

**Section-8B : Particular Specification – E&M****TECHNICAL SPECIFICATIONS - E & M WORKS (Including Appendices)****TABLE OF CONTENTS**

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## SECTION: E.00 ELECTRICAL AND MECHANICAL WORK

### 0. GENERAL

#### 0.1 Scope of Work

The scope of work under these specifications generally covers supply, fabrication, installation/fixing, necessary touch up painting, testing and commissioning and Training to Employer/Engineer (Training plan Shall be submitted to Engineer for Approval and its implementation) of Electrical works. The contractor shall carryout and completes the said work under this contract in every respect in conformity with the current rules and regulations of the Local Electricity Authority, the Indian Standard Institution, Indian Electricity Rules & Act and to all the provisions of the relevant Government Legislation and with the directions of and to the satisfaction of the Employer/ Engineer. The contractor shall furnish all labour and install all materials, appliances, equipment (except those items which will be supplied by the owner to the contractor at site) necessary for the complete provision and testing of the installation as specified herein and shown on the drawings. This is to be noted that Tender drawings are for guidance of the Contractor. Work shall be executed as per approved shop drawings. Exact locations, levels and distances etc. shall be governed by dimensional parameters actually available at site. Any material, appliances, equipment not specifically mentioned herein or noted on the drawings but which are necessary and customary to make complete installation properly connected and in working condition shall be supplied and installed without any extra cost. The work shall include all incidental jobs / minor civil works connected with installation such as excavation in trenches and backfilling, cutting, drilling and grouting etc. following electrical and Mechanical works.

- i. Conduiting, wiring, supply & fixing of modular type switches etc. for lighting, fans etc.
- ii. Conduiting, wiring, supply & fixing of modular type sockets and switches including industrial socket outlets wherever required and as per drawings.
- iii. External lighting including its feeder pillar, cabling, poles all complete, High Mast (as applicable)
- iv. Lighting fixture for internal areas (including verification of lux level achievable in various areas) and external areas.
- v. Fire detection and alarm system including conduiting and wiring/Cabling.
- vi. Safety equipment
- vii. All panels & DBs including Main Distribution Panel, Essential Power Panel (EMDB), AC Power Panel, Main Lighting Power Panel, Escalator Power Panel, Commercial Power Panel, Fire & Water Pump Panel, Emergency Power Panel (UPS), AMF Panel, Lighting Distribution Boards including any other panel/DB as required and mentioned in BOQ.
- viii. Various distribution boards / panels as required with automatic source transfer system/Automatic Transfer switch /Contactor relay based automatic change over system etc.
- ix. Power supply for signage.
- x. DC control supply system as required
- xi. 1.1 kV grade power cables and control cables as per prevailing specification, cable trays, raceways and ducting
- xii. All Motor and equipment shall have of high efficiency to meet the platinum rating as per IGBC norm. Contractor shall submit the detail specification of Motor and all equipment (e.g. Efficiency etc) to review and approval of Engineer. All motors shall fulfil the EMC Directive 2004/108/EC and are tested according to the EN 61800-3 standard or equivalent and relevant Indian standard.
- xiii. Exhaust fans and ceiling fans
- xiv. Ventilation of basement & generator rooms, substation & pump room, air-conditioning of equipment rooms/other rooms etc.
- xv. Protective earthing and lightning protection
- xvi. Cabling, Hume pipes (including area where road or track crossing needed), cable termination, RCC trenches, Poles etc. for external lighting and external cables
- xvii. Uninterrupted power supply system
- xviii. Protection and interlocks
- xix. Fire pumps, fire hydrants, sprinklers and fire system piping

- xx. Clean agent gas-based fire tube system in electrical panels and fire extinguishers, Pressure calculation for fire Suppression system
- xxi. Interfacing with designated contractors / DDCs as per interface matrix
- xxii. Preparation of Drawings and Design Verification complete as required.
- xxiii. Verification of CRD (Construction reference Drawings) issued by Engineer and prepared and submit the WRD (Working Reference Drawings) for site work and Shop Drawing of Equipment to Engineer for review and approval before start of work.
- xxiv. Prepare and submit the As-Built-drawings after completion of Site Work
- xxv. Testing of equipment's at manufacturers work prior to dispatch
- xxvi. Testing at site as required
- xxvii. Loading, transportation and unloading.
- xxviii. Protection of stored materials/ installed work against damage due to dirt, sun and rain including providing tarpaulin/ PVC sheet covers as required.
- xxix. 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
- xxx. All incoming and outgoing cables and wires shall be properly labelled as per the layout/schematic drawings for easy identification. Details of circuits being fed from DBs shall be affixed at the back of the door of each DB.
- xxxi. Housekeeping and clearing of work area during the tenure of contract
- xxxii. Demobilization and clearing of all temporary works/facilities after completion of work at site and cleaning work are before handing over
- xxxiii. Obtaining clearance from Electrical Inspector before and after completion of work.
- xxxiv. The Contractor shall submit completion documents comprising of the following at the time of handing over:
  - xxxv. 6 hard copies of Operating Instructions and Service Manuals for all equipment and the installation along with CD for use by Owners operating staff. The Owners operating staff shall also be instructed in proper operation of specialized equipment /systems.
  - xxxvi. 6 sets of test results of pre-commissioning tests carried out at site.
  - xxxvii. 6 sets of "As Built" completion drawings
  - xxxviii. LOTO (Lockout) Procedures should be followed as per OSHA 1910.147 and BS7671 standard.
  - xxxix. Contractor shall prepare the testing and commissioning procedures documents and submit for approval 60 days before starting any testing activity. No testing activity will be acceptable before approval of testing procedures which details all testing requirements and parameters in compliance with technical specification and applicable standard requirements for each specific stage of testing.
- xl. Bidder shall be a licensed Electrical Contractor possessing a valid Contractor's license of appropriate class in the state, employing licensed supervisors and skilled workers having valid permits as per the regulations of Indian Electricity Rules and local Electrical Inspectors requirements. Copy of contractor's electrical license shall be furnished along with the Bid.
- xli. Work shall be carried out by Authorized Agency and Contractor shall take prior approval from Employer/Engineer before Agency mobilization at Site.
  - a. **EXCLUSIONS (SCOPE UNDER CIVIL CONTRACTOR)**
    - i. The following items shall be made available to the electrical contractors, work done by civil contractor
  - xlii. Items of civil works like foundations for major equipment, masonry trenches with trench covers and insert plate for cable trench supporting purpose (excluding support structure arrangement for cables/pipes) etc.
  - xliii. Some space if available at Station for contractor's site office/stores for the duration of the contract of size considered suitable and separable by K-RIDE. K-RIDE reserves the right to provide alternative space for the purpose, if so necessary, during the tenure of the contract

## 0.2 Definitions and Abbreviations

### A. Definitions

“Voltage (V)” means the difference of electric potential measured in volts between any two conductors or between any part of either conductor and the earth as measured by a suitable voltmeter and is said to be:

- i. “Low” where the voltage does not exceed 250 volts under normal conditions subject, however, to the percentage variation allowed by the rules.
- ii. “Medium” where the voltage does not exceed 650 volts under normal conditions subject, however, to the percentage variation allowed by the rules.
- iii. “High” where the voltage does not exceed 33,000 volts under normal conditions subject, however, to the percentage variation allowed by the rules.

B. Abbreviations

|        |  |
|--------|--|
| A      | Amp  |
| AC     | Alternating current                                |
| ACB    | Air Circuit Breaker                                |
| ACDB   | Alternating Current Distribution Board             |
| ACPP   | Air Conditioning Power Panel                       |
| ADP    | Apparatus Dew Point                                |
| AFC    | Automatic Fare collection                          |
| ASS    | Auxiliary Substation                               |
| ASTS   | Automatic Source Transfer System                   |
| BMS    | Building Management System                         |
| CI     | Cast Iron  |
| cm     | Centimetre   |
| CT     | Current Transformer                                |
| CWS    | Cold Water Supply                                  |
| CPWD   | Central Public Works Department                    |
| DBT    | Dry Bulb Temperature                               |
| DC     | Direct Current                                     |
| DCDB   | Direct Current Distribution Board                  |
| DG     | Diesel Generator                                   |
| DP     | Double Pole  |
| ELCB   | Earth Leakage Circuit Breaker                      |
| ETP    | Effluent Treatment Plant                           |
| EOT    | Electrical Overhead Travelling                     |
| FCO    | Floor Clean Out Plug                               |
| FD     | Floor Drain  |
| FACP   | Fire Alarm Control Panel                           |
| FFL    | Finished Floor Level                               |
| FPP    | Fire Pump panel                                    |
| FRLSZH | Fire Retardant Low Smoke Zero Halogen              |
| FR     | Fire Retardant                                     |
| FT     | Floor Trap   |
| FWS    | Flushing water Supply                              |
| GI     | Galvanised Iron                                    |
| GT     | Gully Trap   |
| HD     | Heat detector                                      |
| HT     | High tension                                       |
| HV     | High Voltage                                       |
| IEEE   | Institution of Electrical and Electronic Engineers |
| kVA    | Kilo volt Ampere                                   |
| kW     | Kilowatt   |
| Kg     | Kilogram   |
| LDB    | Lighting Distribution Board                        |
| LPM    | Litre Per Minute                                   |
| LT     | Low Tension  |
| LV     | Low Voltage  |

|                |  |
|----------------|--|
| M or m or mtrs | metre                                    |
| M&E            | Mechanical & Electrical                  |
| MCB            | Miniature Circuit Breaker                |
| MCCB           | Miniature Case Circuit Breaker           |
| MDB            | Main Distribution Board                  |
| MPCB           | Motor Protection Circuit Breaker         |
| MFM            | Multi-function meter                     |
| MLP            | Main lighting Panel                      |
| mm             | Millimetre                               |
| MS             | Mild Steel                               |
| RRTS           | Regional Rapid Transit System            |
| MV             | Medium Voltage                           |
| PAP            | Passenger Amenities Panel                |
| PD             | Property Development                     |
| PVC            | Poly Vinyl chloride                      |
| PT             | Potential Transformer                    |
| RCCB           | Residual Current Circuit Breaker         |
| RH %           | Relative Humidity (percent)              |
| RI             | Response Indicator                       |
| RTU            | Remote Terminal Unit                     |
| RWMH           | Rain Water Manhole                       |
| S&T            | Signalling & Telecom                     |
| SCADA          | Supervisory Control and Data Acquisition |
| SCR            | Station Controller Room                  |
| SD             | Smoke detector                           |
| SPER           | Signalling and PSD Equipment Room        |
| STP            | Sewage Treatment plant                   |
| SHR            | Sensible Heat Ratio                      |
| SMH            | Sewer Manhole                            |
| TER            | Telecom Equipment Room                   |
| TOM            | Ticket Operating Machine Room            |
| SP             | Single Pole                              |
| UPS            | Uninterrupted Power Supply.              |
| UT             | Urinal Trap                              |
| V              | Volt                                     |
| VRF            | Variable Refrigerant Flow                |
| VRV            | Variable Refrigerant Volume              |
| WB             | Wash Basin                               |
| WBT            | Wet Bulb Temperature                     |
| WC             | Water Closet                             |
| WPP            | Water Pump Panel                         |
| XLPE           | Cross link Polyethylene                  |

### 0.3 Applicable Codes and Regulations

- A. Electrical arrangement shall be based on BS: 7671 - 2001 "Requirements for electrical installations. IEE Wiring Regulations - Sixteenth edition" or other internationally recognized equivalent standard approved by the Employer/Engineer examples of which are:

|      |  |
|------|--|
| ANSI | American National Standards Institute      |
| ASME | American Society of Mechanical Engineers   |
| ASTM | American Society for Testing and Materials |
| BS   | British Standard                           |
| DIN  | Deutsches Institut fur Normung             |
| EN   | European Standard                          |

|        |   |
|--------|---|
| IEA    | Indian Electricity Act                        |
| IEC    | International Electro-Technical Commission    |
| IER    | Indian Electricity Rules                      |
| IES    | Illumination Engineering Society, UK          |
| IS/BIS | Bureau of Indian Standards                    |
| ISO    | International Standards Organization          |
| JIS    | Japanese Industrial Standards                 |
| NBC    | National Building Code                        |
| NEC    | National Electrical Code                      |
| NEMA   | National Electrical Manufacturers Association |
| NFPA   | National Fire Protection Association          |
| VDE    | Verband der Elektrotechnik                    |

**B. Local Codes, Regulations and Standards**

- i. Unless otherwise stated, the electrical system shall be governed by all applicable local codes, code of practices regulations and standards (all latest) issued by the local agencies such as:
  - A. State/ Central Pollution Control Board
  - B. Chief Electrical Inspector
  - C. Karnataka Administration
  - D. Karnataka Police & Fire Brigade
  - E. Electricity Authority
  - F. Indian Electricity Act
  - G. Indian Electricity Rules
  - H. International Electro-Technical Commission
  - I. ISHRAE (Indian Society of Heating, Refrigerating and Air-conditioning Engineers)
  - J. National Building Code
  - K. National Safety Council
  - L. Public Works Department (Central/State)
  - M. Regulations for Electrical crossings of Rail Track

- C. The Contractor shall ensure compliance with the regulations laid down by local authorities i.e., Government, Municipal, Chief Electrical Inspector, and all other statutory agencies including fire safety regulations, fire insurance regulations or other local codes and obtain approvals from relevant authorities at appropriate stages of work as required.

**D. Additional Codes, Standards, Specifications and Manuals**

- i. In addition to local requirements, electrical system shall comply with the codes of practice and standards specified in herein. Local codes, regulations and standards shall take precedence where their standards or requirements are more onerous than other national standards.
- ii. It is to be noted that updated and current standards shall be applicable irrespective of dates mentioned with references/ standards in the tender documents.

**0.4 Contractual Responsibility**

The Contractor shall be fully responsible for ensuring that the manufacture, MAKE, TYPE, quantity and size of equipment's /components / materials brought to site for use in work shall be suitable for the work and shall be compatible with spaces available at site particularly with regard to heights and the widths of approaches to places of installation of equipment's. Approval of shop drawings, calculations, makes, samples etc. given by or on behalf of K-RIDE shall not absolve the Contractor of this basic contractual responsibility.

**0.5 Name Plates**

**CAUTION BOARDS**

Affixing/ pointing caution boards/ danger plates as statutorily required for electrical safety.

**NAME PLATES**

Providing engraved anodized aluminium or approved equivalent name plates of suitable sizes on switchboards/ panels/ equipment etc.

**CIRCUIT IDENTIFICATION**

All incoming and outgoing cables and wires shall be properly labelled as per the layout/ schematic drawings for easy identification. Details of circuits being fed from DBs shall be affixed at the back of the door of each DB.

**0.6 Civil Works, Cleaning and Painting****CIVIL WORKS**

Minor civil work items required for the work like making chases in walls/ceilings, making holes and openings, providing inserts in trenches, grouting sealing of cable trenches to prevent water entry inside rooms, required foundations for street light and high mast poles etc. including making good and painting the civil works.

