaning of the system. All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure, but not less than 7 Kg / Sq. cm for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer-Employer
- b) Piping required subsequent to the above pressure test shall be retested in the same manner. Systems may be tested in sections and such sections shall be securely capped.
- c) No insulation shall be applied to piping until the completion of the pressure testing to the satisfaction of the employer.
- d) The Contractor shall provide all materials, tools, testing equipment / instruments required to perform the test and shall ensure that the plant room and other areas are cleaned up and spill over water is removed. And also ensure that there is no flooding of water.
- e) After the piping has been installed, tested and run for at least ten days of eight hours each, the piping shall be given two finish coats, 3 mils each of approved colour and shade.

10.1.24 TOOLS

Necessary tools kit shall be provided along with DG.set.

10.1.25 D.G. set- data sheet

Sl. No	Details of item / parameter	Description.
1	Engine	
	Rating	
	Minimum Engine Rating	
	Altitude (m)	
	Air humidity	30% Min. 95% Max
	Air temperature (°C)	0 ° C 50 ° C 40 ° C
	Minimum	
	Maximum	
	Average	

Sl. No	Details of item / parameter	Description.
	Standard	BS 5514 and ISO 3046
	Duty	Prime Power rating duty at specified ambient air Temperature of 35°C
	Overload capacity for one hour & In 12 hours of continuous running.	10% over the continuous rating
1.1	Governor	
	Starting method	Electronic type 3-(three) Auto/Manual/Test
	No. of auto starts	
	Selectivity	
1.2	Cooling system	By radiator
1.3	Exhaust System	a. One number or more as required for residential duty
	Silencer	b. 1 number for each exhaust pipe near the engine.
	Flexible connection	c. Nil.
	Scrubber	
1.4	Safety Controls & Instruments	
	Over speed Governor	Trip @ 20% over normal
	One -point thermostat	Audible & visible alarm
	Lub oil temperature	Audible & visible alarm
	Low oil pressure	Trip engine
	Fuel level low	Audible & visible alarm
	Oil Pressure gauge	Yes, required
	Thermometers for lub oil,	Yes, required 2 No's
	Hour counter	Yes, required
1.5	Sundry fittings	Yes, rubber in shear or any other type with 6mm minimum static deflection on load.
	Vibration mounts	To be provided
	Electric pump for fuel filling from barrels & draining engine oil etc.	To be provided
	Hand driven pump for fuel	
2	Alternator	
2.1	Capacity	As per connected electrical load requirement & design
2.2	Rating at 40-degree centigrade Ambient	

Sl. No	Details of item / parameter	Description.
	temperature.	
	a. Continuous duty	a. Continuous duty -Y- Neutral brought out.
	b. Emergency duty	b. 10 percent overload for one hour in hours.
2.3	Minimum efficiency %	91
2.4	Enclosure	IP – 23 (IEC 60529 & IS 4691)
2.5	Winding	Class H
2.6	Cooling	IC 01 (IS-6362)
2.7	Excitation System	Brush less exciter with rotating diode assembly
2.8	Over speed %	120
2.9	Transient response & Response voltage dip	Max. 20% dip on application of full load at stated P.F and recovery in 20cycles
2.9.1	Sustained short circuit	Min. 300% FLC for 3 seconds.
2.9.2	Terminal Box	Suitable for cables as specified
3	Fuel oil capacity.	
3.1	Day tank	10 Hrs of operation at full load supply, over flow, drain, filter and gauge glass etc.
3.2	Pump	Hand driven pump to be provided.
4	Acoustic Enclosure	
4.1	Cooling	Radiator cooled
4.2	Enclosure details	
4.3	Structure	MS Press bent 2 MM
4.4	Panels	
	Type	Steel Fabricated double wall insulated panels
	Panel Thickness	75 mm thick
	Outer Sheet	2mm thick CRC Sheet
	Inner Sheet	0.6 mm thick CRC Perforated Sheet
	Frame & Stiffener	2mm thick CRC Sheet
4.5	Insulation	
	Type	Mineral wool of reputed make as per IS 8183

Sl. No	Details of item / parameter	Description.
	Thickness	75 mm thick (50 mm x 2 slabs)
	Density	48 Kg/m ³
	Anti-droning	HDPE Sheet
	e. Thickness	e. 6mm thick
4.6	Air circulation system	If required as per CPCB norms.
	Air intake.	
	Type	Axial Flow Fan
	Make	Technomac or Equivalent
	RPM	1440 / 2800
	Motor	KIRLOSKAR or Equivalent
	Air Exhaust System	
	Type	Axial Flow Fan
	Make	Reputed Make
	Speed	1400/2800 RPM
	Motor	KIRLOSKAR or Equivalent
	Quantity	1 No. for air exhaust
	Air screen	For radiator exhaust
4.7	Air screen	For radiator exhaust
	Insulated hood	At Canopy top Canopy Air Exhaust
	Silencer hood intake.	
	Type	Air Intake Hood
	Quantity	2 Nos.
	Design	With acoustic splitter & baffles insulated hood cover
4.8	Finishing	Weather Proof " POWDER COATED "
	Sound Reduction (min)	75 dB (A) at one meter.

Notes:

- After 3 auto starts, engine to lock shut.
- Silencer shall be suitable for residential area
- Engine and Alternator ratings shall be for the operating conditions and altitude specified and **NOT NTP ratings**
- Engine BHP shall be selected for alternator KW output at emergency loading condition.

10.1.26**AMF Panel technical data.**

Sl. No	Item	Description
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Sl. No	Item	Description
1	Voltage	415-V- 3 Ph 4 Wire effectively earthed neutral system.
2	Bus bars	Copper
3	Type of AMP panel	Indoor cubicle dead front
4	Enclosure IP protection	IP 54 (IEC 60529)
5	Circuit breakers panels	
	Usage	
	Number	
	Type	
	Pole	4 poles.
	Closing	With 12V / 24V DC closing coil
	Opening	12/24V DC shunt trip coil
	Current rating (A)	As per design and approved drawings.
	Breaking Capacity (KA)	35 kA or as applicable
6	Meters	
	Kilowatt hour meter (KWH)	1-3Ph 4 wire unbalanced load
	Voltmeter	0-500V
	Ammeter	0-400 A with 400/5A CT
	Power-factor meter	Lag 0-1-0 lead
	Frequency Meter (Hz)	45-55 Hz
	KW meter	As per rating
7	Protection.	
	Over load current & earth fault	2 O/C & 1 REF (Restricted Earth Fault)
	Type	IDMT 1.3 Sec. or static relay
	Setting range	OC-50-200% REF-10-40%
	Auxiliary	Under Voltage Relay, Alarm Relay
8	Instrument Transformers	
	Number of CT's for measuring	Set of 3
	Burden	15 VA
	Ratio	400 / 5 A
	Accuracy	1
9	CT's for protection.	
	Number	4 + 1 neutral CT for restricted earth fault. REF

Sl. No	Item	Description
	Burden	15 VA
	Ratio	400/5A
	Accuracy	5 P 10
10	Sundry Fittings	
	ON-OFF Flags	1 no
	Indicating lamps	R-Y-B phase indication.

CHAPTER-11

FIRE DETECTION & ALARM SYSTEM

11.1 Fire Detection & Alarm System

11.1.1 General

This section of the specification includes the design / supply, installation, connection and testing of the microprocessor controlled, analogy addressable intelligent fire alarm equipment required to form a complete, operative, coordinated system. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control panels, auxiliary control devices, annunciators, power supplies and wiring as per design and approved drawings and as itemized in approved Bill of Quantities.

11.1.2 STANDARDS

The equipment and system shall comply to the requirements of the following standards and codes.

Sl .No	Code	Description of code
1	NFPA 72	National Fire Protection Association
2	NEC	No. 70 National Electric Code
3	NEC No. 72-1996	Code for National Fire Alarm Code
4	NEC No. 92 A	Code for Smoke Control Systems
5	NEC.No. 92B	Smoke Management Systems in Malls, Atria, Large Areas
6	NEC.No. 101	Life Safety Code
7	UL - USA	Underwriters Laboratories Inc. (UL) - USA
8	UL.No.50	Cabinets and Boxes
9	UL.No.268	Smoke Detectors for Fire Protective Signalling Systems
10	UL.No.864	Control Units for Fire Protective Signalling Systems
11	UL.No.268 A	Smoke Detectors for Duct Applications
12	UL.No.521	Heat Detectors for Fire Protective
13	UL.No.228	Door Closers-Holders for Fire Protective Signalling Systems
14	UL.No.464	Audible Signalling Appliances
15	UL.No.38	Manually Actuated Signalling Boxes.
16	UL.No.346	Water flow Indicators for Fire Protective Signalling Systems
17	UL.No.1481	Power supplies for Fire Protective Signalling Systems
18	UL.No.1076	Control Units for Burglar Alarm Proprietary Protective Signalling Systems
19	UL.No.1971	Visual Notification Appliances

Other relevant codes of - EN-54 - European Regulations, international and Indian standards

11.1.3 SYSTEM

11.1.3.1 General

- The fire alarm system shall comply with requirements of NFPA Standard No. 72/ EN54 Part 2 for protected premises signalling systems except as modified and supplemented by this specification. The system shall be supervised either electrically or by software-directed polling of field devices.
- The facility shall have an emergency voice alarm communication system. The digitized recorded voice message shall notify occupants that a fire condition has been reported. The message shall instruct the occupants with emergency instructions. Emergency manual voice override shall be provided.
- The fire alarm system shall be manufactured by an ISO 9001 certified company and meet the requirements of IS 2189 or equivalent BS.
- Each designated zone shall transmit separate and different alarm, supervisory and trouble signals to the Fire Command Centre (FCC) and designated personnel in other buildings at the site via a multiplex communication network.
- The system shall be an active / interrogative type system where each transponder and/or addressable device is repetitively scanned, causing a signal to be transmitted to the main fire alarm control panel (FACP) indicating that the device and its associated circuit wiring is functional. Loss of this signal at the main FACP shall result in a trouble indication as specified hereinafter for the input.

11.1.3.2 Description

- The Fire Alarm Control Panel and all transponders shall meet the modular listing requirements of Underwriters Laboratories, Indian codes / EN codes. This includes all printed circuit board assemblies, power supplies, and enclosure parts. Systems which do not include modular labels may require return to the factory for system upgrades, and are not acceptable
- The system shall be designed such that each signalling line circuit (SLC) shall be limited to only 70% of its total capacity is used during the initial installation.
- The FACP and peripheral devices shall be manufactured 100% by a single manufacturer (or division thereof).

11.1.3.3 Basic Performance:

- Alarm and trouble signals from each transponder shall be digitally encoded by listed electronic devices onto an NFPA / EN 54 Style 7 looped multiplex communication system.
- Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto NFPA/EN 54 Style 7/ Class A Signalling Line Circuits.
- Digitized electronic signals shall employ check digits or multiple polling.
- Transponder devices are to consist of low current, solid-state integrated circuits, and shall be powered from local a primary power and standby battery power source.
- Power for initiating devices and notification appliances must be from the main fire alarm control panel or the transponder to which they are connected.
- A single ground or open on any system signalling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
- Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) under any circumstances.
- Hooter / strobe circuits shall be arranged such that there is a minimum of one Hooter/strobe circuit per smoke zone.
- Hooter circuits shall be electrically supervised for open and short circuit conditions. If a short circuit exists on a hooter circuit, it shall not be possible to activate that circuit.
- Audio amplifiers and tone generating equipment shall be electrically supervised for abnormal conditions. Amplifiers shall be located in transponder cabinets to simplify installation and to reduce power losses in wiring.
- Hooter circuits shall be 25 V RMS. Hooter circuits shall have 30% spare capacity for future expansion or increased power output requirements.

- Hooter circuits and control equipment shall be arranged such that loss of any one (1) speaker circuit will not cause the loss of any other speaker circuit in the system.
- Means shall be provided to connect the telephone circuits to the P.A. System circuits to allow voice communication over the PA Systems circuit from a telephone handset.
- A pre-recorded voice module shall be used to store tones and/or messages and transmit them over P.A System circuits automatically upon alarm actuation. The voice module shall be reliable, non- moving parts.

11.1.4 Basic System Functional Operation

When a fire alarm condition is detected and reported by one of the systems initiating devices or appliances, the following functions shall immediately occur:

- The System Alarm LED shall flash.
- A local piezo-electric signal in the control panel shall sound.
- The 80-character LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
- Printing and history storage equipment shall log the information associated with the fire alarm control panel condition, along with the time and date of occurrence.
- All system output programs assigned via control-by-event/ logic equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.
- The audio portion of the system shall sound the proper signal (tone or voice) to the appropriate zones.
- The system shall activate the digitized recorded voice message through the PA system which shall notify occupants that a fire condition has occurred.

11.1.5 MAIN FIRE ALARM CONTROL PANEL AND FIRE COMMAND CENTER:

11.1.5.1

The main FACP Central Console shall contain a microprocessor based central processing unit (CPU). The FACP shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, transponders, local and remote operator terminals, printers, annunciators, emergency voice communication systems and other system-controlled devices. The main FACP and Central Console shall perform the following functions:

- Supervise and monitor all intelligent / addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
- Supervise all initiating signalling and notification circuits throughout the facility by way of connection to transponders.
- Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.
- Visually and audibly annunciate any trouble, supervisory or alarm, condition on operator's terminal, panel display and annunciators.

a. When a fire alarm condition is detected and reported by one of the systems initiating devices or appliances, the following functions shall immediately occur:

- The system alarm LED shall flash.
- A local piezo-electric audible device in the control panel shall sound a distinctive signal.
- The 160-character backlit LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
- Printing and history storage equipment shall log and print the event information along with a time and date stamp.
- All system outputs assigned via pre-programmed equations for a particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

- The system shall activate the digitized recorded voice message through the PA Systems which shall notify occupants that a fire condition has occurred.
- b. When a trouble condition is detected and reported by one of the systems initiating devices or appliances, the following functions shall immediately occur:**
 - The system trouble LED shall flash
 - The 80-character backlit LCD display shall indicate all information associated with the trouble condition, including the type of trouble point and its location within the protected premises.
 - A local piezo-electric audible device in the control panel shall sound a distinctive signal.
 - Printing and history storage equipment shall log and print the event information along with a time and date stamp.
 - All system outputs assigned via pre-programmed equations for a particular point in trouble shall be executed, and the associated system outputs (trouble notification appliances and/or relays) shall be activated.
- c. When a supervisory condition is detected and reported by one of the systems initiating devices or appliances, the following functions shall immediately occur:**
 - The system trouble LED shall flash
 - A local piezo-electric audible device in the control panel shall sound a distinctive signal.
 - The 80-character backlit LCD display shall indicate all information associated with the supervisory condition, including the type of trouble point and its location within the protected premises.
 - Printing and history storage equipment shall log and print the event information along with a time and date stamp.
 - All system outputs assigned via pre-programmed equations for a particular point in trouble shall be executed, and the associated system outputs (notification appliances and/or relays) shall be activated.
- d. System Capacity and General Operation.**
 - The fire alarm control panel shall include a full featured operator interface control and annunciation panel which shall include a backlit 80-character liquid crystal display, individual, colour coded system status LEDs, and an alpha-numeric keypad for field programming and control of the fire alarm system.
 - All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.
 - The system shall include emergency voice communications utilizing distributed amplification and intelligence such that loss of operation by the main FACP will not result in the loss of evacuation signal throughout the balance of the building.
 - The FACP shall provide the following features:
 - Automatic Day / Night Sensitivity Adjust (high/low)
 - Device Blink Control (turn of detector LED strobe)
 - Environmental Drift Compensation (selectable ON or OFF)
 - Smoke Detector Pre-Alarm Indication at Control Panel
 - System Status Reports
 - Alarm Verification, by device, with tally
 - Non-Fire Alarm Module Reporting
 - Upload / Download System Database to PC Computer
 - One-Man Walk Test

- Smoke Detector Maintenance Alert
 - Security Monitor Points
 - Alpha-numeric Pager Interface
 - On-line or Off-line programming
- The Fire Alarm Control Panel shall be capable of supporting interactive Colour Graphics Package with 19" XGA touch screen monitor and mouse. The unit shall provide interactive control with history logging. Manual and override control of the system shall be accomplished through on-screen touch switches. All the zone shall be displayed with colour coded graphics that indicate the status of each zone and its location.
 - The Fire Control shall be capable of supporting integrated fire fighters telephone system which shall automatically dial one or more programmed fire fighter's telephone numbers and convey pre-programmed messages in the event of fire in any of the zone. The fire panel should have a Dialler facility to transmit alarm, supervisory and trouble signal to a Central Monitoring Station (CMS). It shall support dual telephone lines, 20 pps 4/2 communication and configured for Dual Tone Multi-Frequency (DTMF) or pulse modes.

e. Central Processing Unit (CPU):

- The Central Processing Unit shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the central processing unit.
- The CPU shall contain and execute all control-by-event/ logic programs for specific action to be taken if an alarm condition is detected by the system. Control-by-event programs shall be held in non-volatile programmable memory and shall not be lost even if system primary and secondary power failure occurs.
- The Central Processing Unit shall also provide a real-time clock for time annotation of all system displays. The Time-Of-Day and date shall not be lost if system primary and secondary power supplies fail.
- The main FACP central console shall be designed so as to permit continued local operation of remote transponders under both normal and abnormal communication loop conditions. This shall be obtained by having transponders operate as local control panels upon loss of network communication.
- The FACP and CPU shall be modular in construction to allow ease of servicing. The CPU and transponders shall be capable of being programmed on site without requiring the use of any external programming equipment.
- The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients including RFI and EMI.
- Each transponder and peripheral device connected to the CPU shall be continuously scanned for proper operation. Data transmissions between the CPU, transponders, and peripheral devices shall be reliable and error free. The transmission scheme used should employ dual transmission or other equivalent error checking techniques. Failure of any transponder or peripheral device to respond to an interrogation shall be annunciate as a trouble condition.

f. Display:

- The system display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.
- The display assembly shall contain, and display as required, custom alphanumeric labels for all intelligent detectors, addressable modules, and software zones.

- The system display shall provide an 80-character back-lit alphanumeric Liquid Crystal Display (LCD). It shall also provide 14 light-emitting-diodes (LEDs), which primarily will indicate the status of the following system parameters:
 - a. Fire fault
 - b. Earth fault
 - c. System fault
 - d. Power Supply fault
 - e. Acknowledged test
 - f. Sounder fault.
 - g. Delayed mode.
 - h. Disablement.
 - i. Relays disabled.
 - j. Sounder disabled.
 - k. Alarms silenced.
 - l. Power
- The system display shall provide a 25-key touch key-pad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels will be accessible through the display interface assembly to prevent unauthorized system control or programming.
- The system display shall include the following operator control switches:
 - a. Sound alarms
 - b. Silence / resound
 - c. Mute
 - d. Acknowledged
 - e. System reset.

g. Loop Interface (Signalling Line Circuit) Board:

- The SLC board shall monitor and control a minimum of 300/250/198 intelligent addressable devices. This includes 150/125/99 intelligent detectors (Ionization, Photoelectric, or Thermal) and 150/125/99 monitor or control modules.
- The SLC interface board shall not require any jumper cuts or address switch settings to initialize operations.
- The SLC interface board shall provide power and communicate with all intelligent addressable detectors and modules on a single pair of wires.
- The SLC interface board shall receive analogy information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular device. The SLC interface board software shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analogy information may also be used for automatic detector testing and the automatic determination of detector maintenance requirements.

h. Serial Interface Board (SIB):

- The Serial Interface Board shall provide the EIA-232 interface between the fire alarm control panel and Electronic Data Processing (EDP) peripherals.
- The SIB shall allow the use of multiple printers, CRT monitors, and other peripherals connected to the EIA-232 ports.

- The Serial Interface Board shall provide one EIA-485 port for the serial connection of the optional annunciation and control subsystem components.
- The SIB shall include LEDs which indicate that it is in regular communication with the annunciators and other EIA-485 connected peripheral devices.
- All EIA-232 circuits shall be optically isolated, and power limited.

i. Enclosures:

- The control panels shall be housed in UL/EN listed cabinets suitable for surface or semi-flush mounting. Cabinets shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.
- The back box and door shall be constructed of 14 SWG CRCA sheets with provisions for electrical conduit connections into the sides, top and bottom.
- The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
- The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.

j. System Circuit Supervision

- The FACP shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communications with these devices. The CPU shall continuously scan above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information in the history buffer and on the printer.
- The FACP shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communications with these devices. The CPU shall continuously scan above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information in the history buffer and on the printer.
- Transponders that lose communication with the CPU shall sound an audible trouble and light an LED indicating loss of communications.
- Transponder Circuit Supervision: Transponders shall be designed such that they continuously scan all of their initiating and notification circuits. With normal communications between the FACP and the transponders, the transponders shall transmit initiating and notification circuit trouble conditions to the FACP for audible annunciation and printout. With or without communication with the FACP, the transponders shall supervise their circuits and annunciate any initiating circuit and notification circuit failures on LEDs located on the transponder.
- Sprinkler system valves, standpipe control valves, PIV, and main gate valves shall be supervised for off-normal position.
- All speaker and emergency phone circuits shall be supervised for opens and shorts. Each transponder speaker and emergency phone circuit shall have an individual ON/OFF indication (green LED).

k. Field Wiring Terminal Blocks

For ease of service, all wiring terminal blocks shall be the plug-in/removable type and be capable of terminating up to 4 SQ. mm copper wire. Fixed terminal blocks are not acceptable.

l. Printer

- Printers shall be of the automatic type, printing code, time, date, location, category, and condition.
- The printer shall provide hard-copy printout of all changes in status of the system and shall time-stamp such printouts with the current time-of-day and date. The printer shall be standard carriage with 80-characters per line and shall use standard pin-feed paper. The printer shall be enclosed in a

separate cabinet suitable for placement on a desk top or table. The printer shall communicate with the control using an interface complying with Electrical Industries Association standard EIA-232D. The printer power shall be 240 VAC @ 50 Hz.

m. Field Programming

- The system shall be programmable, configurable and expandable in the field without the need for special tools, laptop computers or electronic interface equipment.
- It shall be possible to program through the standard FACP keyboard all standard functions.
- All field defined programs shall be stored in non-volatile memory.
- Two levels of password protection shall be provided in addition to a key-lock cabinet. One level shall be used for status level changes such as point/zone disable or manual on/off commands (Building Manager). A second (higher-level) shall be used for actual change of the life safety program (installer). These passwords shall be five (5) digits at a minimum. Upon entry of an invalid password for the third time within a one-minute time period an encrypted number shall be displayed. This number can be used as a reference for determining a forgotten password.
- The system programming shall be "backed" up on a CD-ROM utilizing an upload/download program. This system back-up disk shall be completed and given in duplicate to the building owner and/or operator upon completion of the final inspection. The program that performs this function shall be "non-proprietary", in that, it shall be possible to forward it to the building owner/operator upon his or her request.
- The installer's field programming and hardware shall be functionally tested on a computer against known parameters/norms which are established by the FACP manufacturer. A software program shall test Input-to-Output correlations, device Type ID associations, point associations, time equations, etc. This test shall be performed on an IBM-compatible PC with a verification software package. A report shall be generated of the test results and two copies turned in to the engineer(s) on record.

n. Specific System Operations

- Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analogy intelligent smoke detectors in the system from the system keypad or from the keyboard of the video terminal. Sensitivity range shall be within the allowed UL window.
- Alarm Verification: Each of the intelligent addressable smoke detectors in the system may be independently selected and enabled to be an alarm verified detector. The FACP shall keep a count of the number of times each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.

o. System Point Operations

- Any device in the system may be enabled or disabled through the system keypad or video terminal.
- Any system output point may be turned on, or off, from the system keypad or the video terminal.
- Point Read: The system shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point will be annunciate for the parameters listed:
 - a. Device Status.
 - b. Device Type.
 - c. Custom Device Label.
 - d. Software Zone Label.
 - e. Device -zone assignments.
 - f. Detector Analog Value.
 - g. All Program Parameters.

- System Status Reports: Upon command from a password-authorized operator of the system, a status report will be generated, and printed, listing all system statuses.
- System History Recording and Reporting: The fire alarm control panel shall contain a History Buffer that shall be capable of storing up to 400 system events. Each of these events will be stored and time and date stamped with the actual time of the activation, until an operator requests that the contents be either displayed or printed. The contents of the History Buffer may be manually reviewed, one event at a time, and the actual number of activations may also be displayed and or printed.
- The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.
- Automatic Detector Maintenance Alert: The fire alarm control panel shall automatically interrogate each intelligent system detector and shall analyse the detector responses over a period of time.
- If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the Trouble Mode, and the particular Intelligent Detector will be annunciate on the system display and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
- The system shall include the ability (programmable) to indicate a "pre-alarm" condition. This will be used to alert maintenance personnel when a detector is at 80% of its alarm threshold in a 60 second period.

11.1.6 **SYSTEM COMPONENTS:**

11.1.6.1 Programmable Electronic Sounders:

- Electronic sounders shall operate on 24 VDC nominal.
- Electronic sounders shall be field programmable without the use of special tools, to provide slow whoop, continuous, or interrupted tones with an output sound level of at least 90 dBA measured at 10 feet from the device.
- Shall be flush or surface mounted as show on plans.

11.1.6.2 Strobe lights shall meet the requirements of the ADA, UL/EN Standard and shall meet the following criteria:

- The maximum pulse duration shall be 2/10 of one second.

11.1.6.3 Addressable Dry Contact Monitor Module

- Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLCs.
- The monitor module shall mount in a 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep electrical box.
- The IDC zone shall be suitable for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
- For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4-inch (70 mm) x 1-1/4-inch (31.7 mm) x 1/2 inch (12.7 mm). This version need not include Style D or an LED.

11.1.6.4 Addressable Control Module

- Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered polarized audio / visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
- The control module shall mount in a standard 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep electrical box, or to a surface mounted back box.

- The control module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to ensure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
- Audio/visual power shall be provided by a separate supervised power circuit from the main fire alarm control panel or from a supervised remote power supply.
- The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC.

11.1.6.5 Isolator Module

- Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC Class A or Class B branch. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop segment or branch. At least one isolator module shall be provided for each floor or protected zone of the building.
- If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
- The isolator module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
- The isolator module shall mount in a standard 4-inch (101.6 mm) deep electrical box or in a surface mounted back box. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

11.1.7 ADDRESSABLE DEVICES - GENERAL

Detectors shall be Microprocessor based intelligent (analogy) and addressable capable of making alarm decisions based on fire parameters information stored in the detector head and shall connect with two wires to the fire alarm control panel signalling device circuits. Detectors not capable of making independent alarm decision shall not be acceptable. Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED. Smoke detector sensitivity shall be set in the fire alarm control panel and shall be adjustable in the field through the field programming software of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL/ EN54.

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (ION, PHOTO, THERMAL). Detectors shall operate in an analogy fashion, where the detector simply measures its designed environment variable and transmits an analogy value to the FACP based on real-time measured values. Detectors shall provide address-setting means using decimal switches or a microprocessor and shall also store an internal identifying code that the control panel shall use to identify the type of device. LEDs shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel. A magnetic test switch shall be provided to test each detector for 100% obscuration, reported to the FACP.

11.1.7.1 Addressable Multi-Criterion detectors

- The multi sensor analog detector shall use a light scattering type photoelectric smoke sensor and an ambient temperature sensor to sense changes in air samples from its surroundings. The detector shall be totally free of radioactive components.
- The integral microprocessor shall employ time based algorithms to dynamically examine values from the two sensors simultaneously and initiate an alarm based on that data.

- The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, age and humidity.
- Smoke density in the chamber shall be measured by a symmetrical optical system.
- Smoke detectors element shall respond to invisible and visible smoke and combustible gases and shall have an inherently stable sensor with built-in automatic compensation for changes in ambient conditions.
- The temperature sensor shall self-adjust to the ambient temperature of the surrounding air and input an alarm when there is a change of 65 Deg F (35 Deg C) in ambient temperature or reaches a fixed temperature alarm set point of 135 Deg F (57 Deg C) nominal.
- The detector shall be suitable for direct insertion into air ducts up to 0.91 m high and 0.91m wide and air velocities up to 0-2.54 m/sec without requiring specific duct detector housings or supply tubes. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%.
- The detectors shall have no moving parts or components subject to wear and tear and shall have serial no. and seal of the approving laboratory/body.
- All electronic circuits must be solid state devices and virtually hermetically sealed to prevent their operations from being impaired by dust, dirt or humidity.
- All circuitry must be protected against usual electrical transient and electromagnetic interference.
- Reversed polarity or faulty zone wiring shall not damage the detector.
- The response sensitivity of each smoke detector shall be field adjustable to a minimum of two pre-determined (factory calibrated) levels. It shall be possible to test the sensitivity of a detector in the field.
- The response (activation) of a detector shall be clearly visible from the outside by a flashing light of sufficient brightness.
- A built-in (optional) integrated circuit shall allow the suppression of brief deceptive phenomenon.
- A built-in barrier shall prevent entry of insects into the sensor.
- The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC or Program/Service Tool.
- The detector shall be designed for fast and simple laboratory cleaning.
- The detector shall be inserted into or removed from the base by a simple push-twist mechanism to facilitate exchange or cleaning and maintenance.
- The detector shall be connected to the Fire Alarm Panel via fully supervised two-wire circuits (Class "A" wiring).
- Systems using central intelligence for alarm decisions shall not be acceptable.
- The manufacturer shall produce and provide test equipment allowing testing and exchanging the detectors up to 7 meters apart at ceiling level.
- During maintenance, interchanging of detectors a system failure should not occur on removal of the detectors from bases.

11.1.7.2 **Addressable manual pull station**

Addressable Manual Pull / Break Glass Station shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Manual Pull / Glass Break Stations shall be constructed of metal/ polycarbonate with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger. Stations shall be suitable for surface mounting or recess mounting.

11.1.7.3 **Addressable Photoelectric smoke detectors**

- The photoelectric smoke detector shall respond predominantly to light white smoke.

- The photoelectric smoke detectors must exhibit uniform response behaviour in course of item.
- The light source intensity shall automatically adjust to compensate for possible effects of dirt and dust accumulation in the sensor/lens.
- Smoke density in the chamber shall be measured by a symmetrical optical system.
- The detectors shall have no moving parts or components subject to wear and tear and shall have serial no. and seal of the approving laboratory/body.
- The detection principle shall employ a multiple light pulse coincidence circuit in order to prevent the false alarms.
- All electronic circuits must be solid state devices and virtually hermetically sealed to prevent their operations from being impaired by dust, dirt or humidity.
- All circuitry must be protected against usual electrical transient and electromagnetic interference.
- Reversed polarity or faulty zone wiring shall not damage the detector.
- The response sensitivity of each smoke detector shall be field adjustable to a minimum of two pre-determined (factory calibrated) levels. It shall be possible to test the sensitivity of a detector in the field.
- The response (activation) of a detector shall be clearly visible from the outside by a flashing light of sufficient brightness.
- A built-in (optional) integrated circuit shall allow the suppression of brief deceptive phenomenon.
- The smoke entry windows of the detector shall be field adjustable to match local air current patterns.
- A built-in barrier shall prevent entry of insects into the sensor.
- The detector shall be designed for fast and simple laboratory cleaning.
- The detector shall be inserted into or removed from the base by a simple push-twist mechanism to facilitate exchange or cleaning and maintenance.
- The detector shall be connected to the Fire Alarm Panel via fully supervised two-wire circuits stub line (class "B" wiring) or a two wire circuit (Class "A" wiring).
- The manufacturer shall produce and provide test equipment allowing to test and exchange the detectors up to 7 meter (23 ft.) above floor level.

11.1.7.4**Addressable Heat Detectors**

- Combined rate of rise/fixed temperature heat detectors shall consist of two independent thermistors designed to automatically compensate changes in ambient conditions.
- All electronic circuits must be solid state devices and virtually hermetically sealed to prevent their operations from being impaired by dust, dirt or humidity.
- All circuitry must be protected against usual electrical transients and electromagnetic interference.
- Reverse polarity or faulty zone wiring shall not damage the detectors.
- The detector shall have no moving parts or components subject to wear and tear and shall have serial no. and seal of approving laboratory / body.
- It shall be possible to test the detector in the field.
- The response (activation) of a detector shall be clearly visible from the outside by a flashing light of sufficient brightness.
- The detector shall be installed into the base by a simple push-twist mechanism to facilitate exchange for cleaning and maintenance.
- The detector shall connect to the Fire Alarm Panel via fully supervised two wire circuit stub line (class "B" wiring) or a four wire circuit (Class "A" wiring).
- It shall be possible to test the sensitivity of detector in the field.
- The manufacturer shall produce and provide test equipment allowing to test and exchange the detectors up to 7 Meters (23 ft.) above floor level.

11.1.7.5 Plug-in Bases

- The detectors of all types shall fit into a common type of standard base.
- Once a base has been installed, it shall be possible to insert, remove and exchange different types of detectors by a simple push twist movement.
- The standard base shall be equipped with screw less wiring terminals capable of securing wire sizes up to 2.5 sq mm and with built in strain limits to prevent permanent terminals deformation and weakening of contact pressure.
- The standard base shall be supplied with a sealing plate, preventing dirt, dust, condensation or water from the conduit reaching the wire terminals or the detector contact points.
- All standard bases shall be supplied with a removable dust cover to protect the contact area during installation and construction phase of the building. It must allow the inspection and verification of the zone wiring before insertion of any detectors. This dust cover shall be removable by a special tool up to 7-meter (23 ft.) above floor level.
- The standard base shall feature a built-in mechanism, which allows mechanical locking of any installed detector head, thus preventing un authorized removal of tampering while maintaining.
- The detector contact points shall be designed to retain the detector safety and to ensure uninterrupted contact also when exposed to continuous severe vibrations.
- All electronic components of bases and modules must be solid state and virtually hermetically sealed to prevent their operations from being impaired by dust, dirt or humidity.
- All circuitry must be protected against usual electrical transients and electromagnetic interference.
- The standard base shall allow Snap-On insertion of an (optional) electronic module to drive remote visual alarm indicators.
- Reversed polarity or faulty zone wiring shall not damage the detectors.
- The standard base shall have a built-in alarm indicator, which is repeatable, by connecting a simple two-core wire to the base. No changes in the zone wiring shall be required to operate the additional alarm indicator.
- A special tool shall enable removal and insertion of dust covers or detectors by a push-twist mechanism, even if the locking device has been activated, up to 7 meter (23 ft.) height from floor level.
- Bases shall be of the same make as that of the detector supplied.

11.1.7.6 Response indicators

Response indicators shall be provided as per design and approved drawings.

11.1.8 CONDUIT AND WIRE:**11.1.8.1 Conduit:**

Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.

Where required, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross-sectional area where three or more cables are contained within a single conduit.

Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.

Wiring for 24-volt DC control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signalling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

Conduit shall not enter the fire alarm control panel, or any other remotely mounted control panel equipment or back boxes, except where conduit entry is specified by the FACP manufacturer.

Conduit shall be 3/4-inch (19.1 mm) minimum.

11.1.8.2 Wire

For all fire alarm system wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and

as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG (1.02 mm) for Initiating Device Circuits and Signalling Line Circuits, and 14 AWG (1.63 mm) for Notification Appliance Circuits.

All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signalling system.

Wire and cable shall have a fire rating suitable for the installation as indicated in NFPA 70 (e.g., FPLR).

Wiring used for the multiplex communication circuit (SLC) shall be twisted and unshielded and support a minimum wiring distance of 12,500 feet. The design of the system shall permit use of IDC and NAC wiring in the same conduit with the SLC communication circuit.

All field wiring shall be electrically supervised for open circuit and ground fault.

Terminal Boxes, Junction Boxes and Cabinets:

All boxes and cabinets shall be UL listed for their use and purpose.

Initiating circuits shall be arranged to serve like categories (manual, smoke, water flow). Mixed category circuitry shall not be permitted except on signalling line circuits connected to intelligent reporting devices.

The fire alarm control panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labelled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The control panel cabinet shall be grounded securely to either a cold-water pipe or grounding rod.

11.1.9 REPEATER PANELS

- Each remote panel in the installed system shall include remote control and display annunciators. These annunciators shall have integral membrane style, tactile push button control switches for the control of system function and LED's with programmable (software controlled) flash rates and slide in labels for annunciation of system events.
- It shall provide the system with individual zone and device annunciation also with zone or device disable.
- It shall provide the system with individual alarm and trouble annunciation per zone/device.
- It should support a minimum of 2x40 characters on its LCD screen indicating current date and time, custom system title, alarm history of the system
- There should be common control keys and visual indicators for; reset, alarm silence, trouble silence, drill and one custom programmable key/indicator.

11.1.10 BATTERIES AND EXTERNAL CHARGER

11.1.10.1 Battery:

- Shall be 12-volt, cell type.
- Battery shall have sufficient capacity to power the fire alarm system for not less than twenty-four hours plus 5 minutes of alarm upon a normal AC power failure.
- The batteries are to be completely maintenance free. No liquids are required. Fluid level checks refilling, spills and leakage shall not be required.

11.1.10.2 External Battery Charger:

- Shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 240-volt 50 hertz source.
- Shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.
- Shall have protection to prevent discharge through the charger.
- Shall have protection for overloads and short circuits on both AC and DC sides.

11.1.11 INSTALLATION

- Installation shall be in accordance with the NEC, NFPA 72, EN 54 and Indian National / local codes.

- All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc. before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.
- All Equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.
- Initiating circuits shall be arranged to serve like categories (manual, smoke, water flow). Mixed category circuitry shall not be permitted except on signalling line circuits connected to intelligent reporting devices.
- The main fire alarm control panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labelled at the main power distribution Panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 4.0 SQ. mm FRLSZH PVC insulated copper wires. The control panel cabinet shall be grounded securely to the system earthing.
- All conduit, junction boxes, conduit supports, and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.
- All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.
- Manual Pull Stations shall be suitable for surface mounting or semi flush mounting as shown on the plans.

11.1.12 TYPICAL OPERATION

11.1.12.1 Actuation of any manual station, smoke detector, heat detector or water flow switch shall cause the following operations to occur unless otherwise specified:

- Activate all programmed sounder circuits.
- Actuate strobe units until the panel is reset.
- Light the associated indicators corresponding to active sounder circuits.
- Release all magnetic door holders to doors to adjacent zones on the floor from which the alarm was initiated.
- Duct type smoke detectors shall, in addition to the above functions, shut down the ventilation system or close associated control dampers as appropriate.

11.1.12.2 HVAC / Smoke Control System Operation:

- On / Auto / Off switches and status indicators (LEDS) shall be provided for monitoring and manual control of each fan, damper, HVAC control unit, stairwell pressurization fan, and smoke exhaust fan. The control System shall be field programmable for either 90A operation or 92A/B operation to allow for future use and system expansion.
- The OFF LED shall be Yellow, the ON LED shall be green, the Trouble/Fault LED shall be Amber/Orange for each switch. The Trouble/Fault indicator shall indicate a trouble in the control and/or monitor points associated with that switch. In addition, each group of eight switches shall have two LEDS and one momentary switch which allow the following functions: An Amber LED to indicate an OFF-NORMAL switch position, in the ON or OFF position; A Green LED to indicate ALL AUTO switch position; A Local Acknowledge/Lamp Test momentary switch.
- Each switch shall have the capability to monitor and control two addressable inputs and two addressable outputs. In all modes, the ON and OFF indicators shall continuously follow the device status not the switch position. Positive feedback shall be employed to verify correct operation of the device being controlled. Systems that indicate on/off/auto by physical switch position only are not acceptable.
- All HVAC switches (i.e., limit switches, vane switches, etc.) shall be provided and installed by the HVAC contractor.

- It shall be possible to meet the requirements mentioned above utilizing wall mounted custom graphic annunciations if the project requires such.

11.1.13 TEST

Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system.

- Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
- Close each sprinkler system flow valve and verify proper supervisory alarm at the FACP.
- Verify activation of all flow switches.
- Open initiating device circuits and verify that the trouble signal actuates.
- Open signalling line circuits and verify that the trouble signal actuates.
- Open and short notification appliance circuits and verify that trouble signal actuates.
- Ground initiating device circuits and verify response of trouble signals.
- Ground signalling line circuits and verify response of trouble signals.
- Ground notification appliance circuits and verify response of trouble signals.
- Check alert tone and pre-recorded voice message to all alarm notification devices.
- Check installation, supervision, and operation of all intelligent smoke detectors using walk test.
- Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.
- When the system is equipped with optional features, the manufacturer's manual should be consulted to determine the proper testing procedures. This is intended to address such items as verifying controls performed by individually addressed or grouped devices, sensitivity monitoring, verification functionality and similar.

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11.1.14 FINAL INSPECTION

At the final inspection a factory trained representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.

11.1.15 INSTRUCTION

- Provide instruction as required for operating the system. "Hands-on" demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.
- The contractor and/or the systems manufacturer's representatives shall provide a typewritten "Sequence of Operation."

The following is the list of products and the names of the approved make against each product. The Contractor shall quote rates for the various items of work after ascertaining the availability, delivery schedule etc. Unless the Contractor stipulates to the contrary in his tender, it shall be presumed that rates quoted are for materials as in the approved list.

The Contractor shall ensure the correct selection of electrical items, meeting the specifications and application duties. Before placing order for procurement, the sample of items intended for use shall be got verified for its suitability to the specification and application duty by the Employer's representatives. However, in case Employer's representative / engineer, whose decision will be final and binding on both parties, considers that the make / model proposed by the contractor does not meet the requirement, the contractor will be required to propose an alternative make acceptable to the Employer's Representative.

TECHNICAL SPECIFICATIONS
PART B-VENTILATION & AIR CONDITIONING

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1. Scope of Work

Scope of work under this contract shall include but not limited to the Design, Manufacturing / Fabrication, testing at manufacturer's workshop, Supply, Installation (including lifting, shifting, assembling etc.), Site testing, and Commissioning of the following system components (confirming to tender specifications, relevant ASHRAE standards and in accordance with the requirements of Bill of quantities and approved drawings).

Outdoor and indoor units of VRF/VRV/ High performance air-conditioning system along with refrigerant piping and drain piping etc: -

- Ventilation fans
- Air distribution system
- Drain Piping
- Electrical works

The price shall include Supply, Installation, Testing, Commissioning of Complete System and items and sub items including that are necessary to complete and make the system working, without any cost impact to Bi-RIDE.

De-mobilization, clearing of all temporary works and facilities after completion of job. The Contractor shall include the supply of entire materials in accordance with this specification and the whole of the work necessary for the complete installation as set down in this Specification and with the accompanying schedules and drawings. Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the scope of work.

1.1. Quality Assurance of Materials and Workmanship

- a. The contractor will supply the equipment's as indicated in the list of approved makes in the tender.
- b. Furthermore, all equipment's must strictly conform to the relevant IS code specified in the tender document. However, the contractor shall submit Vendors data in the approved format.
- c. The contractor shall furnish test certificates of the materials procured for the work. Testing of materials shall also have to be done at contractors cost as and when necessary and required by the Engineer. If the test result of any material does not comply with the results stipulated in the relevant latest IS/IEC code, the materials shall be rejected and no claim shall be entertained on any account what so ever. All the rejected material should be removed from the site of work, without delay.
- d. Where manufacturer have furnished specific instructions relating to the materials used in this job and covering points not specifically mentioned in these documents, manufacturer's instructions shall be followed.
- e. The Schedule of Quantities shall not be used as a basis for ascertaining the quantum of materials to be ordered and these are for guidance only. The Contractor shall assess the quantities of materials to be ordered as per requirement and shall be entirely responsible for the same. The design/drawings of the layouts/system shall be approved from the employers' representative.
- f. Where manufacturers have furnished specific instructions relating to the materials and equipment used in this project, covering points not specifically mentioned in these documents, such instructions shall be followed in all cases.

1.2. Design Parameters

Outside condition as per ISHARE Handbook, Table-1 are as follows:

Outside conditions		DB	WB
	Summer	35.6°C	25.6°C
	Monsoon	27.8°C	25.6°C
Inside Conditions	Summer & Monsoon	24°C	
Fresh Air		As per ASHRAE	
Average lighting Load		As per ASHRAE	

2. Air Conditioning System

The air-conditioning system designed for the Depot having Air conditioning and Ventilated areas:

The following rooms of the Depot's shall be generally air-conditioned: -

a. Depot

S.No.	Building Name	Air-conditioning	Mechanical	Remarks
			Ventilation	
1	Admin Building	√	√	DX System(Split AC units)
2	Canteen	NR	√	Only ventilation system is proposed. Wet scrubber shall be used for kitchen cooking area ventilation.
3	Car Wash	NR	NR	
4	Check Post	NR	NR	
5	DCO Store	Only in-charge room	√	
6	Electrical Sub-station	NR	√	
7	P-way Office	√	√	VRF System.
8	Time & Security Office	NR	√	
9	Inspection Bay Office	Only meeting room	√	
10	Repair Bay Offices	Only meeting room	√	
11	RRV Shed	NR	NR	
12	Stabling Shed	NR	NR	

Note: The above equipment selection is tentative only and final selection shall be as per heat load calculations.

VRF Outdoor Unit location as shown in the layouts at the Balcony/Terrace level is for design understanding and cost calculation purpose, the same may change during the course of construction stage. All the above-mentioned standby units should operate in cyclic schedule set.

Refrigerant circulation shall be hard drawn insulated copper piping network. Final execution drawing needs to be submitted by the contractor.

The Bidder shall be required to quote for total system and guarantee performance in terms of inside conditions as well as power consumption for the application intended.

Comprehensive maintenance contract after 1-year warranty shall be proposed as a part of Schedule of Prices for bidder to quote as an option.

2.1. Considerations

On the basis of architectural drawings, and details available, following actual site conditions and the assumptions made for the load estimation and subsequent system design.

2.2. Automation for HVAC

A state of Art Intelligent Central Controller for the VRF Air-Conditioning is being proposed. The system shall control and monitor.

ON - OFF Control of The System

- Indoor Room Temperature Control and Monitor
- Operating Status Monitoring
- Weekly Timer for On Off Cycle of The Specified Indoor Unit
- Malfunctioning Code Display
- System monitor and control by IP Web Browser

The controller shall support MODBUS protocol and integrated with central BMS system

3. Equipment & Other Specifications

Variable refrigerant flow system equipment: The Scope of this section comprises supply, erection, testing and commissioning of Variable Refrigerant Volume Air conditioning unit, confirming to these Specifications and in accordance with requirements of drawings and of the bill of Quantities.

4. VRF System

- a. The system selected shall be modular system, with number of indoors connected to centrally located outdoor units, as per detail design given in the tender. The outdoor units for all the system shall be air cooled type and mounted on balcony/terrace of the building. Indoor units in various areas shall be as per enclosed drawings / Bill of Quantities.
- b. All the VRF air conditioners shall be fully factory assembled, wired, internally piped & tested. The outdoor unit shall be pre-charged with first charge of R 410A / or equivalent green tribunal approved refrigerant. Additional charge shall be added as per refrigerant piping at site. All the units shall be suitable for operation with 415 V \pm 10%, 50 Hz \pm 3%, 3 Phase supply for outdoor units & 220 V \pm 10%, 50 Hz \pm 3%, 1 Phase supply for indoor units.
- c. The VRF system shall provide stable, trouble free & safe operation, with flexibility of operating desired indoor units. The outdoor units must be capable of delivering exact capacity proportional to the number of indoor units switched on & the heat load in the air conditioned area. The proportional operation shall be achieved by varying speed of the compressor / or digitally controlled sequencing in the outdoor units / change in compressor configuration or capacity as per load. The refrigerant piping shall be extendable minimum 165 m with 50 m level

difference without any oil trap. The system shall be designed for automatic cyclic operation for a bank of VRV/VRF units with settable time feature including providing all related microprocessor, cabling etc.

4.1. Specification of Outdoor Units

Outdoors units of the VRF system shall be compact air-cooled type.

- a. All the compressors of the out-door units must be hermetically sealed scroll type. Each module of outdoor unit must have Inverter scroll compressor, suitable to operate at heat load proportional to indoor requirement / or by change in compressor configuration or capacity as per load.
- b. "Anti-Corrosive" treatment for Al fins of Condenser Coils is mandatory. The treatment should be suitable for areas of high pollution and salt laden air.
- c. Bidder has to furnish the rated / derated capacity of the Indoor units, considering the refrigerant piping of respective outdoor units.
- d. Back up operation, in case of failure of one of the compressors of outdoor unit, for single module outdoor units or failure of one of the modules in case of multiple module outdoor units shall be possible. The VRF outdoor unit shall always be supplying at least 33% of back up operation, of the full load capacity.
- e. The outdoor units shall be suitable to operate within an ambient temperature range of +5 Deg C to + 46 Deg C in cooling mode. The System Equipment Selection to match the higher Ambient requirement of Bangalore .
- f. The entire operation of outdoor units shall be through independent remotes of indoor units. No separate Start/ Stop function shall be required.
- g. Starter for the Out-Door Unit compressor shall be "Direct on Line" type. Inverter compressor / or equivalent system of the unit shall start first & at the minimum frequency / capacity, to reduce the inrush current during starting.
- h. Refrigerant control in the out-door unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.
- i. Noise level of outdoor units shall not exceed 68 dB (A) at a distance of 1.0 m horizontally and 1.5 m above the ground from the unit. Noise level of Indoor Unit shall not exceed 42 dB(A) for non-ductable type unit and shall not exceed 49 dB(A) for ductable type unit.
- j. The outdoor unit shall be modular in design and shall be allowed for side by side installation. There should be no scaling, corrosion or any other physical deformation on the body of outdoor unit.
- k. Each ODU shall be provided with isolation Switch with suitable locking arrangement to avoid mishandling.

4.2. Compressor

- a. The compressor shall be of highly efficient hermetic Inverter Scroll capable of capacity modulation by time averaging method and Vapour Injection Technology.
- b. Each ODU should have minimum 1 no. variable compressor upto 20HP capacity, 2 nos. variable compressors up to 40 HP capacity, 3 nos Variable compressors upto 60 HP capacity & 4 nos. variable compressors upto 80 HP capacity.

4.3. Heat Exchanger

- a. The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fin coil. The aluminium fins shall be covered by anti-corrosion resin film.
- b. The System must have sub-cooling heat exchanger further to Condenser to increase refrigerating effect in Indoor units. The Condenser fins must be coated with Anti- corrosive treatment.

4.4. Fan Motor Speed Control

The condensing unit fan motors to have at least two speed operation to maintain constant head pressure control at all ambient temperatures and modes of operation.

Outdoor units shall be complete with following safety devices:

- High pressure switch/ Low Pressure Switch
- Fan driver overload protector
- Over current relay
- Inverter Overload Protector / Digital Protector
- Fusible Plug/Fuses

4.5. Oil Recovery System

Each unit shall be equipped, with an oil separator to ensure stable operation with long refrigerant piping. The system should have inbuilt oil balancing circuit to avoid poor lubrication. In case if it is not required due to specific design criteria, the same shall be submitted.

Note: VRV/VRF units should be capable of cyclic operation with settable controls.

Unit shall be supplied with

- Installation manual
- Operation Manual
- Connection Pipes
- Clamps
- Units will use R-410A as Refrigerant / Equivalent approved green tribunal compliance refrigerant gas.

4.6. Specifications for Indoor Units

Ceiling Mounted Ductable Type Units / Hide Away Type Units

- a. These units shall be ceiling/Wall suspended with suitable supports to take care of operating weight of the unit, without causing any excessive vibration & noise. The cold air supplied by these units will be supplied to the area to be air conditioned, through duct system or direct supply specified in the tender.
- b. Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room. The electronic expansion valve is to be controlled through a computerized control sensing the return air temperature, refrigerant inlet and outlet temperatures. During the cooling operation, the electronic expansion valve shall control the refrigerant superheat degree at the evaporator.
- c. The unit casing shall be Galvanized Steel Plate.
- d. Unit must be insulated with sound absorbing thermal insulation material like Glass Fiber Wool. The noise level of unit at the highest operating level shall not exceed 42 dB(A) for non ductbale unit and shall not exceed 49dB(A) for ductable unit at a vertical distance of 1.5 m below the units with duct connected to the unit.
- e. The unit must be able to develop external static pressure of 8 mm in hide away type units and 15 mm in ductable type units, at the specified air quantities.
- f. Unit must have Thermal Fuse for fan motor protection, in case of motor overheating.
- g. The unit will be connected in series to a suitable out door unit & it must be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities. The unit will be further connected to Intelligent Building Management System & it shall be possible to operate the unit through this IBMS system.
- h. Each Indoor unit shall be provided with one nos. of relay and control supply shall be made available to the PCB of unit by the contactor. In case of failure of a single indoor unit due to any fault, it shall not affect the operation

of the entire circuit. Electric circuit should follow the scheme as shown in the standard details drawing for HVAC.

5. Specification for Controls System for VRF Air Conditioning System

5.1. Wired Remote Controller

- a. Wired remote controller shall be supplied as specified in the "Bill of Quantities"
- b. The controller must have large crystal display screen, which displays complete operating status.
- c. The digital display must allow setting of temperature with multiples of 1 Deg C.
- d. Remote shall be able to individually program by timer the respective times for operation start and stop for a maximum duration of 72 hours.
- e. Remote must be equipped with thermostat sensor in the remote controller, so as to sense and control the room temperature more comfortably to desired level.
- f. The remote shall be able to monitor room temperature & preset temperature by microcomputer & can select cool/ heat operation mode automatically.
- g. The remote must constantly monitor malfunctions in the system & must be equipped with a "self-diagnosis function" that let know by a message immediately when a malfunction occurs.
- h. It shall be possible to wire the remote up to 500 RMT.
- i. Wireless Remote Controller.
- j. Wireless remote controller shall be supplied as specified in the "Bill of Quantities"
- k. The operation modes & settings as with wired remote controllers must be possible.
- l. Compact light receiving unit to be mounted into wall or ceiling mounted indoor unit shall be included.
- m. Units shall be supplied with followings:
 - Operation Manual
 - Installation Manual
 - Paper Pattern for installation
 - Drain hose / Metal clamp / Insulation for fitting / Sealing Pads / Clamps / Screws etc.,.

5.2. LCD monitor central remote controller & power consumption distributor

- a. LCD Central remote controller shall be supplied as specified in the "Bill of Quantities"
- b. The controller must have LCD Touch screen, which displays complete operating status.
- c. The digital display must allow setting of temperature with multiples of 1 Deg C.
- d. Remote shall be able to individually program by timer the respective times for operation start and stop within a maximum of 1 Weeks' time.
- e. The controller shall be able to monitor room temperature & preset temperature by microcomputer & can select cool/ heat operation mode automatically for all the indoor units.
- f. The controller must constantly monitor malfunctions in the system & must be equipped with a "self-diagnosis function" that let know by a message immediately when a malfunction occurs.
- g. It shall be possible to wire the controller up to 1000 RMT.
- h. Controller shall be compatible with the outdoor & indoor units installed at site.

- i. Units shall be supplied with followings :
 - Operation Manual
 - Installation Manual
 - Paper Pattern for installation
 - All Kind of software if any
- j. The Controller can give report in soft and hard copies for the indoor wise power consumed detail, the same shall be used for metering HVAC power consumption to stack holders.

5.3. Cabling between Indoor and Outdoor Units

The suitable rated cable between indoor and outdoor units shall run in suitable cable containments as approved by the employer representative at site.

6. Refrigerant Pipe Work

- a. Scope of Refrigerant Piping work shall include Supply, installation, testing and commissioning of all interconnecting pipe-work between the condensing unit & indoor units. Refrigerant quality seamless copper tubes with brazed connections and the appropriate Distribution joints and headers shall be used.
- b. The piping should be routed at site in such a manner, that brazed joints in the Refrigeration Piping are kept to a minimum.
- c. All interconnecting piping, joints and U bends within the condensing unit shall be painted with two coats of clear transparent coating of suitable material for protection against corrosion from ambient air pollution.
- d. Each coat shall have dry film thickness of 35 micron or more. The coating shall be strong, flexible and durable. It shall have good adhesive and abrasion resistance.
- e. It shall be resistant to moisture, UV, acid alkali and other chemicals and capable of functioning between -250 C up to 1500 C
- f. The polymer shall be obtained by the mixing of base / monomer with a hardener / polymerisor. It may be brush applied or with the use of a suitable gun.

6.1. Joint Orientation

Proprietary Distribution refrigeration pipe joints and headers shall be installed in an appropriate orientation to enable correct distribution of refrigerant. The Distribution joints shall be factory insulated with pre-formed sections of expanded Polystyrene / equivalent.

6.2. Cleanliness of Piping

All pipe-work must be kept clean and free from contamination to prevent breakdown of the system. All pipe ends shall be kept sealed until immediately prior to make a joint.

6.3. Pressure Testing

After complete installation of refrigerant piping, it shall be pre-pressure tested and repaired if necessary and further pressure tested to 3,800 Pa, to hold for a minimum 48 hours with dry nitrogen prior to insulating the joints. After satisfactory testing, the refrigerant pipe shall be evacuated and dehydrated to (- 755 MM HG) and held for 12 hours.

6.4. Refrigerant Charge

Refrigerant charge must be calculated based on the actual length of the refrigerant pipe work. The refrigerant charging process must be carried out with an appropriate charging station and under supervision of Consultancy.

6.5. Piping Insulation

All suction & liquid lines of the Refrigerant pipe work shall be insulated with Nitrile rubber /expanded polyethylene pipe sections as specified to avoid condensation. Moulded Tee joints of thermal insulating material shall be used at bends. To protect nitrile rubber

insulation of exposed copper piping from degrading due to ultra violet rays & atmospheric condition, it shall be covered poly shield coating with atleast two coats of resin and hardner above nitrile rubber insulation. Fibre glass tape shall be helically wound & coated with painted two coats of resin with hardner to give smooth & plain finish.

6.6. Fixing Pipe Work & Electrical Conduit

The insulated refrigerant piping and electrical conduit shall run on GI tray properly supported by GI rods. The exposed tray on terrace shall be covered by open able GI covers.

Refrigerant copper piping shall be as per ASTM: B280.

OD & wall thickness of copper refrigerant piping shall be as follows:

Size	Thickness	Specification
6.35mm (1/4 in)	0.8 mm	C12200T-O (ANNEALED)
9.52mm (3/8 in)	0.8 mm	C12200T-O (ANNEALED)
12.70mm (1/2 in)	0.8 mm	C12200T-O (ANNEALED)
15.88mm (5/8 in)	0.99 mm	C12200T-O (ANNEALED)
19.05mm (3/4 in)	0.8 mm	C12200T-1/2 H (HALF-HARD)
22.23mm (7/8 in)	0.8 mm	C12200T-1/2 H (HALF-HARD)
28.58mm (1 1/8 in)	0.99 mm	C12200T-1/2 H (HALF-HARD)
31.75mm (1 1/4 in)	1.1mm	C12200T-1/2 H (HALF-HARD)
34.9mm (1 3/8 in)	1.21 mm	C12200T-1/2 H (HALF-HARD)
41.3mm (1 5/8 in)	1.43 mm	C12200T-1/2 H (HALF-HARD)

6.7. Drain Piping

The indoor units shall be connected to drain of PVC pipe. The piping shall be complete with necessary accessories like bends, U traps and fittings. The pipes shall be laid in proper slope for efficient drainage of condensate water.

6.8. Drain Pipe Insulation

Drain pipes carrying condensate water shall be insulated with 6 mm Nitrile rubber having a 'K' value of 0.037 W/m-k at a mean temperature of 20°C and a minimum density of 55 Kg/Sqm. The joints shall be properly sealed with synthetic glue to ensure proper bonding of the ends.

6.9. Installation

The VRV type air conditioning units shall be mounted on vibration isolators and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure. Refrigerant pipes that exposed to outdoor shall be covered with UV coating to protect insulation from direct UV exposure.

All support beams, legs, hangers shall be Galvanised and anchor bolts, vibration isolators, ductworks shall be provided for the installation of the units.

6.10. Testing

The units shall be tested for capacity and COP as per ARI-1230 conditions at manufactures premises before delivery by the consultant / presence of the Owners / their representative reserve the right to witness the tests.

7. Handing over of the VRF System

Following reading/ data shall be generated as a part of handing over of the VRF air conditioning system, apart from the handing over data for air side & indoor design conditions.

7.1. Outdoor Units

- Inlet temperature
- Discharge pipe temperature
- Suction pipe temperature
- Oil pressure
- Condensing Pressure
- Evaporating Pressure
- Power supply voltage
- Inverter compressor frequency
- Inverter current
- Fan operating current
- Total ODU current

7.2. Indoor Units

- Indoor unit operation – On/ off from remote
- Remote control pressure & temperature
- Suction temperature
- Indoor liquid pipe temperature
- Indoor gas pipe temperature
- Electronic expansion valve opening
- Fan operating current

8. Split Air Conditioners

8.1. DX Air Cooled Hi Wall Split Ac Units with Inverter

- a. Hi-Wall Mount Split Units shall be cord less remote control operated and shall be with single or multi splits design as per the ratings and quantities provided in the schedule of quantities. The contractor shall supply and install split system air conditioner with 5-star rating wherever indicated. The system shall be complete in all respects and comply with the specifications as given. All split units shall be eco-friendly type.
- b. The units shall be ready-to-operate type and shall comprise of a Indoor type Fan-Coil unit (installed within the room) and Outdoor Air Cooled Condensing unit connected through insulated refrigerant piping. The system shall be charged with first charge of refrigerant after proper pre-commissioning process.
- c. Single phase connection shall be provided by user at one point near each Hi Wall split unit or at outdoor unit. Rest of the electrical work including cabling from the power point up to the Unit's electrical panel shall be supplied, laid and installed by vendor only.
- d. The units shall be of one among the Approved Makes mentioned elsewhere in this Tender.
- e. Units will use R 410A / R407 as Refrigerant / Equivalent approved green compliance refrigerant gas.

8.2. Brief Features Desired In Indoor (Fan-Coil) Unit

- a. Hi Gloss finish all fiber body
- b. Highly efficient 3 layered air purification system to remove dust/bacteria and odours from the return air.
- c. Four bend heat exchanger design for efficient heat transfer
- d. Noise level of Indoor Unit at operating speed shall be in compliance to NBC-2016.
- e. Operated through remote control having a large LCD display, temperature set-point, sleep mode operation, On/Off timer, Real time clock, Auto-restart, filter status warning, dry mode operation (reduces the humidity without the temperature when required)

8.3. Brief Features desired in Outdoor Condensing Unit

- a. Each condensing unit shall be complete unit with high EER hermetic scroll compressors, air cooled condenser, condenser fans with motors, internal piping, switches and internal wiring and shall be enclosed in weatherproof outdoor type housing.
- b. The casing shall be fabricated from galvanized steel and finished with powder coated paint. The casing shall make the whole unit fully weatherproof. Suitable for outdoor installation.
- c. The necessary charge of refrigerant gas and lubricated oil shall be provided to run the system.
- d. Operating on single phase $230 \pm 10\%$ V supply
- e. Preferred Rotary / Scroll compressor design for low power consumption per ton generated – as per BEE. not exceeding above 1.28 kW per TR.
- f. Electrolytic zinc steel sheet with antirust coated components to ensure rust free outdoor unit even in humid condition.
- g. Hydrophilic fins to improve the heating efficiency by accelerating the defrosting process.
- h. Vibration pad is a part of outdoor condensing units.

8.4. Refrigerant Piping

- a. Supply, Insulation, Pressure testing, Vacuuming, Testing and Commissioning of INVERTER type Split air conditioning including insulated refrigerant piping with gas top-up for additional length, power/ control wiring between indoor and outdoor (as shown in drawing) will be in the scope of vendor/ bidder and nothing extra whatsoever will be paid to successful bidder on this account.
- b. Recommended refrigerant pipe sizes (liquid/ suction /hot gas) between indoor and outdoor to be specified by bidder at tender stage with unit rates.
- c. Recommended electrical wiring / cabling (no of cores x sq.mm) between indoor / outdoor to be specified by bidder at tender stage with unit rates.

8.5. Miscellaneous

- a. The unit shall have control panel, housing the starting switches, contactor, relays etc. Isolation pads shall be provided under the units.
- b. Insulated drain line shall be provided from indoor unit upto drain trap. (to be priced separately).
- c. Suitable M.S. channel supporting frame shall be provided for the condensing unit and supporting arrangement for the indoor units.
- d. Interconnecting power and control cabling shall be provided between condensing unit and evaporator unit.
- e. PVC flexible sleeves shall be provided to cover the insulated refrigerant piping and electrical cabling from indoor to outdoor units.
- f. Compressor current should not flow through indoor unit.

- g. Inbuilt protection in indoor unit against electric fault to be provided.

8.6. Installation

The split type air conditioner shall be mounted on vibration isolators and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure.

- Refrigerant pipes that exposed to outdoor shall be covered with UV coating to protect insulation from direct UV exposure.
- Anti-corrosion protective coating on refrigerant pipes, Bents, Joints of indoor & outdoor unit to be done to avoid leakages
- All galvanized support beams, galvanized legs, galvanized hangers, anchor bolts, vibration isolators, ductworks and shall be provided for the installation of the units.

8.7. Testing and commissioning

After installations are completed, all air-conditioning system shall undergo test run. Any adjustments that are needed shall be made to assure that all air-conditioning system will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each item mentioned below:

- Date and time of test.
- Air-conditioning unit make, type, name and serial number.
- Fan rpm.
- Fan motor amperage
- Rated motor amperage, starter number and ampere rating.
- Fan CFM
- Fresh air CFM in case of ductable units
- Outside conditions (DB and WB)
- Entering coil conditions (mixing) (DB and WB)
- Leaving coil conditions (DB and WB)

During test run, the air filters of testing sets shall be used.

9. Sheet Metal Work

9.1. Codes And Standards

Ducts shall be made of either Galvanized sheets or Aluminium sheet and confirm to IS: 655.

The Galvanized steel sheet shall confirm to IS: 277. Aluminium sheet shall confirm to IS: 737.

9.2. Rectangular Duct Construction:

Max. Side	Thickness - G		Type of joint	Bracing
	GSS	AL		
Up to 750	24	22	25 mm QSS flanges	None
751 to 1500 MS angle	22	20	25 mm x 3 mm MS angle flange.	25 mm x 3 mm
1501 to 2250	20	18	40 mm x 3 mm MS	40 mm x 3 mm

MS angle			angle flange.	at 1.25 m centers.
2251 and above MS angle	18	16	40 mm x 3 mm MS angle flange.	40 mm x 3 mm at 1.25 m centers.

9.3. Hangers For Duct:

Duct size (mm)	Spacing (m)	Size of MS angle (mm x mm)	Size of Rod dia.(mm)
Up to 750	2.5	40 x 40 x 3	10
751 to 1500	2.5	50 x 50 x 3	15
1501 to 2250	2.5	50 x 40 x 3	15

9.4. Duct Installation

- a. All ducts shall be fabricated and installed in workman like manner, generally confirming to IS: 655: 1963 updated. Round duct shall be die- formed for achieving perfect circle configuration.
- b. Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made airtight.
- c. All exposed ducts within conditioned spaces, shall have slip joints - no flanged joints. The internal ends of slip joints shall be in the direction of air flow. Ducts and accessories within ceiling spaces, visible from air-conditioned areas shall be provided with two coats of mat black finish paint.
- d. Changes in the dimensions and shape of ducts shall be gradual. Air-turns shall be installed in all vanes, arranged to permit the air to make the turn without appreciable turbulence.
- e. Ducts shall be fabricated as per details shown on drawings. All ducts shall be rigid and adequately supported and braced where required standing seams, teas, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.
- f. All sheet metal connections, partitions and plenums required to confined the flow of air to and through the filters and fans, shall be constructed of 18 G GSS / 16 G Aluminium, thoroughly stiffened with 25mmx25mmx3mm angle iron braces and fitted with all necessary inspection doors as required to give access to all parts of the apparatus. Doors shall be not less than 45 cm x 45 cm in size.
- g. Plenums shall be panel type and assembled at the site. Fixing of MS angle, iron flanges on duct pieces shall be with rivets heads from inside and riveting shall be done from outside.
- h. Rubber lining 6 mm thick shall be used between duct flanges instead of felt, in all clean room ducting installations.
- i. The contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of this specifications and drawings. The work shall meet with the approval of the engineer In-charge at site in all it parts and details.
- j. The contractor for beams, pipes, or other obstructions in the building shall make all necessary provisions and allowances, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and / or conduits, the ducts shall be transformed, divided or curved to on a side, (the required area being maintained) all as per the site requirements.
- k. If a duct cannot be run as shown on the drawings, the contractor shall install the ducts between the required points by any path available, in accordance with other services and as per approval of site engineer.
- l. 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 MS rods and angle iron.
- m. Ducting over furred ceiling shall be supported from beams, after obtaining approval of site engineer. 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 contractors work on the building.

- n. Where metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitting heavy flanged collars. Where ducts pass through brick or masonry openings, wooden frame work shall be provided within the opening and crossing of ducts provided with heavy flanged collars on each side of the wooden frame work, so that duct crossing is made leak - proof.
- o. All ducts shall be totally free from vibration under all conditions of operation. Wherever duct work is connected to fans, air handling units or blower coil units that may cause vibrations in the ducts, ducts shall be provided with two flexible connections, located close to the unit, in mutually perpendicular directions, flexible heavy canvas sleeve at least 10 cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both ends. The flexible connection shall be suitable for pressures at the point of installation and shall be of approved make.

9.5. Dampers

- a. All dampers shall be louver dampers of robust construction and tight fitting. The design, method of handling, and control shall be suitable for the location and the service required.
- b. Dampers shall be provided with suitable links, levers, and quadrants as required for their proper operation, control or setting devices shall be made robust, easily operable and accessible through suitable access doors in the ducts. Every damper shall have an indicating device clearly showing the damper position at all the times.
- c. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the drawings, for the proper volume control and balancing of the system.

9.6. Supply and Return Air Registers

Supply and return air resisters shall be of anodized Aluminium section construction with individual adjustable bars as shown on drawings and indicated in Bill of quantities. Supply air register shall be generally double deflection type, with removable key operated volume control dampers. Return air resisters shall be generally similar to supply air resister but without dampers. All supply and return resisters behind wooden grilles shall be single deflection type with one-way bars only, the supply air resisters being provided with removable key operated volume control dampers.

- a. All resisters shall be selected in consultation with site engineer. Different spaces shall require horizontal or vertical face bars and different width of margin frames.
- b. All resisters shall have a soft, continuous rubber gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers shall not be less than 75 % of gross face area.
- c. Resister shall be adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to $\pm 50^\circ$ horizontal arcs and up to 30° deflections downwards. Bars shall hold deflection settings under all conditions of velocity and pressure. Excluded Aluminium registers shall have fixed bars.
- d. Set-back vertical members of approved thickness shall reinforce Bar longer than 45 cm.

9.7. Supply and Return Air Diffusers

Supply and return air diffusers shall be of approved make as shown on the drawings and/or indicated in the Bill of quantities. Anodized Aluminium section diffusers.

- a. Round or Rectangular Diffuser: Shall be anodized Aluminium section construction, square, rectangular, or round diffusers with flush fixed pattern. Diffusers for different spaces shall be selected in consultation with site engineer. Supply air diffusers may be equipped with fixed air distribution grids, removable key operated volume control dampers, and anti-smudge rings as required in specific applications, all as per requirements of Bill of quantities.
- b. Linear Diffuser: Shall be anodized Aluminium section construction, one or two-way blow linear diffusers. 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 site engineer and provided as per requirement of Bill of quantities. All linear / square / round diffusers shall have volume control dampers of MS construction.

9.8. Method of Measurements for Air Distribution System

a. Sheet Metal work

Duct Length Shall be measured along the centre line from flange face to face unless otherwise stated. Ductwork shall be measured on the basis of external surface area (length as measured above, multiply by duct perimeter) of ducts including the joints for each duct section. Duct measurement shall be taken before application of the insulation. For taper section average perimeter shall be used for measurement. For special pieces like bends, reducers, branches, and collars, mode of measurement shall be identical to as described above using the length along the centre line. The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles, and angles/flats with double nuts for supports, felt strip between duct and support, vibration isolation, inspection chamber / access panel, splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall not be separately measured nor paid for.

b. Duct Accessories

Shall be measured by the cross section area perpendicular to air flow.

c. Grilles and diffusers:

Width multiplied by height, excluding flanges, volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.

d. Diffusers:

Cross-section area for airflow at discharge/capture area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.

e. Linear diffusers:

Shall be measured by linear measurements only not by cross sectional areas, and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.

f. Flexible connection:

Shall be measured by their cross sectional area perpendicular to the direction of airflow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.

g. 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 anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to or less than 5 % in excess 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 submitted along with the completion documents.

10. Insulation

The scope of this section comprises the supply and fixing of insulation on equipment, piping, ducting, floors etc. conforming to these specifications and in accordance with requirement of Bill of quantities.

The materials to be used for insulation shall be as follows, unless some other material is specifically mentioned elsewhere. The detailed specifications of the materials are listed under respective sub heads:

Drain Pipe Insulation	Closed Cell Elastomeric Insulation with class 'O' for fire rating
Duct Insulation	Closed cell Elastomeric insulation with class 'O' for fire rating
Acoustic Insulation	Resin Bonded Fibre glass in roll form
Equipment Insulation	"Closed Cell Elastomeric Insulation with class 'O' for fire rating"
Floor Insulation	Closed Cell Elastomeric insulation with class 'O' for fire rating (other than plant room)
Fire Duct Insulation	Pre-laminated mineral wool

10.1. Drain Pipe Insulation

- The material for insulation of drain pipes shall be pipe sections of flexible closed cell elastomeric insulation having a 'K' value of 0.037 W/mk at a mean temperature of 20°C and a minimum density of 55 Kg./cubm.
- The thickness of insulation shall be 6 mm thickness.

10.2. Duct Insulation

Internal Acoustic lining for ducting is proposed (discharge duct) with 12.5 mm thick fibre glass as specified with compacted FG 48 kg/m³ density covered with RP Tissue paper and Al perforated sheet.

Acoustic duct lining shall be applied inside the duct for a minimum distance of 3 or 4 meter or as shown in the drawing from the outlet of air handling units or as specified in drawings or as indicated in Bill of quantities. Acoustical duct lining shall be applied as follows:

- The inside surface of the duct shall be cleaned and covered with cold setting adhesive compound.
- Depending on size of duct fit min. 2 or more rows of insulation fixing pins to each face of duct at every 300 mm center distance. Pins shall be self-adhesive, bond on type.

Carefully position insulation over the pins, pressing firmly so that pins penetrate through the insulation. Fit spring clip or lock washer over pins pushing them down until they are tight against insulation. Snip off any excess shank from pin. Seal all joints and openings with self-adhesive tape.

- The aluminum sheet shall be screwed using cup washers. And neatly finished to give smooth inside surfaces. Use of nails shall not be permitted.

Or

- The aluminum perforated sheet shall be screwed along with G.I nut to give smooth inside surfaces.

10.3. Duct Thermal Insulation:

- The materials for duct insulation shall be sheets of closed cell elastomeric insulation. The density of insulation shall not be less than 55 kg/cubm and material shall be in the form of sheets of uniform thickness. The 'K' value at 20°C. Shall not be less than 0.037 W/mK.
- Thickness of the duct insulation shall be as per standard.
- The insulation shall have fire performance of class 'O' as per BS476 Part-7"

11. Inspection and Testing

Pre-dispatch inspection shall be carried out for certain items. All the system equipment's, parts shall be checked for physical damage, before commencing the installation work. Complete fabrication, installation and commissioning work shall be jointly supervised and shall be carried out as per the specifications and instructions of site Engineer In-charge. All the rotating equipment shall be checked for static and dynamic balancing, minimum operating vibration and noise.

All the system / equipment's shall be checked before / after satisfactory commissioning, at manufacturer's works / site as may be required for the approved technical specifications, performance data provided by supplier / manufacturer. Actual capacity of each equipment shall be calculated based on the test readings, recorded jointly, for design conditions / operating conditions. Performance acceptance is subject to comparison of test results with supplier / manufacturer's performance data and contract specification. Acceptance is subject to satisfactory installation, commissioning and performance testing with respect to technical specifications. Rejected items must be replaced or rectified for the defects. In case of system modification / rectification complete performance tests are to be repeated. Site test readings shall be jointly recorded.

In general following Inspection / tests are involved. Type of test, duration of test, testing procedure / parameters, will be as per the applicable BIS codes. However the detail Inspection and test procedure shall be worked out jointly by the purchaser and the contractor along with the approval of drawings, within 30 days from the date of contact agreement.

- a. Pre-dispatch Inspection.
- b. Pre-dispatch testing at manufacturers shop / factory. (Material , performance, pressure, joints, etc.)
- c. Physical Inspection – Pre-installation at site.
- d. Performance testing at site (capacity, power consumption, pressure drop, vibration, etc.)
- e. Calibration at site. (for instruments and transmitters)

12. System Guarantee and Test Certificates

The system shall be guaranteed for performance for one year from the date of satisfactory acceptance and handing over to client in all respects. The guarantee shall be for entire performance of the supplied system and covering intended functionalities desired for intended purpose of the design.

Contractor shall furnish following Test certificates:

- Material testing of various components of the fans, controller and sensors
- Fabrication inspection / test certificates– Radiography and others
- Performance test certificates carried out by manufacturer.
- Performance guarantees certificate / calibration certificate
- All equipment operation and maintenance manual.

Testing The Equipment's at Site

The following aspects shall be considered for performance testing.

- Prevailing conditions shall be as close as to design conditions.
- Type, quantity, location, frequency, duration of test parameters shall be decided and recorded accordingly during the test.
- Rated capacity, power consumption, and other operating parameters shall be checked.
- Functional test for all Instruments, controls (safety and capacity) shall be carried out to check for the expected operation / action / accuracy / response time / repeatability parameters.
- Test Reading sheet:

- For Ceiling Mounted ductable type / Hide away or Furring type Air conditioning System.
- Units: Main volts / Amps.

(i) Compressor:

- Refrigerant suction pressure (LP, Bar) / Temp. °C.
- Refrigerant Discharge pressure (HP, Bar) / Temp. °C
- Discharge cutout pressure (Bar)
- Discharge cut in pressure (Bar)
- Suction cutout pressure (Bar)
- Suction cut in pressure (Bar)
- Compressor motor Amp.

(ii) Cooling Coil:

- Surface(Face) area - Sq.m
- Return (entering coil) air Temp. DBT / WBT °C
- Supply (leaving coil) air Temp. DBT / WBT °C
- Air velocity across the cooling coil - m/min.
- Air volume -CMH capacity

(iii) Air cooled Condenser:

- Surface (Face) area - Sq.m
- Air Temp. In - DBT °C
- Air velocity across the coil - m/min.
- Air Temp. at Fan outlet - DBT °C
- Air Temp. at Grilles, Supply Duct outlets - DBT °C
- Air volume -CMH at Supply Duct outlets
- Air volume – CMH at fresh air intake

(iv) Room Conditions:

- Average reading of DBT / WBT °C, at 12-00 PM, 14-00 PM, and 16-00 PM on a test (summer / monsoon) day, shall be recorded to check the inside / room design condition.

13. Ventilation System

The following areas shall be ventilated as under:

a. Depot**Admin Building**

S. No.	Room Name	Natural Ventilation	Mechanical Ventilation Supply	Mechanical Ventilation Exhaust	Pressurisation
1	Ladies Toilets	●	-	●	-Ve
2	Gents Toilets	●	-	●	-Ve
3	Electrical Switch Gear Room	●	-	●	-Ve
4	Documentation Room	●	-	●	

Canteen Building

S. No.	Room Name	Natural Ventilation	Mechanical Ventilation Supply	Mechanical Ventilation Exhaust	Pressurisation	
1	Ladies Toilets	●	-	●	-Ve	
2	Gents Toilets	●	-	●	-Ve	
3	DA Toilets	●	-	●	-Ve	
4	Store Room	●	-	●		
5	Utility	●	-	●		

Note – Canteen kitchen area shall be provided with wet scrubber for exhaust system and ducted fresh air supply.

Other Building

S. No.	Room Name	Natural Ventilation	Mechanical Ventilation Supply	Mechanical Ventilation Exhaust	Pressurisation
Car Wash – Technical					
1	Car Wash	●	-	●	-Ve
Check Post					
1	Check Post	●	-	●	-Ve
DCO Store					
1	Gas Store	●	-	●	
2	Solvents Store	●	-	●	-Ve
3	Paints & Varnishes Store	●	-	●	-Ve
4	Oil Store	●	-	●	-Ve

S. No.	Room Name	Natural Ventilation	Mechanical Ventilation Supply	Mechanical Ventilation Exhaust	Pressurisation
5	Receipt & Inspection	●	-	●	
6	Stores	●	-	●	
7	Gents Toilet	●	-	●	-Ve
8	Pantry	●	-	●	-Ve
9	Ladies Toilet	●	-	●	-Ve
Electrical Sub-station					
1	DG Room	●	-	●	-Ve
2	Panel Room	●	-	●	-Ve
3	Scrubber	●	-	●	-Ve
4	33 KV Switch Gear	●	-	●	-Ve
5	Transformer-1	●	-	●	-Ve
6	Transformer-2	●	-	●	-Ve
P-way Office					
1	P-Way Store	●	-	●	
2	Traction Equipment Room	●	-	●	
3	Switch Gear Room	●	-	●	
4	Gents Toilet	●	-	●	-Ve
5	Pantry	●	-	●	-Ve
6	Ladies Toilet	●	-	●	-Ve
7	Female Locker Room	●	-	●	-Ve
8	Gents Locker Room	●	-	●	-Ve
Time & Security Office					
1	Gents Toilet	●	-	●	-Ve
2	Ladies Toilet	●	-	●	-Ve
3	Time Office	●	-	●	-Ve
4	Fire Control Room	●	-	●	-Ve

S. No.	Room Name	Natural Ventilation	Mechanical Ventilation Supply	Mechanical Ventilation Exhaust	Pressurisation
RBL Office					
1	Electrical Switch Gear	•	-	•	-Ve
2	Compressor Room	•	-	•	-Ve
3	First Aid Post	•	-	•	-Ve
4	Mill Wright Store	•	-	•	-Ve
5	Brake & Pneumatic Room	•	-	•	-Ve
6	Battery Room	•	-	•	-Ve
7	Pantry	•	-	•	-Ve
8	Gents Toilet	•	-	•	-Ve
9	Ladies Toilet	•	-	•	-Ve
10	Door & CCD Room	•	-	•	-Ve
11	VVVF& APS Room	•	-	•	-Ve
12	HVAC Room	•	-	•	-Ve
13	Bearing Room	•	-	•	-Ve
14	Traction Motor Cleaning	•	-	•	-Ve
15	Testing & Repair Room	•	-	•	-Ve
16	Documentation	•	-	•	-Ve
17	Electrical Switch Gear	•	-	•	-Ve
18	Supervisors Room	•	-	•	
19	Section in-charge	•	-	•	
20	AM-1/AM-2 Room	•	-	•	
Pit Wheel Lathe					
1	Pit Wheel Lathe	•	-	•	-Ve
RRV Shed					
1	Ground Floor Plan	•	-	•	-Ve
Stabling Shed					
1	Store	•	-	•	-Ve
2	Gents Toilet	•	-	•	-Ve

S. No.	Room Name	Natural Ventilation	Mechanical Ventilation Supply	Mechanical Ventilation Exhaust	Pressurisation
3	Ladies Toilet	●	-	●	-Ve
Inspection Bay Offices					
1	Mechanical & Electrical Store	●	-	●	
2	Electrical Switch Gear Room	●	-	●	
3	Documentation Room	●	-	●	
4	Pantry	●	-	●	-Ve
5	Gents Toilet	●	-	●	-Ve
6	Ladies Toilet	●	-	●	-Ve
7	Electrical Section	●	-	●	
8	Electronic Section	●	-	●	
9	Mechanical Section	●	-	●	
10	Custody Room	●	-	●	
11	Electrical Switch Gear	●	-	●	
12	ETU Office	●	-	●	
13	Office-1,2 & 3	●	-	●	

Ducting (For Air-Conditioning)

Maximum air velocity	1500 ft/min, 460 mtrs/min
Maximum friction	0.1 IN WG per 100 Ft run
Maximum velocity at exhaust air grille	500 ft/min, 152 mtrs/min

Ducting (For Ventilation)

Maximum air velocity	2000 ft/min, 600mtrs/min
Maximum friction	0.1INWGper100 Ft run
Maximum velocity at exhaust air grille	600 ft/min, 183mtrs/min

An integrated Air-conditioning system is designed / proposed to maintain the temperature, humidity within specified tolerance and indoor air quality, within desired and comfortable conditions with proper air distribution within the Air-Conditioned area.

Proposed system / system components offered shall have:

- Higher efficiency & Co-efficient of Performance.
- Minimum power consumption, efficient parts load operation.
- Ease of operation and maintenance.
- Minimum vibration and noise level.
- Reliability, Simplicity, Compactness, Modularity and Interchangeability.
- Better Environmental protection and Indoor Air Quality.

13.1. Design Brief and Equipment

The scope of this tender is to design, supply, install, test and commission Toilet Ventilation System, Store & Pantry Ventilation System, Main LT panel Ventilation system and Traction Substation Ventilation system.

13.2. Quality control

Reference codes and standards

AMCA Standard 210: Laboratory Methods of Testing Fans for Rating

BS 848: Fans for General Purposes

IS / IS / IEC 60034 for design, performance and efficiency of motors

ISO 5801: Industrial Fans – Performance Testing using Standardized Airways

- a) Codes and regulations of the jurisdictional authorities.
- b) All fans, drives and accessories shall be designed, constructed, rated and tested in accordance with the recommendations and standards of AMCA / ISO.
- c) Fan tests shall conform to the requirements of AMCA Standard 210 or ISO 5801 or to an Approved equal standard.
- d) Sound ratings shall conform to AMCA standard test code for sound rating of air moving devices or BS 848: Part 2.

13.3. Technical and Installation Requirements

- a. Fans shall have non-overloading characteristic, except for forward curved centrifugal, over their entire operating range. The characteristic curves shall be such that the fan operating point falls between the no flow static pressure and the maximum mechanical efficiency. The fan characteristic shall also be that for a 15 % increase in total pressure over the specified value, the fan shall deliver not less than 85 % of the specified air volume flow rate. The stability of fan operation shall not be affected under such situation.
- b. All axial flow fans with nominal rating above 7.5 kW shall have a minimum efficiency of 70%. The manufacturer's best efficient fans shall be selected through manufacturer' software by engineer in charge during approval.
- c. Each fan unit including motor and drive shall be supplied from the manufacturer as a completely factory-assembled package and all guarantees and test certificates shall be deemed to apply to the entire assembly.
- d. All fans shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty. Additionally, all belt driven fans shall be capable of running continuously at 15% in excess of the selected duty speed.
- e. Lifting eye/Flanges shall be provided on all centrifugal and axial fans.
- f. All fans shall be statically and dynamically balanced.
- g. All centrifugal fan shafts shall have the ends drilled to receive a tachometer.