**HOUSE KEEPING**

Housekeeping and clearing of work area during the tenure of contract

**FINAL PAINTING**

Providing final paint coat to all exposed fabricated steel work and providing matching paint in approved manner over portions of factory painted equipment if damaged during transportation / storage / installation before handing over.

**SITE CLEARANCE**

Demobilization and clearing of all temporary works/facilities after completion of work at site and cleaning work are before handing over.

**0.7 Water and Electricity**

Contractor shall make his own arrangement for water and electricity

**0.8 Statutory Approval**

The Contractor shall deposit applications as prescribed with the appropriate Authorities on behalf of K-RIDE for obtaining sanctions/approvals/permissions/ clearances as detailed below and shall arrange for timely obtaining of the sanctions/ permission/ approvals/ clearance as required. All expenses required to be incurred for obtaining the statutory approvals shall be borne by the Contractor. Only Statutory fees shall however be reimbursed by the K-RIDE against duly signed/stamped receipts.

**0.9 Internal Electrical Works**

Obtaining clearance from Electrical Inspector before and after completion of work.

**0.10 Compliance of Statutory Observation**

Complying with observations, if any, of Electrical Inspector and/or any other Statutory Authority after completion of work in order to obtain a categorical clearance to start beneficial use.

**0.11 Supply of Manuals and Drawings****ALONG WITH TENDER**

Particulars required to be filled in by tenderers, along with descriptive literature as required.

**SHOP DRAWINGS ON AWARD OF WORK BEFORE COMMENCEMENT**

The Contractor shall furnish manufacturer's test certificates in respect of materials/ equipment / components used on work as required and shall submit shop drawings for all works as indicated in the tender to Engineer/ Employer for approval before commencement of work at site/ fabrication/ manufacture.



**COMPLETION DOCUMENTS**

The Contractor shall submit complete documents comprising of the following at the time of handing over:

- i. 6 hard copies of Operating Instructions and Service Manuals for all equipment and the installation along with CD for use by Owners operating staff. The Owners operating staff shall also be instructed in proper operation of specialized equipment/systems.
- ii. 6 sets of test results of pre-commissioning tests carried out at site.
- iii. 6 sets of "As Built" completion drawings as detailed below
- iv. SAT/FAT report,
- v. Inventory list
- vi. warranty certificate

**0.12 Manufacturers Instruction**

Where manufacturers have furnished specific instructions, relating to the materials used in this job, covering points not specifically mentioned in these documents, manufacturer's instructions shall be brought to the notice of the K-RIDE for further instructions in the matter.

**INTERCHANGE ABILITY**

All similar parts and/or equipment shall be interchangeable with one another.

**MATERIAL TESTING**

The Employer/Engineer shall have full powers to require any material used in work to be tested by an independent agency at the Contractor's expense in order to prove its soundness and adequacy.

**INSPECTION AT MANUFACTURERS WORKS**

Prior to shipment of equipment, the Employer/Engineer reserves the right to inspect the equipment at Manufacturer's Works. Contractor shall provide and secure every reasonable access and facility at Manufacturer's Works for this inspection for the Employer/Engineer.

**TESTING AT SITE BEFORE INSTALLATION**

All the System installed as part of this work shall be load tested and performance tested at the time of commissioning. All the consumables, (diesel, oil etc), load banks, test equipment's etc. required for the test shall be arranged by the contractor.

**0.13 Safety Regulations**

The Contractors shall, at their own expense, arrange for safety provisions as per safety codes of Indian Standards Institution, Indian Electricity Act and such other Rules, Regulations and Laws as may be applicable, as indicated below, in respect of all labour, directly or indirectly employed in the work for performance of the Contractors' part of this agreement.

- A. No inflammable materials shall be stored in places other than the rooms specially constructed for these purposes in accordance with the provisions of Indian Explosives Act. If such storage is unavoidable, it should be allowed only for a short period and in addition, special precautions, such as cutting off the supply to such places at normal times, storing materials away from wiring and switch boards, giving electric supply for a temporary period with due permission of Engineer shall be taken.
- B. Protective and safety equipment such as rubber gauntlets or gloves, earthing rods, line men's belt, portable artificial respiration apparatus etc. should be provided in easily identifiable locations. Where electric welding or such other nature of work is undertaken, goggles shall also be provided.
- C. Necessary number of caution board such as "Man on Line, don't switch on" should be readily available in easily identifiable locations.
- D. Standard first aid boxes containing materials as prescribed by the St. John Ambulance Brigade or Indian Red Cross should be provided in easily identifiable locations and should be readily available. Periodical examination of the first aid facilities and protective and safety equipment provided shall be undertaken and proper records shall be maintained for their adequacy and effectiveness.
- E. Charts (one in English and one in regional language) displaying methods of giving artificial respiration



to a recipient of electrical shock shall be prominently displayed at appropriate places.

- F. A chart containing the names, addresses and telephone numbers of nearest authorized medical practitioners, hospitals, Fire Brigade and also of the officers in charge shall be displayed prominently along with the First Aid Box.
- G. Steps to train supervisory and authorized persons of the Engineering staff in the First Aid Practices, including various methods of artificial respiration with the help of local authorities such as Fire Brigade, or other recognized institutions equipped to impart such training shall be taken, as prompt rendering of artificial respiration can save life at time of electric shock.
- H. No work shall be undertaken on live installations, or on installations which could be energized unless one other person is present to immediately isolate the electric supply in case of any accident and to render first aid, if necessary.
- I. No work on live L.T. bus bar or pedestal switchboards should be handled by a person below the rank of a Wireman and such a work should preferably be done in the presence of the contractor's Engineer supervising of the work. When working on or near live installations, suitably insulated tools should be used, and special care should be taken to see that those tools accidentally do not drop on live terminals causing shock or dead short.
- J. Before starting any work on the existing installation, it should be ensured that the electric supply to that portion in which the work is undertaken is preferably cut off. Precautions like displaying "Men at Work" cautions boards on the controlling switches, removing fuse carrier from these switches and these fuse carriers being kept with the person working on the installation, etc. should be taken against accidental energization. "Permit to Work" should, be obtained from the Engineer-in-charge. No work on H.T. main should be undertaken unless it is made dead and discharged to earth with an earthing lead of appropriate size. The discharge operation shall be repeated several times and the installation connected to earth positively before any work is started.
- K. Before energizing on an installation after the work is completed, it should be ensured that all tools have been removed and accounted, no person is present inside any enclosure of the switch board etc. any earthing connection made for doing the work has been removed, "Permit to Work" is received back duly signed by the person to whom it was issued in token of having completed the work and the installation being ready for re- energizing and "Men at Work" caution boards removed.
- L. In case of electrical accidents and shock, the electrical installation on which the accident occurred should be switched off immediately and the affected person should be immediately removed from the live installation by pulling him with the help of his coat, shirt, wooden rod, broom handle or with any other dry cloth or paper. He should be removed from the place of accident to a nearby safe place and artificial respiration continuously given as contained in BIS. Code and Standard prescribed by St. John Ambulance Brigade or Fire Brigade. If needed the affected person should be taken to nearest hospital without loss of time.

#### **0.14 Indemnity**

The Contractor shall be solely responsible for claims arising out of any accident at site of work during the tenure of contract and shall cover such risks with suitable insurance. The K-RIDE shall not be responsible for any direct or indirect consequence of such accidents.

#### **0.15 Certificates**

On completion of the all installation a certificate shall be furnished by the Contractor countersigned by the Licensed Supervisor, under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local supply authority.

#### **0.16 Workmanship**

Good workmanship is an essential prerequisite to be complied for this work. Entire work shall be carried out in the most workmanlike manner by skilled workers under competent supervision

#### **0.17 Technical Requirements**

- A. The design, supply, installation, testing & commissioning of main items of equipment and materials viz. MV / LV switch boards / lighting panels, batteries, battery chargers, UPS, conduit wiring, luminaries, electronic chokes, XLPE/PVC cables and outdoor lighting equipment, lighting poles, high mast lighting etc. shall be made in accordance with the particular specifications, latest codes & standards specified in these documents.

- B. Specifications shall find precedence over the relevant standards indicated. In case of doubt or no mention of specification or standards, the CPWD specifications shall be followed. However, the decision or clarifications of Employer / Engineer on above shall be final & binding. No deviation from the agreed designs shall be accepted unless specifically agreed to by Employer / Engineer and notified. In case of any conflict between specification and the standards the instruction/decision of engineer/employer shall be binding.
- C. The other items of equipment and all components and materials shall meet or exceed the referred standards / specifications (**latest revision**) or equivalent:

|                                |   |
|--------------------------------|---|
| IS:1387-1993                   | General requirements for the supply of metallurgical materials  |
| IS:617-1994                    | Aluminium and aluminium alloy ingots and castings for general engineering purposes  |
| IS:1554 (Part-I) – 1988        | PVC insulated (heavy duty) electric cables: Part 1 For working voltages up to and including 1100 V                          |
| IS: 694 – 2010                 | PVC Insulated cables for working voltages up to and including 1100 V  |
| IS:7098 Part-I 1988            | Cross-linked polyethylene insulated PVC sheathed cables: Part 1 For working voltage up to and including 1100 V              |
| IS: 800-2007                   | Code of practice for general construction in steel  |
| IS: 5 - 2004                   | Colours for Ready Mixed Paints and Enamels  |
| IS: 2551-1982                  | Danger notice plates  |
| IS: 5578-1984                  | Guide for marking of insulated conductors   |
| IS: 10118 Parts I to 4 -1982   | Code of Practice for Selection, Installation and Maintenance of Switchgear and Control gear                                 |
| IS 1913 Part-I 1978            | General and safety requirements for luminaires: Part 1 Tubular fluorescent lamps  |
| IS: 1777-1978                  | Industrial luminaires with metal reflectors   |
| IS: 3553-1966                  | Specification for Watertight Electric Lighting Fittings   |
| IS: 5039-1983                  | Distribution pillars for voltages not exceeding 1 000 V AC and 1200 V DC  |
| IS: 2675-1983                  | Enclosed distribution fuse boards and cut-outs for voltages not exceeding 1000 V ac and 1200 V dc                           |
| IS: 2667-1988                  | Fittings for rigid steel conduits for electrical wiring   |
| IS: 3480-1966                  | Flexible steel conduits for electrical wiring   |
| IS 9537: Part 1 : 1980         | Conduits for electrical installations: Part 1 General requirements  |
| IS 9537: Part 2 : 1981         | Conduits for electrical installations: Part 2 Rigid steel conduits (superseding IS:1653)                                    |
| IS 9537: Part 3 : 1983         | Conduits for electrical installations: Part 3 Rigid plain conduits of insulating materials (superseding IS:2509)            |
| IS 9537: Part 4 : 1983         | Specification for Conduits for Electrical Installations - Part 4 : Pliable Self-recovering Conduits of Insulating Materials |
| IS 9537 : Part 5 : 2000        | Conduits for Electrical Installations - Part 5 : Pliable Conduits of Insulating Material                                    |
| IS 9537 : Part 6 : 2000        | Conduits for Electrical Installations - Specification - Part 6 : Pliable Conduits of Metal or Composite Materials           |
| IS 9537 : Part 8 : 2003        | Conduits for Electrical Installations - Specification - Part 8 : Rigid Non - Thread able Conduits of Aluminium Alloy        |
| IS: 3837-1976                  | Accessories for rigid steel conduits for electrical wiring  |
| IS: 4615-1968                  | Switch socket outlets (non-interlocking type)   |
| IS: 2713 (Parts I to III)-1980 | Specification for Tubular Steel Poles for Overhead Power Lines  |
| IS: 2141                       | Hot Dip Galvanized Stay Strand - Specification  |
| IS: 209                        | Zinc Ingot – Specification  |
| IS: 3618                       | Specification for Phosphate Treatment of Iron and Steel for Protection Against Corrosion                                    |

|                                     |   |
|-------------------------------------|---|
| IS 13340 :                          | Power Capacitors of Self-healing Type for AC Power Systems having Rated Voltage up to 650 V – Specification   |
| IS/IEC60947 : Part 1 :              | Specification for Low-voltage Switchgear and Control gear - Part 1 : General Rules  |
| IS/IEC60947 : Part 2 :              | Specification for Low-voltage Switchgear and Control gear - Part 2 : Circuit Breakers   |
| IS/IEC60947 : Part 3 :              | Specification for Low-voltage Switchgear and Control gear - Part 3 : Switches, Disconnections, Switch Disconnections and Fuse Combination Units                           |
| IS/IEC60947 : Part 4 : Sec 1        | Specification for Low-Voltage Switchgear and Control gear - Part 4 : Contractors and Motor-Starters - Section 1 : Electromechanical Contactors and Motor Starters         |
| IS/IEC60947 : 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 |
| IS/IEC60947 : Part 5 : Sec 2 : 2004 | Low-Voltage Switchgear and Control gear - Specification - Part 5 : Control Circuit Devices and Switching Elements - Section 2 : Proximity Switches                        |
| IS/IEC 60947 : Part 6 : Sec 1       | Specification for low voltage and control gear multifunction equipment. Automatic transfer switching equipment.   |
| IS:383 – 1970                       | Specification for coarse and fine aggregates from natural sources for concrete  |
| IS:456 – 2000                       | Plain and Reinforced Concrete - Code of Practice  |
| IS:516-1959                         | Method of test for strength of concrete   |
| BS:3871, IS:2516                    | MCCBs   |
| IS:8828 – 1996                      | Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations   |
| IS: 4722 – 2001                     | Rotating Electrical Machines - Specification  |
| IS: 3231                            | Specification for Electrical Relays for Power System Protection   |
| IS: 11353 – 1985                    | Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals  |
| IS: 10118 (Parts 1 to 4) 1982       | Code of practice for selection, installation and maintenance of switchgear  |
| IS: 3043 : 1987                     | Code of Practice for earthing   |
| IS: 732 – 1989                      | Code of Practice for Electrical Wiring Installations  |
| IS: 5578 – 1984                     | Guide for marking of insulated conductors   |
| IS: 5216 Part I & II 1982           | Recommendation on Safety Procedures and Practices in Electrical Work  |
| SP: 30 : 1985                       | National Electrical code  |
| IS: 1646 – 1997                     | Code of practice for fire safety of buildings (general): Electrical installation  |
| IS: 2075 – 2000                     | Ready Mixed Paint, Staving, Red Oxide Zinc Chrome, Priming – Specification  |
| IS: 1248 (All Parts) 2003           | Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Specification  |
| IS:13779 – 1999                     | ac Static Watthour Meters, Class 1 and 2 – Specification  |
| IS: 3618 – 1966                     | Specification for Phosphate Treatment of Iron and Steel for Protection Against Corrosion  |
| IS: 6005 – 1998                     | Code of practice for phosphating of iron and steel  |
| IEC 60332 (Various parts)           | Tests on electric cables under fire conditions  |
| IEC 61439 (Part1,2&3)               | Low-voltage switchgear and control gear assemblies  |
| IS/IEC 60947                        | Specification for Low-voltage Switchgear and Control gear   |
| BS:5839                             | Fire detection and alarm systems for buildings  |

|           |  |
|-----------|--|
| IEC 61641 | Low-voltage switchgear and control gear assemblies-guide of test under condition of arch due to internal fault |
| IEC 61869 | Instrument transformer   |

### 0.18 Service Life of the Equipment

The quality of the material, equipment's, cables shall be so as to secure a service life as shown below:

|  |          |
|--|----------|
| Main Switch Boards                                   | 30 years |
| Transformers   | 30 years |
| Sub-main switch boards / distribution boards/ panels | 30 years |
| Cables   | 30 years |
| Fire alarm main panel                                | 30 years |
| Luminaires   | 10 years |
| Tray, trunking and supports                          | 30 years |
| Lightning protection                                 | 30 years |
| Sub-assemblies and components                        | 30 years |
| DG set   | 20 years |
| UPS  | 20 years |
| Batteries  | 10 years |
| All other equipment                                  | 20 years |

Above service life of the equipment is the normal life expectancy of the equipment subject to its maintenance and preservations as per the recommended maintenance practice.