- h. Motor speed shall not exceed 1495 rpm unless otherwise specified.
- i. Nominal motor nameplate rating shall be higher than the peak operating power of the selected fan curve for non-overloading characteristic. The motor rating shall be a minimum of 15% higher than the motor operating point at design conditions unless otherwise specified.
- j. All fans and motors offered shall be of minimum vibration and noise level during operation. Should the vibration and noise level be excessive and not within acceptable standards, additional vibration isolation and sound attenuation shall be provided at no extra cost to the Employer to the satisfaction of the Engineer.
- k. All fans are required to be hot dip galvanised.

13.4. Ventilation Fan

Inline Fan Unit

The scope of this section comprises the supply, erection, testing and commissioning of fans conforming to these specification and in accordance with the requirement of bill of quantities.

Application/ Location as per Layouts and BOQ

The INLINE ventilation fans shall be designed for space saving / low noise generation. Inline fans shall preferably be single skin with swing out motors; these fans shall be complete with casing and impeller. Direction of discharge and rotation position shall be as per the job requirement and shall be marked on the fan assembly.

The duty points shall be mentioned in the schedule of quantities. Brief specifications for the fans are as under.

The proposed fan shall be complete with casing, motor and impeller. Direction of discharge and rotation position shall be in line with the layout shown.

Housing Shall be of GSS powder coated design. The duct connections at the inlet and discharge side of the fan shall be in accordance with the manufacturer standards to avoid transmission of vibrations if any to the ducting.

Impeller Fan shall have Aluminium impeller with backward curved blades suitable for lowest sound power level. Impeller shall be statically and dynamically balanced. Necessary acoustic insulation required to bring down the noise to the value specified in the SOQ shall be carried out if required; the product shall be supplied with factory insulated design in this case.

Ball Bearings Shall be completely maintenance free and can be used in any mounting position at maximum indicated temperature.

Fan motor Fans shall be energy efficient type have external rotor motor or IEC standard motor supplied with built-in thermal contacts. At the critical high temperature point the thermal contact shall open and break the power supply of the Fan. Fan motor shall be insulation class F and protection class IP54.

Drive of the fans shall be direct driven.

Performance Data All fans shall be selected for the lowest operating noise power levels. Capacity ratings, power consumption with operating points indicated shall be submitted and verified at the time of testing and commissioning of the installation. All technical data of fans should be as per AMCA accredited. High temp fans should have valid European certification in accordance with EN12101-3.

Testing Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall confirm to specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

13.5. Propeller Fan Unit

- a. **Scope:** The scope of this section comprises the supply, erection, testing and commissioning of fans conforming to these specification and in accordance with the requirement of bill of quantities.
- b. **Propeller Fan Unit:** Application/ Location as per Layouts and BOQ. These fans shall be of single phase type and installed for Propeller fans shall be of approved make in tender, direct-drive, three or four-blade type mounted on a steel mounted plate with orifice ring to deliver as per duty points. Please refer tender bill of quantities for duty point and quantities as applicable.

- c. **Mounting Plate:** The mounting plate shall be constructed of 12/16 gauge sheet steel, depending upon the fan size and finished with baked enamel paint of approved shade. The mounting plate construction shall be of streamlined venturi inlet type (reversed for supply application). Orifice ring shall be correctly formed by spinning or a stamping to provide easy passage of air without turbulence & to direct the air stream.
- d. **Fan Blades:** 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 shall be quiet in operation and shall be statically and dynamically balanced at the factory.
- e. **Shaft:** Shall be of steel (EN 8), accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed through the full range of specified fan speeds.
- f. **Motor:** The motor shall be dust and moisture protected to IP54 and of a totally enclosed construction with permanently lubricated ball bearings suitable for running in ambient temperatures of up to 50°C and relative humidity of up to 100%. Shall be standard energy efficient (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 750 RPM and. will be suitable for 415 +/- 10% volts, 50 cycles, 3 phase supply and shall be suitable for either horizontal or vertical service, as indicated on drawings and BOQ.
- g. **Accessories :** The following accessories may be required and provide with propeller fans as indicated in the BOQ. Wire guard on inlet side and bird screen at the outlet. Fixed or Gravity operated steel louver shutters built into a steel frame. Regulators for controlling fan speed for single phase fan motors. Single phase preventers for 3 phase fans.

13.6. Axial Flow Fans (Vane Type)

- a. Provide axial flow, direct drive aerofoil fans as specified on the Equipment Schedules and/or Drawings.
- b. Fan Casing

Casing shall enclose the motor and impeller.

Fan casings shall be fitted with matching flanges on the inlet outlet ends with spigots for attachment of flexible connections.

Inspection doors or sight ports to enable direction of rotation to be established shall be provided.

Terminal boxes welded to the casing shall be provided for electrical connection using metallic flexible conduits to fan motor complying with BS 4999: Part 20 for dust and weatherproof conditions.

Grease nipples shall be brought to the outside of the casing in the most accessible position and fitted with lubrication tube made of copper or other Approved material. Gasketed access doors shall be provided in each fan housing or connecting ductwork, suitable for access to adjust or replace blades. For smoke extraction fans, the gaskets shall be suitable for continuous operation in an air stream temperature of 250 °C for not less than two hours.

- c. Impeller.

Impellers shall be of die-cast aluminium alloy.

For hub size of 315mm (dia.) and above, blades shall be manual adjustable without removing the wheel. Positive locking shall be provided for securing the impeller blades into the hub. Spun aluminium hub caps shall be fitted. The blades shall be counter-balanced and mounted on a thrust bearing for vertically installed fans.

- d. Except smoke extraction fans and unless otherwise specified, drive motors shall be of class F insulation (BS 4999 and BS 2757) totally enclosed type and rated for continuous operation in ambient temperature of 50 °C. Performance and rating shall comply with BS 5000 and IEC 34-1 with protection to IP55. All Motors shall be of efficiency class IE-2.
- e. Factory bell mouth shall be provided where no duct connection is required. Fans shall be fitted with bell mouth inlets. Flow cores and bell mouth inlets shall be fabricated in steel and provided with flanges drilled and rigidly bolted to the fans.

- f. Provide wire guards on fan outlet/inlet not connected to ductwork and shall be made freely accessible for maintenance.
- g. Fans shall be provided with mounting feet and spring isolators.
- h. The bearing life of the fan motor assembly shall be of 40,000 hours (L-10 life).
- i. Stationary, curved guide vanes shall be located on the outlet side of the fan to straighten the motion of the air leaving the blades to improve operating efficiency if required.
- j. For smoke extraction fan, adequate clearance shall be provided between blade tips and housing at all points to allow for expansion and contraction over a continuous operation in an air stream temperature range from 0 °C to 250 °C without developing interference to the specified flow capacity. The fabrication/shop drawings shall show the clearance at over a continuous operation in an air stream temperature range from 0 °C to 250 °C as well as any point of minimum clearance in between. The motors in case of smoke extraction fans shall be fire rated for 250°C, 2 hours.

14. VRF System Integration & Customization

The VRF system proposed will be supplied with Central Controller covering all the Indoor units including Guest Room and Public areas and supports BACNet IP Manager platform; Controller shall be having a display module with key board sufficient to execute controls and set point edits for all the indoors under purview. Data from the controller shall be acquired and integrated with Work Station that is positioned at the Reception area. The Reception area PC shall be loaded with VRF Monitoring software (supplied and customized) by VRF Supplier; the VRF Controller and the software shall be seamlessly integrated. It will be possible from the Reception PC to identify the Guest Room of concern and TURN On/Off the Indoor unit of the selected guest room; Hardware compatibility of this Reception Work Station shall comply to configuration required for running the VRF Monitoring & Control software In case of the controller communication other than BACNet IP, it shall be clearly highlighted in the bid.

15. Technical literature and test certificates to be furnished by Contractor

Contractor shall furnish following minimum technical particulars:

Name of manufacturer

- (i) Standard governing specification
- (ii) Manufacturer's type designation
- (iii) Rated system voltage in kV
- (iv) Rated continuous current in amps
- (v) Max. permissible current in amps at 40°C
- (vi) Short circuit current for 1 sec. in kA
- (vii) Minimum permissible bending radius in mm
- (viii) Overall diameter of cable/wire in mm
- (ix) Max. permissible length of cable in drum
- (x) Weight of cable and drum including cable
- (xi) Resistance of Conductor/100m length
- (xii) High voltage with-stand test result in kV
- (xiii) Insulation resistance
- (xiv) Thickness and material of
 - a. Insulation
 - b. Inner sheath

- c. Armouring
- d. Outer Sheath.
- (xv) Compounded use for FRLSZH properties
- (xvi) Chemicals used for protection against rodent and termite attack.
- (xvii) Shelf life of cable accessories for the ambient temperature specified.
- (xviii) Catalogues and brochures giving technical and physical details of the cable such as current rating, de-rating factors, etc.
- (xix) Type test certificates and special test results for cables offered.
- (xx) Shelf life of cable accessories for the ambient temperature specified.
- (xxi) Type test certificates for cable & accessories.
- (xxii) De-rating factor with the proposed method of cable laying

TECHNICAL DATA SHEET FOR VRF SYSTEM

<i>(Technical information to be furnished in following format by Bidder)</i>		
SR	SPECIFICATION	TO BE FILLED IN BY BIDDER
1	OUTDOOR UNIT :	
1.1	COMPRESSOR	
	Make	
	Type	
	Model no.	
	Max. Speed (rpm)	
	No. of Inverter / digital type compressor	
	% of full load capacity	
	% of Power consumption	
	Type of drive	
	List of safety device provided on compressor	
	Test pressure of compressor (kg./sq.cm.)	
	Refrigerant	
	Design conditions (at peak load)	
i)	Suction temperature(°C)	
ii)	Discharge temperature(°C)	
iii)	Suction Pressure (kg./sq.cm.)	
iv)	Discharge Pressure (kg./sq.cm.)	

	Capacity of compressor at design conditions (mentioned in "q") at full load (TR)	
	BKW at design conditions(mentioned in "q")	
	Recommended motor HP	
	Overall dimensions (mm)	
1.2	FAN SECTION :	
	Fan dia. (mm)	
	No. of fans	
	Fan speed (rpm)	
	Type of drive	
	Design air quantity (cu.m./hr.)	
	KW at full load	
	Motor HP	
1.3	CONDENSER COIL :	
	Tube material	
	Tube dia. (mm)	
	Tube thickness (mm)	
	Fin material	
	No.of fins per cm.	
	Coil face area (sq.m.)	
	No.of rows	
	Design air inlet temperature - DB (°C)	
	Design air outlet temperature - DB (°C)	
	Operating Condensing temperature at peak conditions (°C)	
	Degree of subcooling (°C)	
	Velocity of air across coil (m/s)	
	Receiver capacity (kg of refrigerant)	
	Design heat rejection capacity (TR)	
1.4	ELECTRIC MOTOR FOR CONDENSER FAN :	
	Make	
	Type	
	Method of starting	
	Rated output (HP)	

	Range of working voltage (volts)	
	Rated frequency (Hz)	
	Rated speed (rpm)	
	Full load current (Amps.)	
	Starting current (Amps.)	
	Class of insulation	
	Efficiency and power factor at full load	
	Type of vibration isolation	
	for condenser fan and motor	
2	INDOOR UNIT :	
2.1	COOLING COIL :	
	Tube material	
	Tube dia. (mm)	
	Tube thickness (mm)	
	Fin material	
	No.of fins per cm.	
	Coil face area (sq.m.)	
	No.of rows	
	Design ADP (°C)	
	Design air inlet temperature - DB (°C)	
	Design air outlet temperature - DB (°C)	
	Design air inlet temperature - WB (°C)	
	Design air outlet temperature - WB (°C)	
	Velocity of air across coil (m/s)	
	Design heat absorbing capacity (TR)	
2.2	EVAPORATOR FAN SECTION :	
	Maximum air discharge capacity (cu.m./hr.)	
	Maximum static pressure (m.m.w.g.)	
	Maximum fan speed (rpm)	
	Fan diameter (m.m.)	
	Balance (static and/or dynamic)	
	Design air quantity (cu.m./hr.)	
	Design static pressure (m.m.w.g.)	

	Design fan speed (rpm)	
	BKW at full load	
	Motor H.P.	
2.3	ELECTRIC MOTOR FOR EVAPORATOR FAN :	
	Make	
	Type	
	Method of starting	
	Rated output (HP)	
	Range of working voltage (volts)	
	Rated frequency (Hz)	
	Rated speed (rpm)	
	Full load current (Amps.)	
	Starting current (Amps.)	
	Class of insulation	
	Efficiency and power factor at full load	
	Type of vibration isolation	
	for evaporator fan and motor	
2.4	EXPANSION VALVE :	
	Make & type	
	Model	
	Quantity	
	Refrigerant	
	Capacity (TR)	
2.5	COP	
	COP of ODU capacity at 125% Diversity	
	COP of ODU capacity at 100% Diversity	
	COP of ODU capacity at 75% Diversity	
	COP of ODU capacity at 50% Diversity	
2.6	DERATION CAPACITY in BTU / HR	
	Actual derated Capacity of ODU at 40 °C	
	Actual Derated Capacity of ODU at 43.5 °C	

TECHNICAL DATA SHEET FOR VENTILATION SYSTEM

Bidder to enclose technical performance / data sheets and brochures for all equipment / devices offered by them for the ventilation system. In addition,			
1. Axial and Inline drawing indicating dimensions			
2. Power and control wiring diagrams whichever is applicable			
HEAD	AXIAL FAN	INLINE FAN	REMARK
MANUFACTURER			
TYPE			
CAPACITY (M3 / H)			
MODEL			
CASING MATERIAL			Hot Dipped Galvanized Steel
POWER INPUT (KW)			
FANS SPEED (RPM)			
SOUND Pressure Level db			< 69
APROX WEIGHT (Kg)			
TEMP. RATING			300 DEG C FOR 2 Hrs
TYPE OF DRIVE			Direct Drive
Electrical requirement			415 V / 50HZ / 3Ph
Accessories			Silencers, protection guards, mounting brackets, Inlet/outlet cone , Fixtures and other std accessories to be mentioned by bidder

TECHNICAL SPECIFICATIONS
PART C- FIRE SUPPRESSION (FIRE FIGHTING SYSTEM)

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1. Fire Suppression (Fire Fighting System)**1.1. General**

- 1.1.1.** The scope of this section comprises the supply, installation, testing and commissioning of the entire fire fighting system.
- 1.1.2.** All G.I pipes and other accessories shall be cleaned thoroughly before application of primer coats. Two coats of primer shall be applied and thereafter two coats of enamel paint shall be applied. Each enamel paint coat should be given minimum 24 hours drying time. No thinner shall be used. The work shall be done in professional manner and to the satisfaction of the Engineer. No extra amount shall be paid for this work and price may be included with the relevant item itself.
- 1.1.3.** All items provided in this specification shall be provided by the Contractor and no extra payment shall be made.
- 1.1.4.** All power and control cables in the fire system shall be Fire Retardant Low Smoke (FRLS) cables.
- 1.1.5.** All nuts, bolts, washers etc. shall be of Galvanized iron for fitment of pipes, valves and other accessories unless and otherwise specified.
- 1.1.6.** Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work
- 1.1.7.** The Contractor shall obtain approval from Local Fire Department. No extra amount shall be paid for this work and price may be included in the rates.

2. Fire Protection System:**2.1. Scope**

The scope of this section consists of following but is not necessarily limited to supply, installation, testing and commissioning of the fire protection system. The working of the system is as follows:

- a) The Fire Suppression System shall comprise the Fire Hydrants System, the Sprinkler System (Wet type).
- b) RCC Fire Water Storage Tanks (UG tank), each of 1 lakh litre capacity, shall be supplied for the use of fire fighting system.
- c) The Hydrant System and the Sprinkler System, under normal conditions, shall be pressurized by means of the electric motor driven Jockey Pump.
- d) The Hydrant System and Sprinkler System shall be provided with one electric motor driven main pump and stand by diesel engine driven pump.
- e) The starting and stopping of the Jockey pump shall be automatic based on the pressure switches at preset low and high pressure.
- f) The electric motor driven Hydrant Pump starts automatically at pre-set pressure by means of a pressure switch. As soon as the Hydrant Pump starts, the Jockey Pump stops. If for any reason the electric motor driven Hydrant Pump does not start at the pre-set pressure or is unable to maintain the pressure, the stand by diesel engine driven Hydrant Pump starts at the pre-set pressure.
- g) The hydrant pump, electric motor driven shall be stopped only manually.
- h) Contractor shall ensure Hydro Testing for the complete system.

The contractor shall include submission and obtain necessary approval of relevant drawings, schemes and documents from local / fire authorities and also obtain all necessary permissions and NOC for execution of work as well as getting final approvals from the concerned fire officers along with relevant "NOC" for occupation of building. No extra payment shall be made on account of getting the approval. The Contractor shall get all statutory approval of the Fire Fighting System by the local Fire Authority having jurisdiction, without which the work will not be taken over by the Employer. All expenses on this account shall be borne by the Contractor.

- i) Standards

The fire hydrant installation shall conform to and meet with the requirements set out by the following:

Table 01

STANDARDS	DESCRIPTION
IS: 3844-1989	Code of practice for installation of internal fire hydrant.
NBC Part-IV	National Building Code Part-IV: Fire Safety System
IS: 5290 – 1993	Specification for landing valves
IS : 12585	Specification for Thermoplastic Hoses

All the standards mentioned above as well as referred to in the document elsewhere shall be latest.

- j) Shop Drawings: The Contractor shall prepare and furnish all shop drawings in quadruplicate at no extra cost for approval by the Engineer-in-Charge before commencing fabrication/manufacture of the equipment. Such shop drawings shall be based on the Architect drawings and requirements laid down in the specifications and as per site conditions. The manufacture of equipment shall be commenced only after the shop drawings are approved in writing by the Engineer-in-Charge. Such drawings shall be coordinated with all disciplines of work.
- k) Completion/As Built Drawings: On completion of the work and before issuance of certificate of completion, the Contractor shall submit to the Engineer-in-Charge, General layout drawings, drawn at approved scale indicating layout of pump house piping and its accessories "As installed ". These drawings shall in particular give the following:
 - i. General layout of pump house.
 - ii. Panels and other equipment location and sizes etc.
 - iii. Complete Schematic as installed.
 - iv. Location of Hydrants, Earth pipes, route of earthing conductors etc.
 - v. Route of all cables and pipes run along with detail sizes and mode of installation.

2.2. Documents

The Contractor shall submit to the Engineer-in-Charge, the following documents on completion of the work and before issuance of completion

- a) Warranty for equipment installed.
- b) Test certificates.
- c) History sheets of the equipment's.
- d) Catalogues.
- e) Operation and Maintenance manuals.
- f) List of recommended spares and consumables.

For Sanction/approvals from statutory authorities/local fire department, the Contractor shall be fully responsible and shall carry out following activities: -

- a) Submission of working drawing.
- b) Obtaining the approval of drawings.
- c) Arranging inspection of site by officials of the Authority.
- d) Obtaining the final no objection/completion certificate after submitting required documents.
- e) Any other statutory approvals required.

3. Fire Pumps

3.1 Scope

This Chapter Covers the general requirements of Main / Stand-by and jockey fire water pumps.

3.2 Type

The pumps shall be centrifugal type direct driven with a 3 phase, 415 V \pm 10%, 50 Hz. A.C. motor. The main fire pumps will be horizontal split casing (HSC) pump with operating speed not exceeding 1500 rpm for main fire pump

and 3000 rpm for jockey pump.

3.3 Rating

3.3.1 Electric Driven Pump

Electric driven main fire pump suitable for automatic operation and complete in all respect as required. Horizontal type, multistage, centrifugal, split casing pump of cast iron body & bronze impeller with stainless steel shaft, mechanical seal to ensure a minimum pressure of 3.5 kg/cm² at highest and farthest outlet at specified flow of 2850 lpm at 125 & 90 meter head conforming to IS 1520. The pump shall have suitable HP Squirrel cage induction motor, TEFC, synchronous speed 1500 RPM, suitable for operation on 415 volts, 3 phase 50 Hz. AC with IP 55 protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS-325. The pump and motor shall be on M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts, with all accessories etc. as required. Suitable cement concrete foundation in cement concrete 1:2:4 - 300mm high and 150mm projection on all side of base plate, 12mm thick cement plaster in cement mortar 1:4 finished with a floating coat of neat cement duly plastered with anti-vibration pads. Pump Shall Including Pressure Switch, Pressure gauges and all other accessories complete in all respects.

3.3.2 Diesel Engine driven Pump

Diesel Engine driven fire pump suitable for automatic operation comprising of the following and conforming to BS 649/IS 10002 all amended up to date, Horizontal end section/split casing, high pressure single/ multistage centrifugal pump, The installation shall be complete with flexible coupling and coupling guard as required. Fire pump shall have C.I. casing, CS diffusers, bronze impeller (hard finished and dynamically balanced) and SS (304) shaft with mechanical seal, gland packing seal, capable for delivering 2850 LPM at outlet head of 125 & 90 meter to ensure a minimum pressure of 3.5 Kg/cm² at the farthest or topmost hydrant / sprinkler. The installation shall be complete with necessary pressure gauge with gun metal shut off cock on delivery side (The pump should be tested for bench mark duty point test at factory and shall be approved by the Local Fire Authority). Pump shall be capable of furnishing not less than 150% of rated discharge capacity at a head of not less than 65% of the rated head. The shut off head shall not exceed 140% of rated head.

Heat exchanger/Radiator cooled (secondary cooling) diesel engine of speed 1500 RPM suitable for the above pump with automatic starting mechanism and other accessories including fuel tank (fabricated from 3mm MS sheet, painted with two coats of synthetic enamel paint over a coat of primer) of capacity adequate to sustain pump operation for 8 hours continuous working. The tank shall be fitted with Magnetic oil level indicator, man hole with cover, drain valve, air vent including structural supports (painted with approved shade), 2 Nos x 12 volt battery, heat exchanger with necessary piping connections & fittings, flexible coupling, coupling guard & exhaust pipe connection complete as required. Common base plate for (a) and (b) from M.S. channel of required size. Suitable cement concrete foundation with plaster, complete with anti vibration arrangement of cushy foot mountings.

3.3.3 Jockey Pump

Electric driven pressurization Jockey pump suitable for automatic operation and complete in all respect as required. Vertical type, multistage, centrifugal pump of cast iron body and bronze impeller with stainless steel shaft, mechanical seal and flow of 180 lpm at 125 & 90 meter head conforming to IS: 1520. The pump shall have suitable HP SQ cage induction motor TEFC type suitable for operation on 415 volts, 3 phase 50 Hz. AC with IP 55 class of protection for enclosure, horizontal foot mounted type with Class 'F' insulation, conforming to IS: 325. The pump and motor shall be on M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts will all accessories etc. as required. Suitable cement concrete foundation in cement concrete 1:2:4 - 300mm high and 150mm projection on all side of base plate, 12mm thick cement plaster in cement mortar 1:4 finished with a floating coat of neat cement with anti vibration pads.

3.4 Material and Construction

- i. The fire pump shall be single stage / multi stage suction centrifugal type and direct driven conforming to IS: 1520 by electric motor as specified. The pump rating and performance shall conform to the equipment schedule. The pumps should be with mechanical seal of reputed make.
- ii. Pump shall be capable of delivering 150% of the rated capacity at 65% of the rated head and the no-delivery head shall be not more than 140% (150% in case of end suction type) of the rated delivery head. The pump casing shall withstand 1.5 times the no-delivery pressure or 2 times of the duty pressure whichever is higher.

- iii. The electric drive motor shall be squirrel cage induction conforming to IS: 325-1996 and rated for continuous duty (S1). Motor shall have not less than class F insulation and minimum enclosure of IP55. The starter shall be air-cooled fully automatic star delta/soft starter type. Starters shall conform to relevant IS standard and rated for AC-3 duty conditions.
- iv. The pump casing shall be of heavy section close grained cast iron (grade FG 200, IS :210) and designed to withstand 1.5 times the working pressure. The casing shall be provided with shaft seal arrangement as well as flanges for suction and delivery pipe connections as required.
- v. The impeller shall be of bronze or gunmetal. This shall be shrouded type with machined collars. Wear rings, where fitted to the impeller, shall be of the same material as the impeller. The impeller surface shall be smooth finished for minimum frictional loss. The impeller shall be secured to the shaft by a key.
- vi. The shaft shall be of stainless steel and shall be accurately machined. The shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump.
- vii. The shaft sleeve shall be of bronze or gunmetal.
- viii. The bearings shall be ball or roller type suitable for the duty involved. These shall be grease lubricated and shall be provided with grease nipples/cups. The bearings shall be effectively sealed against leakage of lubricant or entry of dust or water.
- ix. The shaft seal shall be mechanical type, so as to allow minimum leakage. A drip well shall be provided beneath the seal.
- x. The pumps shall be directly coupled to the motor shaft through a flexible coupling protected by a coupling guard.
- xi. The pump and motor shall be mounted on a common base plate fabricated from mild steel section. The base plate shall have rigid, flat and true surfaces to receive the pump and motor mounting feet. The pump will be perfectly aligned with the motor so as to avoid any vibration during operation.
- xii. The pump Heads Specified on the Drawings and/or equipment Schedules are for guidance and information only are calculated based on assumed equipment pressure drops. The Exact pump head based on the pipe run and the offered equipment. Calculation shall be submitted for approval. No modification to the piping System shall be allowed without prior approval. Any additional cost for modification of the system (pumps, motors, switchgears, cables, panel boards, switchboard etc.) necessary to meet the specified duties, special conditions and the offered equipment shall be provided at no extra cost to the Employer)

3.5 Pump Foundation

Foundation of pumps in Fire Pump rooms should be of considerable height so that these are not submerged in case of overflow.

3.6 Accessories

Each pump shall be provided with the following accessories: -

- Sluice valves on suction and butterfly valves on discharge
- Reducers, as may be required to match the sizes of the connected pipe works.
- Non-return valve at the discharge.
- Pressure gauge filled with glycerine with siphon & ball valve at discharge side between pump and the non-return valve.
- Each pump shall have independent set of differential pressure switches. The pressure switch shall be snap action SP DT switch rated 10A @ 230 V operated through a stainless-steel diaphragm. The switch shall have a pointer for manual adjustment of set point and all electrical connections shall be terminated in a screwed terminal connector. The entire unit shall be encased in a cold drawn steel (heavy gauge) enclosure. The diaphragm shall be designed for a maximum operating pressure of the system.

3.7 Rubber Mat

Rubber mat shall be provided in front & rare to cover the full length of all panels. Rubber mat shall be 1000 mm wide of required length of 1100 voltage grade.

3.8 Anti-Vibration Mounting

Suitable vibration mounting duly approved by Engineer to be used for mounting the unit so as to minimize transmission of vibration to the structure. The isolation efficiency achievable shall be clearly indicated.

3.9

Operating Conditions for Fire Hydrant Pumps

Table 02

Description	Capacity LPM	Cut in	Cut out
Operating pressure		7.0 Kg/cm ²	
Jockey pump-Hydrant	180	6.50 Kg/ cm ²	7.0 Kg/ cm ²
Fire Pump 1	2850	5.75 Kg/ cm ²	Manual
Fire Pump 2 (Stand By-Diesel Engine)	2850	4.50 Kg/ cm ²	Manual

The pump and motor assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or to the pipe work.

- The pump and motor assembly shall be installed on suitable RCC foundation. The length and width of the foundation shall be such that 150 mm. space is left all around in front & back and 75mm at sides.
the base frame. The height of foundation shall be so decided that the total weight of foundation block is 1.5 times the operating weight of the pump assembly. The foundation shall be isolated from the floor by vibration isolating pads. Angle iron frame of size 35 mm x 35 mm x 3 mm shall be provided on the top edges of the foundation.
- More than one pump and motor assembly shall not be installed on a single base or cement concrete block.
- The suction/discharge pipe shall be independently supported, and their weight shall not be transferred to the pump. It should be possible to disconnect any pump for repairs without disturbing the connecting pipe line.
- A minimum clearance of 1.5 m. around the main pumps shall be provided.
- The motor starters (Direct on line / Star-delta / Soft starter) shall consist of electrically actuated contactors. The starter shall be complete with ON-OFF push buttons, timers and auxiliary contacts and shall be fully automatic. There shall be an indicating lamp with each of the pumps and an ammeter and selector switch with the fire pumps. Fire pump starting shall be annunciate through an electric siren.
- The starter along with isolator shall be housed in a 14 SWG MS box duly rust inhibited through a process of degreasing and phosphating.
- All cabling to and from the pumps to starter and control switch shall be carried out through armoured Fire Survival FRLS Cables of approved makes. Cables shall be laid in accordance with section "MV CABLING". The pump motors and panels shall be double earthed in accordance with IS 3043- 1987 or as shown on drawings and as approved.

4. Pipe Work for Fire Fighting System

4.1. Scope

The scope of work covers supply, fabrication, laying, testing, painting and commissioning of the entire GI piping system for the fire fighting installation i.e. fire hydrant and sprinkler systems.

4.2. Standards

The following standards shall be applicable

Table 03

Sl. No.	Standards	Description
1.	IS – 8757	Glossary of terms associated with Fire safety.
2	IS – 884	Specification for first aid hose reel for fire fighting.
3	IS – 901	Specification for coupling, double male and double female

Sl. No.	Standards	Description
		Instantaneous pattern for fire fighting.
4	IS – 902	Specification for suction hose couplings for fire fighting purposes.
5	IS – 903	Specification for fire hose delivery couplings, branch pipe, nozzles and nozzle spanner.
6	IS – 904	Specification for two-way and three-way suction collecting heads for fire fighting purposes.
7	IS – 907	Specification for suction strainers, cylindrical type for Fire fighting purposes.
8	IS – 908	Specification for fire hydrant, stand post type.
9	IS – 909	Specification for ground fire hydrant.
10	IS –636	Non percolating flexible fire fighting delivery hose.
11	IS –7637	Glossary of terms for fire fighting equipments.
12	IS –937	Specification for washers for water fittings for fire fighting purposes.
13	IS –1641	Code of practice for fire safety of building (general): General principles for fire grading and classifications.
14	IS –1642	Code of practice for fire safety of building (general): Details of construction.
15	IS –1643	Code of practice for fire safety of building (general): Exposure hazard.
16	IS –1644	Code of practice for fire safety of building (general): Exit requirements and personal hazard.
17	IS –1646	Code of practice for fire safety of building (general): Electrical Installation.
18	IS –2871	Specification for branch pipe, universal for fire fighting.
19	IS –2930	Functional requirements for hose laying tender for fire brigade use.
20	IS –5290	Specification for landing valves.
21	IS –8090	Specification for coupling, branch pipe, nozzle, used in hose reel tubing for fire fighting.
22	IS –8442	Specification for stand post type water monitor for fire fighting.

Table 04

Sl. No.	Standards	Description
23	IS –9972	Specification for automatic sprinkler heads.
24	IS –11101	Specification for extended branch pipe for fire brigade use.
25	IS –12349	Fire Protection sign.

Sl. No.	Standards	Description
26	IS –12407	Graphic symbols for protection plan.
27	IS –9668	Code of practice for provision and maintenance of water supplies and fire fighting.
28	IS –3844	Code of practice for installation and maintenance of internal fire hydrants and hose reel on premises.
29	IS –10221	Code of practice for coating and wrapping of underground mild steel pipe lines.
30	IS –15105	Design and installation of fixed automatic sprinkler fire extinguisher system-Code of Practice.
31	IS –325	Three phase induction motors.
32	IS –1822	Motor starter for voltage not exceeding 1000 volts.
33	IS –3624	Burden tube pressure and vacuum gauges.
34	IS –1520	Horizontal centrifugal pumps for clear, cold, fresh water.
35	IS –1239	Mild steel tubes, tubular and other wrought steel fittings.
36	IS –3589	Electrically welded steel pipes for water, gas and sewage.
37	IS –6392	Steel pipe flanges.
38	IS –778	Gunmetal gate, globe and check valves for general purpose.
39	IS –2592	Recommendation for methods for measurement of fluid flow by means of orifice plates and nozzles.
40	IS –732	Code of practice for electrical wiring and fitting of building.
41	IS –900	Code of practice for installation and maintenance of induction motor.
42	IS –1248	Direct acting electrical indicating instruments.
43	IS –2516	A.C. circuit breakers for voltages not exceeding 1000 volts.
44	IS –4047	Heavy duty air break switches and composite units of air break switches and fuses for voltage not exceeding 1000 volts.
45	IS –2208	HRC cartridge fuses links up to 650 volts.
46	IS –1554 (Part II)	PVC insulated (heavy duty) electric cable for working voltage up to and including 11000 volts.
47	IS –1536	Centrifugally Cast Iron Pipe.
48	IS –1537	Vertically Cast Iron Pipe.
49	IS –1538	Cast Iron Pipe Fitting.
50	IS –780	Sluice valve for water works purpose (50 to 300 mm size).
51	IS –13095	Butterfly valves.

5. Fire Hydrant Design

Various pipe sizes of dia – 250mm, 200mm, 150mm, 100mm, 80mm, 65mm, 50mm, 40mm, 32mm and 25mm shall be used and these are purely for contractor's guidance. The contractor shall be responsible for selection of sizes as

per detailed engineering & (Hydraulic Calculations as per Standard) submit to Engineer for approval.

5.1 Piping design to be done by the contractor shall incorporate the following:

- (a) Sluice valves/butterfly valve on suction and butterfly valves on discharge
- (b) External hydrant
- (c) Fire service connection/inlet.
- (d) Test valve.
- (e) Drain connections.

5.2 For testing the system healthiness and automatic operation on daily basis, one test pipe with butterfly/sluice valve shall be provided in common discharge header. For avoiding wastage of water, this pipe shall discharge water in the tank. Flow meter/ PRV/ Expansion bellows

5.3 Non return valve shall be provided at the delivery of each pump and fire service inlet. This shall be of swing type.

5.4 Air release valves with ball valve shall be provided in the piping system for venting trapped air with a size of 25 mm for pipes up to 100 mm and 40 mm for larger pipes.

5.5 Piping drawings showing the sizes of pipe, valves, layout and other details shall be prepared and shall be got approved from the Engineer before the execution of the piping work.

5.6 Hydrants shall be provided internally and externally as shown on the drawings.

5.7 Hydrants shall be provided internally and externally as shown on the drawings. Internal hydrants shall be provided at each landing, escape staircase and additionally depending on the floor area as shown on drawings and as part of detailed design. Landing valve shall be single headed SS (stainless steel) valve with 63 mm diameter outlets and 80mm inlet conforming to IS 5290-1993. Landing valve shall have flanged inlet and instantaneous type outlets and mounted at 1.0m above the floor level. Instantaneous outlets for the hydrants shall be of standard pattern approved and suitable for 63mm diameter fire brigade hoses. The landing valve shall be fitted to a T connection of the risers at the Landing in such a way that the valves is in the centre of the internal hydrant operation. The valve base shall be vertical and the valve facing outside, so that there should be no hindrance in the operation of wheel. Wherever necessary, pressure reducing orifices plate shall be provided so as to limit the pressure to 3.5kg/cm² or any other rating as required by the Local Fire Authority.

5.8 Each landing valve shall have a first aid hose reel cabinet as shown on drawings.

5.9 Landing valve with single 63 mm diameter outlet and 80 mm diameter inlet.

5.10 First-aid hose reel shall be with 45m long 25mm diameter high pressure thermo plastic (IS: 12585 marked) with Ball Valve and 7 mm shutoff nozzle. The entire assembly is mounted on a wall bracket and can swing 180 degree. The water inlet is connected to the riser pipe by means of a socket and valves. The hose tube can be pulled out easily for the purpose of discharge of water.

5.11 2 Nos. 15-meter long 63mm diameter reinforced rubber-lined hoses with SS male and female instantaneous coupling duly marked IS.

5.12 Branch Pipe and Nozzle: - Branch Pipes with nozzle are mounted at the end of hose pipe. Branch pipe is properly finished and free from sharp edges. During operation a fireman has to hold the branch pipe. One end of branch pipe is fixed with hose coupling and the other end is threaded to fit the nozzle. Nozzle is tapered pipe with one end threaded internally which is fixed on branch pipe. The size of other end i.e. nozzle shall be 20 mm (nominal internal diameter).

5.13 The First Aid Hose pipe shall conform to IS: 12585 and be wound on a heavy-duty circular hose drum confirming to IS: 884 – 1985 with a bracket. The hose shall be permanently connected on one end to the wet Riser through a 25m Ball Valve with necessary hose adapter and a SS nozzle at the other end.

5.14 RRL Hoses shall be in two lengths of 15 m each, of synthetic type (UL listed) with instantaneous couplings, neatly rolled into bundles and held in position with steel brackets. Hoses shall be tested and certified by the manufacturer to withstand an internal water pressure of not less than 35 kg/cm² without bursting. The hose shall also withstand a working pressure of 7 kg/ cm² without leakage.

5.15 The internal hose cabinet shall be fabricated from stainless steel sheet. The cabinet shall have double flap-hinged doors with 5.5 mm clear glass and shall have necessary openings for riser main and brackets for all internals. The

cabinet shall be provided with suitable and robust locking arrangement; the hose cabinet shall be of size to accommodate the following.

- i. Landing valves (Single headed).
- ii. Hose pipe.
- iii. Hose reel (45 meters.).
- iv. Branch pipes, nozzles (2 sets).
- v. Fire man's axe and hand appliances.
- vi. Universal locking arrangement.

The Hose Cabinet shall be fabricated from any of the following (as per BOQ):

- i. 2 mm thick MS sheet duly rust inhibited through a process of degreasing and phosphating and painted in red colour.
- ii. 2 mm thick stainless-steel sheet.
- iii. 3mm thick aluminium sheet powder coated to red colour.

5.16

External hydrants shall be as per IS: 5290 with hand wheel control and an 80 mm diameter pipe stand post. Hydrants shall be located at least 2m away from and within 15m from the building wall. Each hydrant shall be provided with a hose cabinet containing 2 x 15m 38 mm diameter synthetic hoses with couplings. The cabinet shall contain a branch pipe and nozzle.

The cabinet shall be 900 x 600 x 450 mm fabricated out of 2 mm stainless steel sheet or powder coated 3 mm thick aluminium sheet. The cabinet shall be wall-mounted or freestanding with its own steel legs depending on the site conditions and as shown on drawings and as approved.

- i. Single headed yard hydrant valve.
- ii. Hose pipe (2 lengths of 15 m).
- iii. Branch pipes, nozzles (2 sets).
- iv. Fire man's axe.
- v. Universal locking arrangement fabricated from 3 mm thick aluminium sheet and postal red coated with 6 mm thick plain glass in front.

5.17

The fire brigade connection shall consist of four headed inlets, as specified in BOQ, 63mm diameter outlets with built-in check valve and drain plugs connected to a 150mm diameter outlet connection to the water reservoir or to the hydrant main. The fire brigade collecting head shall conform material and performance to IS: 904-1983 "Specification for 2-way,3-way and 4-way suction collecting heads for fire fighting purposes". These are provided for connection of fire service hose pipes for either directly pressurizing the system with their pumps or filling water in the tank from a distance. In the first case non return valve with butterfly valve shall be provided for holding water pressure. Fire service inlet shall be provided with each wet riser/down comer and the ring main. The typical arrangement shall be as per CPWD specification part V (Wet Riser and Sprinkler System). These are fixed to 150 mm dia pipe and located in SS Box made of 2 mm thick SS sheet with open able glass cover, these shall be as per IS 904.

6.

Pipe Joints

Flanged/GI Coupling joints shall be provided for connections to valves, pumps, air vessels etc. and on straight lengths at suitable points to facilitate erection and subsequent maintenance. GI flanges shall be in accordance with Table-17 of IS: 6392 "Plate Flanges for Welding" and flange thickness shall be as under. Gasket thickness shall not be less than 3 mm.

Table 05

Pipe dia	Flange Thickness
200 mm	24 mm
150 mm and 125 mm	22 mm
100 mm and 80 mm	20 mm

65 mm	18 mm
40 mm and below	16 mm

All hardware items such as Nuts, Bolts and plate/spring Washers shall be of G.I and appropriate size. Washers shall be used on both sides of the bolt.

7. Valves & Other Accessories

7.1 Butterfly Valve

Butterfly valve conforming to IS: 13095 shall be provided. All valves shall be suitable to withstand the pressure in the system and rating shall be PN. 16. All valves shall be right handed (i.e. handle or key shall be rotated clockwise to close the valve), the direction of opening and closing shall be marked and an open/shut indicator shall be fitted.

i. The material of valves shall be as under:

- Body - Cast iron
- Disc -Cast Bronze or Stainless Steel Seat - Either integral or Nitrile rubber O-ring - Ring- Nitrile/Silicon

ii. Non return valves shall be swing check type in horizontal run and lift check type in vertical run of pipes.

iii. Air release valves shall be of gunmetal body.

7.2 Non-Return Valve

Non-Return valves shall be double flanged with cast iron body and gunmetal internal parts conforming to IS: 5312 and IS: 778.

7.3 Pressure Relief Valve

Each System shall be provided with a Pressure Relief Valves. The valve shall be spring actuated and set to operate as per field requirement. The Valve shall be constructed of bronze and provided with an open discharge orifice for releasing the water. The Valve shall be open lift type.

7.4 Differential Pressure Switch

The pressure switches shall be employed for starting and shutting down operation of pumps automatically, dictated by line pressure. The Pressure Switch shall be diaphragm type. The housing shall be die cast aluminium, with SS 316 movement, pressure element and socket. The set pressure shall be adjustable. It shall be suitable for line pressures up to 15 kg / cm². The scale range for cut in and cut out shall be from 0 to 10 kg / cm².

The Switch shall be suitable for consistent and repeated operations without change in values. It shall be provided with IP: 66 water and environment protection.

The enclosure shall be of aluminium and pressure element and wetted parts shall be of stainless steel. The switch shall be snap acting type with 1 number NO / NC contact.

7.5 Pressure Gauge

Glycerine filled pressure gauges shall be provided. Pressure gauges shall be of minimum 100mm diameter, threaded chromium plated brass ring with heavy glass, bronze spring tube, precision movement and micrometer adjustment. Pulsation dampeners, steel pipe fittings and shut off cocks of needle point globe type, all brass, rated for 1035kPa working pressure shall be provided. Pressure gauges shall be installed with gauge cocks mounted in a location where they can be easily read. Pressure gauges shall be complete with built-in compensators for fluctuation in external factors such as temperature, humidity etc.

Pressure gauge shall be provided near all individual connections of the hydrant system with isolation valves and near each flow switch assembly of the sprinkler system. The gauge shall be installed at appropriate height for easy readability.

The pressure gauge shall be duly calibrated before installation and shall be complete with siphon & shut off valve.

7.6 Ball Valve

The Ball Valve shall be made from die cast brass and tested to 14 Kg/cm² pressure. The valve shall be internally threaded to receive pipe connections.

The Ball shall be made from brass and machined to perfect round shape and subsequently chrome plated. The seat of the valve body- bonnet gasket and gland packing shall be of Teflon.

The handle shall be of chrome-plated steel with PVC jacket. The handle shall also indicate the direction of 'open' and 'closed' situations. The gap between the ball and the Teflon packing shall be sealed to prevent water seeping up to 14 Kg / cm² pressure.

The handle shall also be provided with a lug to keep the movement of the ball valve within 90 degree. The lever shall be operated smoothly and without application of any unnecessary force.

7.7 **Air Release Valve**

~~Air Release Valve shall be gun metal and minimum test pressure of 20 bar.~~

Air release valves with **ball valve shall** be provided in the piping system for venting trapped air with a size of 25 mm for pipes up to 100 mm and 40 mm for larger pipes and no of cycle minimum more than 2000.

7.8 **Air Vessel Tank**

Air vessel tank shall be provided on top of each riser and shall be fabricated out of 6 mm thick M.S. Sheet. The ends shall be dished fabricated out of 8 mm thick M.S sheet. This shall be of 450 mm dia, 2 meter height and installed vertically on suitable legs. The legs shall be provided with M.S. Plate of size 75 mm x 75 mm x 5 mm at the bottom so that the legs do not puncture the roof. The legs shall be grouted in Cement Concrete (1:2:4 parts of cement, sand & aggregate) foundation. Flange connection shall be provided for connection with wet riser pipe. Air release valve and pressure gauge with shut off valve shall be provided. The air vessel shall be tested at 25 kg/cm² pressure before installation.

Air vessel tank shall be provided with inlet & outlet flanged connections pressure switches with valve to operate as per operating sequences including 80 mm dia drain valve, air release valve with stopcock on the top duly painted with two coats of anticorrosive primer inside and outside, epoxy paint inside, two coats of postal red enamel outside of approved make and outside complete as required.

7.9 **Strainers**

Strainer shall be installed at the outlet of each water tank, water pump inlets, water gong inlets, other areas where necessary. Strainers shall be of "Y-type" flanged end, with stainless steel mesh of not less than 2mm x 2mm mesh. The bodies shall be of cast iron, with drain plug and end flange for draining and cleaning out purpose.

7.10 **Orifice Plates**

For restricting pressure at lower levels in the sprinkler system, orifice plates of appropriate sizes shall be fitted at different floor levels, at the branching points from Riser Main.

The Diameter of such orifice shall not be less than 50% of the dia of pipe into which it is to be fitted, which shall not be less than 50 mm dia. These orifice plates must be of stainless steel with plain central hole without burrs and the thickness shall be 3 mm for pipe size up to 80 mm, 6 mm for pipes from 80 to 125 mm dia. and 9 mm for pipes greater than 125 mm dia. Such orifice plate must have a projecting identification tag.

The orifice plate shall fitted not less than two pipes internal diameters downstream of the outlet from any elbow or bend.

Contractor shall submit the design and identify location on drawing before installation.

8. **Installation**

The installation work shall be carried out in accordance with the detailed drawings prepared by the contractor and approved by the Engineer.

In pipe above ground level, expansion loops or joints shall be provided to take care of expansion or contraction of pipes due to temperature changes.

Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to. Open ends of piping shall be blocked as soon as the pipe is installed to avoid entrance of foreign matter.

Piping installation shall be supported on or suspended from structure adequately. The contractor shall provide clamps and hangers etc as per requirement. Proper lines and levels shall be maintained while installing exposed pipes.

Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress on the pipes.

Anti-vibration pads, springs or liners of resilient and non-deteriorating material shall be provided at each support, so as to prevent transmission of vibration through the supports.

Pipe sleeves of diameter larger than the pipe by least 59 mm shall be provided wherever pipes pass through walls and the annular spaces shall be filled with felt and finished with retaining rings. The space in the floor cut outs around the pipe work shall be closed using cement concrete (1:2:4 mix) or steel sheet, from the fire safety considerations, taking care to see that a small annular space is left around the pipes to prevent transmission of vibration to the structure. Riser shall have suitable supports at the lowest point.

Underground pipe shall be laid at least 2 meter away from the face of the building preferably along the roads and foot paths. As far as possible laying of pipes under road, pavement and large open spaces shall be avoided. Pipes shall not be laid under building and where unavoidable, these shall be laid in masonry trenches with removable covers.

To facilitate detection of leak and isolation of defective portion of pipe, valves shall be provided in underground pipe at suitable locations. As far as possible such valves shall be provided over ground. If the valves are to be provided below ground, suitable masonry chamber with cover plate shall be provided with the approval of the Engineer. Locations where vehicles can pass shall be avoided for provision of valve below ground.

Pipe over ground shall be painted in red colour shade no. 536 of IS: 5. Suitable identification shall be provided to indicate the run of underground pipe wherever the route of underground pipe cannot be ascertained from the location of yard hydrant/isolating valves.

It shall be made sure that proper noiseless circulation is achieved in the system. If proper circulation is not achieved due to air-bound connections, the contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification, including the tearing up and refinishing of floors, walls etc. as required.

9. **Pressure Testing**

All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure, but not less than 10 kg/cm² for a period not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer.

Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

System may be tested in sections and such sections shall be securely capped.

Pressure gauges may be capped off during pressure testing of the installation.

10. **Pipe Supports**

For installing pipes vertically or horizontally inside the building standard pipe supports of reputed make shall be used. Following supports shall be used.

- Split pipe support clamps with rubber lining for vertical, horizontal and roof hanging.
- Clevis Hangers for horizontal supports to adjust varying heights.
- Sprinkler Hangers for horizontal supports for pipes from 15 mm dia to 150 mm dia.

Fasteners and fully threaded rods shall be used for installing the pipe supports. The sizes of pipe supports and installation shall be in accordance with manufacturer's recommendations. Typical supports shall be as per CPWD specification part V (Wet Riser and Sprinkler System).

For pipes of size 100 mm and above, with the prior approval of Engineer, 'U' clamp with dash fastener may be used for supporting horizontal pipe from ceiling.

Pipes running horizontal shall be supported from structural beam/slab by using appropriate GI clamps / MS angles with anchor fastener, bolts etc as approved by Engineer.

The spacing of supports shall be as follows:

Table 06

Internal Dia (mm)	Spacing (mm)
15	1800
20,25	2400
32	2700
40-50	3000
65-80	3600

100	4000
150	4500

Supports for horizontal piping longer than 15m in a stretch shall be provided with swivel clamps. Otherwise, the clamps shall be universal clamps or rigid clamps as required by the Engineer

Fixing of clamps/rails etc. - All clamps, rails and accessories shall be fixed to the structure (beam, slab, walls etc.) by using approved good quality anchor fasteners/ suitable GI angles of appropriate size.

11.

Painting

All exposed piping for firefighting shall be distinctly painted 'Fire red' shade 536 to IS: 5- 2004. Pipes shall first receive two coats of red oxide primer uniformly applied and two coats of oil paint applied thereafter. All pipes support shall be painted black as specified for support & clamps.

Painting Schedule - All equipment and piping shall be painted in accordance with the following colour code:

All surfaces to be painted shall be thoroughly cleaned with wire brush to remove completely rust and other extraneous substances. Over the cleaned surfaces one coat of red oxide primer shall be applied completely covering the exposed surfaces. Finishing coat of enamel paint shall be applied one day after the prime coat, after ensuring that the paint is dry. The second coat shall be done before the installation is handed over and after approval to do so from the Engineer-in-charge.

Corrosion protection tape shall be wrapped on M.S. Pipes to be buried in ground. This corrosion protection tape shall comprise of coal tar/asphalt component supported on fabric of organic or inorganic fibre and minimum 4 mm. thick and conform to requirement of IS: 10221-Code of practice for coating and wrapping of underground GI pipe line. Before application of corrosion protection tape all foreign matter on pipe shall be removed with the help of wire brush and suitable primer shall be applied over the pipe thereafter.

The primer shall be allowed to dry until the solvent evaporates and the surface becomes tacky. Both primer and tape shall be furnished by the same manufacturer. Corrosion protection tape shall then be wound around the pipe in spiral fashion and bounded completely to the pipe. There shall be no air pocket or bubble beneath the tape. The overlaps shall be 15 mm. and 250 mm. shall be left uncoated on either end of pipe to permit installation and welding. This area shall be coated in-situ after the pipe line is installed. The tapes shall be wrapped in accordance with the manufacturer's recommendations. If application is done in cold weather, the surface of the pipe shall be pre- heated until it is warm to touch and traces of moisture are removed and then primer shall be applied and allowed to dry.

Table 07

Sl. No	Equipment	Colour
a	Pump motors	Fire Red Shade No.536 to IS: 5 -2004
b	Internal piping	- do -
c	Landing valves & Hose reel cabinets	- do -
d	External Hydrants	- do -
e	Fire brigade connection	- do -
f	Priming tank	- do -
g	Air vessel	- do -
h	Electric panels	Black & Red
i	Fire Alarm Panel	Black & Red

j	Repeater panel	Black & Red
k	Break Glass Unit	Fire Red
l	Hooters/Speakers	Fire Red
m	Sprinkler pipes	Fire Red

12. Testing & Commissioning

All piping after installation shall be tested for a hydrostatic test pressure of 10.5 kg/cm² or 1.5 times the working pressure (whichever is less) maintained for 24 hours. All joints and valves shall be checked for leaks and rectified and retested. During testing all valves except drain & air valves shall be kept fully open.

Piping repaired subsequent to the above pressure test shall be re-tested in the same manner. System may be tested in sections and such sections shall be securely capped.

Pressure gauges may be capped off during pressure testing of the installation.

13. Makes of Materials

For makes of materials refer to list of approved makes of material.

14. Mode of Measurement

All external piping shall be measured along the centre line of the pipe and paid per unit length and shall include

- All pipes & fittings
- Bituminous coating

All internal piping shall be measured similarly but shall include for the pipe supports and clamps.

All valves, air valves, drain valves together with flanges or tail pieces shall be measured per unit.

All excavation and concrete supports and thrust blocks shall be measured as per drawing and paid for per cum.

The cost of pipe supports described above form part of the rate quoted for piping and no extra shall be payable on the account.

All painting shall form part of the cost of equipment piping etc. No separate payment shall be admissible.

15. Firefighting Accessories:

15.1. Scope

This chapter covers supply, installation, testing and commissioning landing valves, first aid hose reels, hose pipes, branch pipes etc., which are vital tools for fire fighting.

15.2. Landing Valve

Landing valves are provided in the system for connection of hose pipes for discharging water for fighting fire by fire brigade or trained personnel.

Sl no	Description
i.	The landing valves shall be as per I.S.: 5290
ii.	The landing valves are of single and double head outlet types
iii.	Material of construction
iv.	Body, outlet and cap etc - Stainless steel
v.	Spindle - Stainless steel for stainless steel body
vi.	Hand wheel - Cast iron

The water discharge shall be not less than 900 Lpm for single head at 7 kg/cm² pressure.

Installation

- i. The landing valve shall be fitted to a T connection of the riser at the landing in such a way that the valve is in the centre of the internal hydrant opening and at a height of 1 meter from floor level.
- ii. The valve base shall be vertical and the valve facing outside. There should be no hindrance in operation of the handle.

15.3. First Aid Hose Reel

First Aid Hose Reel is meant for delivering small quantity of water in early stage of fire and can be operated even by untrained personnel, and thus provides a most effective firefighting facility. It consists of a length of 45 meters and 25 mm dia mm (nominal internal) hose tubing warped around a reel with water inlet pipe, stop valve and 7 mm shut off nozzle. The entire assembly is mounted on a wall bracket and can swing 180 degree. The water inlet is connected to the riser pipe by means of 37 mm socket and valve. The hose tube can be pulled out easily for the purpose of discharge of water on fire.

First aid hose reel shall be as per IS- 884. The coupling, branch pipe and nozzle shall be as per IS: 8090

- Material of Construction:
- Hub and sides : Mild steel
- Wall Bracket : Mild steel.
- Hose tube (25 mm)
- (Nominal Internal dia) : Thermoplastic (Textile Reinforced) Type-2. As per IS-12585
- Nozzle with branch Pipe : Stainless Steel.
- Stop Valve (Ball Valve) : Gunmetal.

Normally M S construction is used, other material may be used in areas having corrosive atmosphere.

The water flow rate shall be not less than 24 LPM and the range of jet shall be not less than 6 meter.

First aid hose reels are installed with internal hydrant within in fire hose cabinet space for which is provided as per architectural drawing. First aid reel drum and brackets etc. shall be painted with two coats of anti corrosive paint & two coats of enamel paint of shade No. 536 of IS: 5. The size of the fire hose cabinet shall be such that there is no obstruction in swinging the hose reel. The location of cabinet shall be such that it does not form an obstruction in passage/escape route.

The length of hose tube shall be such that the nozzle of the hose can be taken into every room and within a range of 6 meter from any part of the room. The length of hose tube shall be such that the nozzle of the hose can be taken into every room and within a range of 6 meter from any part of the room. The inlet valve-shall be at 900 mm above floorlevel. Hose reel bracket should be firmly grouted on the wall with the help of raw bolts.

15.4. Fire Hose Delivery Coupling, Branch Pipe and Nozzles

Material of Construction: Stainless Steel Delivery Hose Couplings

The delivery hose couplings consist of male half coupling and female half coupling. Grooves are provided on outer side on both coupling for binding hose pipes with wires. In female coupling spring loaded cam tooth is provided for holding male half coupling in position. Male half coupling and female half coupling are provided on both sides (ie. on one side male and on other side female) of hose-pipes. Two or more pipes can be joined together with the help of these couplings instantaneously.

Sizes: - These are available in 63 mm dia.

Branch Pipe and Nozzle: - Branch Pipes with nozzle are mounted at the end of hose pipe. Branch pipe is properly finished and free from sharp edges. During operation a fireman has to hold the branch pipe. One end of branch pipe is fixed with hose coupling and the other end is threaded to fit the nozzle.

Nozzle is tapered pipe with one end threaded internally which is fixed on branch pipe. The size of other end i.e. nozzle shall be 20 mm (nominal internal diameter).

15.5. Fire Service Inlet and Fire Service Connection

These are provided for connection of fire service hose pipes for either directly pressurizing the system with their pumps or filling water in the tank from a distance. In the first case non return valve with butterfly valve shall be provided for holding water pressure. Fire service inlet shall be provided with each wet riser/down comer and the ring main. The typical arrangement shall be as per CPWD specification part V (Wet Riser and Sprinkler

System). These are fixed to 150 mm dia pipe and located in MS Box made of 2 mm thick mild steel sheet with open able glass cover.

These shall be as per IS: 904.

Material of Construction – Copper Alloy

15.6. Hose Pipe:

Hose pipes shall be rubber lined woven jacketed and 63 mm in diameter. They shall conform to Type A (Reinforced rubber lined) of IS: 636. They shall be flexible and capable of being rolled. Length of hose pipe will be 15 m.

The hose pipe shall be complete with male and female coupling at the ends.

Besides keeping hose pipe with internal hydrant and yard hydrant spare hose pipes along with branch pipes shall be kept in fire control room/pump room.

16. Automatic Sprinkler System

16.1. Scope

This chapter covers the general requirement of selection, design, installation, testing, commissioning and maintenance of automatic sprinkler system for fire fighting in buildings used for other than industrial and storage purpose.

References: For additional information regarding definitions, planning, design, hydraulic calculations, tables etc. following documents are to be referred to.

IS: 15105:- Design and Installation of Fixed Automatic Sprinkler, Fire Extinguisher Systems - Code of Practice.

IS: 9972:- Specification for Automatic Sprinkler Heads for Fire Protection Service

16.2. Introduction

Fire fighting installations are to be operated manually. Delay in undertaking manual operation due to late detection and or response, may result in spread of fire. In automatic sprinkler system, sprinkler heads are provided through out the areas to be protected at specified locations such as roof or ceiling, walls, between racks, below obstructions and fitted with water supply lines permanently charged with water under specified pressure. The sprinklers operate at pre-determined temperature to discharge water over the affected area below and provide an adequate distribution of water to control or extinguish fire. Only those sprinklers which are in the vicinity of fire that is those become sufficiently heated operate. Operation of sprinkler results in flow of water which initiates fire alarm. Thus sprinklers perform two functions i.e. first to detect fire and then to provide an adequate distribution of water to control or extinguish it. Water distribution from ceiling level, cools down the hot gas which forms beneath the ceiling of enclosure in which fire is developing. This will prevent spread of fire to adjoining areas and contain damage to limited area.

It should not be assumed that the provision of sprinkler system entirely obviates the need for other means of fighting fire and it is important to consider the fire precaution in the premises as a whole.

The system shall be installed only where there is no danger of freezing of water in the pipes at any time. Typical layouts of sprinklers shall be as per CPWD specification part V (Wet Riser and Sprinkler System).

16.3. Classification of Occupancies

Sprinklers are provided in industrial and non-industrial buildings. The design of sprinkler installation depends upon type of occupancy. Buildings are categorized under the following classes for the purpose of designing the installations in IS 15105.

- Light hazard class.
- Moderate / ordinary hazard class.
- High hazard class.
- Storage hazards.

All non-industrial buildings are classified under light hazard class with the condition "If any occupancy or block within light hazard risk is larger than 125 sq.m. in area or having an area less than 125 sq.m but not bound on all sides by masonry or RCC walls raised up to roof, the building should be classified as moderate hazard.

Airport terminal buildings, car parking areas within building or basement, departmental stores/retail shops are also

classified under moderate/Ordinary hazard class.

In order to satisfy above conditions, all non-industrial buildings shall be designed under moderate hazard class. Accordingly these specifications cover moderate/Ordinary hazard class only.

16.4. Selection of Orifice Size

In moderate hazard applications, sprinklers of orifice size 15 mm. shall be used.

16.5. Flow Switch

Flow switch shall have a paddle made of flexible and sturdy material of the width to fit within the pipe bore. The terminal box shall be mounted over the paddle / pipe through connecting socket. The switch shall be potential free in either NO or NC position as required. The switch shall be able to trip and make / break contact on the operation of a single sprinkler head. The terminal box shall have connections for wiring to the Annunciation Panel. The flow switch shall have connections for wiring the seat shall be of S.S to the Annunciation Panel. The flow switch shall have IP: 55 protections.

The flows switch work at a triggering threshold bandwidth (flow rate) of 4 to 10 GPM. Further, it shall have a "Retard" to compensate for line leakage or intermitted flow. The contractor to interface with Electrical Contractor for providing conduct for flow switch cable on required.

16.6. Inspection and Test Valve Assembly

Inspection and testing of the automatic starting of the sprinkler system shall be done by providing an assembly consisting of gunmetal valves, gunmetal sight glass, bye-pass valve and orifice assembly as per approved drawing.

16.7. Sprinkler Type

Sprinklers shall be as per IS: 9972 and following types.

According to type of discharge as per page 90 of CPWD specification part V (Wet Riser and Sprinkler System).

- Conventional pattern.
- Spray pattern.
- Side wall pattern.

According to mounting pattern.

- Conventional pattern.
- Spray pattern.
- Side wall pattern.

According to Release Mechanism.

- Conventional pattern.
- Spray pattern.

According to Orifice Size

- 10 mm.
- 15 mm.
- 20 mm

According to Temperature Rating. Sprinkler shall have one of the following temperature rating and shall be correspondingly colour coded.

i. Fusible Link Type

Table 08

Temp. Rating °C	Colour code
68/74	Natural
93/100	White
141	Blue
182	Yellow

227	Red
-----	-----

ii. Glass Bulb Type

Table 09

Temp. Rating °C	Colour of bulb
57	Orange
68	Red
79	Yellow
93	Green
141	Blue
182	Maroon
204/260	Black

17. Electrical Works

17.1. Scope

This chapter covers the supply, installation, testing and commissioning for the electrical works associated with fire fighting installations, namely, motors, switch boards, power cabling, control wiring, earthing and remote control-cum-indicating panels.

17.2. General

This chapter covers the supply, installation, testing and commissioning for the electrical works associated with fire fighting installations, namely, motors, switch boards, power cabling, control wiring, earthing and remote control-cum-indicating panels. Unless otherwise specified in the tender specifications, all equipment's and materials for electrical works shall be suitable for operations on 415 V I 240 V \pm 10% (3 phase/single phase), 50 Hz. AC system. All electrical works shall be carried out complying with the Indian Electricity Rules, 1956 as amended to date. All materials and components used shall conform to the relevant IS specifications amended to date.

17.3. Power Supply

Following 3 phase, 415 Volt, 50 Hz. supplies shall be made available for fire- fighting installations directly from sub-station. Essential supply for fire pumps. In buildings where power failures are likely to be for long duration, in order to facilitate operation of Pump and maintain pressure in the system, essential supply for Pump and control shall be made available in the pump house. Power cable of adequate size shall be laid from the sub-station directly to the switch board of above pumps. Independent supply shall be provided for water supply pumps, if installed in the same pump house. The power supply for fire fighting is not to be used for any other purpose. If the fire pump house, is away from the sub-station building, the route of the cable shall not pass under the building or permanent structure. Cable shall be laid along the route which is safe from fire. Sufficient spare power shall always be available to drive pumping sets at all times throughout the year. Suitable capacity ACB/MCCB/Fuse Switches/Switch Fuses shall be provided in the electrical panel for extending supplies to fire pumps. Such switches shall be suitably marked with "FIRE SWITCH" and shall not be switched off without permission/intimation to appropriate authority. In case any maintenance work is to be carried out on the electrical panel where from supplies to fire pumps have been extended, alternative arrangement shall be made to ensure that power supply to fire pumps continue to be available for operation any time.

17.4. Motor Starter

The motor starter shall conform to IS: 1822 "Motor starters of voltage not exceeding 1000 volts" and shall be air insulated and suitable for 415 V, \pm 10%, 50 Hz., 3 phase AC supply and shall be integrated in the panel.

Starter for the motor shall be direct on line (D.O.L) for motors up to and including 5.0 KW. Rating and automatic star-delta type for motors of higher ratings unless otherwise specified in the tender specifications.

Each starter shall be provided with the following protections: -

Thermal overload on all the three phases with adjustable settings

Independent single-phase preventer (current sensing type).

Adequate number of extra NO / NC contacts for interlocks, indicating lamps, remote operation etc. shall be provided on the starter / contactor.

Under voltage/No volt trip shall not be provided.

17.5. Switch Boards

The main switch board shall be floor mounted, free standing or wall mounted cubical type and shall be factory built fabricated by one of the approved switch board manufacturer. The board shall be fabricated from 2.0 mm. thick CRCA sheet and powder coated after 7 tank treatment process. The board shall be fabricated with IP 42 degree of protection. It shall be suitable for termination of the incoming cable(s) from bottom.

The capacity of switch gear shall be suitable for the requirements of motor fed/ controlled. Starting currents shall be duly considered.

Switch fuse units shall be used up to and including 32 A and SDFU shall be used for 63 A and above. ACB shall be used for 630 A and above ratings. Alternatively MCCBs of appropriate fault level may be provided.

All switch fuses/SDFU shall be of AC 23 duty as per IS: 4064-1978 as amended up to date. They shall be complete with suitable HRC cartridge type fuses.

Switch boards shall house starters for motors with independent current sensing type single phase preventer for each starter.

Volt meter with selector switch, a set of indicating lamps and fuses for voltmeter and lamps shall be provided. Ammeter with CTs, and selector switch shall be provided with each motor starter. Instruments shall be flush mounted with the panel and have a class index not higher than 1.0. The instruments and accessories shall be provided whether or not specifically indicated in the tender specifications. The fabrication of switchboard shall be taken up only after the drawings for the fabrication of the same are approved by the Engineer. The layout shall be designed for convenient connections and inter-connections with the various switchgear. Connections from individual compartments to cable alleys shall be such as not to shut down healthy circuits in the event of maintenance work becoming necessary on a defective circuit. Care shall be taken to provide adequate clearances between phase bus bars as well as between phase bus bars, neutral and earth. Where terminations are done on the bus bars by drilling holes therein, extra cross section shall be provided for the bus bars. Alternatively, terminations may be made by clamping. Provision shall be made for proper termination of cables at the switchboards such that there is no strain either on the cables, or on the terminators. Cables connected to the upper tiers shall be duly clamped within the switchboard. Identification labels shall be provided against each switchgear and starter compartment, using plastic /aluminium engraved labels. Metallic danger board conforming to relevant IS shall be fixed on each electrical switchboard.

17.6. System Controller

For controlling operation of pumps and indicating fault, system controller shall be provided. The system controller shall consist of relays timer, contactors etc and shall be designed to operate the fire pumps with interlocking and fault indication. Annunciation window shall be provided to indicate following faults Low water level in terrace tank.

Main pump failed to start.

Main pump failed during operation.

Supply to Main Pump failed

Supply to Terrace Pump failed.

Suitable sensors, differential pressure switches, monitors shall be provided at respective location. The control system shall be operational on 12 Volt/24 Volt DC batteries. Battery chargers shall be provided to ensure that the batteries remain, charged. Batteries shall be sealed maintenance free type.

17.7. Remote Indicating Panel

The remote indicating panel shall be provided in the fire control room. This panel shall have necessary status indication of all electric motors.

Back indication to show the status of operation of all the motors and also pressure in the system, water level in underground and over head tank etc. shall be provided.

Panel shall be fabricated from not less than 2.0 mm thick CRCA sheet and powder coated after 7 tank treatment process. The panel shall be dust, damp and vermin proof. This shall be of wall mounting type. This shall be complete with necessary termination arrangements, multi core cables, tag blocks, control transformer, designation plastic.

Labels, double earth studs etc. as required.

17.8. Power Cabling

Unless otherwise specified, the power cables shall be FRLS, XLPE insulated, PVC outer sheathed copper/aluminium conductor, armoured cables 1100 V grade. The power cables shall be of 2 cores for single phase, 4 core for sizes up to and including 50 sqmm, 3-1/2 core for sizes higher than 50 sqmm for 3 phase. All cable below 50 sqmm size shall be with copper conductor and 50 sqmm & above shall be with aluminium conductor.

Power cables shall be of sizes to meet the starting and running current of motors fed and shall be as approved by the Engineer, after taking into consideration the load, the length of cabling.

Cables shall be laid in suitable metallic trays suspended from ceiling, or mounted on walls. Cable ducts shall not be provided in pump rooms. Cable trays shall be of perforated steel sheet with adequate structural strength and rigidity. Necessary supports and suspenders for cable trays shall be provided by the contractor as required.

17.9. Control Wiring

Control wiring shall be done using ISI marked FRLS PVC insulated and PVC sheathed, 2.5 sqmm, 1100 V grade, armoured multi-core copper conductor cable. The control cable shall also be laid in the same manner as power cable.

Runs of control wires within the switchboard shall be neatly bunched and suitably supported/clamped. Means shall be provided for easy identification of the control wires.

Control wiring shall correspond to the circuitry/sequence of operations and interlocks approved by Engineer.

17.10. Earthing

All equipment will be connected on main earth terminal of Electrical works.

17.11. Painting:

All Hydrant and Sprinkler pipes shall be painted with post office red colour paint. All M.S. pipes shall first be cleaned thoroughly before application of primer coat. After application of primer coat two or more coats of enamel paint shall be applied. Each coat shall be given minimum 24 hours drying time. No thinners shall be used. Wherever required all pipe headers shall be worded indicating the direction of the pipe and its purpose such as "TO RISER NO.1" etc.

Painting shall be expertly applied, the paint shall not over run on surfaces not requiring painting such as walls, surfaces etc. Nuts and bolts shall be painted black, while valves shall be painted blue.

17.12. Portable Fire Extinguishers

17.12.1 Scope

The scope of work covers the supply and installation of portable fire extinguishers. The following types are envisaged in these specifications and provided as shown in the schedule of portable fire extinguishers:

- Dry ABC powder extinguisher (6kg / 5kg)
- Carbon-dioxide extinguisher (4.5kg)
- Mono ammonia phosphate extinguisher
- Water expelling type.
- Carbon dioxide fire extinguishers trolley mounted (22.5kg)
- Foam type fire extinguisher trolley mounted. (22.5kg)

17.12.2 Standards

The following standards and rules and regulations shall be applicable:

Table 10

(a)	IS: 15683 – 2003	Portable fire extinguisher Dry power type
(b)	IS: 15683 - 2004	Portable fire extinguisher carbon-dioxide type
(c)	Local Fire Brigade/Authority	

17.12.3**Extinguishers****I. Dry Powder Type**

The extinguishers shall be of 2, 6 and 10 kg capacity, cartridge type unless otherwise specified.

The body shall be of cold rolled carbon steel grade D, 1.5mm thick up to 5 kg and 2mm for 10 kg. The construction shall be similar to 'Soda Acid type' but of the following dimensions:

Table 11

Capacity (kg)	Outside diameter (mm)	Filler opening (mm)
2	100	45
6	150	45
10	175	45

The discharge fitting shall be with 500mm, 10mm diameter hose up to 5 kg and 750 mm,

12.5 mm diameter for 10 kg with a trigger controlled nozzle capable of discharging 85% of the contents as follows:

Table 12

Capacity (kg)	Time (sec)	Throw (m)
2	8 – 10	2
6	15 – 20	4
10	23 – 30	6

A carbon dioxide cartridge conforming to IS: 4947 - 1985 shall be fitted in a cartridge holder with an inner shell. A spring loaded piercing device shall be provided in the cap for piercing the seal of the gas cartridge. A siphon tube of copper or PVC shall be provided for upright operation. The cap and neck ring shall be similar to Soda Acid type extinguisher.

All internal and external components and surfaces shall have anti-corrosive coating of not less than 12 microns applied uniformly as indicated below:

3. Table 13

(a)	Body	Mild steel	Tin alloy
(b)	Cage for acid bottle and spring	Brass sheets	Lead or tin alloy
(c)	Discharge fittings	Leaded – Tin Bronze	Tin alloy
(d)	Strainer	Brass sheets	Lead or Tin alloy

II. Carbon dioxide type.

The extinguishers shall be rated for 2.0 and 4.5 kg by weight of carbon dioxide, unless otherwise stated. The contents shall be with a filling ratio not exceeding 0.667.

The body shall be steel Cylinder made according to IS:7285 -2002 and approved by the chief controller of explosives.

The discharge head shall be simple and safe to operate conforming to IS: 3224 - 2002 with a safety release as per

IS: 5903 - 1970 set to 18.0 to 20.0 N/mm². A siphon tube of copper or PVC shall be fitted. A non-conducting discharge horn and a high-pressure hose (27.5 N/ mm² pressure) shall be fitted with each extinguisher.

The discharge system shall be designed to expel 95% of the contents in continuous discharge as follows:

Table 14

Capacity (kg)	Time (Sec.)
2	8 – 18
3	10 – 20
4	9– 24

III. Water Co2 Fire Extinguishers.

The extinguishing medium shall be primarily water stored under normal pressure, the discharge being effected by release of carbon dioxide gas from a 60 gms cylinder.

The capacity of the cylinder when filled shall be 9 litres \pm 5 %.

The cylinder shall be fabricated from MS sheet, welded at seams, with dish and dome, being of same thickness and of size not exceeding the diameter of the body. The neck shall be externally threaded with leaded tin bronze.

The cap shall be of leaded tin bronze. The siphon tube shall be of brass or GI. The cartridge holder, knob, discharge fittings and plunger shall be of leaded tin bronze and plunger of stainless steel with spring of stainless steel. The discharge tube shall be of braided nylon, of 10 mm diameter and 600 mm length with a brass nozzle.

The extinguisher shall be treated for anti corrosion internally and externally and painted fire red externally. The cartridge shall be IS marked. The Extinguisher body shall be tested to 25-bar pressure for 2 minutes. The Extinguisher shall be IS: 940 – 2003 marked.

17.12.4 General Requirements

All extinguishers shall be standard products, approved by the Tariff Advisory Committee and Local Fire Authority, manufactured and tested strictly in accordance with the relevant Indian Standard. All markings and test results shall be stamped in the appropriate colour markings according to the Indian Standards.

All extinguishers shall have a structurally designed galvanized steel handle and a suitable wall-mounting bracket.

17.12.5 Mode of Measurement

Each extinguisher with its mounting bracket/stand shall be measured per unit and paid for.

17.12.6 Makes Of Materials

For makers of materials refer to list of approved makes of material.

18. Clean Agent Gas & Its Grouping/ Distribution

18.1. Scope

The scope covers supply, installation, testing and commissioning of automatic clean agent flooding system complete for electrical panels (Main distribution panel, Essential power panel, Fire Pump Panel and any other panel as decided by Engineer in Charge) with fire trace tube, cylinder, valves, integration with fire alarm control panel for annunciation. The work shall cover:

- Providing fire trace tube inside the panels.
- Arrangement of Clean agent for flooding of the required panels.
- Audio-visual annunciation devices for indicating incidence of fire.
- Wiring from alarm initiating devices to the above mentioned panels with required conduits as per direction of engineer-in-charge.
- Any other item required to the successful commissioning of the system.
- Providing manual arrangement for discharge of gas inside the above panels.
- Interfacing of panel flooding with BMS OR other protocol.

The electrical panel fire suppression system shall be complete with Clean Agent gas storage cylinders of required capacities, extinguishing agent as specified, polymer fire trace tubing, filling and end-of-line adaptors, pressure

switches, control equipment and all necessary accessories and fittings to form a complete and working installation to protect the specified areas to the approval of the engineer-in-charge. The panels to be protected shall be determined as per the approval of the engineer-in-charge. This will have an interface with Main Fire Alarm & Control Panel. In case of fire in the concerned Panel, indication & alarm should come in Main Fire Alarm & Control Panel.

18.2. Standards

The design and installation of the clean agent gas based Fire Trace tube system is based on the latest applicable codes and also as per the manufacturer's recommendations; the required clean 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.

18.3. System Features

The system shall generally comply with as under:

The complete equipment design shall be reliable in operation. All components of the installation should be located, installed or suitably protected to ensure that no mechanical, chemical or other damage is possible which may render these inoperative.

The design, manufacturing and installation shall be such that there is no maintenance requirement and shall have built-in features for condition monitoring without requiring opening of any part of the installation. In case it is unavoidable for the vendor, the contractor shall seek approval of the engineer at the time vendor approval with the submittal of maintenance manual.

All devices used in the installation shall be capable of functioning satisfactorily between - 29°C and 45°C.

For enclosed tight electrical equipment, the quantity of clean agent for extended concentration of at least 30% throughout the declaration period or for a minimum of 20 minutes.

All cylinders in the battery shall be interchangeable.

Each cylinder shall be provided with its own valve with a dip tube extending to the bottom inside the cylinder, and valve discharge head, which shall be connected to a common manifold through high pressure connecting pipes or tubes.

Flexible hoses used for discharge bend shall preferably be double wire braided (perforated) rubber covered hose suitable to withstand a minimum bursting pressure of 420kgf/cm² at 54°C.

All discharge heads and valves shall be designed taking into consideration the fact that liquefied carbon dioxide expands very rapidly when discharged. The requirements of minimum flow of gas and the temperature at which these are required to operate shall also be taken into consideration. These shall conform to IS: 3224-2002.

All valves under constant high pressure shall have a minimum bursting pressure of not less than 42MN/m² (420kgf/cm²) and those not under constant pressure shall have a bursting pressure of not less than 35MN/m² (350kgf/cm²).

Discharge heads and valves shall be designed to permit a minimum discharge of 85% of the Clean Agent in the cylinder is not more than 30s at a temperature of 27± 1°C.

Nozzles shall be sufficient in a number and so located that the gas discharge pattern shall completely cover the enclosure.

The nozzles shall be designed and located in such a manner that an even distribution of gas will be achieved throughout the protected space and at the same time the discharge from the nozzles shall not cause undue splashing of flammable liquids or creation of dust clouds that might aid spread of fire.

Panel flooding system shall be integrated with nearby detector, which will send the signal to FACP in case of actuation of Clean Agent gas panel flooding system.

18.4. Features of Fire Trace System

The system shall be simple self-activating system, specifically designed for installation inside enclosures, cabinets and machinery housing to detect automatically and extinguish fire at source, at its very early stage. It should be suitable for application where the potential fire risk is located within an enclosed or confined space e.g. electrical panels etc.

The system should be an automatic self-seeking fire extinguisher, which puts fires where they start by means of a flexible fire detection and delivery tube. The tube shall be manufactured from specially produced polymer material to

achieve the desired detection and delivery characteristics. The system shall have capability of linear detection i.e. detection of fire not only at a single stage point but also at any place along the tube's length.

The path of the fire trace tube inside the panel shall be so selected that it should not get damaged due to functioning of the equipment installed inside the panel.

This extinguishing system should be fully integrated with fire alarm system. The system should consist of a valve, connected to a cylinder and to a flexible detection and delivery system i.e. flexible tube. This tube should be routed within the equipment to be protected. In case of fire, the tube shall melt and bursts at the hottest point and the extinguishing agent is then transported through the Fire trace tube exactly to the origin of fire (i.e. the point of burst).

The system should be simple self-activating system without human intervention and suitable for enclosed spaces like engine room, panels.

The system should have fast response - less than 10 seconds.

The system should extinguish fire at early stage and should trigger automatically and also manually. The system should be safe against malfunction and should not need power supply for detection and extinguishing of fire.

The contractor shall submit the quality assurance plan of the vendor for the design, manufacturing and installation of the arrangement in compliance with the applicable standards followed for bought out item and type test results of others which are manufactured at his end

18.5. Technical Specifications of Fire Trace Tube.

The fire trace tube should be a flexible tube made of special polymer.

The tube should have OD 6mm and ID 4mm or thereabout.

The fire trace tube should be fire red in colour (or as directed by engineer) to indicate it is part of fire protection system.

The tube should be non – conductive, non- corrosive and flexible.

The tube should be capable of withstanding pressure up to 20 bars.

The tube under 12 bar pressure should rupture in case of fire between 5 to 45 sec depending up on the rate of temperature.

The tube must have approval for using to detect fire from Loss Prevention Council.

The tube should be routed inside the panel for detecting fire and over heat. No drilling, soldering or any other damaging activity will be carried out inside the panel for fixing tube to detect the fire.

The Clean Agent gas cylinder should have a valve which should operate automatically, in case the pressure in the Fire trace tube reduces due to fire and bursting. The cylinder should have a different valve which is made of virgin brass with the following specifications:

The valve should be a Direct/indirect high pressure valve.

It should operate on sensing the drop in the pressure.

The valve should hold pressure up to 58 bar.

The valve will have provision for connecting pressure switch, pressure gauge, filling in adapter.

The cylinder will be mounted on automatic weight measurement system.

18.6. System Operation

Designed for simple installation, often very near the source of a potential fire trace is a self- activating detection & suppression system that reliably suppresses fires in few seconds. In the event of fire contacting the fire trace tube, the tube bursts at the hottest point. This leads to a rapid reduction of pressure inside the tubing. This will make the differential high pressure valve fitted on the Clean Agent cylinder open instantaneously and the gas stored in the cylinder will get released through the tube at the burst point into the panel.

The drop of pressure in the tube followed by reduction in the weight of the gas in the cylinder due to the discharge will activate an audio-visual alarm unit which will be interfaced / connected with the fire alarm system.

18.7. Design Criteria

Clean Agent gas based fire trace tube system is proposed for the protection of all the major control panels. The gas system proposed is a direct / indirect release high-pressure system. The required Clean Agent gas quantity and size of the cylinder is selected based on the volume of the protected panel.

18.8. Main Components Of The System

The main features of the system are:

- Automatic detection of fire
- Automatic flooding of clean agent gas.
- Activation of audio visual alarm unit
- Manual release valve option
- Indication & alarm in main fire alarm & control panel

The detection of fire is primarily made by a polymer tube, which can detect the fire anywhere along its length. The tube is highly flexible and can be conveniently routed to cover the various hazard areas in electrical panels.

The polymer tube shall be a fixed temperature sensing tube made up of a polymer material to cater to long term leak resistance, flexibility accurate and consistent heat sensitivity and high pressure withstanding capacity. One end of the fire trace tube is connected to the Clean Agent cylinder and the other end to an end of line adaptor through a non-return valve. The Clean Agent cylinder assembly is mounted on a weight monitoring system.

Pressure switch is connected to the end-of-line adaptor, which is electrically connected to an audio visual alarm unit.

In the event of fire contacting the fire trace tube, the tube starts melting and burst at the hottest point. This leads to a rapid reduction of pressure inside the tubing. This will make the differential pressure valve fitted on the cylinder open out instantaneously and the stored in the cylinder will get released through the tube at the burst point into the panel. The rupturing temperature shall be between 90-degree C and 110-degree C.

18.9. Accessories

The system shall include but not limited to the following.

- Fire trace tube
- Indirect high pressure valves
- Pressure switches
- Spring top
- Alarm units
- Clean Agent cylinder
- Hardware items
- Pressure switch to sense the drop in pressure.
- Filling in adapter to change the tube.
- Ball valve for closing and releasing.
- The spring top to protect the Fire trace tube at the cylinder end.
- Straight fitting for connecting Fire trace tube in case of need.
- Cross fittings
- T fittings.
- Cross panel fittings with external insulating jacket.
- End of line adapter.
- Non return valves.
- D/I adapter

All these accessories shall be supplied along with Fire trace tube for installation.

18.10. Miscellaneous Fire Services Equipment

This Section specifies the manufacture and installation of Miscellaneous Fire Services Equipment which shall be provided according to the Drawings for the completion of the Fire Services Installation. The whole installation shall be installed and commissioned in accordance with DFS requirements.

18.11. Standards

Relevant Codes and Standards

- BS 1042: Measurement of Fluid Flow in Closed Conduits
- Codes and regulations of the jurisdictional authorities

19. Fire Fighter's Protective Gear**19.1. Scope**

This document covers specification for the fire fighter's thermal protective gear providing protection to the fire fighter's upper & lower torso, neck, arms & legs and shall comprise of coat, trouser, gloves, & anti-flash hood.

19.2. Coat and Trouser

The coat and trouser shall be supplied as a matched ensemble providing protection to upper & lower torso, including neck, arms to wrist & legs to the ankles. They shall be of loose fitting to facilitate the ease and speed of dressing and to increase the air circulation. They shall be constructed as multi-layer assembly permanently attached to achieve the specified performance and containing: -

Outer shell fabric

Moister barrier

Thermal liner

19.3. Material

The outer fabric shall be made from inherently flame resistant fibre like meta-aramid or equivalent. It shall be resistant to cut, tear, abrasion and puncture. The moisture barrier shall be made of breathable membrane laminated to flame-resistant carrier fabric providing water and chemical resistance while allowing for perspiration to evaporate. The thermal liner shall be made from inherently flame-resistant fabric such as meta-aramid, which shall be quilted to flame resistant scrim fabric providing insulation from radiant and convective heat. The thread used for stitching shall be of high strength made from inherently flame resistant fibre like meta-aramid. Heavy duty moulded open-end zippers with a single slider with FR zipper tape, hook and loop Velcro fasteners of flame resistance type shall be used.

19.4. Design Features (Coat)

The coat shall have two bellowed pockets each 20 cm long and 18 cm wide positioned at front bottom and attached with two rows of stitching. Storm flaps 6 cm long and 20 cm wide shall be provided for these pockets. The storm flaps shall be secured to the bellowed pockets with Velcro fasteners. One pocket 20 cm long and 9 cm wide and 6 cm deep should be provided on the left side above chest for accommodating a radio set. All pockets shall have small drain holes at the bottom corner. The front closure shall have a heavy duty moulded open end zipper with a single slider with FR zipper tape. A flap shall be provided to cover the zip front closure and be secured by a flame resistant Velcro fastener. The reflective tape 50mm wide should be positioned around the bottom hem, chest and sleeve. Elbow reinforcement patches shall be provided at both elbows. Sleeves shall have knitted cuffs made from inherently flame resistant fibre such as meta-aramid and adjustable tabs secured by FR Velcro shall be positioned at each sleeve hem. All seams shall be two needle seams. The coat shall have written FIRE on the upper back with reflective shape of not less than 20 mm width. The height of letter shall not be less than 150 mm.

19.5. Trouser

Two bellowed pocket each 21 cm long and 17 cm wide shall be positioned on each leg above the knee area using two rows of stitching. The pockets shall have 6 cm long and 19 cm wide flaps secured by two FR Velcro closure patches. Drain hole shall be provided at bottom corner of each pocket.