Contractor shall furnish manufacture's certificate for secured service life of the equipment.

### 0.19 Designation of Equipment

- A. Equipment designation shall be identified and labelled in conformity with the plans, schematics, block and single-line diagrams and as built drawings for easy identification, reference & subsequent maintenance. The Contractor shall get the Material and letter sizing (Font Size) approved from the Employer / Engineer before use.
- B. Numbers - Each piece of equipment shall be numbered according to the number of the circuit breaker feeding the piece of equipment. Terminal cabinets shall be numbered sequentially.
- C. Equipment, cables, boards, panels shall be numbered for type and serial number. Each equipment number shall be preceded by a suitable letter designation. A list may be drawn & got approved to adopt in all references.
- D. Letters - Each equipment number shall be preceded by a suitable letter designation uniformly adopted viz.:

| Description   | Abbreviation/ Designation |
|---|---------------------------|
| Automatic Transfer Switch                                 | ATS                       |
| Automatic change over switch/ Change over switch          | ACOS/COS                  |
| Main Distribution Board                                   | MDB                       |
| Control Panel   | CP                        |
| Disconnect Switch   | DS                        |
| Isolator  | I                         |
| Automatic Fare Collection/signalling& Telecom Power Panel | AFC/S&T                   |
| Diesel Generator/ Uninterrupted power system              | DG/UPS                    |
| Normal/Emergency/ Lighting                                | N/E/L                     |
| Motor   | M                         |
| Motor Control Centre                                      | MCC                       |
| Motor Starter   | MS                        |
| Power Panel   | PP                        |

|   |             |
|---|-------------|
| Distribution Board/Sub Distribution board | DB/SDB      |
| Switchboards                              | SB          |
| Switchgear                                | S           |
| Terminal Cabinet/Terminal Block           | TC/TB       |
| Transformer                               | Tr          |
| Other devices/boards in use               | As approved |

These designations shall be subject to modifications and shall be got approved from Employer / Engineer, during execution of works.

#### 0.20 **Operating Parameters**

Operating parameters for electrical works shall generally be 3-phase, 4-wire, 415V, 50Hz unless specified otherwise.

#### 0.21 **Rating, Sizes and Calculations**

- A. Power system shall be provided to suit the equipment chosen for voltage, capacity, and fault duty to which it is exposed.
- B. The ambient temperature and ambient humidity for Electrical Switchgear shall be as per IEC 60947 (Clause 6.1.1 and 6.1.3 of IEC 60947) and for Electrical panel as per IEC 61439 para clause 7.1.1 & 7.1.2.

#### 0.22 **General Features**

- A. All equipment & components must be capable of performing continuous duty at full load.
- B. The panel/boards shall be aesthetic design, dust & vermin proof, modular /extendable maintenance friendly construction so that the defective equipment can be readily replaced/ trouble-shot with ease & speed, when required. The arrangement of controlling switches in the MV/LV Switch Boards / Distribution boards / Panels and their marking shall be such that these are prominent, easily identifiable and accessible. Single line power / control diagrams shall be placed at the back of door or other accessible locations in the board/panels with complete details as required and directed to facilitate easy maintenance.
- C. Prior to shipment of equipment, the Employer / Engineer reserves the right to inspect the equipment at the manufacturers' works and the Contractor shall provide and secure for the Employer / Engineer every reasonable access and facility at the manufacturers' works for such inspection.

#### 0.23 **Quality Control of Equipment, Components and Material**

- A. All major equipment's and materials such as LV Main Distribution/sub-Distribution boards, Switchgear, switchboards, battery, UPS, battery chargers, change over switches, luminaires, electronic chokes, street lighting poles, XLPE cables etc. as required for the work shall be subject to Quality Assurance Programme to ensure proper supply and use of raw materials, processes, installation/execution and tests.
- B. The contractor shall furnish the Quality Assurance Programme prior to fabrication of various assemblies and their supplies for installation. A well-documented quality plan shall be charted indicating all the activities and interfaces relating to the sustained check on quality of workmanship and materials used in various stages of the work and get approval from employer.
- C. All makes of components & accessories shall be got approved before use including the enclosure design before fabrication. Progressive inspections shall be arranged as desired by the Employer / Engineer.
- D. The Contractor shall incorporate adequate standardization to ensure minimum variety and sizes of equipment, accessories, sub-assemblies, systems and practices.

#### 0.24 **Corrosion Protection**

All ferrous components and fittings exposed to the atmosphere shall be hot-dip galvanized unless specified otherwise.

#### 0.25 **Acoustic Criteria**

Noise emanating from the equipment / service installations shall not exceed as per provision given in the relevant international standards for each of the equipment.

#### 0.26 **Spares, Special Tools and Test Equipment**

- A. The Contractor shall recommend a list of special tools and test equipment, which are essential for day-to-day use in both corrective and preventive maintenance beyond DLP/ Maintenance period and

for workshop use in the overhaul of all modules and units likely to be required over the full-service life of the installation.

- B. During construction/commissioning DLP/ Maintenance period, all such tools & test equipment & material required for repair/ replacement/ making good, shall be arranged by the contractor whether explicitly mentioned or not without any financial implication on employer.
- C. Contractor shall, within 90 days from completion of the work, provide a list of recommended spare parts required for the 36 months of service beyond the DLP/Maintenance period.
- D. The Contractor shall recommend stockholding considering lead-time for procurement of the respective items.
- E. Where the Contractor considers that any equipment, which cannot be economically or technically maintained by the Employer (e.g., computer processors) then these items shall be identified and proposals submitted for maintenance of such equipment within 180 days prior to expiry of defect liability period to decide on entering into annual maintenance contract.

**0.27 Service / Working Conditions**

- A. All the equipment's, material shall be designed/ provided to suit/ work continuously under conditions of ambient temperature of 50°C and relative humidity up to 95% non-condensing or as specified NBC.
- B. All the equipment shall be capable of continuous operation under environmental and power supply conditions of Voltage and frequency variation.

**0.28 Indicative Makes**

- A. Contractor shall use the material/ components / products of indicative make as indicated in 'list of indicative makes' enclosed vide Annexure-'2', unless specified otherwise or as approved by the Employer / Engineer.
- B. The Contractor shall quote the rates for material and equipment as per the list of indicative makes. In the event of contractor wanting to use alternate makes other than those stipulated for any reason, the contractor can send a proposal after ensuring that what he proposes meets both the quality, safety standard of the tender specifications/requirements and key dates. He shall also stand full guarantee to his alternate proposal. The alternate makes can be used only after an approval accorded by the Employer, whose decision will be final in the matter.

**0.29 Electromagnetic Compatibility**

- A. All equipment shall conform with the objectives of the European Directive on EMC (89/335/EEC) wherever applicable and where appropriate shall be affixed with the CE mark.
- B. Equipment shall be tested, and the level of conducted interference transmitted, level of immunity to conducted and radiated interference received shall be established for all equipment to conform to the required levels.
- C. Machinery shall comply with the requirements of EN 55081, IEC 801 Part-1 to 3 and BS 6667 Part-1 to 3.

**0.30 Payments**

- A. The stage payment of E&M items may be approved by employer on contractor's request after mobilization.



## SECTION: E.01 MV SWITCHGEAR BOARD

### 1.1 Scope

The scope of work shall cover the design, manufacture, supply, installation, testing and commissioning of all power panels, suitable for 415 volts, 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.

- A. Switchgear OEM only responsible for Design, project Management, Manufacturing, performance, warranty and service for all the panels.
- B. All the ACB, MCCB, MCB, MPCB, RCBO's the service / supply back up required for minimum 15 Years.
- C. 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.
- D. All materials and equipment shall be new, latest advanced version and of the approved make and design and as per schedule of quantities confirming to contract specifications. Employer reserve the right to choose an approved make of the material and all such rates are taken into consideration while quoting.
- E. Selection of ACB , MCCB, and MCB shall be same of 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 certificate from acceptable, reputed laboratories to prove the same, if so desired by Engineer. In view of standardization and Uniformity, mixing of two series of switch gear (even from the same manufacturer) for either MCCB or ACB will not be permitted. In case of higher frame size is required to be provided to achieve 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 specified frame size.

### 1.2 Standards

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

|                                     |   |
|-------------------------------------|---|
| IS/IEC60947 : Part 1 : 1993         | Specification for Low-voltage Switchgear and Control gear - Part 1 : General Rules  |
| IS /IEC 60947 : Part 2 : 1993       | Specification for Low-voltage Switchgear and Control gear - Part 2 : Circuit Breakers   |
| IS/IEC60947 : Part 3 : 1993         | Specification for Low-voltage Switchgear and Control gear - Part 3 : Switches, Disconnectors, Switch Disconnectors and Fuse Combination Units                             |
| IS/IEC60947 : Part 4 : Sec 1 : 1993 | Specification for Low-Voltage Switchgear and Control gear - Part 4 : Contactors and Motor-Starters - Section 1 : Electromechanical Contactors and Motor Starters          |
| IS/IEC60947 : 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 |
| IS/IEC60947 : Part 5 : Sec 2 : 2004 | Low-Voltage Switchgear and Control gear - Specification - Part 5 : Control Circuit Devices and Switching Elements - Section 2 : Proximity Switches                        |
| IEC 61439(Part-1 & 2)               | Specification for Low voltage switchgear and control gear assemblies  |
| IS: 3231 – 1986                     | Specification for Electrical Relays for Power System Protection   |



|   |  |
|---|--|
| IS: 11353 – 1985                            | Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals   |
| IS: 10118 (Parts 1 to 4) 1982               | Code of practice for selection, installation and maintenance of switchgear   |
| IS: 3043 – 2018                             | Code of Practice for earthing  |
| IS: 732 – 1989                              | Code of Practice for Electrical Wiring Installations   |
| IS: 5578 – 1984                             | Guide for marking of insulated conductors  |
| IS: 5216 Part I & II 1982                   | Recommendation on Safety Procedures and Practices in Electrical Work   |
| SP: 30 : 1985                               | National Electrical code   |
| IS: 1646 – 1997                             | Code of practice for fire safety of buildings (general): Electrical installation   |
| IS: 2075 – 2000                             | Ready Mixed Paint, Stoving, Red Oxide Zinc Chrome, Priming - Specification   |
| IS: 1248 (All Parts) 2003                   | Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Specification   |
| IS: 3618 – 1966                             | Specification for Phosphate Treatment of Iron and Steel for Protection Against Corrosion   |
| IS: 6005 – 1998                             | Code of practice for phosphating of iron and steel   |
| IS: 5 - 2004                                | Colours for Ready Mixed Paints and Enamels   |
| IS 1893<br>IEC 61641                        | Seismic compliance zone 3<br><br>Internal Arc Compliance   |
| IS:8828 – 1996<br><br>IEC 61921 & IEC 61439 | Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations<br><br>APFC Panels and Power quality solutions |

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

E. If any of the above standards has been amended or replaced by new standard then amended / replaced standard would apply in consultation with Employer / Engineer.

### 1.3

#### **Abbreviations**

- a) ACB-Air circuit breaker
- b) ALTS- Automatic load transfer switch
- c) APFC-Automatic power factor correction
- d) ATS- Automatic transfer switch
- e) DB- Distribution board
- f) EMC- Electromagnetic compatibility
- g) LEP- Local Electrical Panel
- h) LMCP- Local motor control panel
- i) LT- Low Tension
- j) LVDB-low voltage distribution board
- k) ELECTRICAL PANELS- Low Voltage main switch board
- l) MCB- Miniature circuit breaker
- m) MCCB-moulded case circuit breaker
- n) MFM- Multi function meter
- o) MPCB-Motor protection circuit breaker
- p) RCCB- Residual current circuit breaker
- q) RCBO-Residual Current Circuit Breaker with Over-current
- r) RTU- Remote terminal unit
- s) TB- Terminal block
- t) VFC- Volt free contact

### 1.4

#### **Air Circuit Breakers**

Air Circuit breakers shall be air break, horizontal electrical draw-out type fully interlocked and meeting the requirements of Indian /IEC standards. Breakers shall be rated for an operating

- A. Voltage  $U_e$  of 415/690 V & insulation voltage  $U_i$ : 1000 V, rated Impulse – 12kV for main circuit and rated full load amperes as indicated on drawings. Breaker shall be capable of making and braking

system short circuits as specified. Total discrimination should be available among the breaker up to design fault level.

- B. Breakers shall be electrically operated with remote operation facility, complete with front-of-the-panel operating handle, isolating plug with safety shutters, mechanical ON/OFF indicator, silver plated arching and main contacts, arc chutes suitably designed to provide larger arc elongation, trip free operation. Breakers shall be capable of being racked out into 'Testing', 'Isolated', and 'Service' and Maintenance position and kept locked in any position. Breakers for remote operation shall be 240-volt ac motor operated spring charged accessory fitted in it. All the poles shall have completely insulated from each other internally and double insulation as standard feature. All 4 Pole ACB shall have 100% Neutral rating and capable of setting Neutral protection to N or N/2 to ensure precise neutral protection.
- C. 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/IEC: 60947 with symmetrical rupturing capacity at 415 Volts as per BOQ and drawings. All circuit breakers shall be provided microprocessor-based releases (LSIG) and RS485 port for communication with BMS system. 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 as per drawing 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.

#### 1.5 **Constructional Features**

- A. 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. The ACB shall have front face with insulation class II for safety as per IEC 60947-2. ACB shall conform to stringent environmental directives of RoHS and WEEE.
- B. 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.
- C. 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.
- D. The automatic shutters should be integral part of breaker & locking arrangement should be provided as per standards.
- E. Contacts should be self-aligning type requiring no special effort to align them.
- F. The ACBs shall be fitted with arc chutes on each pole designed to permit rapid dispersion, cooling and extinction of the arc.
- G. ACBs shall have separate main and arcing contacts. Arcing contacts shall be hard wearing material of copper or silver. Main contacts shall be of silver nickel graphite or as per latest standard.
- H. The insulation material shall confirm to Glow wire test as per IEC 60695.
- I. ACBs shall be CE marked.
- J. ACB shall have minimum watt losses in order to restrict temperature rise inside the breaker. ACB release shall offer Real Time Terminal Temperature monitoring and protection.
- K. Remote indication and alarm facilities shall be provided for Circuit breaker open, Circuit breaker closed, Circuit Breaker is ready to close, Circuit breaker tripped on fault, and Switch position of local/remote control selector switch.