Knee enforcement patches shall be provided at both knee fronts.

Waist adjustment straps with FR Velcro 5 cm wide and 12 cm long shall be positioned on the waist at both sides. An elastic suspender crossed over the shoulders and secured at the front shall be provided. These shall be attached to the rear to the trouser waist by heavy duty FR meta-aramid thread stitch. The front of the suspender should run through a high density polypropylene male part, quick release buckle, which affixes into a female part and further attached to a loop of main fabric on the garment front.

Fly front closure shall be with FR Velcro closure. Hanger tab shall be positioned on waist at rear.

A 50 mm reflective tape shall be positioned on both legs at the bottom.

19.6. Performance Requirement

All performance requirement criteria as laid down in EN 469 shall be met and a test report to this effect from an independent laboratory/test house of international repute shall be furnished along with the Technical offer.

Size

The coat and trouser shall be supplied in small, medium and large sizes. The exact measurement of chest and waist shall be given at the time of supply order.

19.7. Marking and Labeling

The trouser and coat shall have individual label giving following information: -

Name & Address of manufacturer.

Year of manufacturer.

Wash and care instructions.

Composition of components.

19.8. Gloves

The gloves shall be designed to meet the requirement of EN 659 or equivalent International Standard. The multi-layer gloves shall have the outer shell made of flame and abrasion resistant material and additional layers and liner made of flame resistant fibres such as meta or para-aramid.

The layers shall be such that dexterity and strength are maximized. The cuff should be made with knit Flame resistant material. The gloves shall be stitched with high strength flame resistant thread such as meta or para-aramid.

19.9. Anti-Flash Hood

A universal size, knitted, elasticized, 'balaclavas' type anti-flash hood shall be made of inherently flame resistant fibre such as meta-aramid or having similar properties.

The hood shall be designed to provide head and neck protection against flame contact and must be comfortable to wear. It shall conform to EN 340.

Note

Coat, Trouser, Gloves, and Anti-Flash Hood shall meet the requirements of the standard specified and certificate to this effect from an independent laboratory/test house of international repute shall be furnished along with the Technical offer.

A sample of each item shall also be submitted along with the Technical bid.

20. Installation, Testing and Commissioning

20.1. Scope

This chapter covers the requirement of Installation, testing and commissioning of fire fighting system.

20.2. Preparation and Approval Of Drawing

On award of the work, the contractor has to prepare working drawings and submit to the Engineer for approval. The work is to be executed as per approved drawings. The stage of approval of drawings is therefore very important. All drawings should be carefully and critically examined before approval. The requirements of various components of fire fighting system have been described in previous chapters dealing with the components. However generally following points are to be taken care while examining and approving the drawings. Site survey should be carried out in detail.

In addition to building plans, layout plan along with landscape plan/horticulture plan and other services plans should be consulted while deciding route of underground pipes from pump house and around the building.

As far as possible, underground pipes are not to be laid under road, pavement, building and long open spaces. The locations along road, foot path in earth may be preferred.

The location of yard hydrants, fire service inlet and fire service connection are to be decided based on distance required as per fire hazard norms. However necessary adjustments are to be made so that these components do not become hindrance in vehicular movement and entrance to the building. Requirement of other building services are also to be given due consideration. Symmetry should be maintained for aesthetic considerations.

Electrical Panel: - Complete wiring drawing, layout etc. are to be examined to ensure that provisions of agreement are incorporated in the drawing. Sizes of various panels and mounting arrangement may be decided keeping in view

ease of operation and aesthetic consideration as well.

20.3. Installation

The following precautions are to be taken during execution of the work

The pump and motor/engine are to be perfectly aligned on the base plate so that there is no vibration during operation. All nuts, bolts, washers shall be of adequate size and galvanized.

The pipe supports should be decided in a way that the weight of pipes and valves are not transferred to the pumps and supports do not cause hindrance in movement inside the pump house. As far as possible, floor supports may be provided in pump house.

All valves shall be installed at a height and in a position that their operation by right hand is conveniently possible.

All pressure gauges should be installed so that the dial is vertical and is visible while entering the pump house.

Electrical panels should not be installed at floor level. The panels shall be sufficiently raised above ground level. If panels are to be mounted on wall, an angle iron frame shall be provided so that at least 75 mm space is left behind the panels. The panels shall be easily approachable.

Cable trays are to be used for laying of power and control cable inside pump house. No cable is to be laid at floor level/in trench. Cable tray layout should give neat appearance. All cable tray shall be adequately supported from the ceiling /floor.

While excavating for laying of external pipes, suitable sign board/ barricading shall be provided to ensure that no person falls in the trench.

The width and depth of trench shall be adequate for laying the pipe 1m below ground level.

No earth or any other matter is to be allowed to enter the pipes. The ends shall be kept closed always.

The anticorrosive treatment is to be applied on the entire length pipe & fittings. The treatment is not to be damaged.

Pressure testing is to be carried out in sections before filling the earth back in the trench.

The earth filling is to be done in layers of 20 cm each and properly rammed so as to avoid possibility of settlement. Surplus earth shall be removed from the site by the contractor.

Where pipes crossing road likely to have heavy traffic, additional protection over pipe shall be provided to ensure that pipe is not damaged.

External hydrants and fire service connection/ inlet shall be located parallel to the nearby road/ foot path so as to give proper appearance. Foundation shall be raised from below ground level and shall be properly plastered in plumb. The hydrants shall be facing the road/ approach. There shall be no obstruction in approaching the hydrants for operation.

Risers shall be parallel to the wall and in plumb. Adequate supports shall be provided from the wall. Opening around the pipe in slab shall be filled with CC and finished with plaster.

Internal hydrant shall be provided in the centre and facing outside for ease of operation. Sufficient space shall be provided around the handle for operation. There shall be no hindrance in moving the first aid hose reel.

Terrace pipes shall be supported on Cement Concrete (1:2:4 parts for cement, sand and aggregate) pedestals of adequate height. The pipe route shall be such as no hindrance is created in movement at the terrace. Pipes shall be sufficiently raised above terrace. It is to be ensured that water proofing is not damaged during laying of pipes.

20.4. Testing

- a) Initial Testing: - During laying of fire pipes, the same shall be subjected to 10 kg/cm^2 hydraulic pressure for a period of 24 hours, in sections. After completion of the work, all valves/ fittings shall be installed in position and entire system shall be tested for 24 hours at a pressure of 10 kg/cm^2 or 1.5 times the rating pressure. The drop of pressure up to 0.5 kg/cm^2 shall be accepted.
- b) Final Testing: - After completion, all operation checks (as per Para '2.4.1.14' of CPWD specification part V - Wet Riser and Sprinkler System) shall be carried out for automatic operation of the systems. For this purpose, landing valves may be opened at different locations. The exercise shall be repeated couple of times to ensure trouble free operation of the system.
- c) Flow Test: - The design flow of pumps shall be checked. The pump shall be operated after opening a number of landing valves at different locations. Design pressure is to be maintained in the pump house.

Water discharge is to be measured by drop in level in UG tank for a certain period. All pumps shall be tested one by one. The flow rate shall be not less than as specified while maintaining the design pressure in pump house.

20.5. Inspection by Local Fire Officer

After completion of the work and testing to the entire satisfaction of Engineer, the installation shall be offered for inspection by Chief Fire Officer or his representative. Testing as desired by the Fire Officer shall be carried out. The contractor will extend all help including manpower during testing. The observation of Chief Fire Officer which are a part of agreement shall be attended by the contractor.

20.6. Pre-Commissioning

On completion of the installation of all pumps, piping, valves, pipe connection, insulation etc. the Contractor shall proceed as follows:

Prior to start-up and hydraulic testing, the Contractor shall clean the entire installation including all fittings and pipe work and the like after installation and keep them in a new condition. All pumping systems shall be flushed and drained at least once through to get rid of contaminating materials. All pipes shall be ensuring clearance of debris inside & outside, cleaning and flushing shall be carried out in sections as the installation becomes completed.

All strainers shall be inspected and cleaned out or replaced.

When the entire systems are reasonably clean, a pre-treatment chemical shall be introduced and circulated for at least 8 hours. Warning signs shall be provided at all outlets during pre-treatment. The pre-treatment chemical shall:

Remove oil, grease and foreign residue from the pipe work and fittings;

Pre-condition the metal surfaces to resist reaction with water or air.

Establish an initial protective film;

After pre-treatment, the system shall be drained and refilled with fresh water and left until the system is put in to operation. Details and procedures of the pre-treatment shall be submitted to the Engineer for approval.

Check all clamps, supports and hangers provided for the pipes.

Check all the equipment, piping and valves coming under hot water system and operate each and every valve on the system to see if the valves are functioning properly. Thereafter conduct hydro test of the system.

Fill up pipes with water and apply hydrostatic pressure to the system as given in the relevant section of the specification. If any leakage is found, rectify the same and retest the pipes.

Fire Protection System

Check all hydrant valves by opening and closing: any valve found to be open shall be closed. Check all the piping under hydro test.

Check that all suction and delivery connections are properly made for all pumps sets. Check rotation of each motor after decoupling and correct the same if required. Test run each pump set. All pump sets shall be run continuously for 8 hours (if required with temporary piping back to the tank).

20.7. Commissioning and Testing

Pressurize the fire hydrant system by running the jockey pump and after it attains the shutoff pressure of the pump then, open bypass valve and allow the pressure to drop in the system. Check that the jockey pump cuts-in and cuts-out at the preset pressure. If necessary, adjust the pressure switch for the jockey pump. Close bypass valve.

Open hydrant valve and allow the water to flow into the fire water tank in order to avoid wastage of water. The main fire pump shall cut-in at the preset pressure and shall not cut out automatically on reaching the normal line pressure. The main fire pump shall stop only by manual push button. However, the jockey pump shall cut-out as soon as the main pump starts.

When the fire pumps have been checked for satisfactory working on automatic controls, open fire hydrant valves simultaneously and allow the hose pipes to discharge water into the fire tank to avoid wastage. Check

each landing valve, male and female couplings and branch pipes, for compatibility with each other. Any fitting which is found to be incompatible and do not fit into the other properly shall be replaced by the Contractor. Each landing valve shall also be checked by opening and closing under pressure. Check all annunciations by simulating the alarm conditions atsite.

Flushing the System: - Before commissioning, the entire system shall be flushed to ensure that any earth/ foreign matters which might have entered during installation are taken out. For this, pump may be operated and valves opened at different locations.

As soon as the work is complete, the system shall be commissioned and made available for use. Requirement of firefighting installations is equally important during occupation of the building. If the building is to be occupied in part, firefighting system of building completed shall be commissioned by isolating the system of under construction portion of the building.

The firefighting system shall be maintained and manned from the very first day of its commissioning.

Any defects noticed during the warranty period shall be promptly attended by the contractor and availability of the system at all time is to be ensured.

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TECHNICAL SPECIFICATIONS

PART-D: PLUMBING PUMPS & WTP

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1. PUMPS FOR UTILITIES (Drinking Water/Sewage/Drainage)

1.1. General

- a) This Section specifies the manufacture and installation of drinking water supply pump sets, drainage sump pump and sewage ejector pumps system.
- b) Pumps shall be electrically operated and directly driven.
- c) The pump heads specified on the Drawings and / or Bill of Quantities are for guidance and information only, and are calculated based on assumed equipment pressure drops. The exact pump head based on the pipe run and the offered equipment shall be carefully checked and re
- d) - calculated for each pump before ordering the equipment. Calculation shall be submitted for approval. No modification to the piping system shall be allowed without prior approval. Any additional cost for the modification of the system (pumps, motors, switchgears, cables, panel boards, switchboards, etc.) necessary to meet the specified duties, special conditions and the offered equipment shall be provided at no extra cost to the Employer.
- e) For pumps in parallel operation at any particular time, the pumps selected shall have a steep characteristic. For single pump operation at any particular time, the pump selected shall have a flat characteristic. Pumps with curve indicating excessive shut-off head shall not be used.
- f) The pump construction shall meet the maximum required working conditions, liquid temperature, test pressure, and nature of the liquid to be handled as specified.
- g) All pumps and motors shall be of minimum vibration and noise level during operation so as to meet the respective noise criteria.
- h) Additional vibration isolators and sound attenuators shall be provided by the contractor as may be required by the Engineer at his own cost if the noise level is found excessive and not within the requirements.
- i) Each complete pump unit including motor and drive shall be supplied from a single manufacturer as a complete factory manufactured package. All guarantees and test certificates shall apply to the entire assembly.
- j) All pumps shall be factory painted in accordance with the manufacturer's recommendations. Any damage to finishes shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.
- k) Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work

1.2. Standards

Relevant Codes and Standards

BS 599: Methods of Testing Pumps

BS 5316: Acceptance Tests for Centrifugal Mixed Flow and Axial Pumps

1.3. Quality Control

Nameplate: Each pump and motor shall have an identification plate showing the code number and a specification plate showing full details of the pump size, rated speed, rated kW, class of insulation, impeller diameter, pump characteristics, flow and any other pertinent information required by the Engineer.

1.4. Drinking Water Supply Pump Sets (Treated Water Pump)

The pump sets shall be complete with, motor starter panel and control unit. Pump sets shall be of package type, being designed and manufactured by manufacturers normally supplying this type of equipment, and who can show evidence of having furnished such equipment that has been in successful operation for at least ten years. Locally assembled pump sets will not be accepted.

Capacity of each pump and motor shall not be less than that specified and designed for all conditions of parallel operation. Each motor shall be of sufficient capacity to operate over the entire head capacity range of its respective pump without exceeding the name plate power rating.

The pump casings shall be of close-grained cast iron, accurately machined and assembled with metal-to-metal joints.

The casting feet shall be integrally cast with the lower casing and be immediately adjacent to suction and discharge

flanges in order to transmit pipe load to the base and foundation.

The impellers shall be of gunmetal or bronze, mechanically balanced and keyed to shaft. Renewable guide rings shall be provided in the casting, keyed to prevent rotation.

The shafts shall be stainless steel to BS 970 Grade 316. Gunmetal sleeves shall be provided to protect the shaft in the water space and through the shaft seal. The sleeves shall be keyed to prevent rotation and secured against axial movement for leakage of water along the shaft.

The bearings shall be of ball or roller type protected against ingress of water, dirt and other matter.

Leakage of water along the shaft to be prevented with a mechanical seal.

Mechanical seals shall be specifically designed for pump working pressures and shall be of stainless steel construction with S.S. springs and tungsten carbide seats.

The pump sets shall be complete with inter-connecting pipe work, isolating and check valves, and flexible connectors and with flanged connection ready for connection to the pipe work system.

Pumps & motors shall be assembled on galvanized base plate of rolled steel & sloping channel type, with tapped drain connection at pump end. The base plate shall be designed & supplied by the pump manufacturer.

Strainers shall be installed at suction side as shown on the drawings.

Discharge (and in suction line, where shown in the drawings) pressure gauges complete with isolating cock shall be provided.

1.5. Drainage Sump Pumps and Sewage Ejector Pumps

Pump sets shall be provided for the locations and duties, as required.

The pump sets shall be of the sewage or dirty water type in accordance with their duty requirement. The sewage pumps shall be of the non-clog type with open impellers. The dirty water (seepage) pumps shall be of the closed impeller or vortex type. The submersible pumps shall be rated in accordance with IP 68 and shall have corrosion class in accordance with appendix A of IEC 364-5-51.

The efficiency of the pump set at duty point shall not be less than 90% of the maximum efficiency for the pump.

The pumps shall be of the centrifugal type, vertically mounted, close coupled to their fully submersible electric drive motors. Pump impellers shall be cast iron to GG 25 conforming to ASTM 35B or cast stainless steel. Shaft, studs, nuts, screws and washers shall be Stainless Steel Grade 304, S15.

The bearings shall be of the rotating element type, grease packed and sealed for life.

The pump shall have two mechanical seals. The seals shall work independently of each other, one to seal off the motor, one to seal off the pumped fluid. An oil chamber shall act as a buffer between the seals and a coolant for the seals. A moisture detection probe in the oil chamber shall detect the presence of water in the chamber and thus the deterioration of the lower seal. The probe shall operate a remote alarm.

A lifting chain with shackles, rings etc. shall be fitted to each pump, which shall support the weight of the pumps during installation and removal from the sump. The chain shall comply with BS 1663 and be hot-dipped galvanized.

Motors shall be submerged and cooled by the liquid in which it is submerged. The windings shall be protected against burnout by a thermostat or thermistor arranged to trip the pump. Motor insulation shall be class 'H', motors up to 5.0 H.P shall have DOL starters and above

5.0 H.P shall have star delta starting.

The submerged cable shall be multi-core and fully insulated LSHF to BS 7211. The cable shall be sealed and glanced into the motor before the pump leaves the factory. The cable junction box shall be sealed from the outside. The cables shall be supplied long enough to reach the starters. For all low point seepage sumps the starters are quite far from the nearest station seepage sump. Therefore the cable shall go into a waterproof isolation socket, which shall be cabled to the starter. The isolation sockets may be a composite arrangement, but in either case the Pump Number shall be clearly labelled on the plug and the socket.

The pump sets shall be complete with boltless self-aligning duck-foot assembly, which allows removal of the pumps without disturbing the pipe work. Guide rails on which to raise and lower the pumps shall be of galvanized steel and complete with all fittings and support brackets.

Pump duties shall be achieved with the impeller shaft speed not exceeding 2900 rpm unless otherwise specified.

Pump connections shall be screwed to BS 21 up to DN 50 and flanged to BS 4504, PN 10 for DN 65 and above.

The permissible service pressure of cast iron pump casings shall be generally in accordance with the manufacturer's recommendations. No pump part or component part shall be subjected to a gauge pressure in excess of 10 bar, except where specifically listed in the Equipment Schedule.

Impellers shall be keyed to the drive shaft, the impeller being retained by a hexagonal nut.

1.6. Raw Water Supply Pump Sets Control (Filter Feed Pumps)

There shall be duplicated pump sets in the system, one duty and one standby. The pumps shall be automatically controlled to maintain the water pressure in the system as indicated on the Drawings.

The pump control shall have the following features:

- (a) An overriding float switch of differential type shall be provided in the water tank to cut off the pumps operation when the tank has been exhausted.
- (b) Automatic change - over facility shall be provided, the standby Pumps shall automatically start on the failure of the duty pump.
- (c) Lead / lag selection and automatic alternation shall be provided for the control circuit. After one pump has finished one operation, the other pump shall stand as the duty pump for the next cycle.
- (d) Duty / standby and auto / off / manual selectors shall be provided.

1.7. Sump Pumps Control

For the two-pump arrangement, one pump shall act as duty and the other one as standby. The pumps shall be automatically controlled to transfer the soil and / or waste water to the manhole or the nearest drainage pipe connections.

Automatic controls shall be of float - type mercury switches suitable for use with soil or waste water. Each pit shall be fitted with four switches at different levels to correspond with the required depths of water and to initiate the relevant controls to operate the pump and / or raise the alarm suitably.

The pump control operation shall be:-

- a) When the water level in the sump pit reaches the first pre-determined high level, the duty pump shall be started and continue to run until the water level falls back to the low level.
- b) For duplicated pump sets, if the water level continues to rise to the second pre-determined level, the second pump shall also be called to operate in parallel with the first pump. The pumps shall only be stopped when the water level drops back to the low level.
- c) Automatic and manual change-over facilities shall be provided for the pumps.
- d) A lead / lag selection and an automatic alternation facility shall be provided. After one pump has finished one operation, the second pump shall act as duty pump for the next cycle.
- e) An extra high level alarm shall be provided at the vicinity of the pit or one of the control panels, when the water raises up to the extra high level, an audible and visual alarm shall be raised.
- f) Remote monitoring and control shall be required as follows:-
 - (1) Run / Stop status of the sump pumps such as sewage pumps and waste sump pumps.
 - (2) Overload alarm for the above pumps
 - (3) High water level for the sump pits.
 - (4) Power supply failures for the above pumps.
 - (5) Auto / Manual mode status of the pumps.
 - (6) Run / Stop control of the above pumps.

1.8. Float Switches

Provide all float switches required for pump control and alarm system. (The high / low level alarm.)

Provide all cables and conduit between the float switches in the water tanks and sump pits and the BMS or LMCP, as required.

All the alarms of the sump pits shall be wired back to the associated LMCP in the pump rooms or at the vicinity of the

pit respectively, as instructed by the Engineer. Should any one of these alarms be actuated, an audible and a visual alarm shall be indicated on the LMCP and transmitted to the Station BMS.

1.9. Speed of Pump

Unless otherwise specified, all pumps shall be selected for lowest noise level in operation and shall not exceed 2900 r.p.m. Bearings shall be of the silent type.

1.10. Pump / Motor Couplings

A coupling shall be provided between the pump and motor and shall be semi-flexible of the steel pin / rubber bush type, accurately aligned. The coupling shall be used solely to reduce shock to the bearings and shall not be utilized to compensate for misalignment. Pin and bush couplings shall be provided to the same accuracy of alignment as rigid couplings, and the Contractor shall demonstrate correct alignment.

1.11. Maintenance Facilities

Pump installations shall be complete with adequate facilities for maintenance and future replacement of plant. Lifting eyes shall be provided for pumps and motors. Details of any requirements for overhead runways and hoists shall be submitted for approval.

Each pump shall have a pressure gauge installed to indicate discharge pressures. Gauges shall be 100 mm dial calibrated to read directly in KPa of range to match the respective pump duties.

1.12. Installation

Pumps and appurtenances shall be installed in the space provided and made readily serviceable.

Provide drains for bases and stuffing boxes piped to and discharging into floor drains and drain funnels.

Provide air cock and drain connection on pump casing.

Reduction in line size shall be by utilizing long radius reducing elbows or reducers. Support piping shall be provided adjacent to pumps such that no weight is carried on pump casings. Supports shall be provided under elbows on pump suction and discharge line sizes of 100 mm and over.

Base mounted pumps shall be checked, aligned and certified prior to start-up.

1.13. Site Testing

Test pumps in actual operating conditions to verify compliance with this Specification. Check all wiring for connection and continuity. Test performance of all relays and logic.

Promptly correct all excessive vibration, noise, rattles or other objectionable factors or replace the defective item and retest the systems.

Check controls in the presence of the control manufacturer's authorized representative and make all necessary adjustments to secure proper control.

1.14. Testing at Manufacturer's Works

Pumps shall be tested over the full range of their capacities. The range shall be from closed valve condition to a point corresponding to a discharge of 15 % in excess of the maximum discharge in the specified range of duties. Testing shall determine the output, power consumed and mechanical efficiency. Copies of the NPSH design curve shall also be provided.

Head / quantity curves, pump efficiency / quantity curves, overall efficiency / quantity and power / quantity curves shall be drawn. The curves produced shall be used to demonstrate that the pump will be capable of meeting the full range of operating conditions at Site.

All pump components subject to pressure shall be hydraulically tested to a pressure of 1.5 times the sum of the closed valve head plus the maximum suction pressure for 5 minutes.

2. TECHNICAL DETAIL

2.1. Interface

The E&M contract and civil contractor must interface in Detail Design stage as well as in Installation and Testing & commissioning stage for efficient working and proper design of pumps.

2.2. Design Specifications for Valves and Pumps

The valves in the network shall be manually operated resilient seated Sluice valve as per BS 5163 non-rising stem, as per specifications below:

Pressure Rating	:	PN 16
Type	:	Flanged/Socket type applicable for HDPE pipes
Body	:	DI Bonnet
DI Key Cap	:	DI
Wedge Gate	:	Ductile Iron (Fully vulcanized with EPDM rubber) Spindle SS-410
Bonnet Gasket	:	EPDM
O-Rings (Stem Sealing)	:	EPDM Internal hardware : SS-316

The valves in the pump rising main shall be manually operated resilient seated mounted flanged/ wafer type Butterfly valve as per IS 13095:1991 PN 16/BS: 5155 PN16 non-rising stem, as per specifications below:

Pressure Rating	:	PN 16
Type	:	Flanged/wafer/lugged wafer type
Body	:	DI (IS 1865)
Disc	:	SS-304
Body Seat Ring	:	EPDM Shaft and hand wheel : SS-410
"O" Ring	:	EPDM
Internal hardware	:	SS-316

The check valves shall be dual plate type Conforming to IS 5312, BS 5153, BS 1868

Pressure Rating	:	PN 16
Type	:	Flanged/wafer/lugged wafer type
Body	:	DI (IS 1865)
Disc	:	SS-304
Body Seat Ring	:	EPDM
Internal hardware & Bolts	:	SS-304

The pump sets shall be submersible centrifugal type and shall be selected based on the following minimum requirements as stated below:

- i) Head loss
- ii) Discharge based on continuous operation for water supply
- iii) Pump efficiency to be not less than 85% of the maximum possible for the particular type of pump chosen
- iv) Pump shall be selected considering maximum life span based on corrosion analysis of the water or content of solid to be pumped
- v) The pump should be maintenance free with liquid level controlled automatic operation and capable of remote interface & monitoring
- vi) The pump shall be noise and vibration free
- vii) The duty and standby pumps shall be identical
- viii) The NPSH of the pump shall always be lower than the atmospheric NPSH to avoid cavitation due to vaporization
- ix) 100% standby shall be provided for each installation
- x) Pump shall be provided with in-built protection against dry running, reverse rotation pump failure
- xi) Pressure gauges shall be complying with IS: 3624. Glycerine filled dial shall be provided where the gauge is subjected to pressure pulsation and / or vibrations. The internal parts of pressure gauge shall be stainless steel. The accuracy of the pressure gauges shall be ± 1 % of full scale, accessories such as snobbery, isolation valve & drain valve shall be provided. Impulse tubing and fittings as required shall be provided.

The submersible pumps provided to supply potable water from sump as per specifications detailed below:

Casing : Ci-Ni Impeller CF 8M Shaft : SS 304

Guide pipe : GI

Lifting Chain : MSEP/ST-ZN Solid handling : max 5 mm Pump rpm : 2900 rpm

Motor rpm : 2900 rpm

Each pump shall have a complete set of discharge arrangement with sluice/butterfly valves, non-return valves and accessories.

The under given velocities shall be followed while designing the suction and delivery of pumps;

Pump Suction: 1-1.5 m/sec Pump Delivery: 2-2.5 m/sec Header: 1.8-2 m/sec

Motor shall be Squirrel Cage- Submersible Motor (Energy Efficient), 3 Phase, 415 V/50 Hz, 2900 rpm, IP 68 with F class insulation and shall have VFD. The pump shall be provided with control panel. The motors shall be rated a minimum of 25% more than its rated KW or as per the applicable standards.

The power to the control panel shall be taken from the MCC of the Effluent Treatment Plant. The cost of cable from the ETP MCC to the pump control panel shall be in the scope of the Contractor under the present contract. The contractor is advised to visit the site to take all consideration for the same. Running hour meters shall be provided for Main Pump Motors of the above pumps.

Building connection

Potable Water Connection to the building shall be through a Stainless Steel (SS) strip saddle and no direct connection shall be made on the HDPE pipe directly. This is necessary to prevent leakages and any contamination in the potable water network.

3. WATER TREATMENT PLANT

3.1 General

This Section specifies the furnishing and installation to complete and operate softening plant for reducing the Hardness of raw water to below 5 mg/lit commercial zero to generate water fit for make-up requirements.

All materials shall be new and of the best quality conforming to specifications and subject to the approval of Engineer-in-charge-in-Charge.

All equipment shall be of best available make manufactured by reputed firms.

All equipment shall be installed on suitable foundations, true to level and in a neat work-man-like manner.

Equipment shall be so installed as to provide enough clearance between the end walls and between equipment to equipment.

Piping within the pump houses shall be done to prevent any obstruction in the movement within the pump house.

3.2 Standards

IS: 8419 Requirements for water filtration equipment.

IS: 10500 drinking water (For parameter being controlled by Water Softener Plant).

IS: 2825 Code for unfired pressure vessels.

3.3 Quality Control

Engage the services of a specialist for initial cleaning and pre-treatment.

Specialist's services shall include monthly laboratory testing of water samples and adjustment of water treatment system.

A complete testing report regarding the quality of the supplied water together with the recommended water treatment system shall be submitted for Approval prior to ordering.

3.4 Softening Plant

The softener vessel shall be made of Mild steel (rubber lined) pressure vessel conforming to IS:2825, up flow "Cation" Ion Exchange type.

The softener plant shall be designed to generate water commercial zero hardness at rated output at given raw water quality without any operational problem. Any additional provision required to make the item complete shall be

deemed to be included in the price.

The softening plant shall be complete with Initial charge of Ion Exchange resin, regeneration assembly comprising of power valve, ejector, brine suction valve, and all necessary piping. The Contractor is required to submit the make, grade and quantity of resin being offered by him and the quantity of regenerant required for each regeneration.

The Softening System shall consist Dual Media Filter (DMF) pressure vessel type pre-filter of made of mild steel (rubber lined) conforming to IS:2825. The rate of filtration of DMF shall not be more than 15 cu.m/hr/sq.m. Working and test pressures shall be as per BOQ. Thickness of vessel rubber lining not less than 3mm.

3.5 Under drain system

Each filter shall be provided with an efficient under drain system comprising of collection pipes, polypropylene nozzles of manufacturer's design. The entire under draining system shall be provided on M.S. Plate or cement concrete supports provided by the contractor.

3.6 Face piping

Each filter shall be provided with interconnection face piping comprising of inlet, outlet and backwash complete with diaphragm valves/ball valves.

3.7 Accessories

Each vessel shall be provided with the following accessories:

Air release valve with connecting piping.

100mm dia bourden type gunmetal pressure gauges with gunmetal isolation cock and siphon on inlet and outlet.

Sampling cocks on raw water inlet and filtered water outlet.

Individual pressure tight manhole drain connection with ball valves.

Connection with valve for air scouring.

Rate of Flow Indicators in the raw water inlet line.

Quantity meter in the filter water outlet line

3.8 Filter media

Each filter shall be provided with clean and washed filter media, conforming to IS: 8419 (Part-I) following is recommended.

Coarse Silex Pabbles	6.0 - 10.0mm size (150mm deep)
Fine Silex Sand	1.4 - 2.5mm size (600mm deep)
Anthracite	0.80 - 1.6mm dia (600mm deep)

The above filter media arrangement may be altered to suit contractor's own design for the most efficient performance.

3.9 Test kits

Provide one test kit with initial requirement of reagents for the following:

Hardness Test Kit

Residual Chlorine Indicator

PH meter (electronic)

The contractor shall supply the details of equipment (Including Test kit) with literature for the equipment quoted by him along with.

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TECHNICAL SPECIFICATIONS

PART-E: AIR COMPRESSOR (COMPRESSED AIR SYSTEM)

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1. **Air Compressor**

1. **General Description**

- 1.1.1 55 cfm Air compressor-2(1w+1s) Nos., are required for production of compressed air for the RBL at Soladevanahallii Depot of BSRP
- 1.1.2 170cfm Air compressor-2(1w+1s) Nos. are required for production of compressed air for the PWL, IBL, ICS at Soladevanahallii Depot of BSRP.
- 1.1.3 The specification covers the design, manufacture, supply, installation, testing and commissioning of Air Compressors. The compressor shall have high efficiency & low power consumption. The supply shall comprise stationary type, electric motor driven, self-lubricating, Maintenance free Rotary Screw type complete with suction filter, air/Oil/Water separator, air cooled after cooler, Oil/Water filter, water cooler integrated refrigerated air drier & moisture trap, microprocessor-based control panel all housed in silenced package provided on anti-vibration mounts. The supply shall include air reservoirs (02 no's), air filters, pipes and pipe couplings, electric controls, and all other accessories to make the equipment & installation fully functional. A set of service tools and special tools shall also be supplied along with compressor. The compressor and installations shall be designed considering ease of maintenance and requiring minimum service in order to optimize down time.
- 1.1.4 Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work

2. **Technical Characteristics**

3. **Technical Particulars 170cfm Compressor**

Each compressor shall be capable of giving an output of 170 CFM of air at an operating pressure of 10 Kg/cm². Two compressors shall work together in the system with full synchronization and redundancy.

The compressors shall be provided with capacity control system to reduce the load on motors at the time of start and to give reduced output to match with the requirements. Arrangement shall also be incorporated for automatic shutdown in the event of prolonged off-loads operation. The compressor units shall be equipped with condensate separator with both auto & manual drain.

The compressors shall be driven by adequate capacity TEFC squirrel cage type 3-phase Induction motors (30 kw), having insulation class F, through preferably a permanent alignment geared drive (any better arrangement shall be explained with advantages in the offer). Star-delta type starter with contactor relays and single-phase prevention shall be used. The ingress protection of all motors shall be IP55. Pre wired connections between the motor and starter should be provided. The compressor shall be suitable for continuous and heavy-duty operation. The contractor shall submit the compressor drive installed motor power (in kW & hp). The manufacturer shall use all modern techniques of vibro- acoustics optimization for extremely low noise and vibration level. The compressors permissible noise level measured at a distance of 1m from the acoustic enclosure shall be less than 70 dbA. The compressor shall be provided with integrated Oil/Water removal filter with filtration level of 0.01ppm. The temperature of air leaving the compressor unit shall not be more than 10°C above the ambient. The contractor shall submit equipment and piping layout drawing (preferably a 3 dimensional drawing) considering space available in the compressor room & reservoirs outside. Depot layout drawing with compressor room marked is enclosed.

4. **Technical Particulars 55cfm Compressor**

Each compressor shall be capable of giving an output of 55 CFM of air at an operating pressure of 10 Kg/cm².

The compressors shall be provided with capacity control system to reduce the load on motors at the time of start and to give reduced output to match with the requirements. Arrangement shall also be incorporated for automatic shutdown in the event of prolonged off-loads operation. The compressor units shall be equipped with condensate separator with both auto & manual drain.

The compressors shall be driven by adequate capacity TEFC squirrel cage type 3-phase Induction motors (11

kw), having insulation class F, through preferably a permanent alignment geared drive (any better arrangement shall be explained with advantages in the offer). Star-delta type starter with contactor relays and single-phase prevention shall be used. The ingress protection of all motors shall be IP55. Pre wired connections between the motor and starter should be provided. The compressor shall be suitable for continuous and heavy-duty operation. The contractor shall submit the compressor drive installed motor power (in kW & hp). The manufacturer shall use all modern techniques of vibro-acoustics optimization for extremely low noise and vibration level. The compressors permissible noise level measured at a distance of 1m from the acoustic enclosure shall be less than 70 dbA. The compressor shall be provided with integrated Oil/Water removal filter with filtration level of 0.01ppm. The temperature of air leaving the compressor unit shall not be more than 10°C above the ambient. The contractor shall submit an equipment and piping layout drawing (preferably a 3 dimensional drawing) considering space available in the compressor room & reservoirs outside. Depot layout drawing with compressor room marked is enclosed.

5. Mechanical part

All the equipment of the compressor package shall be mounted on a common base frame for foundation less installation. The base frame shall be made sturdy with facility for mobile crane & fork lifting arrangement.

A twin element suction air filter on the intake side of the compressor, a compressed air- Oil/Water separator, Oil/Water cooler and a non-metallic cartridge type Oil/Water filter shall be provided.

6. Suction filters

The dust filter (pre-filter) shall be capable of filtration up to 1 micron absolute with 99.5% efficiency for solid particles. Heavy-duty dry type intake air filter, conveniently located for quick and easy replacement with cyclonic separation and arrangement for pre- filter separation shall be provided.

7. Compressor

Single stage self-lubricated, Maintenance free rotary screw compressor having high efficiency and reliability shall be provided. It shall be equipped with: -

The air intake valve should be maintenance free pneumatically controlled vacuum controlled without spring Intake valve assembly for Load/ No load regulation.

Non-return valve at element discharge.

Automatic Oil/Water stop valve

vacuum gauge adopter

Air & Oil/Water separator

Compressor shall have air and Oil/Water separator which shall consist of vertical design welded vessel that secure excellent Oil/Water perspiration, Oil/Water separator element to provide clean quality air by separating Oil/Water and the carryover is less than 1.5 ppm along with minimum pressure valve, Safety valve. Delta Pressure sensor before Oil/Water separator and Oil/Water draining arrangement

8. Air after cooler & Oil/Water cooler

The air after-cooler should be aluminium block type to cool the compressed air and shall be high efficiency air cooled after-cooler and Oil/Water cooler. A suitable capacity fan cooling arrangement shall be provided. Full flow type Oil/Water filter with thermostatic bypass valve (the TEV should be stainless steel or cast iron and it may be integrated in the Oil/Water filter housing to enable the compressor to reach its temperature immediately after start up) to avoid condensation and Oil/Water restrictor to regulate Oil/Water flow shall also be provided. The water separator unit should be integrated in the after-cooler and should be capable of removing 100% condensate without any loss of air.

9. Capacity regulation system

The compressor shall be equipped with transducers to set discharge air pressure to desired limits/pressure band, Load/No load system with automatic start/stop through solenoid control valves & timer, moisture separation trap in the regulating line for separation of water and control tubing.

10. Compressor control

Each compressor shall be provided with advance microprocessor based graphical 3 to 5 inch high definition colour display with clear pictograph and self-explanatory navigation with real time operating system with ergonomic user interface. The control shall have following features:-

Maximize energy efficiency by controlling the main drive motor by regulating system pressure within predefined pressure band (+/- 0.1 bar band).

Simultaneous multiple compressor control from any of the compressor control.

Continuous monitoring of critical parameters including service and warning indications, error detection, compressor shutdown and maintenance scheduling.

Using an ambient sensor to monitor the required dew point suppression, the control shall start and stop the dryer when the compressor has stopped thereby minimizing energy use and protecting the air system from corrosion due to moisture.

The compressor shall draw no starting current peaks and shall have high power factor.

The general equipment shall include the following:

Automatic (timer controlled) start-up and shutdown,

Auto start facility after power failure, load indicator & an additional gauge (pressure gauge), emergency shutdown button, Identification plate with the following information:

Type, capacity and serial number of compressor,

Type, capacity and serial number of motor.

All electrical and electronic control, regulation and other items shall be contained in a dust-tight cabinet, part of the compressor package. It shall be designed such that all parts are easily accessible for inspections, repairs and general maintenance.

11. Air dryer

The compressor shall have an integrated air cooled type refrigerant dryer in the downstream of the compressor within the same canopy & the design shall make the installation more compact. The air drier shall stop working atomically when the compressor stops functioning. The output quality of air shall be 3°C-7 °C at dew point and pressure drop across the dryer should not be more than 0.2 bar-0.3 bar. To ensure optimum removal of the water contained in the air it shall have main design features like:-

Compact size air to air & air to refrigerant heat exchangers for maximum heat transfer and minimal pressure drop.

Hermetically sealed refrigerant compressor. Type of Refrigerant used shall be explained with advantages in the offer.

Shall be conceived as a sliding module Integrated water separator with automatic/manual drain Digital display of lowest air temperature on the panel Large capacity condensers to convert refrigerant gas in to liquid for efficient cooling.

These dryers shall be installed on a vibration-damped base. A pre-filter shall be fitted on the intake side of the dryer and final filter on the outlet side of the dryer at the downstream of the dryer, an Oil/Water trap filter (final filter) retaining Oil/Water aerosols shall be installed. Its efficiency shall be 99.5% at 0.1 micron. This efficiency test should be carried out at manufacturer site in presence of employer's representative.

The filter element shall be made of thermo compressed glass micro fibers or equally effective other material and the supplier shall submit comparative advantages.

The output pressure sensor must be installed at the output of the compressor after the refrigerated air dryer and shows the pressure after considering the losses among the dryer.

12. Reservoir

The Contractor shall install two numbers of approx. 1800 Liters reservoirs in an area downstream of the dryers. The reservoirs shall be suitable for service pressure of 15 Kg/cm² and shall have an inspection hole at the top as well as an automatic condensing bleeder. The inlet and outlet pipe flanges shall be designed for the full rated output of two compressors working separately. These shall be equipped with a 0 to 15 Kg/cm² pressure gauge as well as a safety valve. One isolation valve should be provided at inlet of each receiver tank to isolate the reservoir tank from each other. Moisture trap unit should be provided at the bottom of the reservoir. There shall be no air loss due to condensate drain.

13. Pipe connection

Stainless steel, quarter-turn ball type valves of sufficient dimensions shall be provided. Compressor reservoir connection shall enable flexibility in connecting the compressors to the reservoirs. A schematic diagram shall be provided for approval before execution. A valve shall be provided to enable isolation of each compressor from airline. One isolation cock between each RBL, IBL, ICS, ETU & Pit wheel lathe building should be provided. Condensate drain taps unit are required in each of the lines.

14. Electrical installation

Power supply: 360-440V, 50 Hz + 3%, three-phase, 4 wires.

Electrical switchboard/control cabinet

The electrical shall comprise of:

A three-pole main isolating switch fitted with HRC fuses or equivalent isolating device.

A main circuit breaker, Star delta starter for each compressor motor or equivalent VFD, soft starter, with over load protection for both main and fan motor. Contactors for other appliances, Phase sequence relay to avoid operation of the motor in reverse direction, Thermal/magnetic protection for each appliance, Single phasing protection.

The location of this cabinet shall be proposed according to its dimensions and the electrical power supply distribution point. It shall comply with the regulations in force and its front panel shall have indication lamps (one orange lamp per phase). The degree of protection of the cabinet shall be IP 55 and ventilation shall be through louvers.

The electrical supply to both compressors shall be given at one point. All terminal boards and power supply cables shall be marked in accordance with the electrical schematic diagrams. The functions of the main components shall be identified by engraved labels whose contents shall be identical to the electrical schematic diagrams.

15. Cabling

Each appliance shall have its own cabling and wiring from the cabinet. The main cable should be XLPE insulated.

16. Protection and Safety

All equipment shall be designed for operation in a railway environment. In particular, the equipment shall be protected from the detrimental effects caused by:

Numerous interference phenomena caused by nearby high-current equipment likely to frequently switch on and off,

Nearby apparatus generating high frequencies (radio, telephone, converters, etc.),

Miscellaneous interference noise, as well as against power supply anomalies such as high undulation rates, high over-voltages, slow voltage variations,

The compressor should have inbuilt protection for high air Oil/Water temperature should start giving warning of temperature at 110 degree centigrade and will trip at 120 degree centigrade,

The compressor should have protection for all moving parts like pulleys, belts, etc.

17. Standards

The entire supply shall comply with the requirements of the standards in force.

Work related to the production of the equipment shall comply with the relevant Indian/European Standards, Codes of Practice and latest statutory requirements of India including the following:

Table 1.

STANDARD	DISCRIPTION
BSEN287	Approval testing of welders for fusion welding
BSEN288	Specification and approval of welding procedures for metallic materials
BS5304	Code of practice for safety of machinery
BSEN60073	Specification for coding of indicating devices and actuators by colours and supplementary means.
BSEN60529	Specification for degrees of protection provided by enclosures (IP code).

18. Finish

1.5.1 Equipment (compressors, dryers, electrical cabinet)

All metal parts shall be painted & all bolting and fasteners shall be made of high tensile steel.

1.5.2 Ventilation ducts and Electricity cableway

The ducts and all attaching parts (on the partitions or others) shall be galvanized prior to assembly. After manufacture, the machined components or duct parts shall be galvanized.

1.5.3 Partitions, floor

The necessary paint touch-ups shall be executed on the walls and floor of the room after erection of the installation.

1.5.4 Valves

Handles of normally open valves shall be painted green and Handles of normally closed valves shall be painted red.