#### 1.6 **Operating Mechanism**

- A. The Circuit Breaker shall be trip free with stored energy type operating mechanism, closing spring shall be able to manually charged by operating the front lever with mechanical ON/OFF indication. Breaker shall be convertible from manual to Electrical at site. The operating mechanism shall be such

that the circuit breaker is at all times free to open immediately the trip coil is energized. The operating handle and mechanical trip push button shall be at the front of and integral with the Circuit Breaker.

- B. The Circuit Breaker shall have the following 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.
- i. "Service"- Both main and secondary isolating contacts closed
  - ii. "Test"- Main isolating contacts open and secondary isolating contacts closed
  - iii. "Isolated"- Both main and secondary isolating contacts open.
  - iv. Maintenance"- Circuit Breaker fully outside the panel ready for maintenance.

#### 1.7 **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 withdrawn from the cubicle when in the "ON" position. To achieve this, suitable mechanism shall be provided to lock the Breaker in the tripped position before the Breaker is isolated. The racking shutter should open only when ACB is off Condition.
- 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. Interlock shall be provided between ACB operating mechanism and the arch chutes to prevent closing of ACB in case the arc chutes are not properly secured.

#### 1.8 **Circuit Breaker Auxiliary Contacts**

The Circuit Breaker shall have minimum 6 changeover auxiliary contacts rated at 10 A 220 /415 volts, 50 Hz. The auxiliary contacts could be used as NO or NC as per requirement & there should be provision to add minimum 6 aux. contacts, if required for future use. They shall close before the main contacts when the circuit breaker is plugged in and vice versa. When the circuit breaker is drawn out of the cubicle. The changeover contact should be replicable without disturbing any critical parts like trip unit/mechanism of breaker.

#### 1.9 **Anti -Pumping**

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

#### 1.10 **Mechanical & Electrical Life.**

The Circuit Breaker up to 1250, 1000, 800 Ampere shall have minimum Mechanical life of 20000 operations & minimum electrical life of 8000 operations. All ACBs shall be provided with mechanical operation counter.

#### 1.11 **Type Test Certificates**

- A. The ACBs shall be type tested and certified for compliance to IS/IEC: 60947/IEC-61439 International Testing Authorities. Supplier should submit combined sequence test certificates for the same. All ACB shall confirm to EMI / EMC Standard & shall be immune to harmonics to avoid nuisance tripping.
- B. All incomer & outgoing ACBs shall be provided with RS 485 / ethernet ports for BMS (Building Management System) connectivity through MODBUS protocol.

#### 1.12 **Protection**

- A. The true RMS sensing microprocessor-based communication inbuilt numerical release with intrinsic RS 485 port for communication by open protocol shall be provided on circuit breaker for offering protection against overload (long time) with adjustable time delay, short circuit (short time) with intentional delay, earth fault protections with intentional time delay & instantaneous protection all with adjustable settings. There shall be LCD /LED display for actual value display for showing the percentage loading in each phase built in the trip unit. The release shall have an LED/LCD display to show RMS current in all three phases, neutral (4 pole) and energy /power parameters. The release should have separate LED indication for each LSIG protection along with display. The release shall also offer additional protections like under & over voltage, current & voltage unbalanced, phase sequence etc. The release shall be self-diagnostic with indication. All the adjustment should be on line and the circuit breaker need not be switched 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 between ACBs to reduce thermal stress on the system. The release should provide last 10 trips fault history including cause of fault as well level of fault current. Acknowledgement of settings should be visible on the screen of release. Communication feature should be independent of trip unit i.e. any outside disturbances should not affect the trip unit of circuit breaker. The trip unit should be self-powered & password protected.

#### 1.13 **Moulded Case Circuit Breakers**

- A. Moulded Case Circuit Breakers shall be standard products of established manufacturers as indicated in list of indicative makes best suited to the application duty and shall conform to IEC 60947-2 / IS 60947-2 / IS 13947-2, MCCBs shall be suitable for fault levels as specified in BOQ/drawings or higher. Upstream breakers shall be of higher kA rating compared to downstream breakers, required to ensure total discrimination, coordinated protection of the distribution system. MCCB's shall be provided in fixed type cubicles. It shall conform to IP 20.
- B. MCCBs shall be current limiting type with trip time of less than 10 millisecond suitable for 3 phase 415 Volts AC 50 HZ supply with neutral 4P/3P/2P as required and rated for insulation voltage 690- 750 V, rated operating voltage of 415V for 3 Phase, Rated impulse withstand voltage -8kV, Service short circuit breaking capacity (Ics) as specified and required as per relevant standards. All Breakers/MCCBs shall incorporate front adjustable interchangeable trip units with adjustable overload and adjustable short circuit and earth faults. All the MCCBs shall have microprocessor-based releases and all incomer MCCB with RS485 port for communication with BMS system. All MCCB's offered shall have double insulation feature as standard. MCCB's offered shall be from the same series to have a commonality of appearance and spares management. No mixing of series is allowed within a manufacturer's range of MCCBs. Four pole MCCBs shall have flexibility of setting neutral current N or N/2. The mechanical operations MCCBs shall be > 15000 operations.
- C. 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.
- D. MCCBs shall be provided with suitable 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.
- E. Door interlock to prevent door being opened when the breaker is in ON position (extendable rotary handle to be invariable provided).
- F. Interlock to prevent the breaker being switch ON with the door open.
- G. All MCCBs shall have suitably rated minimum 6 changeover auxiliary contacts unless specified otherwise. All Models 3 & 4 Poles versions shall be of same type, design and make and utilization category 'A'.
- H. 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.
- I. Each MCCB shall have a facility for padlocking in the off position.
- J. MCCBs shall have Copper spreader links with phase barriers as feature.
- K. MCCBs protection releases should be shrouded to avoid unauthorized tampering.
  - i. In-built RMS sensing
  - ii. Central front from O/L S/C adjustments.
  - iii. Inbuilt thermal memory with option of switch ON and OFF from MCCB.
- L. MCCBs shall have cross bolted/shrouded terminals to withstand thermodynamic stress at higher short circuit current.
- M. MCCBs shall be CE marked.
- N. MCCBs shall not have any load line biasing.

- O. MCCBs shall be type tested and certified from local/International testing authorities for conformance to IEC/IS standards.
  - P. All releases shall be tamper proof.
  - Q. There should be total discrimination between ACBs and MCCBs up to the design fault level of the downstream devices.
  - R. Earth fault protection shall be inbuilt feature of MCCB where earth fault has been asked in BOQ/drawing.
  - S. MCCB's for motor protection shall be selected as per Type 2 coordination chart of manufacturer.
- 1.14 **Motor Protection Circuit Breaker**  
 Motor circuit breakers shall comply with the general recommendations of standard IEC 60947-1, -2 and -4-1.
- A. The devices will be in utilization category A, conforming to IEC 60947-2 and AC3 conforming to IEC 60947-4-1
  - B. Rated operational voltage of 415V 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 withstand voltage (U<sub>imp</sub>) of 6 kV
- 1.15 **Requirements for MPCB: -**
- A. The motor circuit breakers will be designed to be mounted vertically or horizontally without derating  
 Power supply will be from the top or from the bottom
  - B. 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
  - C. 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.
  - D. The motor circuit breakers will be actuated by a rotary operator clearly indicating the position ON (I), O+FF (O), trip
  - E. In order to ensure isolation with clearly visible breaking conforming to standard IEC 60947-2 paragraph 7.2.7:
    - i) The mechanism will be designated so that the different types of operators will only be in position (0) if the main contacts are physically separate
    - ii) In position (0) the operating devices will indicate the isolated position
    - iii) Isolation is enhanced by the double break of the main circuit
  - F. Motor circuit breakers will accept a padlocking device in the "isolated" position.
  - G. 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
  - H. The motor circuit breakers will be current limiting for a mains voltage of 400 V, the maximum let-through energy (I<sub>Z</sub> t) on short circuit being extremely low.
  - I. The motor circuit breakers will have a high electrical and mechanism durability of at least 5 times that required by the standard.
  - J. Protection Functions
    - i) The motor circuit breakers will be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection.
    - ii) In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) will be factory set to an average value of 12 I<sub>r</sub>.
    - iii) All the elements of the motor circuit breakers will be designated to enable operation at an ambient temperature as per IEC without derating
    - iv) The thermal trips will be adjustable on the front by a rotary selector.
    - v) The adjustment of the protection will be simultaneous for all poles.
- 1.16 **Starters**
- A. Every motor starter shall be designed to perform the following functions efficiently and safety:
    - i. To start the motor without damage to the drive or driven equipment whilst regulating the starting current to the satisfaction of the requirements of this Specification and ensuring that at all stages



- of starting, the motor will develop sufficient torque to accelerate the load.
  - ii. To stop the motor.
  - iii. To prevent damage to the motor due to overload, disconnection of one phase etc.
  - iv. To prevent damage to reduced voltage started motors and danger to personnel due to resumption of the electricity supply following a failure.
  - v. To prevent the damage to the motor due to stalling or internal electrical or mechanical faults by quickly disconnecting the supply.
  - vi. To prevent damage to the motor or the starter itself due to improper, unskilled or hesitant operation or failure to complete a starting sequence once it is connected.
  - vii. To enable the motor and starter to be completely isolated from the main supply and from all control supplies for inspection and repairs by means of Fixed type unit for each starter circuit.
- B. Each motor starter assembly shall comprise MCCB/MPCB, contactors, protection relays, electronic circuitry, control switches, lamps and instruments and accessories as specified hereinafter. It shall include control devices for automatic control systems. The whole unit shall be enclosed in the cubicle, from which no access can be gained to adjoining cubicles.
  - C. The specified starter types are based on estimated motor ratings. The final selection of starter shall be based on the installed motor rating. Starters and associated overload devices shall be selected in accordance with the run-up time of the associated motor/driven load, the maximum thermal capacity of the motor and frequency of starting, and the duty cycle. All starters shall have suitable protection for phase-to-phase, phase-to-neutral and phase-to-earth faults, overloads, and single phasing, with additional protection measures as specified. Overload relays/releases as specified shall have inverse time delay characteristics compatible with the motor drive to which they are applied for all protective devices the short-circuit capacity (Isc) shall be capable of withstanding a fault current of the panel, as a minimum. The specifications of incoming and other circuit breakers (ACB/MCCB etc.) shall be as per specified in the relevant Section.
  - D. All starters shall be in accordance with section 7.2 of IEC 60947-4-1 or EN 60947- 4-1 and shall be adequately rated for conditions in which it shall operate.
  - E. All starters shall be type tested by a competent and internationally recognized testing authority for type 2 co-ordination in accordance with IEC 60947-4-1 or EN 60947-4-1.
  - F. All contactors shall be electro-magnetic type with utilization category AC3 to IEC 60947-1.
  - G. All starter shall be of electrically held on pattern and shall not release until the voltage falls below 70% of nominal.
  - H. Type of starters for other mechanical equipment such as plumbing, drainage, fire services pumps and other motor circuits shall be as specified in this clause subject to ratings of the motors selected during working drawing production as per in this section. The starters shall also comply with the requirements laid down in the Code of Practice of Electricity (Wiring) Regulations. Voltage for motors shall be 415V 3- phase or 240V 1-phase, as required. Motors rated 0.37kW and larger shall have a rated voltage of 415V, 3-phase, 50Hz. Motors rated smaller than 0.37 kW shall be operated at 240V 1-phase. Direct-On-Line motor starters shall be used for motors up to and including 2 kW at 415 volts, 3-phase. All motors over this limit shall be equipped with reduced voltage starters of the Star-Delta type. Details are specified on the drawings and BOQ.
- 1.17 **Switch Fuse Units & Disconnects/Isolators (Where Applicable)**
- A. 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.
  - B. 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.
  - C. 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 5KA at 415 Volts.

- D. Switch contacts shall be designed with arc repelling features to extinguish the arc quickly to provide long contact life.

#### 1.18 **Isolators**

- A. 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 IP 65 enclosures from the Isolator manufacturer only.
- B. Painting, earthing and labels shall be provided as generally conforming to relevant standard indicating for MV Switchgear and as shown on drawings.

#### 1.19 **Metering, Instrumentation & Protection**

- A. The metering required to be provided for each incoming feeder shall be as per the drawing & Bill/schedule of quantities. Such metering shall not be provided on the front panel of the Circuit Breaker compartment. A separate compartment shall be provided for the Metering and Protective relays as required. Instrument testing plugs shall be provided for testing the KWH meters and relays.

#### 1.20 **Current Transformers (CT)**

- A. Current transformers shall comply with approved standard and shall be compatible with and provide the necessary accuracy, over current factors, characteristics, performance and VA rating for the satisfactory operation of the relevant protection devices, instruments and meters.
- B. Current transformers shall be capable of withstanding the maximum short time withstand current for the value and duration specified for the assembly within which it is mounted.
- C. CTs shall be cast resin type conforming to IS 2705 – 1992 (with all amendments) in all respects. CT's shall be non-hygroscopic, tropicalised and non-combustible. CT's shall be single piece epoxy resin moulding, windings and magnetic core being embedded in epoxy resin under vacuum to provide total encapsulation. Partial discharge measurement as per IS 11322/IEC 44-4 shall be carried out as a routine test to ensure insulation reliability. CTs shall have rated primary current, rated burden and class of accuracy as specified in Schedule of Quantities and drawings. Rated secondary current shall be 5A unless otherwise stated. Accuracy class for metering CT's shall be 1.0 and for protection CT's 5P10. 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:
  - i. Name and make
  - ii. Serial number
  - iii. Transformation ratio
  - iv. Number of cores
  - v. Rated burden
  - vi. Rated voltage
  - vii. Accuracy class
- D. Test links shall be provided in the secondary connections of all current transformers to facilitate testing of instruments, meters and protection devices. These shall be so arranged as to ensure that the transformers secondary winding cannot be open circuited.
- E. CTs shall be mounted such that they are easily accessible for inspection, maintenance and replacement. Wiring for CT shall be with 2.5-sqmm copper conductor, FRLSZH, PVC insulated wires with proper terminations and wiring shall be bunched with cable straps and fixed to the panel structure in a neat manner.
- F. Calibration certificate of CT from external laboratory shall be provided to the purchaser at the time of inspection/ installation.

#### 1.21 **Potential Transformer (PT)**

- A. PTs shall be cast resin type conforming to IS 3156 (Part-I, II and III) 1992 in all respects. PTs shall be rated for 33/11 KV/110 volts and shall be connected star/star. Primary winding shall be impregnated polyester resin under vacuum to provide high dielectric strength between the terminals as well as adjacent layers. After resin impregnation, the winding is encapsulated under vacuum in epoxy resin.



The magnetic core laminations shall be made up of cold rolled grain-oriented steel having high permeability and low hysteresis loss. All material shall be non-hygroscopic, non-combustible, resistant to power arc and suitable of tropical environment. Partial discharge measurement as per IS 11322/IEC 44-4 shall be incorporated as a routine test for ensuring high insulation reliability.

#### 1.22 Meters

- A. Direct reading electrical meters shall conform to IS 13779 suitable for single phase/three phase supply system in all respects. Accuracy of direct reading shall be class 1.0 for voltmeter and 1.0 for ammeters. Other instruments shall have accuracy of 1.5.
- B. All meters shall be digital type and multifunction meters should be with RS 485 connectivity to suit BMS System wherever mentioned in BOQ. Suitable memory and software for logging the information along with real time metering information must be available. The meters must have required level of protection and sufficient number of auxiliary.
- C. Meters shall be suitable for continuous operation between 0°C and +50°C.
- D. 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 instrument glass. Selector switches shall be provided for ammeters and voltmeters used in three-phase system.
- E. Energy meters shall be electronic type with dual indication RS 485 connectivity TOD facility, switch board mounting type suitable for unbalanced loads. In case of two incoming feeders, a summation CT shall be provided with the meter.
- F. The energy meters for DG Set & Transformers shall be calibrated and got certified by appropriate agency as required.
- G. Ammeters shall be digital indication type normally be suitable for 5A secondary of current transformers.
- H. Voltmeter circuits shall be provided with protection through MCB as required
- I. Wattmeter shall be of 3-phase Digital type and shall be provided with a maximum demand indicator as required and with RS-485/RS232/Ethernet connectivity as per requirement.
- J. Three phase power factor meters shall be of Digital type with current and potential coils suitable for operation with current and potential transformers provided in the panel. Scale shall be calibrated for 50% lag - 100% - 50% lead readings.
- K. Trivector meters shall be two elements, integrating type. Meters shall conform to IEC 62052 and 62053 in all respects. Energy meters, KVAH, kVA, and KVARH meters shall be provided with integrating registers. The registers shall be able to record energy consumption of 500 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.
- L. Square / rectangular pattern flush mounting meters complying with the requirements of the relevant Indian/international Standards shall only be used.
- M. The display for single meters i.e. ammeter or voltmeters shall be 3.5 digits and integral meters shall be page display type as specified in BOQ.
- N. Meters shall be suitable for continuous operation as per IEC 898.
- O. Meter shall be suitable for 3 phase, 4 wire systems, balanced as well as unbalanced load. All instruments and associated apparatus shall be capable of carrying their full-load current without undue heating. They shall not be damaged by the passage of fault currents up to the rating of the associated switchgear through the primaries of their associated instrument transformers. The instrument meter shall be earthed by a conductor of not less than 2.5 mm<sup>2</sup> cross-sectional area.
- P. Energy meters shall be two / three element, switch board mounting type suitable for unbalanced loads. In case of two incoming feeders, a summation C.T. shall be provided with the meter.
- Q. The display for meters i.e., ammeter, voltmeters or multifunction meter shall be auto ranging type.
- R. Separate current transformers for a feeder shall be provided for protection device and for instrumentation.

#### 1.23 Relays

- A. Protection relays shall be equipped to indicate cause of tripping. Relays shall be designed to make or break the normal circuit current with which they are associated. Relay contacts shall be of silver or platinum alloy and shall be designed to withstand repeated operation without damage. Relays shall

be of draw out type to facilitate testing and maintenance. Draw out case shall be dust tight. Relays shall be capable of disconnecting faulty section of network without causing interruption to remaining sections. Analysis of setting shall be made considering relay errors, pickup and overshoot errors and shall be submitted to Employer / Engineer for approval. All relays shall be hand reset type from front of panel.

- B. The relays shall be duly compensated against fluctuation in ambient temperature and frequency and shall have single phase prevention feature.
- C. Over current relays shall be microcontroller type with inverse definite minimum time lag characteristics. Relays shall be provided with adjustable current and time settings. Setting for current shall be 20 to 200 % in steps of 5%. The IDMT relay shall have time lag (delay) of 0 to 3 seconds. The time setting multiplier shall be adjustable from 0.1 to unity. Over current relays shall be fitted with suitable tripping device with trip coil being suitable for operation on 5 amps.
- D. Earth fault relays shall be same as over current relay except the current setting shall be 10% to 40% in steps of 5%.
- E. Under voltage relays shall be of microcontroller type and shall have inverse limit operation characteristics with pickup voltage range of 40 to 80% of the rated voltage.
- F. Indicating lamps - Multiple LED type indicating lamps shall be provided for indication of phases and Breaker position 'OFF', or 'ON', as required in the BOQ.
- G. Control Wiring - All control circuits shall be provided with protective MCBs. Instrument testing plugs shall be provided for testing the meters. Cables intended for wiring of control, instrumentation, metering equipment shall conform to relevant IS and shall be suitable for max. operating temperature 90° C.

#### 1.24 **Switch Board Construction**

- A. General – The panel manufacturer should have ISO 9001/9002 – 2000 certification having adequate manufacturing & testing facilities.
- B. All medium voltage switchboards shall be suitable for operation at three phase/three phase 4 wire, 415-volt, 50 Hz, neutral grounded system with a symmetrical short circuit level as BOQ.
- C. The Switch Boards shall comply with the latest edition with up-to-date amendments of relevant Indian Standards and Indian Electricity Rules and Regulations.

#### 1.25 **Switch Board Configuration**

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

#### 1.26 **Constructional Features**

- A. The panels shall be of the approved design to suit local conditions as prevailing at different SUB URBAN STATIONS.
- B. The Electrical Panel (other than DB) shall be designed for indoor use in the form of freestanding, floor mounting extendible, self-contained, flush fronted cubicles and sectionalized as necessary to face easy transportation and erection, containing all the equipment indicated on the Drawing, BOQ and specified hereinafter.
- C. All the electrical distribution and sub distribution boards/ panel shall be sturdy and robust, modular, extendable, metal enclosed, moisture, dust, termite & vermin proof rigid, free standing or wall mounting dead front welded structure of sheet steel cubicle pattern, single front, and suitable for indoor mounting to accommodate and support all equipment mounted on them without vibration or movement. Structural members shall not obstruct access to equipment, units nor sub-assemblies. Checking and removal of components shall be possible without disturbing adjacent equipment.
- D. Enclosure shall comply with IS: 60947 Part-I 1993. All adjoining units, doors and covers shall be fully Neoprene gasket unless specified/ approved otherwise and equipped with integral lock. The enclosure protection shall be not less than the following or as specified in BOQ:

- |     |                                 |   |             |
|-----|---------------------------------|---|-------------|
| i.  | Installations at platforms      | : | IP 54/IP 65 |
| ii. | Installation at concourse level | : | IP 54       |

- iii. Installation at road level : IP 65
- E. All panels/boards shall be dead front, front operated, dust, vermin proof, extensible, top/bottom cable entry, compartmentalized made of CRCA sheet steel of thickness 2.0mm & rigid supports for components and with lockable hinged doors. The Panels shall be completely design verified assembly as per 61439 – 1 & 2. LV Main Switchboards shall be Totally Type Tested (TTA) and Switch board configuration with Form 4b Type-6 construction as per IEC 61439-1&2 or EN61439-1&2. All type tests shall be as defined in IEC 61439-1&2 or EN 61439-1&2. Built up from compartments housing circuit breakers, control gear, relays, bus bars, controls and other items of equipment. All holes in metalwork shall be protected by substantial grommets or bushes to protect wiring passing through them. The maximum overall height of panels and the maximum/ minimum height of the operating handles from floor level shall be as per standard norms.
  - F. The frame work shall be finished with standard two coats of final paint of approved color shade after necessary chemical degreasing and primer coating as per standard practice.
  - G. All panels and covers shall be properly fitted and secured with the frame. Fixing screws shall enter holes tapped into an adequate thickness of metal or provided with hank nuts. All functional feeder to be provided with Metallic cam lock in the construction of the Switch Boards.
  - H. The switchboard shall be designed for the incoming and Outgoing LV feeders as per the provisions of IS: 8623 (Part I)–1993 also for type and routine test, IS 60947:1993 and IEC Pub 947-5-1 to latest version. Generous space shall be provided for vertical rising cables, their bending and termination. Also IS 8623 -Part 1 for type and routine test to be followed.
  - I. The switchboard panel shall have provision for top / bottom in coming and bottom / top out going to suit site conditions of cable entries.
  - J. The switch board / panel shall be divided into cubicles and all front doors of cubicles containing MCCBs shall be inter-locked so that the doors cannot be opened unless the MCCB is off. Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of live parts.
  - K. The layout of the equipment and the components shall be such as to ensure creepage distances and isolating distances specified in the latest version of IS: 8623. The sub-assemblies of similar equipment shall be interchangeable.
  - L. All connections shall normally be accessible from the front side of the panel. Where connections are not accessible from the front, the back side shall be provided with doors with handles and panel type locks. Required number of lifting lugs fixed on separate sections of the framework shall be provided. Two earthing studs shall be provided on the framework.
  - M. All panels shall have digital meters connected through RS 485 port to BMS. All other BMS connections, unless specified otherwise, shall be through potential free contacts and it should be ensured that all such connection points are brought to one place at a suitable terminal strip duly numbered, easily accessible for the purpose. BMS wiring shall start from this designated terminal strip.
  - N. 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 drawing. 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.
  - O. The LV main switch boards 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 IEC61641.
  - P. Test certificate 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.

- Q. Classification of the equipment shall be minimum class C and the access to it should only be limited to authorized persons. In case of internal arc occurs, the assembly's ingress protection shall be retained so as to avoid any foreign element penetration inside the electrical assembly

**1.27 Switchboard Dimensional Limitations**

- A. A base channel of minimum size 75 mm x 40 mm x 3 mm or as per OEM standard thick shall be provided at the bottom.
- B. A minimum of 200 mm blank space between the floor of switch board and bottom most units shall be provided. The overall height of the Switch Board shall be limited to 2400 mm. The height of the operating handle, push buttons etc. shall be restricted between 300 mm and 1850 mm from finished floor level.
- C. Switch board compartmentalization - The Switch Board shall be divided into distinct separate compartments comprising:
- D. A completely enclosed ventilated dust and vermin proof bus bar compartment for the horizontal and vertical busbars.
- E. Each circuit breaker, switch fuse units and MCCB housed in separate compartments enclosed on all sides.
- F. Sheet steel hinged lockable doors for each separate compartment provided and duly interlocked with the breaker/switch fuse unit in "on" and "off" position.
- G. Separate and adequate compartments for all Circuit Breakers provided for accommodating instruments, indicating lamps, control contactors and control fuses etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, busbars and connections.
- H. A horizontal wire way with screwed cover provided at the top to take interconnecting control wiring between vertical sections.
- I. Separate cable compartments running the height of the Switch Board in the case of front access Boards provided for incoming and outgoing cables.
- J. Cable compartments of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top.
- K. Adequate and proper support provided in cable compartments to support cables.
- L. Inter-changeable feeder compartments for all identical feeders of same rating.

**1.28 Switch Board Bus Bars**

- A. The bus bar and interconnections shall be of electrolytic tinned copper and of rectangular cross sections suitable for full load current for phase bus bars and full rated current for neutral bus bar as specified in BOQ and shown on drawings and rated for a temperature rise over the ambient temperature specified as per IS/IEC standards, based on insulated conductor rating (IS:8084-1976) and the maximum current density for copper shall be 1.4 amp per square meter. Bus bar supporting system shall be suitable to withstand the stresses of sustained symmetrical fault level at 415 volts for 1 second as per design calculation or as per schedule of quantities.
- B. The bus bars shall be insulated with coloured, heat shrinkable PVC Sleeves. Accessible bus bar joints shall be shrouded in an approved manner. Minimum clearances between phase to phase and between phases and neutral (including protruding nuts and bolts if any) shall be 25 mm. Minimum clearance between phases and earth (including protruding nuts and bolts if any) shall be 20 mm.
- C. While providing the bus-bar section, the total load may be considered which may be transferred to an individual panel through the inter-connection between panels in the event of failure of incoming supply to the other panels. The diversity factor of various loads shall be taken as 1 for design purposes. The bus bar shall be designed for easy extension in future at either end.
- D. An earthing bus made of Copper/GI as approved shall be provided throughout the switchboard/panel with securely connected earthing terminals at both ends.
- E. Protective earthing shall be related to the incoming feeder as follows:

| Phase conductor | Protective conductor   |
|-----------------|------------------------|
| up to 16 sqmm   | equal size             |
| 16 to 35 sqmm   | 16 sqmm                |
| over 35 sqmm    | 50% of phase conductor |

- F. In case of dissimilar materials, the Protective Conductor shall be suitably sized for equal conductance.
- G. All internal wiring, busbar metering etc. shall conform to IS: 5578 – 1984 with all amendments.
- H. All bus bar connections in Switch Boards shall be bolted with high tensile strength steel bolts and nuts. Additional cross section of bus bars shall be provided wherever holes are drilled in the bus bars. No insulation tape shall be used in the busbars / interconnections.
- I. Feeder connections shall be solid copper bars duly insulated with bimetallic clamps wherever required.
- J. Shrouds for bus bar joints / tapping points shall be FRP only. Bus insulators shall be flame retardant, track resistant type with high creepage surface and non-hygroscopic material such as epoxy/SMC/. Busbars shall be supported and braced to withstand the stress due to max. short circuit current and also the thermal expansion.

#### 1.29 **Components Installed in The Assembly**

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

#### 1.30 **Instrument Accommodation**

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

#### 1.31 **Terminal Arrangement**

- A. Both incoming and outgoing cables shall have top / bottom entry depending on site requirement.
- B. The marking and arranging of switchgear, bus bars, connections and small wiring shall be clear and comply with an approved international standard. Terminal blocks for low voltage wiring shall be of the rail mounted type moulded from high-grade non-hygroscopic melamine having all live parts fully shrouded and assembled in banks with marking tags to fit into moulded tag slots.
- C. Terminals for final connections for indication, instrumentation and metering circuitry shall have test probe facilities.
- D. Cables are to be terminal by terminal blocks with non-ferrous terminals conforming to IEC 60947.

#### 1.32 **Contactors**

- A. Contactors shall comply with IEC 60947-4-1 and shall be of the break type having an uninterrupted rated duty, and utilization category AC 3. The contractors shall be capable of frequent switching & shall operate at 55° C for AC3 applications.
- B. Contactor operating coils shall be AC suitable for the phase to neutral voltage of the supply and shall be protected by means of a low current MCB/cartridge fuse.
- C. Main contactors shall be silver faced.
- D. The rated voltage of the contactors shall be equal or superior at 415 V and rated insulation voltage shall be 690/1000 V. The rated impulse voltage of the contractor shall be 8 kV.
- E. Contactors shall not dropout at voltage at 70% of rated voltage and minimum pickup voltage shall be 85% or as specified.