1.5.5 Piping

All the compressed air piping shall be GI. GI pipe of various sizes i.e. 100mm, 60mm, 25mm, 20mm, 15mm dia shall be provided wherever required. MS pipes shall conform to IS:1239(PART I) "C" Class – 1979 and B 3589 complete with all fitting such as elbows, sockets, tees, unions, reducers, flanges, clamps, plugs and etc. with threading, jointing and making connections including cutting holes in wall/floor/slab and making good the same to its original finish. No sharp bend shall be permitted. All the pneumatic piping up to the end point of work shop and supply point of all machine shall be done with heavy duty pipe & and high quality connectors, valves, gauges and all other accessories to connect and supply for under floor wheel lathe machine. Wherever pipes are passing through wall or floor etc. same shall be repaired after completion of work and restored to original finish.

Table 02.

MS Pipe confirm to IS: 1239 (PART I) "C" Class – 1979 and B 3589

Nominal Bore	Outside Diameter	Heavy (C-Class)	
mm	mm	Thickness mm	Weight kg/mtr
3 mm	10.32	2.65	0.493

6 mm	13.49	2.9	0.769
10 mm	17.1	2.9	1.02
15 mm	21.43	3.25	1.45
20 mm	27.2	3.25	1.9
25 mm	33.8	4.05	2.97
32 mm	42.9	4.05	3.84
40 mm	48.4	4.05	4.43
50 mm	60.3	4.47	6.17
65 mm	76.2	4.47	7.9
80 mm	88.9	4.85	10.1
100 mm	114.3	5.4	14.4
125 mm	139.7	5.4	17.8
150 mm	165.1	5.4	21.2

19. Assembly and Miscellaneous Services

1.6.1 Connections to the appliances

Connections of piping to all appliances shall be such that removable parts can be disassembled without requiring disassembly of the control systems, valves, and plugged accessories. It shall be possible to remove all piping elements placed in the way of removable items.

1.6.2 Welding

Visual inspections and ultra-sonic inspections shall be carried out during and after performance if necessary.

1.6.3 Reliability and maintenance

All component parts, and especially relays, shall be heavy-duty type providing high reliability under normal machine operating conditions. All sub-assemblies performing the same function shall be 100% identical and interchangeable.

1.6.4 Identification

All the following electrical and pneumatic equipment shall be marked by an engraved plastic label indicating the function and the code number: -

- appliances,
- valves,
- cocks and fittings,
- Measuring and control equipment.

All symbols shall be in accordance with the standards and shall be marked on the drawings, schematics and maintenance manuals. The normal flow direction of the fluids shall be indicated with white, black or conventional coloured arrows, depending on the background colour so that satisfactory visibility is provided due to the contrast.

Presentation of labels:

white lettering on black background: minimum letter height 6mm, Attached by rivets. Wherever possible, the

labels shall be affixed to the equipment itself. Labels for valves and special accessories and gear shall be secured with a chain and by gluing.

20. Checks and Tests

1.7.1 In-manufacturer's plant

During manufacture, and prior to delivery, verifications and checks shall be carried out as per BS standards to ensure that the supply is in accordance with the technical specification and with the approved design documents. All quality checks shall be carried out, as required, during manufacture on the Contractor's or on the sub-contractors' premises. The Contractor shall arrange for quality checks on all supplies on his sub-contractor's premises prior to delivery of these supplies to his workshops. The measure of FAD shall be carried out as per ISO1217, Ed-3, and Annexure-C 1996. Operation of safety and protection devices shall also be checked. All the checks & tests carried out during FAT (factory acceptance test) shall be recorded and shown for verification to the inspecting engineer.

1.7.2 At-site

SAT (Site acceptance test) after installation of the equipment, operating tests shall be carried out to check that equipment design makes it suitable to fulfill the scheduled functions. The purpose of the tests is to record and acknowledge that the equipment is capable of performing regular service under different operating conditions.

21. Spare Parts

Training The contractor shall supply along with the machinery Spare Parts required for two years after the expiry of defect liability period. The quantities of spare parts shall be sufficient for the full operation of the machinery for the first two years following the expiry of the Defects Liability Period for the works. The list shall be provided in the offer.

22. Training

The contractor shall provide following training for operation and maintenance staff One-week training for four staff for operation of Compressor.

One-week training for four staff for maintenance of the Compressor. (One week means six working days with eight working hours)

All required training material should be provided for the intended training.

23. Maintenance

The contractor shall maintain complete installation during the Defect Liability Period. It shall include labour, parts, and consumables like Oil/Water, filters (air filter, Oil/Water filter, and Oil/Water separator etc.), various types of Oil/Water s for top up etc. During DLP each and every item including manpower etc. shall be arranged by the contractor.

24. Documents to be provided

All documents shall be provided in English for Execution of Work Prior to manufacture of equipment, the Contractor shall send the following documents for approval well in advance:-

Dimensional drawing of the foundations and anchoring of the elements of the machine, and dimensions of the cabinet,

A detailed technical note indicating the weight of components and removable parts, and including a list of all parts with the respective sub-contractor's references,

General equipment & piping layout drawings and detailed assembly drawings, detailed drawings of mechanical parts, pneumatic diagrams, detailed descriptive and operating note, detailed electrical diagram for troubleshooting including cable index, connection diagram with markings,

Documentation, drawings, notes and references of sub-contractors, installation and commissioning procedure, Schedule of work and completion period.

At Completion of Work

The Contractor shall provide the entire documentation, up to date:

The list of general drawings and detailed drawings of electronic and electrical diagrams with complete nomenclature, the general nomenclature of the supply including sub-contractors, mechanical drawings, electrical, electronic, pneumatic and hydraulic diagrams required for maintenance and troubleshooting of the machine, illustrated lists of mechanical and electrical parts itemized in accordance with the diagrams and drawings mentioned above and including the addresses of the various contractors, two sets of maintenance and adjustment manual with summary of circuits and functions and among other information, a lubrication manual including location of lubrication points, type of lubricants, frequencies, and quantities, two sets of operating manual (start up and user's instructions), Complete documentation of equipment from sub-contractors, Complete documentation on motors and major components.

25. Gunmetal Ball Valve

A ball valve is a valve with a spherical disc, the part of the valve which controls the flow through it. The sphere has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is and perpendicular to the ends of the valve, and flow is blocked. The handle or lever will be in line with the port position letting you "see" the valve's position. Ball valves should be durable and work to achieve perfect shutoff.

The details are as under:-

- Ports: 100 mm/65 mm/50 mm/25 mm/15 mm (BSPP, BSPT & NPT).
- Body width: As per size.
- Flow: 89-136 CFM.
- Working pressure: 7-15 Kg/sqcm.
- Design pressure: 38 Kg/sqcm.
- Temperature: 1 to 60 degree centigrade.
- Body: Gun metal.
- Ball: Stainless steel.
- Handle: GI or stainless steel.
- Seats: Teflon.
- Seal: Teflon.
- Fully opening: 90 deg angle.

26. Auto Drain Valve

Auto Drain Valves help in purifying the air by getting it rid of the pollutants periodically and automatically. These Drain Valves and air drain valves are used to remove the condensate from the pneumatic piping.

The details are as under:

- Material of construction: Aluminium/Brass.
- Media: Air/Water.
- Direct acting/External pilot type: 1/2" Inlet.
- On time setting: 0 to 99 sec Variable.
- Off time Setting: 0 to 99 Min settable & variable in steps of 1 min.
- Pressure range: 1-15 kg/sqcm.
- Operation: Normally open / normally closed.
- Seat: VITON/Neoprene/Teflon.
- Temperature: 2 degree centigrade to 60 degree centigrade.
- Coil Enclosure: Fly lead/Terminal Box.

27. Pressure Gauge

Bourdon type pressure gauges covering ranges between 0-15 Kg/sqcm consist of 'C' type/ helical type Bourdon Tubes made of nonferrous/ AISI 316 SS, closed at the upper end and the open end is soldered/argon welded firmly to the connecting socket. Pressure causes the Bourdon to expand or contract. The motion of the closed end of the Bourdon tube is transferred to the pointer mechanism through rack and pinion arrangement. Any backlash error is being completely eliminated by providing suitable hair spring. The gauge with the Bourdon tube is suitable under normal operating conditions for measuring Air.

The details as under:-

- Material: Sheet metal casing-brass internal.
- Body dia: 150 mm.
- Pressure: 0-15 Kg/sqcm.
- Range: Plus/minus 2%.
- Robust but lightweight.

28. Filter Regulator

Filter regulator provides unsurpassed sensing, regulation and filtration performance for pneumatic system. It can provide the clean dry air necessary to achieve the peak performance required by fluid power system. The connectors should simplify the plumbing of all components. Its innovative one touch fitting technology provides dramatic time savings during the installation of both air fittings and pneumatic flow controls.

The general features are under:

- Ports: 1/2" (BSPP, BSPT & NPT).
- Body width: 60 mm or as required.
- Flow: 20-136 CFM.
- Pressure: 0 -15 bar.
- High efficiency 5 micron element.
- Excellent water removal efficiency.
- Robust but lightweight aluminium construction.
- Positive bayonet latch to ensure correct & safe fitting.

Aspiration plus balanced poppet that provides quick response and accurate pressure regulation.

29. Non Return Valve

Wafer type (Plate type) check valve/NRV has short face-to-face dimensions and low weight allows a simple space saving installation between the companion flanges. The valves are suitable to mounting between weld neck or slip on type companion flanges of different standards. Opening and closing of the valve will take place at an extremely low-pressure difference over the valve disc. The eccentric disc shaft combination with the disc seat guarantees a positive shut off returning media. It should be compact in design.

Features:

- Body Type: Single Plate, Short Type.
- Material: Cast steel.
- Suitable For Horizontal and Vertical Mounting.
- Shorter overall length, mounting requires minimum space.
- Low Pressure Drop.
- Maintenance Free.
- End Connection: Wafer Type, Flangeless.
- Size Range: 60mm to 100mm.

- Pressure Rating: 15 kg/sqcm.
- Seat Leakage: Zero Leakage, Tight Shut Off.
- Temperature Range: 1 to + 70 C.
- Mounting Between: ASA 150 flanges.

30. **Cast Iron Butterfly Valve**

The butterfly valve should suitable for isolating or regulating air flow. The closing mechanism takes the form of a disk. It should be lighter in weight. The disc should positioned in the center of the pipe, passing through the disc is a rod connected to an actuator on the outside of the valve. Rotating the actuator turns the disc either parallel or perpendicular to the flow.

The butterfly should be a metal disc mounted on a rod. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn so that it allows an almost unrestricted passage of the fluid. The valve may also be opened incrementally to throttle flow.

The general features are as under:

- Type: Wafer type.
- Material: Cast Iron PN 16, IS: 210 FG 220.
- Test pressure: 15 Kg/cm²
- Suitable For Horizontal and Vertical Mounting.
- Suitable for ASA 150 standard flanges.
- Temperature Range: 1 to + 70⁰ C.
- Low Pressure Drop.
- Maintenance Free.
- Size Range: 60 mm to 100 mm.
- Pressure Rating: 15 kg/sqcm.

31. **Special Requirements**

- The system shall be designed to operate at the normal workshop temperature Arrangement shall also be incorporated for automatic shutdowns in the event of prolonged off-load operation. The compressor shall be capable of direct placement on firm floor near to the consumption point. High discharge air temperature shut down system should be provided to limit the compressed air temperature up to 120 deg C.
- The sound level for the overall of the installation shall not exceed 70 dB at a distance of one meter and shall, in no case whatsoever, create vibrations in the ground or in the partitions.

32. **BMS Compatibility**

All the compressors / system shall be design such that it should be compatible with BMS for compressor operation monitoring and it should be with open software protocol for easy compatibility with other software.

33. **Spares and Tools List**

Table 03. Mandatory Tools

S.No.	DESCRIPTION	UNIT	Qty.
1	VACUUM CLEANER (With Extension)	Nos	2
2	AIR BLOWER	Nos	2
3	LED TORCH	Nos	2
4	LINE TESTER	Nos	2

S.No.	DESCRIPTION	UNIT	Qty.
5	CRIMPING TOOL	Nos	2
6	HACKSAW	Nos	2
7	TOOLS KIT	Nos	2
8	LUX METER	Nos	1
9	TONG METER	Nos	2
10	MAGNET	Nos	2
11	ROPE NYLON 50 METER	Nos	2
12	DRILL MACHINE with standard bits.	Nos	2
13	PLIER	Nos	2
	A) 185 mm	Nos	2
	B) 165 mm	Nos	2
14	MEGGER 1000V	Nos	2
15	MULTIMETER	Nos	2
16	EARTH TESTER	Nos	2
17	ALUMINIUM LADDER		
	A)4 FEET	Nos	2
	B)A TYPE	Nos	2
	C)20 TO 36 FEET EXTENDABLE	Nos	2
18	FIRST AID BOX	Nos	2
19	KEY BOX	Nos	2
20	SCREW DRIVER-6"	Nos	2
21	SCREW DRIVER-8"	Nos	2
22	SCREW DRIVER-10"	Nos	2
23	SCREW DRIVER-12"	Nos	2
24	SCREW DRIVER SET	Nos	2
25	SPANNER KIT As per S.NO. 28 & 29	Nos	2
26	CROW PLIER	Nos	2
27	TORQUE WRENCH	Nos	2
28	D end SPANNER-6/7 TO 22/23,24/27,30/32	Nos	2
29	Ring SPANNER-6/7 TO 22/23,24/27,30/32	Nos	2
30	PIPE WRENCH	Nos	2

S.No.	DESCRIPTION	UNIT	Qty.
31	ADJUSTABLE WRENCH	Nos	2
32	HAMMER (2 Kg)	Nos	2
33	CHISEL FLAT	Nos	2
34	ALLEN KEY	Nos	2
35	SCISSOR	Nos	2
36	SPIRIT LEVEL	Nos	2
37	CLAMP METER	Nos	2
38	BOX SPANNER	Nos	2
39	Service Tools & Special Tools for	Set	1
40	Service Tools & Special Tools for EOT	Set	1

Table 04.

Mandatory Spare for Compressor (for each compressor)

Sr. No	DESCRIPTION	Quantity (in Nos)
1	Air Filter	1
2	Kit Air/Oil Filter	1
3	Oil Separator Kit	1
4	ROTO Fluid (20 Lits.)	1
5	Oil Stop/Check Valve Kit	1
7	Unloader Valve Kit	1
8	Pressure Transducer	1
9	Temp. Sensor	1
10	Solenoid Valve	1
11	Minimum Pressure Valve Kit	1
12	Thermostat Valve Kit	1
13	Oil Level Gauge	1
14	Suction Hose	1
15	C/ V To Air/Oil Tank	1
16	Mpv To Unloader Valve	1
17	Oil Filter Assembly.-Oil Cooler	1
18	Oil Cooler To O/F	1

19	Oil Filter To O/S/ V	1
20	Scavenging Line	1
21	Mpv To After Cooler	1
22	After Cooler To Outlet	1
23	Motor Overhauling	1

Note:

- i. Any additional Spares/tools required for maintaining the system for a period of two years after the DLP in case of Air Compressor and high mast lighting tower, may also be added by the tenderer in spare list provided as part of technical submission. However, the same shall be reviewed during DLP and any additional spares required for maintenance for these systems for a period of two years after DLP shall have to be provided by the contractor without any extra cost.
- ii. The bidder shall provide data of each Compressor in separate sheets with latest Standard's to be followed.

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TECHNICAL SPECIFICATIONS
PART-F : LAN SYSTEM

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1.0 Scope

This technical specification covers for design, providing, testing & commissioning of LAN system with all accessories and components for all buildings, other locations of depot of BSRP.

Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work

2.0 Technical details Form- Passive Components

Table A	
1) Passive (UTP & Fiber) Items	
1) Category 6 UTP, 4 Pair Cable	
Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
Characteristic	Required Specification
Features	Category 6 Unshielded Twisted Pair 4 pair 100 Ohm cable shall be compliant with ANSI/TIA/EIA-568-C.2 performance verified up to 250 Mhz. Additional Transmission Performance Specifications for 4-pair 100 Ohm Category 6 Cabling.
	The 4 pair Unshielded Twisted Pair cable should be RoHS Compliant.
Mechanical Characteristics	Construction: 4 twisted pairs separated by internal X shaped, 4 channel, full separator. Half shall not be accepted.
2) INFORMATION OUTLET & FACE PLATE (Dual Port)	
Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
The acceptable Make & Model for the items to be supplied under the scope of this bid are indicated against each. The bidder has to fill up any one of those Make & Model. The required specifications are also indicated against each of these items. It is mandatory to fill up the compliance against each of them. If multiple Make & Model for any item is indicated or if the required specifications are not complied with, such bids are liable for rejection. The specification & other details are provided in the following table.	

3.0 Mounting Cords (7 Feet & 3 Feet)

Table B

Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
Characteristic	Required Specification
Features	Category 6 Equipment cords
	The work area equipment cords shall, at a minimum comply with proposed ANSI/TIA/EIA-568-C.2 250 Mhz. Commercial Building Cabling Standards Transmission Performance Specifications for 4 pair 100Ohm Category 6 Cabling.
	Should be RoHS Compliant
	Modular cords should include a molded strain relief boot.
	Should be covered by ETL verification / UL Listed program for compliance with TIA 568-C.2. Certificate to be submitted with bid.
Mechanical Characteristics (Cable)	Conductor size: 24 AWG stranded bare copper
	Jacket: PVC
	Temperature range: -20oC to +60oC
Mechanical Characteristics (Plug)	Operating life: Minimum 750 insertion cycles
	Cat 6 Cable should be RoHS Compliant.
	Approvals: UL or ETL

4.0 24 Port Jack Panel

Table C	
Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
Characteristic	Required Specification
Type	24-port, Unshielded Twisted Pair, Category 6, TIA / EIA 568
Port Arrangement	Keystone Krone type. Ports must be replaceable in 8 Port Module.

Category	Category 6
Circuit Identification Scheme	Patch Panels Rear Cable Management without tie-wrap with simplified numbering labels
Height	1 U Rack Mountable
Performance Characteristics to be provided along with bid	Attenuation, NEXT, PS NEXT, FEXT and Return Loss

5.0 6 Core Single Mode Optic Fiber Cable (Ofc)

Table D	
Fiber Type.	9/ 125, Telcordia's GR-20 and ITU-T 652.D Compliance
	Cable Construction will be Telcordia GR-20 / IEC 794-1.
Attenuation	@1310nm < = 0.35 dB/Km @1550nm < = 0.20 dB/Km
Coating / Cladding	non-circularity <= 12 microns.
Tensile	rating ---1200N
Armoring	Corrugated Steel tape Armor(For outdoor cables)
Jacket	Outer:-High density polyethylene, anti -termite, anti -rodent suitable for direct burial application.
	Min Bend 20 X Outer Diameter.
	Weight approx 90 Kg/Km.
Test	Test (Must pass) : IEC794-1-E1 , IEC794-1-E2 , IEC794-1-E3 , IEC794-1-E4 , EIA-455-104 , IEC794-1-E7 , IEC794-1-E10 , IEC7941-F1 , IEC794-1-F3 and IEC794-1-F5
Marking	Marking should be Identification marking at regular intervals of 1 meter.
Temperature	Operating Temperature : -40 Degree C to +70 Degree C

6.0 Optical Fiber Patch Cords Sm, Duplex Lc To Sc – 3 Mtr.

Table E	
Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
Characteristic	Required Specification

Type	Duplex LC/SC, 9/125 micron SM fiber, factory terminated ceramic connectors. Qualifies as per ITU-T G652 D Fiber.
Connector Type	Plastic molded plug type connectors
Outer Sheath	PVC Jacket Standard 2.5mm ceramic ferrule Compact in size and easy to connect Recommended by EIA/TIA 568
Bending	Macrobending, Max. (100 turns) 0.05 dB (1,310/1,550nm@50mm) 0.05 dB (1,625nm@60mm) Macrobending, Max. 0.05 dB@1,550nm (1 turns@32mm mandrel)
Length	3 mtrs

7.0 LIU,12 AND 24 Port Rack Mount Enclosure

Table F	
Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
Characteristic Features	Required Specification
	1U, 19 Inch Rack mountable Metallic Distribution Enclosure with Adaptor Plate and Splicing Tray with air ventilation provision on the enclosure.
Features (Contd.)	19 " Rack Mountable Cabinet
	Complete Steel, fully powder coated
	Panel cover is of slide out for easy maintenance
	Universally compatible (e.g. ETSI std compliant)

8.0 Digtail Sc Sm Simplex Length-1.5 mtrs

Table G	
Acceptable Make & Model	
• Systimax	
• Tyco	
• R&M	
• Clipsal	
Characteristic	Required Specifications
Features	Simplex SC, 9/125 micron SM fiber, factory terminated ceramic
	Connectors. Qualifies as per ITU-T G652 D Fiber
	Length 1.5 Mt.

Bending	Recommended by EIA/TIA 568
	Specifications
	Macro bending, Max. (100 turns) 0.05 dB (1,310/1,550nm@50mm)
	0.05 dB (1,625nm@60mm)
Server/Networking Racks	Macro bending, Max 0.05 dB@1,550nm (1 turns@32mm mandrel)

9.0 42 U Floor Standing Network Rack with Accessories

Table H	
Acceptable Make & Model:	
• Rittal	
• APW	
• NETRACK	
• HCL	
Characteristic	Required Specification
Size	42U floor Standing
Door	Front Transparent Lockable Glass Door

10.0 15 U Wall Mount Network Rack with Accessories

Table I	
Acceptable Make & Model:	
• Rittal	
• APW	
• NETRACK	
• HCL	
Characteristic	Required Specification
Size	15 U wall mount rack
Door	Transparent Lockable Glass Door

11.0 9 U Wall Mount Network Rack with Accessories

Table J	
Acceptable Make & Model:	
• Rittal	

• APW	
• NETRACK	
• HCL	
Characteristic	Required Specification
Size	9 U wall mount rack
Door	Transparent Lockable Glass Door

---XXX---

TECHNICAL SPECIFICATIONS
PART-G : ACCESS CONTROL SYSTEM

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BIOMETRIC ATTENDANCE SYSTEM

SPECIFICATION FOR BIOMETRIC ATTENDANCE SYSTEM

1) General Objective

The intent of this specification is to describe the requirements of BIOMETRIC ATTENDANCE SYSTEM proposed for Bi-RIDE Depot's.

The Biometric Attendance System shall be supplied, configured and commissioned by the manufacturer or its authorized registered agent, to the requirements of the client or persons responsible in coordinating the technical requirements of the system.

2) Scope of Work

- a) The Vendor shall furnish a fully operational Biometric access system at the main entry across all the Location in PAN India
- b) The Supplier shall refer to the schematics for detailed understanding of the system to be furnished.
- c) The bidder/supplier shall be responsible for engineering and functioning of a complete system, fully meeting the intent and requirements of the specifications, Any mismatch in communication protocol, interfacing shall be brought to the knowledge of the Purchaser before placement of order.
- d) The Functional, Technical & Architectural Specifications in subsequent Section are required to be met mandatorily by this proposed Biometric Attendance System.
- e) Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work
- f) The manufacturers proposed by the bidders should meet the following basic pre-qualification conditions:

FUNCTIONAL SPECIFICATIONS

3) Attendance Management System

Following are the specifications required

- a. Should provide Employee Self Service & Manager Self Service modules
- b. Employee Biometrics Registration Capability (Finger Print based / Card based)
- c. Employees Attendance Capture Capability
- d. Employees should be able to raise Attendance Regularization requests
- e. Attendance Regularization Capability (Managers)
- f. System should be capable of report generation & analytics (as per HR requirements)
- g. System should allow seamless attendance for employees with frequent mobility to other locations
- h. If finger print can't be read because of any disease, scars, tattoos, bandage or similar issue, alternate mechanism should be provided.
- i. Role Based Application Attendance

4) Leave Management System

- a. Should provide Employee Self Service & Manager Self Service modules
- b. Leave Requests Submission (Employees)
- c. Edit Leave Application
- d. View Leave Transaction Details, Leave Summary
- e. Leave Application Approval (Managers)
- f. Leave Cancellation capability (by Employees, Managers)
- g. Role Based Application Access
- h. System should be capable of report generation & analytics (as per HR requirements)

5) Integrations Capability

- a. Capability of Integration with Payroll System
- b. Capability of Integration with HRMS System
- c. Capability of sharing API for 3rd party interface

ARCHITECTURAL / TECHNICAL SPECIFICATIONS

6) Technology/ Information Security

- a. Installation of Biometric devices will be at multiple office location. The device should communicate with the central server, which will be placed in the Data Center.
- b. The Biometric device should communicate with central server over secured LAN/Internet
- c. Application Servers to be available in High Availability(HA)
- d. Biometric device communication in HA mode should be automatic. No manual/script based intervention should be required to leverage HA based communication between device and application servers
- e. All Finger print / registration/Employee Data should be encrypted/Protected during transit and at rest
- f. Biometric device should contain WiFi, USB port form of external access and data storage in case its necessary
- g. Device must support version control feature in order to remotely monitor and provision application and system software. Remote device management feature must be provisioned as a part of the device deployment
- h. If there is a network failure between the device and server, mechanism should be available to handle the

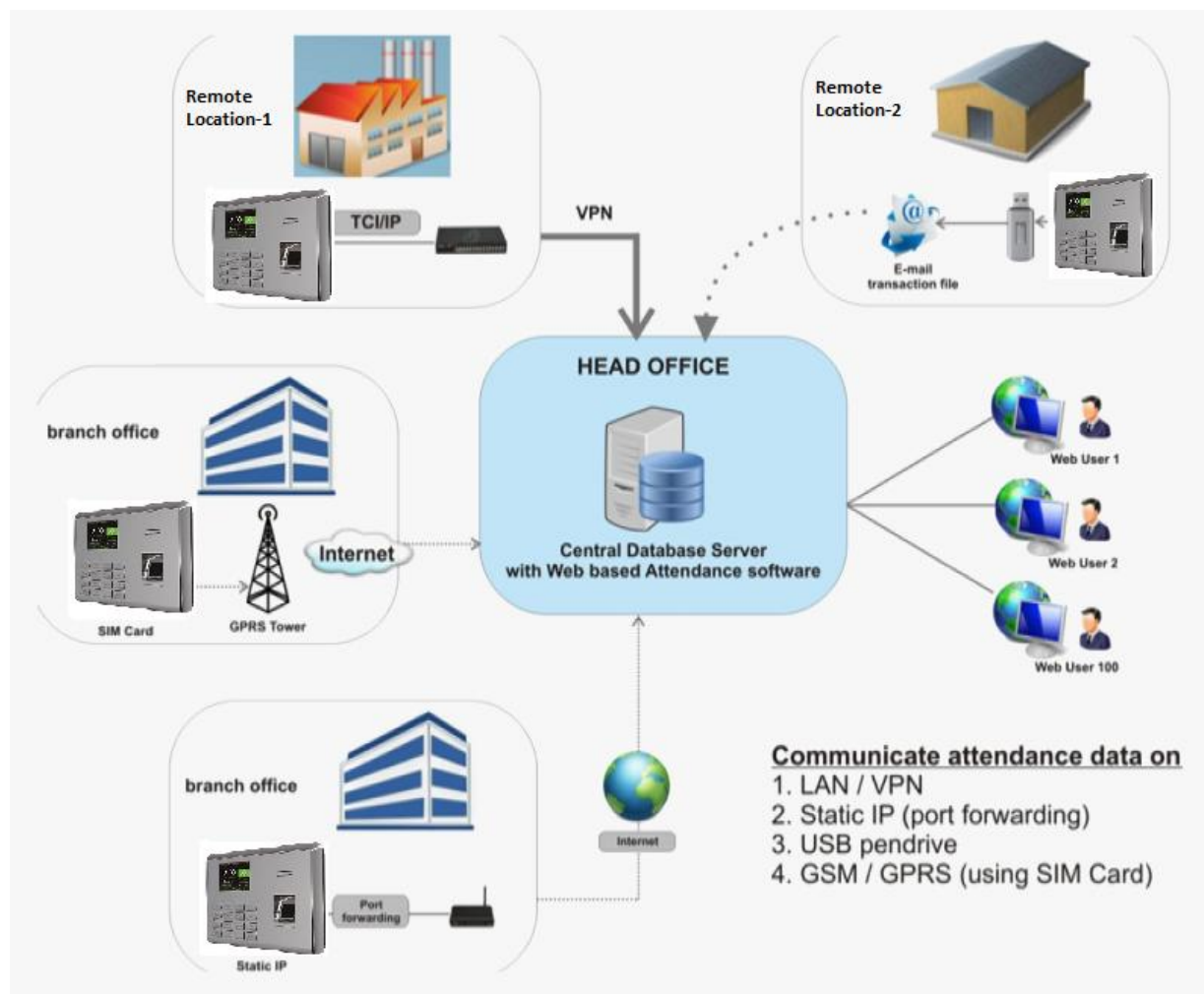
- transactions at respective reader level.
- i. Biometric device admin access should be password protected. Database should be either on Oracle 12c or SQL Server 2012 or higher
 - j. Communication between Device and application servers will happen over MPLS WAN/LAN/Internet. Device should be able to handle such latency
 - k. Centralized Device maintenance, new user registration, user data purging and administration is required

Table No. 1 Biometric Reader Specification

Sl. No.	Features		Minimum Specifications	Compliance Yes/No
1	Storage Capacity	Fingerprints templates	10000	
		Card Storage	10000	
		Transaction storage	1,00,000	
		Card reader	Inbuilt EM Prox Card (Optional Support Mifare)	
		CPU	1.2 Ghz Microprocessor	
2	Biometric	Fingerprint sensor	500 DPI Optical sensors	
		FAR	≤0.0001%	
		FRR	≤0.01%	
		Identification speed	<0.5 sec	
3	Audio/Visual	Display	2.8" Color TFT	
		Keypad	Yes	
		LED Indicator	Green/Red	
		Schedule Bell/Speaker	Mini Speaker	
4	Communication	Communication	TCP/IP, USB;RS485	
		Push data	yes (support both static IP and domain server)	
		Interfaces	RS 232, 2 Relay ,Wiegand IN & OUT ,	
			Input for smoke detector	
5	Power & environment	Power Supply	DC 12V: 1.5Amp	
		Operating Temperature	0 °C- 45 °C	
		Operating Humidity	20% ~ 80%	
		Dimension	213*155*107.81mm	
6	Exit Readers	Support exit readers	any weigand reader	
7	Features	Battery Backup	2-3 hours	
		Card readers	EM Prox /Mifare	
		Standard Features	Automatic Status Switch, Self-Service Query, DST, T9 Input, 9 Digit User ID, Scheduled Bell, Photo ID, ADMS,Lock, sensor, Exit button, Alarm, duress FP, Mult-verification	
		Communication	Ethernet and USB	
8	Compatible Software and SDK		Desktop & web application	
			API for desktop applications	

Sl. No.	Features	Minimum Specifications	Compliance Yes/No
		Web based Device Manager/ePush server using Push data. Helps developers & integrators	
9	Major Applications	Time & Attendance Management	

7) Architectural Layout



TECHNICAL SPECIFICATIONS PART-H : LIFTS

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Technical specification of passenger lifts-machine room less type

1.0 Codes & Standards

The following Indian Standard Specifications and Codes of Practice, currently applicable and updated as of date irrespective of dates given below, shall apply to the equipments and the work covered by this contract. In addition the relevant clauses of the Indian Electricity Act 1910 and Indian Electricity Rules 1956 as amended up to date shall also apply. Wherever appropriate Indian Standards are not available, relevant British and/or IEC Standards shall be applicable.

34. Sl. No	35. Code	36. Description of code.
1	IS 14665 (Part-1) – 2000	Electric Traction Lifts – Guide line for outline- dimension
2	IS 14665 (Part-2) – 2000	Electric Traction Lifts – Code of practice for installation
3	IS 14665 (Part-3) – 2000	Electric Traction Lifts – Safety Rules
4	IS 14665 (Part-4) – 2000	Electric Traction Lifts – Components
5	IS 14665 (Part-5) – 2000	Electric Traction Lifts – Inspection manual
6	IS 2363 – 1981	Glossary of terms relating to wire ropes
7	IS 2365 – 1977	Steel wire suspension ropes for lifts and hoists
8	IS 4289 – 1984	Flexible Trailing Cables for lifts
9	IS 7098	1100 volt grade XLPE insulated armoured cables
10	IS 1554 – 1988	1100 volt grade PVC insulated armoured cables
11	IS 694	1100 volt grade FRLS PVC insulated copper conductor wire
12	IS 9537 – 1981	Rigid steel conduits
13	IS 3480 – 1966	Flexible steel conduits
14	IS 7403 – 1974	Code of practice for selection of standard worm and helical gear boxes
15	IS 732 – 1963	Code of practice for electrical wiring installations(system voltage not exceeding 650 volts)
16	IS 5216 – 1982	Safety procedure and practices in electrical works
17	IS 1646 – 1997	Electrical installation fire safety of buildings

18	IS 14665 (Part-4/Sec 1 & 9): 2001	Electric Traction Lifts Part – 4 Components
19	IS 14665 (Part-5): 1999	Electric Traction Lifts Part – 5 Inspection Manual
20	IS 7754-1975	Specifications for hoist way door-locks
21	IS 1735-1975	Rules for design, installation, testing and Operation of lifts, escalators and moving parts

In addition the relevant clauses of the following, as amended up to date shall apply.

- The Indian Electricity Rules 1956
- The Indian Electricity Act 1910
- Bombay Lift Act 1939
- Delhi Lift Rules
- Fire safety regulations pertaining to lifts

The Contractor shall also take into account local and State regulations as in vogue for the design and installation of lifts.

Wherever appropriate Indian Standards are not available, relevant British and/or IEC Standards shall be applicable. BIS certified equipment shall be used as a part of the Contract.

2.0 Intent of Specification

It is not the intent of Technical Specifications to completely specify all aspects of design / construction features of equipments and all details of work to be carried out never the less the intent of the Technical Specification is to ensure that the equipments and the work shall fully comply with and conform to the relevant Bureau of Indian Standard Specifications, Codes of Practice, Indian Electricity Act, Indian Electricity Rules and other Statutory Regulations as may be applicable and to the best available standards of engineering, design and workmanship. The equipment and work shall perform in manner acceptable to Owners who shall interpret meaning of the applicable Specifications / Codes and shall have the right to reject any equipment or work, which, in their assessment, is not complete to meet the Standard / Code. The components / materials, which may not be specifically stipulated in the Specification, but which are necessary for satisfactory installation and/or operation of any portion of the work, shall also be provided within the contract rates without any extra cost. Contractor shall carry out and complete the work in all respects to the satisfaction of Owners as per the contract agreement and as directed by engineer-employer and as required as per site condition.

2.1 Scope of work.

This technical specification covers for work of design, supply, erection & commissioning of correct capacity- passenger machine-room-less lift for important building of depot, like Admin building /OCC/ Pway /ETU / other shed & Buildings as per site requirement and as per employer requirement. Number of lifts with Capacity like 6 passenger / 8 passengers /10 passenger / 13 passengers as per approved design / drawings shall be provided.

Also scope of the contract shall comprise of providing equipment's, components, materials, scaffolding, testing equipment, trial operation and free comprehensive maintenance during performance guarantee period (one year after completion) etc. required for completion of the work as per the contract Agreement.

Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the quoted rate and scope of work

2.2 Conformity of work as per central / local authorities

The work shall conform to all the provisions of the relevant government legislation, regulations and Bye-laws of the Central / Local Authorities and of the concerned electricity supply authority. The Contractor shall also be responsible for giving all notices required under the said Acts /regulations/ laws.

3.0 Preliminary Site visit.

Contractors are advised to visit the site after taking prior permission from employer for familiarizing themselves with working conditions available at site as also with the statutory levies and their prevailing quantum payable at site. Contractors shall not be entitled to claim any extra payment on account of lack of such knowledge after award of contract.

3.1 Power Supply

The available system of electric supply is 415 volts +10% -20% between phases and 240 volts between phase and neutral - 3 phase 4 wire AC 50 Hz system. In addition, for illumination within lift with single phase 240 volts AC single phase 50 Hz , control voltage with single phase 240 volts & and suitable DC voltage for lift control circuit.

3.2 Ambient Conditions

All equipments components and materials used in the work shall be suitable for continuous operation / use at rated output with permissible overload at the following extremes of ambient conditions likely to be encountered at site.

- Temperature from minimum 0° C to maximum 50° C
- Related humidity from minimum 10% RH to maximum 100% RH

4.0 Testing

- Testing of equipments at manufacturers work prior to dispatch.
- Testing at site as required

4.1 Transportation, Storage, insurance etc.

- Loading, transportation and unloading.
- Protection of stored materials / installed work against damage due to dirt, sun and rain including providing tarpaulin/ PVC sheet covers as required.
- Providing security arrangements /watch and ward for stored materials and installed works to guard against pilferage including providing temporary covers on conduit outlets after drawing of wires before fixing switches/fittings etc.
- Comprehensive insurance with owners as beneficiaries against pilferage during Transportation /storage/installation valid till handing over.

4.2 Name plates

Providing engraved anodized aluminium or approved equivalent name plates of suitable sizes on lift panels / equipments etc.

4.3 Associated Civil Works

- Construction of lift shaft as per capacity, dimension required as per guidelines of lift manufacturer.
- All steel items required for lift in lift pits and hoist ways including pit ladder, beams, ceiling hooks as required inside lift shaft etc.
- Minor civil works of making cutting in walls / ceilings, making holes and openings, grouting etc including external / internal painting of lift shaft

4.4 Final Painting

Providing final paint coat to all exposed fabricated steel frames & other fabricated items and providing matching paint for factory painted equipment if damaged during transportation /storage / installation before handing over.

4.5 Statutory compliance and approval

Complying with rules, regulations & norms of Electrical Inspector / other statutory authority for carrying out work and after completion of work

- Obtaining approval from Lift inspector for satisfactory installation of the lift and as well as for clearance required for lift operation.
- Obtaining any other statutory permission /clearance /approval from concerned authority as required.

4.6 Manuals, drawings etc.**4.6.1 General Arrangement drawings of lift**

The contractor shall submit GA drawings of Lift system to employer for approval before commencement of work at site.

4.6.2 Operation and maintenance manuals

Six sets of operation and maintenance manual with drawings including control circuit drawings shall be submitted to the employer after completion of work along with six sets of as built drawings.

5.0 Trial Operation and Performance Guarantee

Trial operation of each lifts for a minimum period of 4 weeks after obtaining clearance from Lift inspector

The Lift shall be subjected to trial operation for a period of not less than 4 weeks after completion of installation, testing, commissioning and obtaining statutory approvals /permissions /clearances as required. If any defect or deficiency is noticed during this trial operation, same shall be rectified by the Contractor with own cost and shall once again do trial operation after rectification till all the lift operate satisfactorily for a period of one month. Lifts shall be operated during working hours on working days during this trial operation period unless otherwise stated.

5.1 Performance Guarantee

The entire work executed under this contract shall be guaranteed against manufacturing defects and due to bad workmanship for a period as per the manufacturer / not less than one-year period after the exact date of completion as defined in para 5 above. Any defect arising out of reasons attributable to manufacturing defect shall be rectified / replaced to the satisfaction of the employer at free of cost - during the performance guarantee period.

6.0 Technical Data of Lift

Appendix-IV covers technical data of passenger lift. All technical data of lift shall be submitted to employer in standard form before to start of work and after completion of works in all respects as per the contract.

6.1 Group Supervisory Control Panel

A group supervisory control panel shall be located in the Engineering / depot control center duly considering entire BMS work under the scope of E&M contractor for the following details

- Direction of travel
- Lift operational / out of service / under maintenance
- Location of lift car
- Fault condition of any safety

This panel shall interface with the BMS Systems

7.0 Lift Machine and Controller

a) Lift machine.

The lift machine shall be suitable for operation on 415 volt 3 phase 50 Hz AC supply with a voltage variation of +10% and -20% and shall be placed directly at top of the Lift shaft with suitable rigid supporting structure with steel beams etc.

The lift machine shall be geared reduction / gearless type and shall consist of a motor, electromechanical brake, sheave shaft and sheave all completely mounted on a common bed plate. Resilient anti vibration mountings of suitable design shall be provided to minimize vibration transmission to the building structure. Bearings shall be of sleeve ring type with oil ring bearing. Smooth wheel shall be fitted to the shaft of the hoist machines to race the lift cars up or down by manual operation. Removable wheels shall be located in easily accessible locations. The hard alloy cast iron or steel sheave shall have rope grooves to ensure proper traction and minimum steel rope wear. Adequate means of lubrication shall be provided for all bearings.

Means for manual operation of the lift car shall be made by providing winding wheel suitably marked to indicate the direction of the movement to enable the lift car to be brought to the nearest landing. There shall be a warning display for switching off electrical supply before the manual operations. A prominent notice shall be provided stating that hand winding shall be undertaken by authorized persons and detailing step by step procedures to be taken to move the lifts in case of emergency. Each lift shall be provided with independent service switches.

b) Brake

Electro-mechanical break shall be provided to stop the lift machine when the car is travelling at rated speed with 125% load. The brake shall be spring applied and electrically released. It shall come into action after the lift has come to a complete halt to hold the car in position. The brake shall operate automatically with the safety devices during failure of the main power supply. It shall be released electrically. It shall be possible to release the brake manually - such release requiring the action of manual force to move the lift in short stops.

8.0 Motor

- a. The drive motor shall be an AC self-lubricating motor suitable to withstand frequent peak currents encountered in lift duty and shall have high starting torque and low starting current.. Thermistors shall be embedded in the stator windings to indicate the temperature rise in the motor. The motor shall have Class F insulation and shall be suitable for 180 starts per hour with a maximum temperature rise of 50-degree C over the ambient.
- b. Machine room less lifts / elevators.

The gearless traction machine and compact PM (permanent magnet) motor are installed within the hoist way and the slim control panel located in the shaft side wall.(as per manufacturer guidelines.

9.0 Control system**9.1 Description**

The Lifts shall have state of art microprocessor based AC variable voltage variable frequency (ACVVVF) drive. Single lifts shall be provided with directional collective control for one car (also called Simplex Full Collective Control).

Two lifts adjacent to each other in one location shall be provided with Directional Collective Control for two cars with Group Supervisory Control as stipulated in para 8.2.8 of IS 14665 (Part-II/Section- I) : 2000 also called Duplex Full Collective Control.

3 lifts adjacent to each other in one core shall be provided with directional collective control for 3 car with group supervisory control as stipulated in para 8.2.8 of IS 1665 (Part- I/Sec- 1) : 2000 also called triplex full collective control. The control system shall regulate dispatching of individual cars and shall provide service to all floors as different traffic conditions arise minimizing unproductive factors. The system shall respond automatically to UP and DOWN peak, balanced or light traffic etc.

Some of the technical parameters required are indicated as in below table.

Sl. No	parameter	Value / range.
1	Starting current	1.2 - 1.5 times full load running current
2	Power saving	50 - 55%
3	Levelling accuracy	± 5 mm
4	Acceptable voltage fluctuation	+10 to -20%
5	Rate of acceleration / deceleration (M/S ²)	0.6 - 1.5 (Adjustable at site)
6	Maximum jerk (M/S ³)	0.7 - 1.5 (Adjustable at site)
7	Maximum vibration in car horizontal / Vertical	20/18 dBA
8	Maximum noise level in car during travel	48 dBA
	Maximum noise level in machine room at 1 mtr from machine	62 dBA
9	Maximum door noise level while closing and opening at a	52dBA

	distance of 1 mtr from car door	
--	---------------------------------	--

The controller shall be wall/floor mounted, vertical, totally enclosed cubicle type with hinged doors on the front and the rear to provide easy access to all components in the controller. The cubicle shall be well ventilated such that the temperature inside never exceeds the safe limits of the components at ambient room conditions in the machine room.