- F. The contactor should be modular in design and should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors. The contactors from 4 kW to 400 kW will be associated with the same auxiliary contact block range.

### 1.33 **Wiring**

- A. All wiring for relays and meters and other associated equipment shall be with FRLSZH, PVC insulated, stranded copper conductor wires.
- B. The wiring shall be colour coded and labelled with approved ferrules for identification. PVC ferrules yellow in colour, locked to avoid movement & with black engraved letters shall be provided at each end of all wires marked to correspond with equipment/circuit designation & termination numbers as specified / approved or as required.
- C. A separate bunching & separate route shall be followed for AC& DC wiring.
- D. The minimum size of copper conductor control wires for switch-boards shall be 1.5 mm<sup>2</sup>.
- E. Wiring shall be terminated through cage clamps or using crimping lugs where former not feasible, without joints or Tee on their run. Wiring shall be run on sides of panels, neatly bunched, secured without affecting equipment mounting.
- F. All control circuit shall be protected by a MCB.

### 1.34 **Cable Terminations**

- A. The Switch Boards shall be complete with supporting clamps and brackets etc. For termination of 1100 volt grade aluminium/copper conductor PVC/PVCA cables, Knockout holes of appropriate size and number shall be provided in the Switch Board in conformity with the location of incoming and outgoing conduits/cables. Gland plates, gland-brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated.
- B. The cable terminations for the MCCB's shall be brought out to the rear in the case of rear access switchboards or in the cable compartment in the case of front access Switch-Boards. The Contractor shall co-ordinate the cable sizes and corresponding crimping type copper lugs for each Incomer and Outgoing feeders and correct size lugs shall be provided bolted up in the switchboard.
- C. Space heaters - The Switch Board shall have in each panel thermostatically controlled space heaters adjustable in the range of 30° C to 100° C with a controlling 15-amp 230-volt switch socket outlet to eliminate condensation.

### 1.35 **Earthing**

- A. All switch panels shall be provided with protective earthing as specified.
- B. A main earth bar of GI or aluminium as required shall be provided throughout the full length of the Switch Board to earth all switchgears with a provision to make connections to the sub-station earths on both sides.
- C. The frame of the Circuit Breaker shall be positively earthed when racked into the cubicle. Protective earthing of the switch-boards shall be connected to the building earth.
- D. All non-current carrying metallic components shall be permanently connected to earth.
- E. Material used for the earthing busbar shall be same as the main busbar.
- F. The tin-plated copper earthing busbar inside the panel shall have cross- sectional area as per calculation/Specified.
- G. A continuous earthing busbar shall be provided along the whole length of each Electrical Panels and shall be provided with terminals for connection to the metal housing of incoming busways, cable trunking and cladding or armouring of all incoming and outgoing cables and to the substation earth.
- H. Switchboards shall be provided with two earthing terminals, one at each end, for the connection of external earth conductor for earthing. The earthing bars shall be fixed at rear interior bottom portion throughout the length of the switchboard, bonding all gland plates, and other component parts of the switchboard to a main earth point adjacent to the intake position.
- I. All terminals, connections, relays and other components which may remain live when access doors are open shall be screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.
- J. Where several outgoing circuits occupy a common cabling chamber, all copper work, cable lugs, terminations and terminal blocks shall be fully segregated by compartmentation to enable work on any one circuit to be carried out with other circuits remain live.

- K. Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts. Control cables shall be segregated from primary conductors.
  - L. The protective earthing configuration shall be TN-S unless otherwise specified.
- 1.36 **Sheet Steel Treatment And Painting**
- A. Sheet Steel materials used in the construction of these units should have undergone a rigorous rust proofing process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognized phosphating process. The steel work shall then receive two dip-coats of oxide filler/ primer before final painting. Castings shall be scrupulously cleaned and fettled before receiving a similar oxide primer coat. The manufacturer is required to have 7 tank treatment facility for this.
  - B. All sheet steel shall after metal treatment be powder coating should be RAL 7035 or as approved to IS 5 on the outside and white on the inside. Each coat of paint shall be properly stove and the paint thickness shall not be less than 80 microns. The panel manufacturer should have in-house power coating facility.
  - C. Name plates and labels - Suitable computerized laminated powder coated name-plates and identification labels of metal for all Switch Boards and Circuits shall be provided. These shall indicate the feeder number and feeder designation.
- 1.37 **General And Technical Requirements Of Electrical Panels**
- A. The Electrical Panel shall be same as low- voltage switchgear and control-gear assemblies defined in IEC 61439-1 or EN 61439-1 built up from compartments housing circuit breakers, control gear, relays, bus bars, controls and other equipment as defined in BOQ.
  - B. All panels should be factory built of proven design with OEMs as well as switch board manufacturer approved as covered by clause 3.10 of IEC 61439-1.
  - C. The Electrical Panel shall pass the internal arc fault containment tests in accordance with IEC 61641 for fault current ratings as defined in BOQ for a minimum time of 0.3sec.
  - D. The degree of Ingress Protection for Electrical Panels shall be IP 54 unless otherwise specified in BOQ.
  - E. The degree of protection provided by enclosures for electrical equipment against external mechanical impacts shall be IK 10 unless otherwise specified in BOQ.
  - F. Seismic zone sustainability test certificates shall be produced wherever applicable
  - G. The Electrical Panels and the associated equipment, including switchgear and control gear assemblies shall be certified for the category of duty specified as per Annex A of IS/IEC 60947-1.
  - H. The main circuit as defined in vide clause 3.1.3 of IEC 61439-1 shall have an insulation voltage of 1000 V AC or as specified in the BOQ.
  - I. The ambient temperature and ambient humidity for Electrical Panel shall be as per IEC61439-1 (clause 7.1.1 and 7.1.2 of IEC 61439-1) and Switchgear shall be as per IEC60947(Clause 6.1.1 and 6.1.3 of IEC 60947).
  - J. The secure service life of Electrical Panels shall be at least 30 years as defined in General Scope of Work. The design features to secure the service life of 30 years shall be submitted at the time of design approval.
  - K. The Electrical Panel shall have a rated short time withstand current of 50kA and 35 kA for 1 second as per BOQ.
  - L. The Electrical Panels shall be a minimum of Form 4b Type 5 in accordance with BS EN61439-2/IEC 61439-2 & Eiema's Guide to Forms of Separation.
- 1.38 **Terminal Blocks**
- A. Both incoming and outgoing cable shall have top or bottom entry depending on site requirement.
  - B. Each terminal block compartment shall have not less than 20 % or 4 spare terminals whichever is greater.
  - C. Terminal blocks for low voltage wiring shall be moulded from high-grade non-hygroscopic melamine, comprise bank of rail-mounted blocks with all live parts fully shrouded, screw- clamp, spring loaded insertion, solder-lug or stud type terminals as appropriate to the design and duty of the cables to be terminated. Pinch-type screws, where the screw is in direct contact with the conductor, shall not be used.



- D. Each terminal shall be provided with claw-type washers, crimp lugs or other approved means for connection of the wires. Plain and spring washers, nuts and lockouts shall be electro-tinned.
- E. Terminals shall be assembled in banks and each terminal shall be complete with marking tags to fit into moulded tag slots.
- F. Terminals for final connections for indication, instrumentation and metering circuitry shall have test probe facilities and an integral disconnecting device to facilitate testing.
- G. Terminations shall be grouped according to function and no more than two wires Connected to one terminal. Labels shall be provided adjacent to the terminal block to identify the function and voltage of each group.
- H. All terminals to which 240 V or 415 V AC circuits are connected, where they are in individual terminal blocks, shall be provided with a transparent insulated cover which in addition to any other form of identification and shall have a label engraved suitably indicating the voltage.
- I. Terminals for the control supply which may be still alive when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact.
- J. All terminals shall bear a permanent identification number or letter.

#### 1.39 **Marshalling Unit**

- A. In main distribution Electrical Panels separate marshalling chamber shall be provided for BMS interfaces terminals or wherever required as per BMS requirement.
- B. Single location interface for different LV components of main distribution panel or other Electrical panel where ever necessary or as per BOQ shall be provided through marshalling chamber for BMS interface.
- C. All interface terminals and ports for BMS shall be wired up to the marshalling chamber. Necessary marking and ferruling shall be provided for individual termination.
- D. Control command interface and other terminals having potential should have due separation from VFC interface terminals. Control and signal cable wiring from different relays, sensors, transducer, controller and contactor releases shall be through separate wiring bunch to avoid fault current or external magnetic/ electric interface.
- E. Necessary multi dropping and single point interface provision shall be done through suitable short links. Communicable devices using standard protocol communication shall be looped as per BMS requirement.
- F. Marshalling chamber should have provided with necessary mounting arrangement or space provision for BMS remote I/O module/ PLC equipment along with its associated interface equipment and power supply unit or as per BOQ.
- G. Junction box for control wires to suit four poles of ACB connection shall be provided as per requirement.
- H. Connecting cable with connector between ACB communication unit and junction box shall be provided.
- I. 24V DC source unit or as required (Incoming supply shall be taped form the control supply available in the panel) for communication of ACB/MCCB with SCADA/BMS system.
- J. Panel manufactures shall provide the required termination and interface detail for BMS work. In case of requirement of supervision and guidance during BMS commissioning, same shall be inclusive to the panel manufacture's scope of work. It is the responsible of panel manufactures to provide necessary interface detail such as data point register address during BMS commissioning or supervise as appropriate during installation and testing of BMS system.
- K. Marshalling box shall comply with EMC (electromagnetic Compliance) and protected from any electrical or magnetic interface. Required protection against any BMS or panel component has to be inclusive to respective contractor's scope of work. Any specific interface requirement not specified here with shall be wired up to the marshalling chamber interface terminal. BMS/SCADA interface point should only confine to marshalling box.

#### 1.40 **Installation & Foundation (If Required)**

- A. The location of each foundation shall be correctly set out in accordance with the approved foundation layout drawing. Base channels shall be grouted, levelled in cement concrete pad for switchgear and other cubicle panels, etc. with reference to a bench mark in the building. Pedestal type panels and

superstructures shall be erected by grouting foundation bolts into the foundation in cured holes left in foundation blocks. For concreting on existing floors, a proper bonding surface shall be made by chipping the floor. The final finish to the surface of the floor shall be given after all equipment has been installed. If floor is broken for installation of equipment, it shall be restored to original finish after completion of installation.

- B. The concreting shall be done in accordance with the provision of Indian Standard Code of Practice for Plain and Reinforced Concrete, IS: 456-2000. Concreting material shall conform to the following:

|              |  |
|--------------|--|
| IS: 383-1970 | Specification for coarse and fine aggregates from natural sources for concrete |
| IS: 269-1989 | Specification for 33 grade ordinary Portland cement                            |
| IS: 516-1959 | Method of test for strength of concrete  |

- C. Suitable grooves or niches shall be provided in the foundation block at the time of casting to enable embodiment of earth strips without calling for chipping of the blocks. Subsequently conduits of appropriate size shall be embedded in the foundation blocks for cabling, in the first instance, wherever required.
- D. All foundations shall be cast in the presence of the Employer / Engineer. All foundation and grouted bolts shall be cured for a minimum period of 48 hrs.
- E. Foundations shall be prepared as per manufacturers drawing, shall be levelled, checked for accuracy and the switchboards installed. Busbar connections shall be checked with a feeler gauge after installation. Tightness of accessible bolted bus joints shall be checked using calibrated torque wrench. Sealing of cable and boxes to prevent moisture entry shall be checked. Switchboard earth bars shall be connected to the earth grid.
- F. Fabrication drawings of all panels shall be approved by the Employer / Engineer before fabrication.

#### 1.41 **Testing And Inspection**

- A. All switchboards shall be factory inspected by Employer / Engineer before finishing and dispatch.
- B. Certificate for all routine and type tests for circuit breakers in accordance with the IS:13118-1991 shall be furnished.
- C. All panels shall be meggered phase to phase and phase to neutral using a 1000/500V megger with all outgoing feeders in closed position. The megger value should not be less than 2.5 MΩ between phases and 1.5 MΩ between phases and neutral.
- D. All meters and relays shall be calibrated and tested through secondary injection tests.
- E. All field tests shall be witnessed by authorized Employer / Engineer and recorded. The contractor shall give due prior notice. An appropriate format shall be prepared by the Contractor for this purpose. The test format shall have prior approval from Employer. Test results will be witnessed and signed by the Contractor and Employer / Engineer.

#### 1.42 **Tests On Switch Board / Panels**

The switchboards shall be totally type tested assemblies as per IEC 61439 Part 1 & 2 and certified for internal arc as per IEC 61641 & IS 3439/1 from reputed lab. Electrical Panel shall be tested for Mechanical impact in accordance with IEC 62262 for minimum of IK 09 for glazed door or IK 10 for blind door category

##### A. Type Test

Contractor shall submit the Type Test Certificates of OEM/Manufacturer with respect to the concern clauses as detailed below. In case of Non-availability of Type Test Certificates, OEM/Manufacturer shall perform all the tests specified in IEC-61439, Part-1 & 2 and other associated standards from reputed NABL accredited laboratory as approved by the Employer/ Engineer. OEM/Manufacturer shall request officially the Employer/ Engineer with details of such tests for witnessing on confirmation of schedule from the testing laboratory. Employer/ Engineer shall be nominated for witnessing the tests and observations during such tests shall be recorded jointly

- i. Internal Arc
  - ii. Mechanical impact
- B. Design verifications
- i. General

- ii. Strength of Materials and Parts
- iii. Degree of Protection of enclosures
- iv. Clearances and Creepage distances
- v. Protection against electric shock and Integrity of protective circuits
- vi. Incorporation of switching devices and components
- vii. Internal electrical circuits and connections
- viii. Terminals for external conductors
- ix. Dielectric properties
- x. Verification of Temperature rise
- xi. Short Circuit withstand strength
- xii. Electromagnetic compatibility
- xiii. Mechanical operation
- C. Type and Routine Test - Routine tests shall be carried out on the assembly in accordance with IEC 61439 standards. Type test certificates from a reputed independent laboratory, especially those related to short circuit level and IP Protection will have to be submitted for engineer Approval.
- D. Type test certificates from the manufacturers for the switch board / lighting panel & components viz. ACBs, MCCBs, MCBs, change-over switches shall be furnished. These shall include following but not limited to:
  - i. Temperature rise of bus bars and components
  - ii. Dielectric strength of electrical parts
  - iii. Short circuit capacity of bus-bars and components
  - iv. Continuity of protective circuits
  - v. Mechanical operation of switchgear
  - vi. Degree of protection and protective measures against direct and indirect contact
  - vii. Clearances and creepage distances
- E. Acceptance Tests - Following minimum tests but not limited to shall be carried out as follows for ensuring integrity of the cable anchorage during handling and installation:
  - i. General visual check, including measurement of overall dimensions, location, number and types of devices, terminal boxes, etc.
  - ii. Manual and electrical operation of circuit breakers etc. and electrical operation of contactors/automatic change-over switches.
  - iii. Dry insulation test with power frequency voltage.
  - iv. Insulation resistance of circuits.
- F. Testing
  - i. The firm shall submit valid type test of the equipment conducted at accredited / authorized / reputed / nominated by K-RIDE laboratory. The type test shall be as per the governing specification.
  - ii. K-RIDE may carry out Routine and factory acceptance tests as required for equipment.
  - iii. The manufacturer shall not change the Bill of Material used in the manufacturing of samples used for Type testing. In case the bill of material is changed then Employer/Engineer may ask for the repetition of those type tests which he considers relevant.