The controller shall operate within the supply voltage variation of plus 10% to minus 20% of the nominal voltage. An inbuilt voltage stabilizer shall be provided in the controller for the purpose.

The Controller shall include protection against the following abnormalities and shall cut off the power supply, apply the brake and bring the car to a rest in the event of any of the abnormalities occurring.

- a) Over load
- b) Over current
- c) Short circuit
- d) Earth fault
- e) Over speed
- f) Under voltage
- g) Overvoltage
- h) Single phasing
- i) Phase reversal

9.2 Features

Control system features are detailed as below.

Attendant Operation

All lifts shall be provided with attendant control facilities.

A key switch for change of operation mode shall be provided in a lockable recess panel on the car operation panel. After gaining control on the lift, the attendant shall be able to stop the car at any storey , floor level . The attendant can also by pass the landing calls (but not cancel them) or reverse the direction of travelling.

Automatic By-pass

Load weighing devices located either on car top or under the car cage shall be provided for all lifts.

Over load device

A load weighing devices shall operate when the load in the car exceeds the rated capacity. The operation of the device shall activate buzzer sound and flashing 'overload' signals. At the same time the car doors shall be prevented from closing, when the excess load has been removed from the car, the buzzer alarm shall be muted automatically and the car shall function normally. The sensitivity shall be 30 kg for Passenger lifts and 5% of the contract load for service lifts.

Emergency Cranking

The hoisting machines shall be provided with a set of special tools including a hand crank or its equal to allow release of hoist brake and provide for manual movement of the car in case of emergency. These tools shall be hung up on a tool board fitted to a wall in the lift machine room, with instructions of their use clearly written on the board both in English and the local language. The lift system supplier shall qualify his bid with respect to manual cranking. Before use of manual cranking mechanism, main switch to be put off as per codes and safety practice.

Automatic self-levelling

All lifts shall be provided with automatic self-levelling feature that shall bring the lift car level to within ± 5 mm of the landing floor levels regardless of load or direction of travel. The automatic self leveling feature shall correct for over travel and rope stretch.

9.3 Automatic rescue Device

Battery operated **Automatic Rescue Device (ARD)** shall be provided for each lift which shall allow the lift car to release to next floor landing with lift door open and shut down for operation. The ARD shall be operated automatically in case of any power failure to the lift installation for more than a preset time (0-10 minutes)

LIFT CAR, DOORS AND SAFETY DEVICES

10.0 CAR ENCLOSURES-

General requirement

10.1 Frame

Every lift car body shall be carried in a steel car frame assembly which shall have sufficient mechanical strength to resist the forces applied by the safety gear or impact of the car on the buffers. The deflection of the steel members carrying the platform shall not exceed 1/1000 of their span under static conditions when the rated load is evenly distributed on the platform

At least four renewable guide shoes or shoes with renewable linings or sets of guide's rollers shall be provided two at the top and two at the top and two at the bottom of the car frame assembly.

10.2 Load plates, notice boards and instructions

A stainless steel load plate indicating the rated load of the lift shall be fitted inside each lift car.

The following notice boards shall be supplied and securely mounted in each car denoting

- a) The name of the company, telephone number and emergency instruction
- b) "No smoking" which shall be manufactured from stainless steel sheet of red letter
- c) A metal housing containing necessary tools, together with clear instructions for moving the lift car and releasing passengers in emergency shall be provided at suitable location.

Details of all the notice signage shall be submitted to the Engineer--employer for approval before fabrication.

10.3 Enclosure finishes

Finishing of the car enclosure shall be as below.

a. Passenger Lifts

- Walls: - painted with suitable paint, as per Employer. Lift floor shall be with good tiles, granite floor finish etc as per approval of employer.. Load intensity to be catered for is 275 kg. Contractor to furnish maximum weight of the floor finish permissible
- Car & landing doors: - Hair line stainless steel finish.
- Ceiling: - Ceiling finish shall be durable and shall be provided as per employer. Alternatives design for all aspects of lift car shall be submitted to employer for approval before procurement of lift.

b. Fixtures and fittings in each car

Following fixtures and fittings matching with interior design and as approved by Architects shall be provided in each lift car.

- Hand rail: A stainless steel pipe hand rail of approved finish.- 3 nos on three sides or 2 nos on two sides inside - lift cabin
- Mirror- on one side.
- Cabin fan: side throw ventilation grills with blower above false ceiling with switch control or automatic operation of fan with respect to operation of lift cabin.
- Normal & Emergency light: totally with indirect fluorescent fixtures with switch control
- Alarm System: An emergency alarm bell, including wiring shall be provided and connected to a plainly marked push button in the car operating / control panel. The alarm bell shall be located in central security room. The alarm unit shall be solid-state siren type, to give a waxing and waning siren when the alarm button inside the car is pressed momentarily. Built in 3 way intercom system with telephone instrument inside the car / inside the control

panel and reception / security, (as directed by employer) including wiring telephone instrument and associated EPABX shall be provided.

- Lift operation supervisory control panel shall be located at reception / security and shall also be provided with intercom facility. The panel shall have interconnectivity with BMS
- Sealed Maintenance free battery capable of maintaining the following in each lift for 30 minute after mains failure.
 - Emergency light in car
 - Cabin fan
 - Intercommunication System
 - Alarm bell
- One no. 16 amp switch socket outlet to IP 54 and a permanent weather proof type luminaries to IP54 (with lighting switch) adequately protected shall be provided on the top of the lift car inside lift shaft for maintenance.
- One no. 16 amp switch socket outlet to IP 54 at bottom of lift car inside lift shaft for maintenance.
- Necessary lighting inside lift shaft shall be provided as per the length / height of lift shaft

10.4 Operation Panel

A car operating panel / control panel incorporating following control / indications shall be provided in each lift car along with auxiliary car operating panel on the other side of the door to enable the lift to be operated from either side.

The finish of the panel shall be integrated with the interior.

- LED Illuminated push buttons of micro pressure type corresponding to the floors served.
- Door open and door close button.
- Emergency stop button.
- Emergency alarm button.
- Two position key operated switch for 'with attendant' and 'without attendant' operation.
- Ventilation fan ON/OFF switch with auto OFF when there is no call after 120 seconds.
- Built in intercom of the hands free type as well as space for providing EPABX telephone instrument and 5 pair telephone trailing cable to communicate from car to Central Monitoring Station (at remote location) and vice-versa.
- Dynamic car direction display.
- Car position indicator
- Audio/Visual overload warning indicator
- Digital car temperature indicator
- Digital voice synthesizer for announcing special messages with background music.

10.5 Landing fixture

The landing fixtures shall be recess mounted on a base junction box in the wall by the side or on top of landing doors as required

Each landing fixtures shall consist of micro touch type landing call buttons with illuminated call acknowledge signal and illuminated digital type car position indicators on separate stainless steel face panels with hairline finish.

The following landing fixtures shall be provided for each lift

- a. Lowest floor
 - Up call button
 - Digital car position indicators
 - Travel direction indicators
 - "In use" indicator to signify the lift door is opened for delivery at a certain landing
- b. All floors other than lowest and top most floor

- Button up and down call buttons
 - Travel direction indicators
 - Digital car position indicators
 - “In use” indicators to signify the lift door is opened for delivery at a certain landing
 - Manual by pass key switch for lift landings.
- c. The top most floor
- Down call button
 - Travel direction indicators
 - Digital car position indicators
 - “In use” indicators to signify the lift door is opened for delivery at a certain landing
 - Manual by pass key switch for lift landings.

12 V 20 W tungsten halogen spotlights shall be supplied and installed on the underside of the hall lanterns. The spot lights on a particular floor shall be lit up to signify the lift cabin reaching particular floor. These spotlights shall be switched off after lift cabin left that particular floor. For passenger cars, the spotlights on the parking floor shall be turned off after a present period adjustable from 15 to 150 sec. Should a call from the parking floor be registered, spotlight of the assigned parking car shall be switched on again together with the opening of the landing doors to attend the call.

10.6 Provisions for use of lifts by Handicapped persons

Wherever lift is required as per by-laws, provision of at least one lift shall be made for the wheel chair user with the following cage dimensions of lift recommended for passenger lift of 13 persons capacity by Bureau of Indian Standards:

<i>Clear internal depth :</i>	<i>1100 mm</i>
<i>Clear internal width :</i>	<i>2000 mm</i>
<i>Entrance door depth :</i>	<i>900 mm</i>

- Inscriptions for the car control panel as also for the floor signals shall be provided in Braille also. The Braille signage will be posted outside the lift.
- The level of car operating panel inside the car as also signalling push buttons etc. outside the car on each landing shall be lower than normal so that they could be within the reach of person sitting on a wheel chair also
- A hall lantern with audible chimes shall be provided at each landing.
- A hand rail not less than 600mm long at 900mm above floor level shall be fixed adjacent to the control panel.
- The time of an automatically closing door should be minimum 5 seconds and the closing speed should not exceed 0.25 M / Sec.
- The interior of the cage shall be provided with a device that audibly indicate the floor the cage has reached and indicate that the door of the cage for entrance / exit is either open or closed.

11.0 Car and Landing Doors

11.1 General requirements

- All car doors shall extend to the full height and width of landing opening unless otherwise specified and shall be operated with variable frequency door operator. A similar imperforate door shall be provided for every landing opening in the lift hoist way enclosure. The top track of the landing and car doors shall not obstruct the entrance to the lift cars. All car and landing doors shall have a fire resistance of not less than 1 hour.
- In addition, all the car and landing doors shall meet the following general requirements.
- Car door locking devices
- Every car door shall be provided with an electrical switch to prevent the lift car from being started or kept in motion unless the car door is closed. A mechanical locking device shall also be provided to prevent door opening from inside the car whilst the car is in motion.

- Landing door locking devices Every landing door shall be provided with a mechanical locking device to prevent opening of the door from the landing side in normal cases unless the lift car is in that particular landing zone.
- Projections and recesses
Any projections on or recesses in the exposed parts of the car doors or landing doors shall not exceed 10 mm to avoid finger trapping between sliding parts of the door and any fixed part of the cars or landing entrances.
- Sliding car and landing doors shall be guided on door tracks and sills for the full travel of the doors. The distance between the cars and the landing sills shall not exceed 35 mm.
- Door locking devices
- All doors locking devices, door switches and associated actuating rods, levers or contracts, shall be inaccessible from the landing of the car.
- Protective devices
- Protective devices shall be fitted to the leading edges of both car door panels. It shall automatically initiate reopening of the door in the event of a passenger being struck (or about to be struck) by the door in crossing the entrance during the closing movement.
- The obstruction of either leading edge when closing shall actual the protective device to function
- "Door open" alarm
- "Door open" alarm shall be provided in the car to initiate alarm and a continuous buzzer if a car or landing door has been mechanically kept open for a present period. The period shall be adjustable from 0-10 minute.
- **Emergency landing door unlocking devices and key**
Every landing door shall be provided with an emergency landing door unlocking device. When operated by an authorized person with the aid of a key to fit the unlocking triangle, the landing door shall be unlocked irrespective of the position of the lift car for rescue purpose. When there is no "unlocking" action, the key shall only be able to stay in the locked position.
In the case of coupled car and landing doors,. The landing doors shall be automatically closed by means of weight or springs when the car is outside the unlocking zone.

11.2 Lift door Protection

Multiple-Infra red door protection and mechanical shoes shall be provided for all lift to control door movement which shall cover the entire door opening effectively.

12.0 Counter Weight

The counter weights shall be contracted from multiple metal sections contained and secured within a steel frame and shall be equal to the weight of the car plus around 45% of the contract load. Counter weights preferably made of cast iron.

13.0 Guide Rails

The car and the counterweight shall be guided by two rigid steel guide rails throughout their travel. The strength of the guide rails, their attachments and joints shall be sufficient to withstand the forces imposed due to the operation of the safety gear and deflection due to uneven loading the car. This deflection shall be limited so as not to affect the normal operation of the lift. The guide rails shall have machined guide surfaces

14.0 Steel Ropes

Cars and counterweights shall be suspended by steel wire ropes which shall comply with the following requirements

- a) The normal diameter of the rope shall be at least 9 mm and 7 mm for governor ropes.
- b) The tensile strength of the wire shall be
 - 1570 N/mm² or 1770 N/mm² for ropes of single tensile
 - 1670 N/mm² for outer wires and 1770 N/mm² for inner wires of ropes of dual tensile.
- c) The ratio between the pitch diameter of sheaves or pulley and the nominal diameter of the ropes shall be at least 40, regardless of the number of strands.

- d) The factor of safety for the ropes shall be not less than 10.
- e) The strength of rope termination shall be at least 80% of that of the rope.
- f) The specific pressure of the ropes in the traction sheave grooves shall conform to the requirements as detailed in BS 5655 : Part 1 : 1986 and EN 81

15.0 Safety Devices

Safety devices shall be capable of operating only in the downward direction and stopping fully loaded car, at the tripping speed of the over speed governor, even if the suspension devices break, by gripping the guides, and holding the car there. All safety devices statutorily required by Lift Inspector, including but not restricted to the following shall be provided.

a. Self-Levelling

The Lifts shall be provided with self-levelling features of ± 5 mm accuracy.

b. Terminal slow down switches

These shall be provided and installed to slow down the lift car when approaching the top and bottom landings. The slow down switches shall act independently from the normal car operating device.

c. Over travel limit switches

These shall be provided and installed to stop the car within the top and bottom clearance, independent of the normal car operating device. The bottom over travel limit switch shall become operative when the bottom of the car touches the buffer.

When the over travel limit switches are operative, it shall be impossible to operate the car until the car has been hand would to a position within the normal travel limits.

d. Terminal Buffers

Suitable spring buffers mounted on RCC foundation blocks shall be provided for stopping the car in case of mal-operation. Dowels for the purpose shall be left while casting the pit floor alternatively floor reinforcement could be exposed by chipping for welding additional reinforcement for Dowels.

e. Interlocking

Adequate interlocking is to be provided so that the car shall not move, if the landing doors are even partially open and also the lift is overloaded.

f. Over speed governor

Over speed governor shall be of centrifugal type and shall operate the safety gear at a speed at least equal to 115% of the rated speed and less than the over speed governors shall be driven by flexible wire ropes with the following requirements.

- The breaking load of ropes shall be related to the force required to operate the safety gear by the safety factor of at least 8
- The nominal rope diameter shall be at least 7 mm
- The ratio between the pitch diameter of the over speed governor pulley and the nominal rope diameter shall be at least 30

The over speed governors shall be sealed after setting the tripping speed.

The breaking or slackening of the governor rope shall cause the motor to stop by an electric safety device.

g. Alarm bells

A concealed 200 mm diameter alarm bell shall be installed in the main security area. The alarm bell shall sound when the alarm bell button in the car operating panel is pressed. The bell shall mute when the pressure on the alarm bell button is released.

h. Emergency Stop Switches

An emergency stop for use by maintenance personal shall be provided in each lift car.

i. Fireman Switch

- Each Lift shall have a fireman switch with glass front for access by the firemen. The operation of this switch shall cancel all calls to this lift and shall stop at the next nearest landing if travelling upwards. The doors shall not open at this landing and the lift shall return to the ground floor. In case the lift is travelling downwards when the fireman's switch is operated it shall go straight to the ground floor bypassing all calls enroute. The emergency stop button inside the car shall be rendered inoperative.
- The fireman's switch shall be located adjacent to the lift opening at the terminal floor and shall be at a height of approximately 2 m above the floor level. For easy identification of fire men, lift which conform to the local authorities requirements, a red and white diagonal striped backing shall be provided behind the glass of the firemen's switch.
- A permanent notice of prominent size indicating the floors served shall be provided and displayed adjacent to the firemen's lift at the terminal floor. The notice shall be made of laminated plastic sheet or other approved materials with red letters on white background. Details of the notice shall be submitted to the Engineer-in-Charge for approval prior to fabrication.

16.0 Safety Items

Following safety items shall be provided in the machine room / at convenient suitable location for machine room less type lifts.

- First aid box.
- Fire buckets
- Danger plates

17.0 Control of noise and vibration.

17.1 General

The whole of the lift assembly, including the opening and closing of the car and landing doors shall be quit in operation and shall be free of rattling or squeaking noises. Lift doors operation shall be smooth to avoid the transmission of impact noise to the surrounding structure.

Noise level resulting from the operation of the lifts, including direct sound transmission, breakout noise and re-radiation of structure borne noise, shall not exceed the specified noise criteria of the adjacent spaces. Vibration resulting from operation of lifts of escalators shall not be perceptible in any occupied areas.

17.2 Car construction

All elements of the lift car construction shall be sufficiently rigid to avoid generation of noise by panel excitation as a result of movement. The total noise level in a moving lift car shall not exceed 55 dBA with the ventilation system operating.

17.3 Machinery

The lift motors shall be fitted with vibration isolation mounting having a static deflection of at least 20 mm. Provision shall be made for the control vibration isolation measures employed to ensure that structure borne noise resulting from the operation of the lift machinery is not audible in any occupied area.

Lift machinery noise levels under normal operating conditions shall not exceed 70 dBA at 1 m from the equipment in free field.

17.4 Arrival chimes

Noise from arrival chimes shall not exceed 60 dBA.

The above levels shall be measured at 3 m from the arrival chimes using a noise meter set to 'fast' response. Chimes with adjustable loudness shall be provided.

18.0 Safety Requirements

General requirements of lifts shall be as follows:

- Lift motor room shall be located preferably on top of the shaft and separated from the shaft by the floor of the room.
- Landing doors in lift enclosures shall have a fire resistance of one hour.
- Lift car door shall have a fire resistance rating of one hour.

- Grounding switches at ground floor level shall be provided for the lifts to enable the fire services to ground the lifts.
- Suitable arrangements such as providing slope in the floor of lift lobby shall be made to prevent water used during fire fighting etc. at any landing from entering the lift shafts.
- A sign shall be posted and maintained on every floor at or near the lift indicating that in case of fire, occupants shall use the stairs unless instructed otherwise. The sign shall also contain a plan for each floor showing the locations of the stairways. Alternate source of power supply shall be provided for all the lifts through a manually operated changeover switch.
- Fire Lifts – All lifts shall be provided with fire man's switch and shall be termed as 'Fire Lifts'.
- In case of fire, only fireman shall operate fire lifts. In normal course, it may be used by other persons.

19.0 Associated electrical works -

19.1 Scope-

Based on power requirements of lifts furnished by the lift manufacturer, power supply for the lifts machines, terminating in a switchboard / control board preferably at suitable location for machine room less type lifts shall be provided by the contractor. The earth bar provided on this switch boards shall be connected to the building earthing system also by the Contractor. All cabling / wiring / loop earthing beyond this switchboard for interconnection with the lift controllers / motors / indicators / push buttons / safety devices etc. shall be provided by the contractor and its cost shall be deemed to be included in the quoted rates.

19.2 Cabling

- Cabling between switchboard and the control box / lift motor shall be with XLPE insulated HR PVC sheathed 1100 volt grade aluminium conductor armoured cables conforming to IS 7098 or PVC insulated, PVC sheathed, 1100 volt grade aluminium conductor armoured cables conforming to IS 1554 or by copper cables shall be terminated in glands fitted with armour clamps the gland body shall be provide with an internal conical sating to receive the armour clamping cone and clamping nuts which shall secure the armour wires. A PVC shroud shall be fitted to cover the gland body and exposed armour wires
- Trailing cables for the lifts shall be EPR insulated stranded copper conductor flexible cables conforming to IS 9968
- Control cabling shall be with multi core stranded copper conductor PVC insulated and sheathed 1100 volt grade cables conforming to IS 8130. Minimum size of the cable shall be 2.5 sq mm.
- Where cables pass through walls or floor slabs, pieces of GI sleeves shall be provided for cast into the wall / floor and cable shall be drawn therein. Annular space around the cable in the sleeve shall be sealed with fire proof sealant supplied by the Contractor.

19.3 Wiring

- All wiring shall be carried out with FRLS PVC insulated 1100 volt grade stranded copper conductor wires conforming to IS 694 drawn in G.I rigid / flexible conduiting system and / or G.I. raceways. Minimum 2.5 sq mm size wires shall be used. Wires shall be cut only at terminations. Intermediate jointing shall not be permitted. Drawing, cutting and terminating of the wires shall comply with the relevant Indian standard specifications and shall be carried out in the most workmen like manner as per standard practice. All normal care like cutting the insulation with a pencil edge, taking care not to cut the strands and proper tightening of terminal connector screws to avoid loose connection or breaking of conductors etc. shall be taken.
- Heavy gauge black enamelled screw type ISI embossed G.I conduits with superior quality accessories approved by Engineer -in-Charge shall be used in the work. Conduits could either be recessed in floors / walls or fixed on surface with saddles and clamps. Final connections to vibrating the equipment shall be made with metal flexible conduits. Raceways fabricated from minimum 1.6 mm thick galvanized G.I sheets could be used specially in the machine room for interconnection wiring. Entire work shall be carried out in work man like manner as per standard practice

19.4 Earthing

Metal enclosures of all electrical equipment and devices including frames of motors, controllers, switchgear, conduits and raceways etc. shall be properly earthed so as to form an equi potential zone. Loop earthing of vibrating equipment shall be

done with flexible copper earthing braid or flexible cables. The lift motor frame shall be connected to the building earthing system termination at the switchboard by duplicate loop earthing conductors of appropriate size.

20.0 Associated civil & structural items.

All civil and structural items of work associated with erection and operation of lifts shall be provided by the Contractor at his cost including (but not restricted to) the following.

- Construction of lift shaft / well
- Steel Beams for machine- motor on top of shaft / roof slabs over lift well for lifting lift cabin.
- Temporary scaffoldings and safety barricades during lift installation in and around lift wells
- Sill angles
- Bearing plates
- Buffer supports
- Chequered plates
- Fascia plates
- Ladders in pits (G.I)
- Safety railing on car top
- Separator /stretcher beams if required.
- Dowels for terminal buffers in pit floor during casting.
- Necessary hooks on ceiling at top of lift shaft.
- Necessary drainage pipes / system at bottom of lift shaft, for drain out accumulated water if any inside the lift shaft.
- Complete cement plastering of walls inside the lift pit and outside the lift shaft for smooth finish.

The Contractor shall ensure erection and fixing of steel work in such a manner that no RCC wall or any other structural member is damaged.

21.0 Maintenance of lifts

The Contractor shall provide free comprehensive maintenance service for a minimum period of **one year** from the date of handing over of the lift to Employer or for the specified period of lift manufacturer. After expiry of this free comprehensive maintenance period, Employer reserve right to enter into annual maintenance contract with the contractor as per rates finalized in the contract

The maintenance services rendered by the contractor (free maintenance for one year after handing over and as per AMC if entered into for subsequent years) shall include routine and preventive maintenance as also breakdown maintenance if and when required. Maintenance services shall be provided with 24 hour emergency call out service.

22.0 Routine and preventive maintenance

Program of routine and preventive maintenance during the free (1 year) maintenance period as also during the tenure of annual maintenance contract shall comply with minimum requirements as below.

a) Weekly

- To check all bearing oils, oil rings, oil chains, etc. All machines should be carefully checked and repaired for abnormal temperature rise.
- To check and repair all relays and contacts as wells as their movements and repair as necessary
- To clean traction machines, relays panels, control panel, starter panels, selectors, governors, car top, car gates, sills and pits
- To check brake action and adjust if necessary
- To check and repair movement of door switches, gate switches and emergency stop switches
- To check and repair indicator lamps and indicator
- To check and repair annunciation lights, buzzer and car lights

- To check and adjust levelling differences, brake slippage, acceleration, deceleration and riding comfort.
- To check and repair movements of car control buttons, switches and the like.
- To check and repair operation of weighting devices.

b) Monthly

- To turn grease cups for speed governors and compensating pulleys
- To check and oil selectors
- To top up rail lubricators to clean ropes oil if necessary
- To clean traction motor brushes, brush holders and internal frame. Adjust slip rings if necessary. Check commutators.
- To oil electric brake pins
- To oil all pins of door operation and door opening mechanisms
- To clean hoist way, beams slow down cams, outside cages, rails and counterweight rails
- To clean, oil and adjust door closer and levers
- To clean main sheave, secondary sheaves and rope sheaves on car top and counterweigh top
- To clean and repair brake wheels and shoes
- To oil compensating rope tensioning pulleys.

c) Every Two months

- To clean and oil door hangers, door rails, interior of hanger case. If necessary adjust eccentric rollers, car door hangers, door connecting ropes and chains
- To check and repair door shoe
- To clean and oil safety fears
- To clean and oil car and counterweight guide shoes. Adjust if necessary
- To clean and oil interior of terminal limit switches and position switches. Check rubber rollers of terminal limit switches.
- To check oil clean and repair interior of door switches, gate switches. Replace worm parts if necessary
- To check and repair flexible cable
- To check and repair movement of limit switches
- To clean and oil interior of car control switches.
- To clean and check push buttons of care control panels
- To check, clean and repair the sleeve and plungers of the electromagnetic brakes.

d) Every three months

- To check and repair the operation of terminal limit switches and final limit switches.
- To check and repair the governor switches.
- To clean the brush holders and commutators of the door motors.
- To check and repair the traction ropes for broken wire, wear elongation and even tension. Adjust if necessary.
- To remove the dust inside the traction machines and controls panels using electric blower
- To clean and repair the indicator lamps
- To check the voltage of rectifiers and thyristors

e) Half yearly

- To check and repair the operation of safety gears
- To check oil for oil buffers

- To check and clean the hall buttons and contacts
- To check and repair the compensating chains or ropes
- To check and oil the bearing of door motors
- To grease the secondary sheaves, car top sheaves and counterweights.
- To check the wear of guide shoes of cars and counterweights

f) Annual

- To clean the wire connection box of every landing and car cages. Tighten all screws and check the conditions of cables at conduit inlets and outlets
- To check and tighten screws and foundation bolts of traction To check and repair the conditions of worm gear and thrust bearing of the gear boxes
- To check and tighten screws of control panels, starters panels and relay panels
- To remove the dust inside the landing indicator switches by electric blower
- To test all safety devices
- To dismantle, clean and adjust the electromagnetic brake of gearless machines
- To change gear oil and motor oil
- machine, secondary sheaves, exterior of lift frame, guide rail, guide rail clamps and bracket etc.
- To test the over current relays
- To provide all labour, materials, tools and transport to carry out annual inspection and load test according to the requirement of the employer

All the scheduled maintenance services described above shall be properly programmed and agreed with the Engineer-in-charge in order not to affect operation of the lift systems.

23.0 Breakdown maintenance during warranty / defective liability period.

The Contractor shall also undertake to provide a comprehensive breakdown service whereby qualified technicians shall attend to each breakdown as soon as practicable after a breakdown is reported and carry out immediate remedial work at a reasonable speed according to the nature of the breakdown. Any faulty equipment or components shall be quickly replaced.

In circumstance such that the Contractor fails to attend the breakdown within four normal working hours after notification of the breakdown and where remedial work is interrupted during normal working hours for purposes other than obtaining replacement parts, the employer reserves the right to order such action as may be necessary to expedite completion of remedial work which shall be at the contractors expense without abrogation of the Contractors responsibilities

24.0 Spare parts provision during warranty / defective liability period

The Contractor shall keep sufficient spare parts during the maintenance period to ensure that replacement for defect items, parts can be carried out immediately

A competent engineer shall be provided to investigate the fundamental cause of a fault temporary quick fix solution will not be accepted.

The employer shall at his discretion, take action to recover all losses incurred rising from the failure of the contract to perform the duties either wholly or in part as detailed in this section.

25.0 Safety aspects & procedures

- Since lift installation consists of a number of electrical and mechanical components having linear/ rotary motions, utmost caution should be exercised while working and all safety precautions shall be rigorously followed.
- Only authorized persons shall be allowed to work on lift installations and officer empowered for such authorization shall keep proper record thereof during the test, inspection and maintenance except where necessary.
- If during erection any safety or protection devices is inoperative, special care must be taken to avoid accidents on this account.

- Supply at main incoming iron clad switch or circuit breaker shall be switched off before examining any part of the equipment. Whether during periodical inspection, or while carrying out any work on the equipments (including using the winding handle at times of mains failures) unless power is particularly required for particular operation or tests on the lifts. The breaker located in OFF position.
- Whenever the car needs to be moved by use of winding handle in the machine room
 - a) Power at incoming shall be switched off, before applying the handle.
 - b) Power shall be restored only after this handle is removed from winding shaft and brakes are applied.
- The landing and car buttons shall be keep out of circuit by switching on the 'Maintenance Switch' located on the top of the lift car during maintenance work. Whenever maintenance switch is not proved emergency stop switch inside car and or attendant control switch should be used.
- Before carrying out any repair work it shall be ensured that none of the electro-mechanical door locks are short circuited either from the controller or at the landings
- As a general precaution, fascia plate between the door headers and the corresponding upper landing sill on each floor must be provided.

26.0 Testing of lift at site

a) Levelling Test:

Accuracy of the floor levelling shall be tested with the lift empty, fully loaded.

The lift shall be run to each floor while travelling both in upward and downward directions and the actual distance of car floor above / below landing floor shall be measured. In each case there shall not be any appreciable difference in these measurements for levelling at the floors when the car is empty and when it is fully loaded. The tolerances for levelling shall be as ± 5 mm accuracy.

b) Safety gear Test:

Instantaneous safety gear controlled by a governor should be tested with contract load and a contract speed, governor being operated by hand. Two tests should be made, however, with wedge clamps or flexible clamp safeties, one with contract load in the car and the other with 68 kg (equivalent to one person) in the car. The stopping distance obtained should be compared with specified figures and the guides, car platform, and safety gear should be carefully examined afterwards for signs of permanent distortion.

Counterweight safety gear should be tripped by the counterweight governor and the stopping distance noted. In this case, however the governor tripping speed should exceed that of the car safety governor but by not more than 10 percent.

During the safety gear test, car speed (from the governor or the main sheave) should be determined at the instant of tripping speed with that stated in I.S. The governor jaws and rope should be examined for any undue wear.

c) Speed measurement.

This should be measured with contract load in the car, with half load, with no load, and should not vary from the contract speed by more than 10 percent. The convenient method is by counting the number of revolutions, made by the sheave or drum in a known time. Chalk mark on the sheave or drum and a stop switch will facilitate timing but care must be exercised to ensure that no acceleration or retardation periods are included. If the roping is 2 to 1 the sheave speed is twice the car speed. Alternatively, the speed can be measured by a tachometer applied directly to shaft immediately below the sheave.

d) Lift balance:

After the above test, some of the weight shall be removed until the remaining weights represent the figures specified by the Contractor. With this condition car at half way travel the effort required to move the lift car in either direction with the help of winding wheel shall be as nearly as can be judge by the same.

e) Car and landing doors interlocks:

The lift shall not move with any door open. The car door relay contact and the retiring release cam must be tested. The

working of the door operation and the safety edges and light equipment if any provided shall also be examined.

f) Controllers:

The operation of the contactors and interlocks shall be examined and it shall be ascertained whether all requirements laid down in the specifications have been met.

g) Normal Terminal Stopping Switches:

This shall be tested by letting the car run to each terminal landing in turn, first with no load and then with contract load and by taking measurements, top and bottom over travels can be ascertained.

h) Final Terminal Stopping Switches:

The normal terminal stopping switches shall be disconnected for this test. It shall be ensured that these switches operate before the buffers are engaged

i) Insulation Resistance:

This shall be measured (after removing the electronic PCB's and their connection) between power and control lines and earth and shall not be less than 5 mega-ohms when measured with D.C. voltage of 500 volts. The test shall be carried out with contactors so connected together as to ensure that all parts of every circuit are simultaneously tested.

j) Earthing

All conduits, switches, casing and similar metal work shall have earthing continuity.

k) Ropes:

The size, number construction and fastenings of the ropes should be carefully examined and recorded.

l) Buffers:

The car should run on to its buffers at contract speed and with contract load in the car to test whether there is any permanent distortion of the car or buffers. The counter weight buffers should be tested similarly.

27.0 Tests at Manufacturer's place/factories

High Voltage Test:

The dielectric or electric apparatus (excluding motors, generators and instruments which are tested in accordance with the appropriate Indian Standards wherever they exist) shall be capable of withstanding a test voltage of ten times the working voltage with a maximum of 2000 Volts when applied.

- between the live parts and case of frame with all circuits completed.
- between main terminals or equivalent parts with all circuits open, and
- Between the lift parts of independent circuits.

Note -- Owing to the impracticability of applying tests (ii), (iii) mentioned above on controllers and similar apparatus after controller wiring has been completed, these tests may be made at convenient stages of manufacturer.

➤ **Method of applying high voltage**

The test shall be made with alternating voltage of any convenient frequency, preferably between 49 to 60 cycles per second. The test voltage shall be approximately sine-wave form and during the application of voltage with peak value, as would be determined by spark gap by oscillograph or by any other approved method shall not be more than 1.45 times the RMS value. The RMS values of the applied voltage shall be measured by means of a voltmeter used with a suitably calibrated.

➤ **Duration of High Voltage Test:**

The test shall be commenced at a voltage of about one third of the test voltage which shall be increased to the full test voltage as rapidly as is consistent with the value being indicated by the measuring instrument. The full test voltage shall be maintained for one minute. At the end of this period, the test voltage shall be rapidly diminished to one third of its full value before switching off.

The oil buffers are examined after the above tests have been made to determine if there has been any oil

leakage or distortion and to ensure that the buffers return to their normal positions.

Buffer Test:

A copy of the test report shall be intimated after testing at works.

Performance Test:

This test is meant for passenger lifts and is conducted to watch the performance of lift installation in terms of passenger handling capacity and waiting interval as obtained at site vis-a-vis design, data and conducted as below

- Waiting interval - (T)- This can be worked out by taking the average of several round trip times as observed physically and then dividing it by the number of lifts in that bank.
- Handling capacity $H = \frac{300 \times Q \times 100}{T \times P}$

Where

H = Handling

capacity as the percentage of the peak population handled during minutes.

P = Total population to be handled during peak morning / even in period. (It is related to the area for which particular bank of lifts serves).

Q = Average number of passenger carried in a car.

T = Waiting interval.

Service Temperature Test

A continuous run of one hour should be made with number of starts and stops to reproduce as nearly as practical the anticipated duty in service. (The standard duty cycle is for 90 to 180 start per hour). It is very difficult in practice to carry out this test with alternate starts at full load and no load and it is necessary therefore to simulate these cycles. A suitable test for all motors except squirrel cage motors is to run the car up from the bottom landing with contract load and stop at each floor. From the top floor a nonstop run is made to the lowest floor and the upward journey with stop is then repeated. The time intervals between stops and starts at the floors should be uniform and such as to give about 150 starts in one hour. At the end of this run the temperatures of the armatures and fields of the motor and generator are recorded. The temperature rise should, not exceed 55 deg c or 75 deg c for classes A or B insulation respectively.

APPENDIX – I**Check list for joint inspection**

Sl.No	Details	Remarks
1.	Place Inspection	
2.	Date of Inspection	
3.	Name of the manufacturer	
4.	Visual inspection details	
5.	Verification of layout for any discrepancies	
6.	Instruction plate showing / displaying at each landing of lift car	
7.	Depth of lift	
8.	Ladder provision inside the lift shaft for maintenance	
9.	Number light fittings and spacing between them inside lift shat.	
10.	Number of counter weight blocks	
11.	Weight of each counter weight block	
12.	Total Weight of all counter weight blocks.	
13.	Material of counter weight blocks.	
14.	Guard-for counterweights in the pit.	
15.	Details of conduits / wires and earthing.	
16.	Provision of check nuts and split pins in rope fastenings and terminations	
17.	Steel rope details	
18.	Number of steel ropes.	
19.	Details of buffer inside lift shaft	
20.	Top car clearance	
21.	Bottom car clearance	
22.	Top counterweight clearance	
23.	Bottom car run by	
24.	Bottom counterweight run by	
25.	Hand lamp with flexible cord inside the lift shaft details	
26.	Plug and socket inside the lift shaft details	
27.	Danger plate on door	
28.	Adequate ventilation	
29.	Any other	
30.	Circuit diagram on wall.	
31.	Earthing-	

32.	Whether machine body controller, car frame, limit switches, and conduit properly earthed and check earthing continuity	
33.	Machine and controller	
34.	Oil leakage if any.	
35.	Abnormal temp rise of oil, bearing and motor	
36.	Abnormal noise or vibrations – noise level check	
37.	Whether UP and DOWN (direction arrows on motor or fly wheel marked)	
38.	Whether rubber pads provided under machine and its bed plates	
39.	Whether protection against breakage of rope or taps	
40.	Whether control circuit have independent fuses	
41.	Whether cable ferrules marked	
42.	Gap between the car and landing sill	
43.	Operation	
44.	Operation of all floor buttons from within the car in up and down direction on both attendant and auto control	
45.	Operation of car by calls given from landing buttons in up and down direction on both attendant and auto control	
46.	Operation of door close and door open button	
47.	Emergency alarm	
48.	Emergency stop	
49.	a. Number of lights inside lift cabin b. fan inside lift cabin	
50.	Emergency key opening	
51.	Operation on type of control stipulated in contract	
52.	Operation of car top safety switches to make the lift inoperative from within the car and speed of operation	
53.	Door locking as checked from each floor	
54.	Any abnormal noise / vibration jerk internal and stopping	
55.	Sideway play if any in the car	
56.	Working of position and direction indicators in car and at each landing	
57.	Functioning of sensitive reopening arrangements on moving edge of doors	
58.	Smooth sliding movement of car and landing doors.	
59.	Whether car is stopped in between the floor and whether the doors can be opened manually from inside	
60.	Opening of landing or car door when lift is in operation to see that the movement of lift stops	

61.	Operation of fireman switch	
62.	Check for brake release device and hand winding provisions	
63.	Safety Devices	
64.	Functioning of protection for single phasing and phase reversal	
65.	Function of protection for automatic power cut off device before the car and counterweight load on buffers	
66.	Function of overload relays	
67.	Operation of safety gear and also see for undue deformation of guide rails and stopping distance	
68.	Check operation of safety switches	
69.	Operation of upper limit switch & Positions	
70.	Operation of lower limit switch & positions	
71.	Operation of electrical protection against opening of emergency door	
72.	Checking of slip rope slip after 3 complete trips by putting a reference mark on the sheave & rope 60mm/12mm ,60mm/20mm	
73.	Test to see that the lift does not start in upward direction on no load and down direction on full load and on single phasing	
74.	Check application of brake on full load in down direction at full speed by switching off the power supply and for overheating	
75.	Load Test- lift .no	
1.	No Load <ul style="list-style-type: none"> a. Up direction <ul style="list-style-type: none"> ➤ Stating current AC (Amp) ➤ Running Current : AC (Amp) ➤ Travel (Meters) Speed: Mete r/ Sec b. Down direction <ul style="list-style-type: none"> ➤ Stating current AC (Amp) ➤ Running Current : AC (Amp) ➤ Travel (Meters) Speed: Mete r/ Sec 	
2.	Full Load <ul style="list-style-type: none"> a. Up direction <ul style="list-style-type: none"> ➤ Stating current AC (Amp) ➤ Running Current : AC (Amp) ➤ Travel (Meters) Speed: Mete r/ Sec b. Down direction <ul style="list-style-type: none"> ➤ Stating current AC (Amp) ➤ Running Current : AC (Amp) ➤ Travel (Meters) Speed: Mete r / Sec 	
76.	Any other test	
77.	Size of the lift well	

78.	Internal depth of car platform	
79.	Size of the car door	
80.	Rope protection against breakage have been carried out and test results found	
81.	Insulation resistance test & high voltage test have also been test. I. R. is found a.----- M ohm b. HV test with stood c. HV test not with stood	

APPENDIX – II**Instruction to be displayed in Hindi / English in the lift car and at lift landings of passenger lift**

Sl. No.	Inside the Car	Sl. No.	Outside the Car
1	Lift Number.....	1	Lift Number.....
2	Capacity Kg.	2	Capacity Kg.
3	No Smoking	3	Please stand in – Q –
4	Operator-push buttons / switches correctly.	4	Please keep lift neat and clean.
5	Do not lean against lift door	5	Smoke not permitted inside the Ca r.
6	Watch before stepping door	6	None other than lift operator shall operate the lift.
7	Do not be panic in the event of break down.	7	Do not force open the landing door
	Press alarm button and follow the instruction of authorized staff	8	Watch before you step into and out of the lift-car.
		9	Avoid use of lift during fire.
		10	Complaints if any may be sent to ____.

APPENDIX-III

Technical data of passenger lift

Sl. No	Description of technical data	Details of provision item wise.	Remark
1	Name of manufacturer / Country of manufacturer		
2	Lift serial number & type.		
3	Type of leveling method		
	Parameters pertaining to particular lifts		
4	Nos of Lifts in lift core		
5	No of lift		
6	Capacity 10 passenger / 13 passenger / 700 kg / 1000 kg 3.		
7	Speed – meter per second		
8	No. of landings		
9	No. openings		
10	Operations		
	Passenger lift Simplex collective selective		
11	Hoist way size		
12	Size of Passenger lift Width x depth like 2250 mm x 2100 mm		
13	Clear headroom above last landing 3800 mm		
14	Pit depth		
15	Car enclosure		
16	Dimension		
17	Height of false ceiling from bottom		
18	Car finish		
	Primer painted bare G.I wall to enable owners to provide enclosure finish of employer choice		
19	Car floor 25 mm recess in floor with primer painted bare G.I finish to enable employer to provide floor finish of their choice. Load		
20	Car & landing doors		
21	Dimension		
22	Door Automatic power operated center opening door		
23	Finish-Hair line stainless steel finish		
24	Sound isolation to be provided for car platform		

Sl. No	Description of technical data	Details of provision item wise.	Remark
25	Bumper Strips Stainless steel bumper strips at base and 1 meter above floor on all sides of car except opening side		
26	Machine		
27	Machine room location		
28	Machine type		
29	Power Supply 415V/240V, 50 Hz		
30	Acceptable voltage fluctuation +10 to -20%		
31	Machine parameters- number of V- V-groove pulleys of motor and number of grooves of pulley		
32	Reduction gear ratio		
	Motor details		
34	Motor serial number		
35	Motor power in HP / kW		
36	Starting full load current		
37	Running current		
38	Starts per hour permissible.		
39	Speed in r.p.m.		
40	Motor insulation class		
41	Max. starting torque (kg.f.m)		
41	Temperature rise in full load		
42	Rate of acceleration / deceleration (m/sec ²)		
43	Jerk (m/sec ²)		
43	Brake (type)		
44	Potential free contacts for BMS		
45	Motor protection		
	Lift power panel Control panel details		
46	Sl. No of Lift power panel / Control panel		
47	Location of power panel Control panel		
48	Type of Control drive AC VVVF		
49	Control system parameters		
50	Safe device - Auto fail		

Sl. No	Description of technical data	Details of provision item wise.	Remark
51	Automatic bypass		
52	Overload device		
53	Anti nuisance device		
54	Emergency cranking		
55	Guaranteed automatic self leveling ± 5 mm		
56	Load weighing bypass		
57	Sound isolation near machine equipment.		
58	Hoist / Governor ropes(roping)		
59	No. and construction of rope		
60	Size		
61	Roping ratio		
62	Factor of safety		
63	Material of rope		
64	Guide rail size		
65	Cable size for power requirement		
66	Noise level during travel in car 55 dBA to core in car with ventilation fan operating		
67	Fixtures / signals inside car		
68	Number of Hand rail / details stainless steel finish		
69	Number of fluorescent light fixtures inside the car with switch control		
70	Emergency light in car and alarm bell with SMF battery with 30minute back with charging facility when power supply is on		
71	VentilationNumber of fans inside the car with switch control or auto start when lift in operation.		
72	Car operating Panel2 nos car operating panels(1 auxiliary) on either side of the lift door with following button and indications		
73	LED Illuminated push buttons of micro pressure type corresponding to the floors served		
74	“Door open” and “Door close” button with arrow indicators		
75	Emergency stop button		
76	Emergency alarm button		
77	Ventilation fan ON/OFF switch with auto OFF when there is no call after 120 seconds.		