**INDICATIVE LIST OF ITEMS TO BE INCLUDED IN FAT PLAN FOR ELECTRICAL PANELS**

*(This list is an indicative List for the inspectors to be conducted during FAT of Power Panels. However, the detailed FAT plan needs to be developed for the specific Panel based on approved GADs and Contract Specifications and as per the tests defined in Clause – 11 of IEC 61439 -1 (Routine Verification) /as per the relevant Standards as applicable.)*

| S. No   | Description  | Type of Check                                   | Remarks  |
|---|--|---|--|
| <b>GENERAL</b>  |  |   |  |
| A   | All items/ components (switchgears, cables, Wires, meters, relays etc.) used are as per the Approved Makes, Vendors and ratings  | Visual Check & Certification before Call letter | Obtain confirmation from Panel Manufacturer for each Panel duly verified by the Main Contractor. |
| B   | Obtain the Factory Test Report of Incoming / Raw Material  | Verify  |  |
| C   | Obtain the Internal Test reports / Manufacturer Test Report of Internal Quality Tests done on Panel offered for Inspection as per ISO 9001.  | Review  |  |
| D   | Confirmation from Panel Manufacturer that Panel has been manufactured strictly as per approved GADs.   | For record                                      |  |
| E   | List of tools required for Inspection and copy of their Calibration Certificates from independent Labs / Authorities.  | Check for Validity                              |  |
|   | <b>Note:</b> All the above are to be made part of this FAT report  |   |  |
|   | Panel must be of Modular construction as per PS. The Inspection team shall carry the approved GAD, approved Bill of materials, Contract Specification, relevant standards, copy of Approvals and approved FAT Plan from the office before proceeding for the FAT inspection to the factory premises. |   |  |
| <b>Physical/ Dimensional Checks (as per approved GADs).</b> |  |   |  |
| 1   | Check the Length, Breadth and Height of the complete Panel.  | Measurement                                     |  |
| 2   | Check dimensions of each Sections and Cubicles.  | Measurement                                     |  |
| 3   | Check Number and dimensions of Space for future additions as per Specifications & Bod.   | Measurement                                     |  |
| 4   | Check dimensions of the Doors/back Panels, etc. (Note: Back Panel sections should not be too bulky to handle by one individual. May be taken care during GAD and checked during FAT).  | Measurement                                     |  |
| 5   | Check height/ dimensions of all front Mounting Accessories (such as indicators. Measuring instruments, knobs, etc.)  | Measurement                                     |  |
| 5.1   | EPB (Emergency Push Button) at 1300 mm where applicable.   | Measurement                                     |  |
| 5.2   | All Relays & indicating instruments between 300 to 1800 mm   | Measurement                                     |  |
| 5.3   | Max. Operating Height should not be more than 1800 mm  | Measurement                                     |  |
| 5.4   | Blank Space between the Floor of Switch board and bottom unit (Min. 200 mm or as per PS)   | Measurement                                     |  |
| 6   | Check size/ height of Base Frame (may be min. 100 mm. or as per PS).   | Measurement                                     |  |
| 6.1   | The make of the manufacturer of bought out items is clearly displayed on the items where possible.   |   |  |
| 6.2   | Check that all materials used in the manufacturing of the  |   |  |

|      |   |                          |  |
|------|---|--------------------------|--|
|      | electrical panel are fire retardant, low smoke & zero halogen.  |                          |  |
| 7    | Verify Material and Thickness of Load bearing and Non-Load Bearing Member of Panel Enclosure:   | Certificate/ Measurement |  |
| 7.1  | Panel Structure   |                          |  |
| 7.2  | Bus bar Section   |                          |  |
| 7.3  | Cable Alley   |                          |  |
| 7.4  | Switchgear/ feeder sections   |                          |  |
| 7.5  | Doors   |                          |  |
| 7.6  | Gland Plate   |                          |  |
| 8    | Check Quality of Sheet Metal Painting and Color used. It should be as per the Specification/Approved drawings.  | Visual/ Measurement      |  |
| 9    | Check for the Quality of Sheet Metal Workmanship. There shall not be any sharp edges, burrs, dents, etc. on the panel.  | Visual                   |  |
| 10   | Check Number and Quality of the Door Hinges. Ensure that doors is strongly supported and should not have any unwanted deflection/ shakiness. When door is closed, it is latched at adequate places with adequate crushing of gasket on metal frame. | Visual                   |  |
| 11   | Check Quality of the Door handles, Locks etc.   | Visual                   |  |
| 12   | Check interlocking of Doors, Switchgears, incomers, outgoings and couplers as per the design logic and drawing  | Verify and Visual Check  |  |
| 13   | Check and compare the sealing arrangements all around the panel to ensure intended ingress Protection is achieved and compare with the Type test reports.   | Verify and Visual Check  |  |
| 13.1 | Simple Paper insertion test for IP54. Insert a paper in the gasket and metal frame, close the door and pull the paper. It should not pull out.  |                          |  |
| 13.2 | Check Quality of Gaskets/ sealing rubber, etc. for the Doors. The arrangement shall be such that it is replicable during maintenance.   |                          |  |
| 13.3 | Check Quality of Gaskets / sealing rubber, etc., around the cut-outs for Measuring & indicating instruments, Switchgears, Relays etc.   |                          |  |
| 13.4 | Proper sealing of knock-outs/ cut-outs/ gaps for control cabling bus bar, etc., between different feeders/sections within the Panels.   |                          |  |
| 14   | Check the Lifting arrangements (Hooks etc.) are provided.   | Visual                   |  |
| 14.1 | Adequate Number of Lifting points/ Hooks  |                          |  |
| 14.2 | Adequate Strength of Lifting Points/ Hooks  |                          |  |
| 15   | Check proper identification markings, numbering labelling, tags have been provided.   | Visual                   |  |
| 15.1 | For the Panel   |                          |  |
| 15.2 | For each incoming and Outgoing Feeders  |                          |  |
| 15.3 | For Measuring and indicating instruments  |                          |  |
| 15.4 | Danger Plates/ Signages   |                          |  |

|                             |  |                                  |  |
|-----------------------------|--|----------------------------------|--|
| 16                          | Check for rust, any sign of initiation of corrosion, oxidation, etc., on the support members / nut bolts/ bus bars/ terminal points, etc. Initiation is an indication of use of defective material.                      | Visual                           |  |
| <b>CABLE ALLEYS</b>         |  |                                  |  |
| 17                          | Check for Cable Entry Arrangement (top Entry/ Bottom entry) as per GADs.   | Visual                           |  |
| 18                          | Check for Maintenance/ Working space in Cable Alleys, etc.   | Visual/ Measurement              |  |
| 19                          | Check for adequate Space for accommodating Cable Loops, etc.   | Visual/ Measurement              |  |
| 20                          | Provision for securing/ clamping cables in Cable alley for proper dressing of cables.  | Visual                           |  |
| 21                          | Check for Knock outs for Glanding of different smaller sizes of Cables in Marshalling box (to be used for BMS cables).   | Visual                           |  |
| 22                          | Thickness of Glanding Plates should be minimum 5.0 mm & strong enough to take the simultaneous load/ forces of cables glanded on to it. The Cables shall be well supported and not exert any force on the glanding plate | Measurement                      |  |
| 23                          | Proper dressing / harnessing of internal control cables and wiring within the Panel.   | Visual                           |  |
| 24                          | Provision of identification tags/ ferrules on the internal control cables and wiring within the Panel.   | Visual                           |  |
| <b>EARTHING ARRANGEMENT</b> |  |                                  |  |
| 25                          | Check that Material of Earth Bus provided in Panel is as per PS.   | Visual                           |  |
| 26                          | Check the Size of continuous Earth Bus provided in the Panel as per IEC.   | Measurement                      |  |
| 27                          | Check if the Earth Bus is properly supported and connected to the outside terminals.   | Visual                           |  |
| 28                          | Check that proper earthing has been provided throughout the Panel and all non- current carrying parts are properly earthed.  | Visual                           |  |
| 29                          | All the Gland plates have been earthed properly  | Visual                           |  |
| 30                          | All Doors and openable sections must be earthed through flexible wires/ jumpers (dual if required as per Specs)  | Visual                           |  |
| 31                          | Cases of all instruments and apparatus shall be earthed by a conductor of suitable size (but not less than 2.5 sq. mm)   | Visual                           |  |
| 32                          | Check that the Frame of Switchgear is earthed, when racked in to the Cubicle.  | Visual                           |  |
| <b>BUS BAR SECTION</b>      |  |                                  |  |
| 33                          | Check Bus bar dimensions as per Approved GAD (Only rectangular Busbar is permitted)  | Measurement                      |  |
| 34                          | Neutral bus shall be of full size  | Measurement                      |  |
| 35                          | Material of the busbar shall be as per approved specification  | Visual/ Certificate              |  |
| 36                          | Quality (Conductivity) of the Material of the busbar (Copper / Aluminum) shall be as per approved specification  | Certificate/ Measurement         |  |
| 37                          | Check the quality of conducting material used for Bus bar and the Quality of Tinning on the Copper Bus bar.  | Certificate/ Measurement/ Visual |  |

|  |  |                                  |  |
|--|--|----------------------------------|--|
| 37.1                                   | Factory tinned Bus bars to be used. Obtain the Factory Test certificate and attach the report.   |                                  |  |
| 37.2                                   | Tinning of Bus Bar edges after cutting/ sizing also to be checked.   |                                  |  |
| 38                                     | Check that the Bending of Bus Bars should be on Rollers of adequate diameter to avoid undue bending stresses   | Confirmation & Cross-Check       |  |
| 39                                     | Check the fixing/ mounting arrangements of Main bus bar to ensure that there are no undue stresses due to misalignment of fixing arrangements. (Focus on the location where Panel is divided in to different sections to ensure that the Bus Bar sections match properly). | Visual                           |  |
| 39.1                                   | Check the proven design of bus bar connections of OEM & its compliance in the manufactured product   |                                  |  |
| 40                                     | Bus bar must be color coded for Phase identification   | Visual                           |  |
|  | Note: In case, sleeve is to be provided over the Bus bar for color coding as per PS, then the material of the sleeve must be as per the relevant clauses of PS.  |                                  |  |
| 41                                     | Check the distance between Bus bar supports and compare with Type tested assemblies/ Approved GADs.  | Measurement                      |  |
| 42                                     | Bus Bar Supports should be of approved material.   | Confirmation                     |  |
| 43                                     | Measure minimum Electrical clearances between the bus bars for different Phases, Neutral and Earth. (Main Bus as well as Tap off Bus bars) (Minimum clearance will be between Live parts and Earth)  | Measurement                      |  |
| 44                                     | Check the interconnecting/ Tap – off links between Main Bus and bus sections for proper tightness etc. (connection with the double split cast brass clamp is permitted)  | Measurement                      |  |
| 45                                     | Interconnection between Bus Bar and Switchgear – must be high conductivity Copper Bar and must be insulated and Color coded  | Visual                           |  |
| 46                                     | Proper compartmentation at locations where connecting Links enter the Switchgear section, bus bar sections and Cable Alley must be ensured. For Stations, separate compartments for incoming and Outgoing cable terminations, to be ensured.                               | Visual                           |  |
| 47                                     | Proper Shrouding of Bus bar joints / tap off points to be ensured. Material to be as per PS of the Contract.   | Visual                           |  |
| 48                                     | Proper clearances and segregation must be maintained between Terminals / Tap – offs of different feeders from Main Bus Bars.   | Measurement                      |  |
| <b>INTERNAL WIRING, TERMINAL BLOCK</b> |  |                                  |  |
| 49                                     | Check if the Wiring for all power and Control circuit is being provided as per Approved GAD / Specifications.  | Verify Material Test Certificate |  |
|  | Note: - Internal Wiring in LT panels to be LSZH/ FS as per Specs.  |                                  |  |
| 50                                     | Termination arrangements   |                                  |  |
| 50.1                                   | Terminal blocks should be of Non- Hygroscopic of Melamine  | Verify Material                  |  |
| 50.2                                   | At terminal points– Plain and Spring Washers with electro– tinning to be used  | Visual                           |  |
| 50.3                                   | Check the tightness of wiring termination  | Visual                           |  |
| 50.4                                   | Terminal should have test probe facility   | Visual                           |  |
| 50.5                                   | All Live parts of Terminal blocks must be fully shrouded   | Visual                           |  |



|   |  |  |  |
|---|--|--|--|
| 50.6  | Spare Capacity of Terminals  | Visual   |  |
| 50.7  | Cable terminations should be with lugs of adequate size and with proper crimping   | Visual   |  |
| 50.8  | No more than two wire to be connected to the Terminal  | Visual   |  |
| 50.9  | Terminals should have identification Labels.   | Visual   |  |
| 50.1  | All cables should have identification ferrules   | Visual   |  |
| 50.11   | Check if the adequate size of the cables/ wires is being used for the control wiring   | Measurement  |  |
| 50.11   | All the internal wiring shall be properly dressed and randomly check the traceability of the wires from the wiring diagram     | Visual   |  |
| 50.12   | Check Provision of Protection for Control wiring as approved   | Visual   |  |
| <b>MARSHALLING BOX for BMS (if applicable)</b>  |  |  |  |
| 51.1  | Marshalling Box/ Separate chamber for the BMS connection is provided as per the Approved GAD                                   | Visual   |  |
| 51.2  | Check the BMS points have been provided as per the approved I/O schedule   | Visual   |  |
| 51.3  | Provision of Soft links points for the control shall be checked  | Visual   |  |
| 51.4  | All the terminals for the BMS shall be properly secured and identification mark along with the voltage level shall be provided | Visual   |  |
| 51.5  | Randomly check voltage level at the BMS points for any leakage voltage etc. (at Potential free contacts)                       | Measurement  |  |
| 51.6  | No power wiring/ cable should pass through marshalling box   | Visual   |  |
| <b>SWITCHGEARS, PROTECTIONS, INDICATIONS, ANNUNCIATIONS AND MEASURING INSTRUMENTS</b> |  |  |  |
| 52  | Detailed Check list for these items of the Panel may be prepared based on the GADs / Contract Specifications                   | Factory Test Certificates and Test during FAT          |  |
| 53  | Test Certificates / Calibration Certificates for Measuring instruments to be ensured   | Factory Test Certificates                              |  |
| 54  | Check Surge Arresters (if applicable) have been provided   | Visual & Test Manufacturer's Reports                   |  |
| 55  | Separate CTs for Measurement and Protection of relevant Class and Burden as per PS to be ensured                               | Visual & Test Manufacturer's Reports                   |  |
| 56  | Check Control Logics, Interlocks and Protections Schemes in detail as per the approved plan/ arrangement.                      | Visual, Simulation, Primary & Secondary Injection etc. |  |
| 57  | Check the working of ALTS & Controls provided for safe operation.  | Visual, Simulation, Primary & Secondary Injection etc. |  |
| <b>MISCELLANEOUS</b>  |  |  |  |
| 58  | Check the lights, sockets, anti-condensation heaters and air circulation means provided in the Panels as per GADs.             | Visual   |  |
| 59  | All the Control and power wiring must per properly segregated.   | Visual   |  |
| 60  | Padlocks and interlock provision and Functions to be checked for the safety for each.  | Visual   |  |
| 61  | Check for extendibility of the Panels (including Bus Bars) on either side.   | Visual   |  |

|    |  |  |  |
|----|--|--|--|
| 62 | Check provision of entry for Fire Trace Tube and internally with in the various cubicles and adequate sealing arrangements.  |  |  |
| 63 | Ensure that there are No Joints in the cables used   |  |  |
| 64 | The tests defined in Clause– 11 of IEC 61439- 1 (Routine Verification)/as per the relevant Standards as applicable are also to be performed for which separate Test sheet may be prepared. |  |  |
| 65 | The make of the manufacturers of bought out items is clearly displayed on the items where possible.  |  |  |
| 66 | Check that all materials used in the manufacturing of the electrical panel are fire retardant, low smoke & zero halogen.   |  |  |

**A. DATA SHEET**

| S.No. | Description | Unit | Values |  |  |
|-------|-------------|------|--------|--|--|
|       |             |      |        |  |  |
|       |             |      |        |  |  |
|       |             |      |        |  |  |
|       |             |      |        |  |  |
|       |             |      |        |  |  |
|       |             |      |        |  |  |
|       |             |      |        |  |  |

Length marking: Length shall be marked with number at one-meter intervals on the sheath.