Sl. No	Description of technical data	Details of provision item wise.	Remark
78	Built in 3 way intercom system with telephone instrument in the car, machine room and reception /security (as directed by		
79	Dynamic car direction display		
80	Digital Car position indicator		
81	Audio/Visual overload warning indicator		
82	Power socket -Outlet A 15 amp 3 pin 240 volt switch socket outlet in concealed housing with hinged cover shall be provided in each car		
83	Music Background music speaker to be provided		
84	Voice synthesizer		
85	Lift in use/ lift out of orderA suitable box above the lifts landing with LED illuminated sign of "LIFT OUT OF ORDER" coming up simultaneously at all doors.		
86	Is neutral wire available for control circuits		
	Provisions for use of lift by Handicapped persons		
87	Hand rail A hand rail not less than 600 mm long at 900 mm above floor level shall be fixed adjacent to the control panel.		
88	Car operating panel Inscription in Braille also to be provided. Level to be lower than the normal so as to be accessible by a person sitting on wheel chair		
89	Hall buttons-Inscription in Braille also to be provided. Level to be lower than the normal so as to be accessible by a person sitting on wheel chair		
90	Car position indicator The interior of the cage shall be provided with a device that audibly indicate the floor, the cage has reached and indicate that the door of the cage for entrance / exit is either open or close		
91	Hall lantern To be provided along with an audible chime		
92	Any other feature The time of an automatically closing door should be minimum 5 second and closing speed should not		
	Landing signals		
93	Hall buttons LED Illuminated push buttons of micro pressure type up-call / down-call (as per floor buttons)		
94	Car Position Digital indicator with direction of travel		
95	Hall gong Up/down indicator with single stroke gong/chime at all landing		

Sl. No	Description of technical data	Details of provision item wise.	Remark
	Safety Devices		
96	Door safety Multiple infrared device to cover the total height of the door and with protective leading edge device to operate in case of failure of infrared protection		
97	Car safety-type Doors to be provided with safety shoes		
	a. safety shoe (one on each panel of car door) shall extend the full height of the projection beyond the front edge of the car.		
	B Should this shoe touch a person or object while the car door is closing the car and hoist way doors shall return to the open position. The doors shall return to the expiration of a pre-determined interval and thereafter-close automatically.		
98	Counterweight safety-type		
99	Door interlocks in car-type		
100	Door locks in landing-type		
101	Enclosure & degree of protection of electrical equipment.		
102	Lift leveling ± 5 m		
103	Terminal slow down switches		
104	Over travel protection Limit switches to be provided		
105	Buffer- Spring Buffer to be provided		
106	Interlocking of car and Lift well doors To be provided as per specifications		
107	Guaranteed governor tripping 110% to 140%		
108	32. Alarm bells		
109	Flexible guide clamp safety devices		
110	Automatic Rescue Device Battery operated ARD		
111	Emergency stop switches		
112	Associated Civil and structural works All civil and structural items of work associated with erection and operation of lifts shall be provided by the Contractor at his cost including (but not restricted to) the following.		

Sl. No	Description of technical data	Details of provision item wise.	Remark
	a. Hoisting hook or beam in machine room roof slabs over Lift well for lifting lift equipments		
	b. Temporary scaffoldings and safety barricades during lift installation in and around lift wells.		
	c. Sill angels		
	d. Bearing plates		
	e. Buffer supports		
	f. Checquered plates		
	g. Fascia plates		
	h. Ladder in pit		
	i. Safety railing on car top		
	j. Separator/ stretcher beams if required		
	Dowels for terminal buffers in pit floor during casting		
113	Fireman's switch To be provided at GF/ Lobby level		
114	Material of balance weights Number of balance weights Weight of each balance weights.Total weight of balance weight. 34.		
115	Number of pulleys Material of pulleys.		
116	Statutory approvals Certificated To be provided.		
117	4 week trial operation		

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TECHNICAL SPECIFICATION
PART-I- AUTOMATIC INERT GAS FLOODING SYSTEM

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TECHNICAL SPECIFICATION FOR AUTOMATIC INERT GAS FLOODING SYSTEM

1. AUTOMATIC INERT GAS FLOODING SYSTEM

1.1. GENERAL

- 1.1.1. This Section specifies the construction and installation of automatic gas flooding system.
- 1.1.2. The automatic gas flooding system shall be complete with gas storage cylinders, extinguishing agent, pipe work, discharge heads, valves, control equipment and cables and all necessary accessories and fittings to form a complete and working installation to protect the specified area to the approval of the Engineer.
- 1.1.3. Unless otherwise specified, automatic gas flooding systems shall be of the total flooding type with a high pressure open-ended piping installation on the distribution side. The automatic gas release mechanism shall be operated by means of fire detection units in the protected compartment or manually by a pull handle or push button as described below.
- 1.1.4. The installation shall fully comply with NFPA Code 2001.

1.2. STANDARDS

1.2.1. Relevant Codes and Standard

NFPA-70 and BS 6387	Performance Requirements for Cables Required Integrity Under Fire Condition.	Maintaining Circuit
NFPA-72	Fire Alarm Code.	
NFPA 2001	Clean Agent Fire Extinguishing Systems	

- 1.2.2. The whole gas flooding system shall be provided by a single FM / UL / LPCB / VDS listed manufacturer. Locally assembly system shall not be accepted.

1.3. TECHNICAL AND INSTALLATION REQUIREMENTS

1.3.1 DESIGN REQUIREMENTS

- 1.3.1.1. The Inert Gas total flooding systems shall be, unless otherwise specified, designed to achieve retained oxygen concentrations of 12.5% confirming to NFPA-2001.

1.3.2. DESIGN CALCULATION

- 1.3.2.1. The Contractor shall justify the selection of components and pipe sizes for the system and shall submit full calculation for approval. Where computer program is used, but does not show all calculation steps, it will be necessary for the Contractor to submit evidence that the computer program produces a design that will perform in accordance with the specification as indicated by UL listing or approved by any similar widely recognized independent regulatory body. The same must be approved by Engineer.
- 1.3.2.2. The calculation shall be based on the equipment offered. Valves, distribution valves as well as bends and junctions shall be represented in the calculations as equivalent lengths of pipe. The actual size and location of pipes and nozzles and the number of nozzles shall be designed based on the calculated flow rates and terminal pressures required to ensure successful operation. The calculation or computer programme shall provide all the information necessary to complete the installation including the quantity of gas used to flood to the required concentration, the allowance for losses, the total quantity required, the flow rate, start and

end pressure of each section of pipe and the orifice size for each nozzle.

1.3.2.3. The Inert Gas shall be pressurized to a pressure confirming to NFPA 2001 latest version.

1.3.2.4. Gas cylinders, distribution pipe work, valves, nozzles and fittings shall be manufactured to withstand the maximum pressure of stored agent allowing for variations in ambient temperature.

1.3.3. **SYSTEM OPERATION AND EQUIPMENT**

1.3.3.1. The system shall be operated automatically and manually, and shall comprise the following equipment:

- a) Control panel with built-in maintenance free battery, trickle charger, visible warning indicator and supervisory buzzer;
- b) Interface with Smoke / Heat detectors;
- c) Audible warning - alarm bells and hooters;
- d) Visible warning - flashing and warning signs;
- e) Manual release units;
- f) Discharge nozzle and pipework;
- g) Automatic / Manual control unit;
- h) Time delay unit;
- i) Gas bottles, associated equipment and accessories.

1.3.3.2. The installation shall operate on a 24 V DC source connected to the control panel.

1.3.4. **SAFETY FEATURES**

1.3.4.1. The system shall incorporate the following safety features so as to protect persons entering the protected areas: -

- a) Suitable sign plates and warning labels in both English and Hindi shall be installed at the entrance door.
- b) A visible warning indication lock - off device shall be provided at the entrance of the protected area showing the following status of the system:

Green Lamp	System on manual control with automatic control locks off. (Safe to enter).
Amber Lamp	System on automatic control. (Not safe to enter).
Red Lamp	System being operated. (Danger - do not enter, gas discharged).

1.3.5. **CONTROL PANEL**

1.3.5.1. The control unit shall include the following: -

- a) "Mains On" indication;
- b) "System Fault" indications;
- c) Separate "Zone Fire / Fault" indications;
- d) Indication of "Gas Discharge";
- e) Power unit;
- f) Battery and charger; and

- g) Switches for bell silencing, testing and resetting of the system

1.3.6. BATTERY CHARGER AND BATTERIES

- 1.3.6.1. A 24 V DC trickle type battery charger and batteries shall be provided with the following components: -
- a) Trickle and boost charger assembly;
 - b) Rotary type selector switch;
 - c) One incoming double pole control fuse; and
 - d) Maintenance free batteries.
- 1.3.6.2. The unit shall be suitable for use on single phase supply voltage as specified in the General and M & W Specifications and shall automatically maintain the 24 V batteries in a state approximate to full charge and at the same time compensate for the standing load.
- 1.3.6.3. Batteries shall be of maintenance free sealed Ni-Cd 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 to operate in the "alarm" condition continuously for at least one hour.

1.3.7. DISCHARGE TIME

- 1.3.7.1. The system shall be designed as per the requirements of NFPA Code 2001.

1.3.8. DISCHARGE NOZZLE

- 1.3.8.1. The discharge nozzles shall be conical type made of hot pressed stainless steel bodies with chromium plated finish complying with DFS requirements. A sample of the nozzle shall be submitted for approval prior to ordering the equipment. The orifice size of each nozzle shall be calculated and submitted for approval before ordering. Nozzles shall be furnished with ceiling plate if they are installed under false ceilings.

1.3.9. MANUAL AND AUTOMATIC AND OPERATION MECHANISM

- 1.3.9.1 The unit shall be of flush pattern, consisting of manual mode, automatic mode and discharge mode, operated by key switch together with indicating lights for the following:

"Red" - System being operated

"Green" - System in manual mode

"Amber" - System in automatic mode

- 1.3.9.2 A manual release unit shall be provided in a suitable position outside each entrance to the protected compartment. The manual release unit shall consist of a pull handle or push button mounted in a box with "break glass" cover. The box shall be so designed that its glass front may be readily replaced and that its front cover can be opened with a key for operating the switch without breaking the glass.

- 1.3.9.3 An emergency release handle with direct mechanism shall be provided in an accessible position at or near the gas cylinders. The emergency release shall require no power supply to operate and it shall be provided with a removable pin to prevent accidental release of gas. Provision shall be made for operation of the emergency release to activate the relays or ETL to cause simultaneous shutdown of ventilation, air-conditioning equipment etc. and to sound the alarms.

- 1.3.9.4 The operation of the gas release mechanism shall require minimum power from an external electrical, pneumatic or mechanical source and shall preferably be operated by a falling weight device. No springs shall be used in any position where their failure or fracture would prevent the correct operation of the gas release mechanism or cause the inadvertent release of the gas.
- 1.3.9.5 All release devices and mechanisms shall be designed for the designed working conditions and shall not readily be rendered inoperative or susceptible to accidental operation. The system shall be properly designed against mechanical, chemical or other damage that would render them inoperative.
- 1.3.9.6 Flashing Sign / Warning Sign: Flashing sign and warning sign shall be of flush pattern complete with red indicating light together with clear indications in both Hindi and English characters. The flashing sign shall carry the following messages: "DANGEROUS, DO NOT ENTER" and "EVACUATE IMMEDIATELY". A sample of this sign shall be submitted for approval before ordering. The sign shall be installed above exit sign level. At the entrance of the protected area, a notice shall be posted on the door with the following message: - " Warning: Inert gas flooding system in operation, switch to manual mode before entering."
- 1.3.9.7 Warning Notice and Instruction Plate: Suitable warning notices and instruction plates shall be put up at doorway position and within the gas protected area and store to give warning to maintenance personnel. Full details of system operation, reset procedure and procedure to follow during an emergency situation shall be displayed. Warning notices and instruction plates shall be in the form of red Perspex sheet of minimum 4 mm thick, with letters and characters engraved in white. The main gas identification symbol shall be spraypainted.

1.3.10. GAS STORAGE BOTTLE

- 1.3.10.1. Provide a battery of gas cylinders suitable for both automatic and manual control. The cylinders shall conform to BS 5045 and shall be supported securely in frames bolted to the wall. The mounting of the cylinders shall be such that all external parts can be readily inspected.
- 1.3.10.2. Each cylinder shall be fitted with an automatic pressure release device which shall function when the pressure of the liquid within the cylinder exceeds a predetermined value, which shall be less than the test pressure defined in BS 5045.
- 1.3.10.3. Inert Gas cylinders shall be constructed in accordance with the appropriate parts of BS 5045, EN 1964-2:2001, ISO 9809-2:2000, IS 7285 and must have CCOE's approval. Test pressure for cylinders shall be confirming to CCE & NFPA. The Test Certificates shall be submitted for the approval of the Engineer.
- 1.3.10.4. Each cylinder shall be complete with gas valve / actuator, pressure gauge, flexible hose, check valve and all other necessary accessories.
- 1.3.10.5. Means shall be provided to prevent gas discharging into empty containers and to prevent loss if the gas is released when any of the cylinders is disconnected.
- 1.3.10.6. Safety latches shall be provided in each bank of gas cylinders to prevent accidental discharge of gas during maintenance. Safety latches shall incorporate a set of contacts to initiate a warning at the control panel that the system has been locked off.
- 1.3.10.7. Gas cylinders shall be painted signal red as specified in BS 381C. The type of extinguishing agent, tare weight, gross weight etc. shall be clearly painted on each cylinder with white paint.

1.3.11. SYSTEM OF WIRING

- 1.3.11.1. The system wiring shall be of fire survival cable to BS 7846 Category CWZ.

1.3.12. PIPEWORK

- 1.3.12.1. All the pipework, fittings and the associated works for the gas flooding system shall conform to the relevant sections of this M & W Specification.
- 1.3.12.2. Pipe shall be pressure tested after erection by means of nitrogen gas at a pressure specified in NFPA for 30 minutes. Pressure loss of more than 3% of the initial pressure will not be acceptable. Test certificate issued by an approved surveyor shall be submitted for record. Only Teflon tape shall be used as sealant for threaded joints.
- 1.3.12.3. All the pipework shall be purged by means of compressed air before installation.
- 1.3.12.4. All the pipework and conduit for this system shall be painted with the colour as specified by the Engineer after installation is completed.
- 1.3.12.5. The whole gas discharge system including cylinders, pipework and nozzles shall be securely fixed to the structure with saddles or brackets correctly spaced so that all components will remain in place when subjected to the pressures and forces produced during discharge. Fixings shall allow for movement due to thermal expansion.
- 1.3.12.6. The system shall be guarded so that it shall be impossible to obstruct the operation of any moving parts.

1.3.13. QUALITY OF EXTINGUISHING AGENTS

- 1.3.13.1. Inert Gas used shall be of good commercial grade, free of water and other contaminants that might cause container corrosion or interfere with free discharge through nozzle orifices. Its purity should meet with the requirements of NFPA-2001.

1.4. SUBMITTALS:

- 1. The installing contractor shall submit the following design information and drawings for approval prior to starting work on this project:
 - a. Field installation layout drawings having a scale of not less than 1:1000m detailing the location of all agent storage tanks, pipe runs including pipe sizes and lengths, control panel(s), detectors, manual pull stations, abort stations, audible and visual alarms, etc.
 - b. Separate layouts or drawings, shall be provided for each level, (i.e., room, under floor, and above ceiling) and for mechanical and electrical work.
 - c. A separate layout or drawing shall show isometric details of agent storage cylinders, mounting details and proposed pipe runs and sizes.
 - d. Electrical layout drawings shall show the location of all devices and include point-to-point wiring runs and a description of the method(s) used for detector mounting.
 - e. Provide an internal control panel wiring diagram which shall include power supply requirements and field wiring termination points.
 - f. Complete hydraulic flow calculations, from manufacturer flow calculation program, shall be provided for all IG-541-300bar Extinguishing System. The individual sections of pipe and each fitting to be used, as shown on the isometrics, must be identified and included in the calculation.
 - g. Provide calculations for the battery stand-by power supply taking into consideration the power requirements of all alarms, initiating devices and auxiliary components under full load conditions.
 - h. A complete sequence of operation shall be submitted detailing all alarm devices, shutdown

functions, remote signaling, damper operation, time delay and agent discharge for each zone or system. Submit drawings, calculations and system component data sheets (including venting requirements) for approval to the local FIRE Prevention Agency, owners Insurance Underwriter and all other Authorities Having Jurisdiction before starting installation.

- i. Submit approved plans to the Architect/Engineer for record.
2. The bidder should be the manufacturer or an authorized, trained and certified reseller of a Manufacturer of IG-541-300bar system. Documentation to validate the same shall be submitted along with the bid documents.
3. The system engineering company should prepare & submit along with the bid documents, the piping Isometric drawing and support the same with a hydraulic flow calculation generated by using the agent's design software. The calculations shall validate the fill density assumed by the bidder.
4. The bidder shall submit copies of the datasheets of the hardware used in the system. The bidder shall also submit copy of CCE approval letter for the cylinder proposed to be used. These documents shall be attached to the bid.
5. The bidder shall also submit calculations to evidence the qty of agent considered for the system.
6. The successful vendor must submit, along with the supply invoice, a filling certificate for the agent from the manufacturer.
7. The System Company should provide, as part of handing over, the as-built drawing, operation manual and maintenance manual. The as-built drawing shall exactly match the Isometric drawing submitted with the flow calculation prior to commencement of work.

1.5. INSPECTION AND MAINTENANCE

1.5.1 SYSTEM INSPECTION AND CHECKOUT:

After the system installation has been completed, the entire system shall be reviewed, inspected and functionally tested by qualified, trained personnel, in accordance with the manufacturer's recommended procedures.

1. All cylinders and distribution piping shall be checked for proper mounting and installation.
2. All electrical wiring shall be tested for proper connection, continuity and resistance to earth.
3. The complete system shall be functionally tested, in the presence of the ENGINEER representative, and all functions, including system and equipment interlocks, must be operational at least five (5) days prior to the final acceptance test.
 - a. Each detector shall be tested in accordance with the manufacturers recommended procedures.
 - b. All system and equipment interlocks, such as door release devices, audible and visual devices, equipment shutdowns, local and remote alarms, etc, shall function as required and designed.
 - c. Each control panel circuit shall be tested to avoid any trouble which causes system failure.

1.5.2 TRAINING REQUIREMENTS:

Prior to final acceptance, the installing contractor shall provide operational training to each staff. Each

training session shall include control panel operation, manual and (optional) abort functions, trouble procedures, supervisory procedures, auxiliary functions and emergency procedures.

1.5.3 **OPERATION AND MAINTENANCE:**

Prior to final acceptance, the installing contractor shall provide complete operation and maintenance instruction manuals to the ENGINEER. All aspects of system operation and maintenance shall be detailed, including piping isometrics, wiring diagrams of all circuits, a written description of the system design, sequence of operation and drawings illustrating control logic and equipment used in the system. Checklists and procedures for emergency situations, troubleshooting techniques, maintenance operations and procedures shall be included in the manual.

1.5.4 **AS-BUILT- DRAWINGS:**

Upon completion of each system, the installing contractor shall provide four (4) copies of system "As-built" drawings to the ENGINEER. The drawings shall show actual installation details including all equipment location (i.e.: control panel(s), agent cylinder(s), detectors, alarms, manuals and aborts, etc) as well as piping and wiring routing details. These drawings will show all modifications carried out in rooms or other facilities including doors and/or release devices completed. One (1) copy of reproducible engineering drawings shall be provided reflecting all actual installation details.

1.5.5 **ACCEPTANCE TESTS:**

1. At the time "As-built" drawings and maintenance/operations manuals are submitted, the installing contractor shall submit a "Test Plan" describing procedures to be used to test the control system(s). The test plan shall include a step-by-step description of all tests to be performed and shall indicate the type and location of test devices to be employed. These tests shall demonstrate that the operational and installation requirements of this specification have been met. All tests shall be carried out in the presence of the ENGINEER representative and shall not be conducted until the Test plan has been approved.
2. The tests shall demonstrate that the entire control system functions as designed and intended. All circuits shall be tested: automatic actuation, solenoid and manual actuation, audible and visual alarm devices, and manual override of abort functions. Supervision of all panel circuits, including AC power and battery power supplies, shall be tested and qualified.
3. The general contractor shall be responsible for adequately sealing all protected space(s) against loss or leakage.
4. Upon acceptance by the ENGINEER, the completed system(s) shall be placed into service.

1.5.6 **SYSTEM INSPECTIONS:**

1. The installing contractor shall provide two (2) inspections of each system, installed under this contract, during the one-year warranty period. The first inspection shall be at the six-month interval, and the second inspection at the 12-month interval, after system acceptance. Inspections shall be conducted in accordance with the manufacturer's guidelines.
2. Documents certifying satisfactory system(s) operation shall be submitted to the ENGINEER upon completion of each inspection.

1.5.7

WARRANTY:

All system components furnished and installed under this contract, shall be guaranteed against defects in design, materials and workmanship for the full warranty period which is considered standard with the manufacturer, but in no case less than one (1) year from the date of system acceptance.

1. **Title of the page: Specification of EOT Cranes.**

2. **Description:**

Sr. No	Item Name	Specification	Qty
1.	EOT Crane for Workshop Bay	Capacity: 15/5 Ton Width of Span about 16 mtr	1
2.	EOT Crane for Pit wheel lathe bay	Capacity: 2 Ton Width of Span about 10 mtr	1
3.	EOT Crane for Bogie repair Shop & Ancillary Shed	Capacity: 10 Ton Width of Span about 19 mtr	1
4.	EOT Crane for Pit Wheel Lathe Shed: This crane will be pendant operated only. Hence cabin operation and remote pendant operation clauses are not applicable to this crane	Capacity: 5 Ton Width of Span: 10 mtr	2

3. **Purpose:** Overhead **cranes** or **EOT Cranes** are required for indoor material and Coaches/Bogies handling in Depot

4. **Detailed specification:**

The scope covers supply, erection, testing and commissioning of EOT cranes along with DSL, rails over crane girders of LT and other standard accessories and items required to make the crane fully functional. The scope shall cover complete crane comprising bridge structure with platform and hand railing, track wheels for longitudinal and cross travel, travelling mechanism for longitudinal and cross travel, hoisting mechanism, brake mechanism separately for long travel, cross traverse and hoisting, trolley, service platform, lifting tackle, slings/chain, cabin & pendant control, electrical motors, control gear and equipment along with maintenance spares and tools.

5. The scope shall also cover supply and fixing of gantry rail 60kg/m on the crane girder and supply and fixing of DSL along the entire length of the shed as indicated in GAD of sheds.

6. The cranes shall be designed, manufactured, erected, and tested generally in accordance with the following specifications:

- IS 3177-1999 (latest) IS Code of Practice for EOT Cranes or equivalent international standard like DIN.
- IS 807-206 (or latest) Code of Practice or equivalent international standard like DIN for design, manufacture, erection, and testing (structural portion) of cranes and hoists.
- IS 3938-1979 (or latest) or equivalent international standard like DIN for Electric wire rope hoists.
- Design of the crane structure as well as all the component parts of the crane mechanism shall conform to class of duty IV. The class of duty is based on design parameters stipulated in IS 807-1976 (or latest) or equivalent international standard like DIN. If any of the conditions mentioned in these specifications is at variance with those of the ISS, the technical specifications here under shall prevail.

The bidder shall ensure that crane dimensions like span, gantry height etc and crane clearances are compatible and suitable as per GADs of the shed enclosed with bid document. The cranes shall meet the following broad technical parameters:

7. **15T EOT Crane**

7.1	Type	Conventional double girder
7.2	Main Hoist capacity	15T
7.3	Auxiliary Hoist capacity	05T
7.4	Class of Duty	IV(Four)
7.5	Crane controls	Moving pendant & Cabin and remote operation
7.6	Span	About 32m
7.7	Speed Main Hoist	4.5 m/min
7.8	Speed Auxiliary Hoist	6.3 m/min
7.9	Speed Long Travel	40 m/min
7.10	Speed Cross Travel	20 m/min
7.11	Lift of Hook above floor level (MH)	12 m
7.12	Drop of hook below floor (MH)	1 m
7.13	Lift of hook above floor level (AH)	12 m
7.14	Drop of hook below floor (AH)	1 m
7.15	Centre distance between hooks MH & AH	1 m
7.16	Type of Hook required	C Type or suitable
7.17	No of EOT Cranes required	As stated in para 2 above
7.18	Approx. travel length	Approx. 150 Mtr Crane stabling Indoor

8. 10T EOT Crane

8.1	Type	Conventional double girder
8.2	Main Hoist capacity	10 T
8.4	Class of Duty	IV(Four)
8.5	Crane controls	Moving pendant & Cabin and remote operation
8.6	Span	About 19 Mtr
8.7	Speed Main Hoist	4.5 m/min
8.9	Speed Long Travel	40 m/min
8.10	Speed Cross Travel	20 m/min
8.11	Lift of Hook above floor level (MH)	12 m
8.12	Drop of hook below floor (MH)	1 m
8.16	Type of Hook required	C Type or suitable
8.17	No of EOT Cranes required	As stated in para 2 above
8.18	Approx. Travel length	Approx. 130 Mtr Crane stabling Indoor

9. 5 T EOT Crane

This crane will be pendant operated only. Hence cabin operation and remote pendant operation clauses are not applicable to this crane.

8.1	Type	Conventional double girder
8.2	Main Hoist capacity	5 T
8.4	Class of Duty	IV(Four)
8.5	Crane controls	Moving pendant
8.6	Span	10 Mtr
8.7	Speed Main Hoist	4.5 m/min
8.9	Speed Long Travel	20 m/min
8.10	Speed Cross Travel	10 m/min
8.11	Lift of Hook above floor level (MH)	8 m
8.12	Drop of hook below floor (MH)	3 m

8.16	Type of Hook required	C Type or suitable
8.17	No of EOT Cranes required	As stated in para 2 above
8.18	Approx. Travel length	Approx. 40 Mtr Crane stabling Indoor

10. Each of the 15/5 T crane shall be supplied with
 - a. Two-legged wire rope with hook as per IS 2762:1982 capacity 15T, length 3.8m-1 no per crane.
 - b. Two-legged wire rope with hook as per IS 2762:1982 capacity of each leg 5T, length 3M.
 - c. 02 Nos. four-legged wire rope with hook as per IS 2762:1982 capacity of 15T, length 3M.
 - d. Lifting Tackle for lifting of coach body, along with wire rope 1 No for each crane
11. Each of the 7.5 T crane shall be supplied with
 - a. Two-legged wire rope with hook as per IS 2762:1982 capacity 7.5 T, length 3.8m-1 no
 - b. 02 Nos. four-legged wire rope with hook as per IS 2762:1982 cap. of 7.5 T, length 3M.
 - c. Lifting Tackle for lifting of wheel sets 2 No.
 - d. Lifting Tackle for lifting Traction motors 2 nos.
12. Each of the 10 T crane shall be supplied with
 - a. Two-legged wire rope with hook as per IS 2762:1982 capacity 10 T, length 3.8m-1 nos.
 - b. Four-legged wire rope with hook as per IS 2762:1982 cap. of 5 T, length 3M-1 nos.
13. DSL Guard is required to be provided on the crane at the bottom portion at the DSL end to prevent sudden touching of steel rope to the DSL. Jacking Pads should be provided on the end carriages to facilitate dismantling of wheels and bearings. Maintenance cabin should be provided for the maintenance of down shop lead with suitable ladder. Lighting provision shall be made on the crane with accessibility for maintenance.
14. Crane controls should be conveniently located. The various controls should be suitably interlocked to prevent accidental movement of the crane. Suitable limit switches, one each for long and cross travel and two each for main and auxiliary hoists should be provided to prevent over-travel. Electrical interlocks should ensure safety in crane operation while hoisting and traversing.
15. Provision should be available to display power ON/OFF status of DSL for LT and CT, in that RYB coloured bulb should be provided at suitable location.
16. The hoisting, LT and CT motion shall be provided with fail-safe electro-hydraulic thrusters brakes/ DC Disc brakes are also acceptable. The maximum braking torque for LT and CT should not less than 100% of full load torque for each brake. For hoist motion, two brakes should be used and the braking torque for each brake should not be less than 125% of full load torque. One of the two hoist brakes shall be applied with a time lag of 3 seconds in relation to the first. Double shoe brakes should be used for each drive. Brakes should be mounted on the input pinion shaft of all gear boxes. The brake shoe should be of hinged type. Brake levers should be forged, and hinge pins should be provided with steel bushes at the bearing points. Brake drums should be of forged or cast steel.
17. The following voltages shall be used in the crane (a) 415+/-10%V 3 phase 50+/-3%Hz AC for drive motors (b) 230+/-10%V single phase 50+/-3%Hz AC for lighting (c) 24V+/-10% single phase 50Hz+/-3% AC for hand lamp socket outlets (d) 110V+/-10% single phase 50Hz+/-3% AC. The voltage shall be obtained through individual separate transformer units connected to 3 phase 415V AC supply.
18. DSL and current collection gears shall be shrouded, and colour coded. The DSL shall be at safe clearance from electric lines and structure members and shall be adequately insulated as required.
19. Pendant push button shall have control for LT, CT and hoist motions, supply voltage to the pendant control shall be 110V AC. Pendant shall be moving type and the movement of pendant will be independent of trolley. On all the motions the circuit shall be so designed that brakes come into operation immediately in the event of tripping of motor main circuit breaker. If the pendant is of metal, it should be effectively earthed. On all pendant cranes,

safety means shall be provided to prevent inadvertent operation from floor while maintenance work is being carried out on the crane. Adequate guards shall be provided to prevent accidental contact of pendant ropes or holding wire rope/ chain with cross traverse.

20. All electrical connections shall be through crimped sockets/ thimbles. Bare conductors shall not be mounted on the crane bridge. Drag chain cable made of copper multi stranded conductor of adequate size in flat/ round configurations shall be used as bridge conductors. Well-designed trolleys and supporting cable clamps shall be used. All crane motors shall TEFC squirrel cage type and designed for 150 starts / hour. The motor shall be suitable for heavy duty crane hoisting service having cyclic duty factor not less than 40% for class III and 60 % for class IV cranes. The motors shall be suitable for 50 Deg C ambient temperature and 415+/-10% 50Hz +/-3% 3 phase 3 wire AC supply.
21. The scope also covers supply of portable push button type radio remote control along with two step push button type transmitter, receiver, antenna & cable, 2 sets of rechargeable batteries, battery charger and other standard accessories and items for controlling all the motions of the cranes. The radio remote control shall be provided in addition to the main control system through the pendant/ master controller. Transmitter of the radio remote control shall meet the feature like, 3 stage audible and visual low power warning, audible and visual alarm, removable magnetic key (waterproof), shock resistant to 50G, 4-digit password protection, RF output power <10 mW, approximate power consumption approx. 32mA, modulation <25 KHz; narrow band F.M, large mushroom E stop switch, AA rechargeable batteries, internal antenna, programs receiver from ground through RE communication (no need to climb on crane to change frequency or address), two dual axis joysticks, range 100 meters, 16 Strap for transmitter slinging. Receiver of the radio remote control shall meet the feature like, power interruption protection, relay's contacted failure detection circuit, shock resistance mounting provision, impact durability up to 20G, external integrated antenna, enhanced watchdog circuit, FDDI (frequency deviation detection indicator) tracing circuit, sensitivity: <to- 110dBm, adjacent channel restrain > 80dB, supply voltage 115/230/380 50/60 Hz +/-10%, signal alarm, light and E-stop button
22. For all the motions spring return jockey switches or push button shall be used. Two step two direction jockey switches in case of cabin control shall be used for all the motion. The rest position of jockey shall conform to zero position or off position During running the rest position means deceleration to stop. On all motions the circuit shall be so designed that brakes come into operation immediately in the event of tripping of motor main circuit breaker. Each controller shall be fitted with necessary steps for the forward and reverse motion to give smooth and step-less acceleration between each position.
23. One triple pole manually operated MCCB, serving as main incoming protective device fitted with short circuit and overload releases and rated to carry at least combined full load currents of the two motions of the crane having largest power that can work together, should be provided. The circuit breaker shall have a rupturing capacity to withstand and clear fault current of the order of 30KA.
24. Safety switches shall be provided at each end of crane bridge so that under any emergency conditions, by operating anyone of the switches, the incoming circuit breaker is tripped. Further a mushroom head type of push button shall be provided in the operator's cabin in cabin operated crane so that the main incoming circuit breaker can be tripped under any emergency conditions. A pilot lamp incorporated in the control circuit shall glow when any of the switches is operated.
25. All power and auxiliary contactors, and relays shall be mounted in a sheet steel cubical with lockable hinged doors. Panels shall be front wired with readily accessible terminal blocks. Single core, copper conductor shall be used for control circuit wiring in the panel.
26. All contactors etc shall be mounted securely in a vertical arrangement, considering vibrations during crane operation. All the equipment's shall be so mounted in panel as to enable its easy replacement from the front. Power and control terminals blocks shall be separated from each other by means of replaceable insulated spacers. Terminal block shall have adequate clearance and a minimum of 20% spare terminals block shall be provided in terminals strips.

27. All equipment's inside the panel shall have permanent identification labels in accordance with circuit diagram. Terminal blocks shall be robust, Sheet steel used for fabrication of panels shall have a minimum thickness of 2mm. Bottom of panel shall be at least 150mm above the floor.
28. Lighting shall be provided in the driver's cabin, staircase etc, with bulkhead fittings with dust proof covers. Four numbers of under-slung LED type lamps, with shock absorbing and anti-swing suspension arrangement shall be provided for uniform floor illumination. Minimum of one socket outlets for hand lamps shall be provided at each driver's cabin, long travel side and in the area where control panel, resistors and transformers shall be installed. Hand lamps shall operate at 24V AC supply. Industrial type metal clad plug and socket shall be provided.
29. All wiring for power control & lighting circuit shall be carried out with 1.1 KV grade flame retardant low smoke (FRLS) PVC/ XLPE insulated copper cables as per IS 694 and IS 1554 Part I with smoke index and typical index corresponding to ASTM 2843 & IEC332 I. Minimum size of power & control cables shall be 4 mm² & 1 mm² respectively. All cables shall be of reputed make and approved ISI brands. Labels of permanent nature shall be provided on supports of all switches, fuses, contactors, relays etc. All panels, controllers, resistors etc shall be properly marked for each motion. All power control cable, lighting and other cables shall be ferruled at both ends. All equipment terminals shall also to be marked likewise.
30. Earthing to the crane shall be through fourth conductor of DSL. All the electrical equipment's of crane shall be connected to the crane structure by means of earthing links. The crane structure in turn shall be made electrically continuous by providing jumpers over riveted or bolted joints. Equipment's fed by flexible cables shall be earthed by means of spare core provided in the flexible cable.
31. Suitable buffers should be provided to prevent over travel of the crane in both long and cross travels. Hand railing of tubular construction should be provided on bridge foot walks, end carriages, staircases, the landing in the cabin, trolley, and any other location, as necessary. All sheaves should be provided with rigid guards to retain the ropes in the grooves.
32. All parts requiring replacement, inspection and lubrication should be easily accessible without the need of dismantling other equipment or structures. Full length chequered plate platforms should be provided alongside both bridge girders. Access to the cabin from the bridge girder platform should be via a staircase. Minimum clear width of such staircase should be 600mm. Foot walks should be of sufficient width to give at least 500 mm clear passage at all points except between railing and bridge drive where this clearance may be reduced to not less than 400 mm. Cabin and crane travels walkway of crane structure should be laid with rubber mat or wooden planks.
33. Steel plates used for bridge girders and diaphragms should be Grade B to IS 2062 (latest) or equivalent international standard like DIN. Connections in general should be as per Clause 26 of IS 800:2007 (latest) or equivalent international standard like DIN.
34. All butt welds on structural members subject to tension should be radio graphically tested. All other welds should be subjected to magna-flux or dye penetration test. The box girders should be so constructed as to eliminate any possibility of accumulation of water or oil inside them.
35. End carriages should be strong enough to resist all stresses that may be imposed upon them under varied service conditions, including collision with other cranes or stops. The length of the end carriages should be such that no other part of the crane is damaged in the event of a collision. End carriages should be fabricated from rolled steel sections or plates, welded together to form a box. Suitable stiffening diaphragms should be provided wherever required. The material used should be steel Grade B quality to IS 2062 (latest) or equivalent international standard like DIN.
36. Suitable jacking pads should be provided on each end carriage for jacking up the crane while changing track wheels. These jacking pads should not interfere with replacement of track wheels.

37. The trolley frame should be welded rolled steel box section, designed to transmit the load to the bridge rails without undue deflection. The material used should be steel Grade B quality to IS 2062 (latest) or equivalent international standard like DIN. The top of the trolley frame should be plated all over, except for opening(s) required for the ropes to pass through. The trolley wheels should be double flanged. The axle bearings should be of spherical roller type. The bearing housing should be designed for easy removal of wheels and bearings for maintenance.
38. The rail wheels shall be double flanged with straight tread. They shall be capable of taking misalignments in the span. These wheels shall be manufactured from medium carbon alloy steels and shall be solid forged and heat treated to have hardness between 300 – 350 BHN on the tread and flanges to a depth of not less than 8 mm. The wheels should be shrunk/ press fit on the axles.
39. The operator's cabin should be rigid metal frame construction. It should be fitted at one end of the crane opposite to the DSL side and shall be so placed that the operator has an unobstructed view of the load and surroundings. The cabin size shall be minimum 1.5m x 1.5m. The cabin floor should be extended to form a landing platform with a steel stairway to provide access to the foot walk above. The layout of controls should be such that the crane can be operated from a seated position. Fully adjustable padded seat, rubber matting, suitable fan and lighting arrangement should be provided inside the driver's cabin. One fire extinguisher shall be provided for extinguishing any electrical fire.
40. The rope drum shall be made from steel to IS 2062-1984 (or latest) or equivalent international standard like DIN quality. The rope drum shall be stress relieved after fabrication. T-joints shall be radio graphically checked. Free extra turns as specified in IS 3177 or equivalent international standard like DIN shall also be provided. The drum shall be flanged at both ends.
41. Hoisting ropes, if of the conventional type, should be of 6x36 constructions and made out of the best plough steel having tensile strength of around 180 Kg/mm². Ropes should be parallel right hand lay as per IS 2266-2002 or equivalent international standard like DIN (or latest). However, preference will be given to the use of Hyflex type wire rope, which has physical properties that are superior to conventional wire rope, in particular a much lower tendency to rotate.
42. All gears and pinions must be made from forged blanks, should be hardened and profile ground for longer life and silent operation. At all stages only helical gears should be used. Overhung or split gears and pinions should not be used. All gear boxes shall be of completely enclosed splash lubricated type.
43. Gear boxes shall be made of graded CI/ MS fabricated, duly stress relieved. Gear boxes shall be provided with breather vents, easily accessible drain plugs and a suitable oil level indicator or dip stick. Facial clearance between inner surface of the gear box and the face of the nearest gear/ pinions shall be at least 10 mm.
44. LT/CT gear boxes should be of a modular, integral design. Motors may be either flange-mounted or foot mounted, or a combination of the two. In case of foot mounted motors, split type gear boxes shall also be acceptable. MH/AH Gear Boxes shall be of the conventional split type.
45. All couplings shall be of medium carbon steel and shall be designed to suit the maximum torque that can be developed. Hardness of geared portion in the gear coupling shall be more than 250 BHN. Bolted connections shall be easily accessible for inspection and tightening.
46. Hooks shall be Standard plain shank type trapezoidal section conforming to IS 15560, IS5749 and IS 8610 (latest) or equivalent. Hooks should be mounted on grease lubricated anti-friction thrust bearings and a protective skirt should be fitted to prevent rotation of the hook. Proof load test as per IS Specification shall be conducted, either in-house or from a recognized test house.
47. Suitable buffers should be fitted on the four corners of the crane also at the four ends of the bridge girders. Buffers should be rigidly bolted, along the centre line of the crane rail or trolley rail as the case may be. All buffers should

have energy absorbing capacity to stop the bridge or trolley in either direction when travelling at a speed of least 40% full load rated speed. Bridge buffers should have a contact surface of not less than 125 mm diameter.

48. Greasing points should be provided for all grease lubricated bearings, parts of the hoist, cross traverse, and long travel, at convenient location to facilitate greasing with ease.
49. Crane shall be manufactured to the following tolerances:
 - a. Span over LT wheels +6mm.
 - b. Diagonal on wheels +5 mm
 - c. Long travel wheel alignment +1mm
 - d. Tilt of wheels or Balance Axle +1mm/1000mm (Horizontal & Vertical)
 - e. Trolley wheel gauge +3mm
 - f. Trolley track gauge +3mm
 - g. Difference in height between trolley rails (H) for different trolley track gauge (S) shall be within the following limits: S up to 2500 mm- H 4mm, S from 2500 to 4500mm- H 6mm and S above 4500mm- H 8mm.
50. For cabin operated crane suitable dead man's handle shall be provided. Sufficient provision shall be made for alarm during the crane working. A foot operated gong shall be provided to caution to the workers. A continuous ringing bell shall be provided for long travel motion of the crane.
51. All parts of the crane shall be thoroughly cleaned of all loose mill scales, rust, or foreign matter. All parts inaccessible after assembly shall be painted before assembly. All parts except motors, gears, thrusters etc shall be painted with two coats of red oxide zinc chromate primer to IS 2074 or equivalent international standard like DIN, followed by two coats finishing paints (ready mixed oil-based paints) as per the relevant IS code of colour scheme prescribed for EOT cranes. The interior of all gear box housing shall be painted with two coats of oil resistant enamel paint. All machined pads and bearings surface on structures or housing shall be painted with white lead.
52. The scope covers supply of maintenance tools & tackles with the crane: a tool box containing D/E Spanners required sizes- 1 Set, Grease gun-1 No, Oil can-1 No, Screw Driver of required sizes- 1 Set, Nose pliers- 1 No, Insulated pliers- 1 No, Hammer 2 lb- 1 No, Allen Key required sizes-1 Set, Hydraulic jack- 1 No
53. The scope covers supply of following maintenance spares, one set for each type of crane.
(1 set for 15/5T, 1 set for 10T, 1 set for 5T and 1 set for 2T)
 - i. Fixed & moving contact tips for contactors- 1 no of each size.
 - ii. Contactors coils- 1 set consisting of 3 no of each size.
 - iii. Limit switches- 1 set of MH, 1 set of CT, 1 set of LT.
 - iv. Current collectors- 2 set.
 - v. Fuse links- 1 set of each size.
 - vi. Thrusters- 1 of each size
 - vii. Brake Liners with rivets- 1 pair of each size.
 - viii. Main spring for thrusters' brakes- 1 of each size
 - ix. Brakes shoes complete with lining- 1 pair of each size.
 - x. Oil seals for gear cases- 1 for each size of gear box and geared coupling.
 - xi. A set comprising of 2 numbers each of long travel and cross travel motion wheels duly machined without axle and bearings- 1 set.
 - xii. Motors: LT motors :1 Nos, CT motors: 1 Nos, 1 Hoist Motor

54. For warranty and AMC, relevant clauses in General specification will be applicable.