\*Bidder to furnish the data

**1.43 Submittals**

- A. The Submittals to be submitted by the contractor for approval and before ordering for procurement shall include following guaranteed performance particulars:
- Switch boards/panels' Name & Make
  - Bus Bar: i) Size, ii) Material, iii) Rated capacity, iv) Busbar supporting system and the short circuit with-stand capacity
  - Moulded case circuit breakers: Rated capacity, Rupturing capacity, Make, No. of NO/NC contacts, Conformity to Standards.
  - Miniature circuit breakers: Rated capacity, Rupturing capacity, Conformity to Standards
  - Voltmeter & Ammeter: Make, size, Range, accuracy class, Indication type
  - Residual current devices: Name, Make, rated capacity, Range, sensitivity,
  - Air Circuit Breakers: capacity, rupturing capacity, Protections, Auxiliary contacts & accessories, Conformity to specifications.
- B. List of Switch Boards - Switch boards and panels as per following list need be provided. The incoming & outgoing feeders, indications, metering and protection details are shown on various drawings as also referred in BOQ.

| SNO | PANEL NAME                        | ABBREVIATION | LOCATION |
|-----|-----------------------------------|--------------|----------|
| A   | Main Distribution Board           | MDB          | ASS/TSS  |
| B   | Emergency Main Distribution Board | EMDB         | ASS/TSS  |
| C   | Main Lighting &Power Panel        | MLPP         | ASS/TSS  |
| D   | Emergency Power Panel (UPS)       | EPP          | ASS/TSS  |
| E   | Air conditioning Power panel      | ACPP         | ASS/TSS  |

| SNO | PANEL NAME                           | ABBREVIATION | LOCATION                |
|-----|--------------------------------------|--------------|-------------------------|
| F   | Escalator Power Panel                | ESPP         | ASS/TSS                 |
| G   | Fire & Water pump panel              | FWP          | PUMP ROOM               |
| H   | Commercial Power Panel               | CPP          | ASS/TSS                 |
| I   | Light & Power Distribution Boards    | LPDB         | AS INDICATED IN DRAWING |
| J   | Air Conditioning Distribution Boards | AC DB        | ASS/TSS                 |
| K   | Active harmonic filter panel         | AHF          | ASS/TSS                 |

1.44

**Active Harmonic Filter Panel**

1.0

**Technical Specifications -Active Harmonics Filter (AHF) (up to 100A-415V-3Ph-4Wire System)**

1.1

**Scope:**

1.1.1

Design, Engineering, Manufacture of Active Harmonic Filter for harmonic filtering, Load balancing and Power Factor correction purpose. The sizing to be done accordingly.

1.2

**Standards:**

| 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,<br>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   |

1.3

**System Description:**

1.3.1

**Performance Requirements:**

- a) 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.
- b) Converter design shall be a three-level design to optimize performance and minimize heat losses.
- c) Performance as defined assumes a properly sized AHF and impedance installed on nonlinear loads. Impedance shall be 3% or larger on every nonlinear load.
- d) THD(v) shall be limited to not more than 5 percent as contributed by the loads at the location of each AHF. A THD(v) set point may be set to optimize performance of the AHF and maintain less than THD(v) set point. [Note: AHF cannot remedy THD(v) that is caused by other electrical systems or devices that AHF is not connected to remedy.]
- e) \*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.
- f) \*Displacement power factor (PF) shall be corrected to 0.95 or better at the location of each AHF.
- g) Displacement PF shall never go leading due to AHF performance or design.
- h) \*Source current imbalance shall not exceed 2% phase-to-phase after correction. (\*Sizing should be done accordingly)

### 1.3.2 **Service Conditions:**

Active harmonic filter shall be suitable for the following conditions:

- a) **Operating Ambient Temperature Range:** Up to 100A shall have an operating temperature range of 0 °C to 45 °C.
- b) **Maximum Altitude:** 3300 feet (1000 m) with derating at 1% per 100 meters
- c) **Humidity:** to 95 percent, non-condensing.

### 1.4 **Equipment Size/Ratings**

1.4.1 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.

1.4.2 AHF amperage output ratings shall be 60, 100 amperes. Actual ratings required are detailed in the electrical one-line drawings in this document. Up to 10 units of any size combination shall be able to be paralleled to inject current according to the information received from one set of supply current transformers (CTs) located at the source of supply for loads and all active harmonic filter. This known as closed loop logic and CT location.

1.4.3 When parallel units are employed if one or more units is off line, the remaining units shall adjust their total output to attempt to make up for the unit(s) off line. All units operating in parallel shall have a common digital series communications connection between all of them.

1.4.4 Each unit that receives the primary CT is considered a master unit. If any master is off line, another master shall control the system. Units not receiving primary CT are considered slaves. AHF that turns off all units when one is taken offline in the parallel arrangement is not acceptable. AHF that shut off the nonlinear loads (i.e. VSD) when AHF faulted is not acceptable.

1.4.5 All floor standing units shall provide incoming bus bar terminations for both top and bottom entry. At least two cables per phase may be landed. AHF floor standing units shall include a door-interlocked circuit breaker rated at 200,000 AIC (amperes of interrupt capacity) at rated voltage up to 480 VAC.

1.4.6 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 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 Incoming power shall be connected to the input circuit breaker within a power cable entry plenum. Once cable installation is complete and plenum covers are re-installed there shall be no access to incoming cabling.

1.4.9 A service port is provided in the front cover of each unit chassis (IP00) such that with power disconnected a USB connection from a laptop computer may examine past performance and review all parameter set points and the event log. This may be used for commissioning or service.

### 1.5 **Active Harmonic Filter Unit**

#### 1.5.1 **Enclosure:**

Provisions shall be made for locking disconnects in the off position. Provisions for additional padlocking shall be made by the Employer using an approved lockout/tag-out device. AHF shall be provided in IP31 enclosure with bottom cable entry. When noted in the electrical one-line drawings, the AHF shall be incorporated into MDB-1.

#### 1.5.2 **Function of AHF:**

- a) AHF shall monitor the total current of the loads under review utilizing two CT mounted on the supply AC lines in MDB-1 for all three phase loads and all AHF. If phase-to-neutral loads are connected (four wire system), three CT shall be required.

- b) AHF shall analyze the content of the supply current for harmonics from the 2nd to the 51st harmonic and shall determine the reactive current content representing displacement power factor and supply current balancing.
- c) AHF shall inject cancellation for every harmonic order from 2nd to 51th order. AHF with designs to inject less than all harmonic orders are unacceptable. To ensure optimum system performance, all nonlinear loads shall have input line reactors included that are rated 3 percent or higher impedance (inductance).
- d) AHF shall include an option to achieve optimized PF correction. Optimized PF correction is designed to prevent correction when the system PF is better (closer to unity) than the programmed PF set point. Any AHF that reduces the system PF to attain a reduced set point are unacceptable.
- e) AHF shall provide field selection as harmonic filter, reactive current correction, or supply current balancing or any combination of the three modes. All modes shall be required for this project.
- f) AHF shall provide for current balancing of AC supply for harmonic and reactive currents regardless of actual load distribution per phase. AHF shall have up to 30 seconds of logic ride through in the event of power loss. AHF shall be designed with a current limiting function to protect the IGBT. When the current limit level is attained on any harmonic order, a message shall be displayed indicating the output capacity is operating at maximum capacity. Operation shall continue indefinitely at this reduced level without trip or degradation of AHF.
- g) AHF shall have automatic restart capability upon power loss return and fault resets.
- h) 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.
- i) AHF shall monitor the incoming air temperature and invoke a hard trip of the unit at 124°F (51°C).
- j) AHF shall be compatible with SPD, EMC filters, SCR (thyristor) snubber circuits, and switched mode power supplies (SMPS).

### 1.5.3 Operator Interface:

- a) 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.*
- b) 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
- c) HMI shall display operating and setup parameters and event/fault messages in plain English, no cryptic codes or symbols are permitted on the display. HMI shall display the mains voltage and CT current. Parameter adjustment shall be made via HMI and shall be password protected. HMI shall record and display an event log with time and date stamp. Event log shall be cleared via the stop function or power-off. A minimum of 100 events shall be stored.
- d) HMI shall provide external communications via an RJ45 connectors. Mudbugs TCP/IP shall provide

remote run/stop and display of operating parameters, set-up parameters and diagnostic functions. HMI shall have a safety feature that shall lock out all other forms of control during service and commissioning. After 15 minutes of non-use the lockout shall clear and control functions shall revert to full functionality and remote-control capability. HMI shall display a flashing warning screen in the event of a fault. HMI shall download pertinent parameters to a USB memory device to permit remote diagnostic evaluations and to save unit set up parameters.

- e) HMI shall include, but shall not be limited to, an on-board commissioning guide with automatic detection features. AHF shall automatically check for proper AC line phase rotation. No specific phase rotation is required. AHF shall automatically test for CT phase rotation and polarity. If installation is incorrect, AHF shall be able to rotate and reorient CT's through its own logic calculation. If proper alignment cannot be achieved, a fault warning and lockout of operation shall occur. AHF shall automatically calibrate the CT for optimum harmonic cancellation performance. AHF shall perform at full capacity for a period of 15 minutes to validate components meet temperature performance requirements in the installed location. In the event any of the above cannot be reconciled, HMI shall lock out AHF function until commissioning agent corrects, verifies, and clears each test.

#### 1.6 **External Current Transformer**

Split core type current transformers shall be installed as defined herein and as shown on the Electrical Drawings. Primary current ratings of the CT' shall be according to full load current rating of the circuit on which installed. Current transformer ratio shall be as shown on the electrical on-line drawings. Secondary rating shall be 1 or 5 amperes.

Current transformers rated for 50-60 hertz shall be used. Class 1 (or better) accuracy shall be provided.

#### 1.7 **Source Quality Control**

Prior to shipment, the manufacturer shall fully test the performance at full current and voltage while functioning as a harmonic correction device to assure compliance with equipment specifications defined herein. A certified test report shall be provided to the Employer.

#### 1.8 **Execution**

##### 1.8.1 **Examination**

###### a) **Verification of Conditions:**

Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Employer and the Employer's representative/Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

##### 1.8.2 **Installation**

Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings. Install low voltage active harmonic filters in accordance with the NEC and all applicable Central, state and local codes.

##### 1.8.3 **Field Quality Control**

Field inspection and testing shall be performed by certified technician from the manufacturer. Perform start-up tests in accordance with manufacturer's instruction manual. Document equipment nameplate and test data on the test report.

##### 1.8.4 **Demonstration**

Provide the services of a factory authorized service representative of the manufacturer to provide start-up service and to demonstrate and train the Employer's personnel. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Train the Employer's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventive



maintenance. Review data in operation and maintenance manuals with the Employer's personnel. Schedule training with the Employer, through the Employer's representative/Engineer, with at least seven day's advanced notice.

#### 1.9 **Submittals**

- a) **Product Data:** Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications.
- b) **Shop Drawings:** Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer's standard product data.
- c) **Wiring Diagrams:** Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturers installed wiring and field installed wiring, and between components provided by the manufacturer and those provided by others.

#### 1.10 **Quality Assurance**

##### 1.10.1 **Qualifications:**

**Manufacturer Qualifications:** Manufacturer shall be a firm engaged in the manufacture of low voltage active harmonic filters of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years.

**Installer Qualifications:** Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing low voltage active harmonic filters similar in type and scope to that required for this Project.

**Inspecting and Testing Agency Qualifications:** To qualify for acceptance, an independent inspecting and testing agency hired by the Contractor shall demonstrate to the Employer's representative/Engineer's satisfaction that they are qualified according to ASTM E 329 to conduct testing indicated.

##### 1.10.2 **Regulatory Requirements:**

Comply with applicable requirements of the laws, codes, ordinances, and regulations of Central, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

##### 1.10.3 **Electrical Components, Devices, and Accessories:**

Electrical components, devices, and accessories shall be listed and labeled as defined in NEC, Article 100, by an inspecting and testing agency acceptable to authorities having jurisdiction and marked for intended use.

##### 1.10.4 **Pre-Installation Conference:**

Conduct pre-installation conference in accordance with. Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Employer and the Employer's representative/ Engineer.

#### 1.11 **Delivery, Storage, And Handling**

Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

#### 1.45 **Automatic Source Transfer System.**

##### A. Scope

1. The scope of work covers supply, installation, testing and commissioning of automatic source transfer systems meeting the intents of these specification.

##### B. System Features.

1. The system basically controls 2 nos. circuit breakers (MCCB's or ACB's) where one breaker is connected to the 'normal' source and the other breaker to the 'second' source. The breakers are electrically & mechanically interlocked through internal or external connections so that only one of the two breakers is 'ON' to the load. The breakers shall be 3PN if the 'normal' and 'second' sources of supply are from the same transformer. They should be 4 P if the 'second' source is from the diesel generator or any other independent generating source.
- C. In an automatic transfer system, there shall be an electrical and mechanical interlocking system, auxiliary control unit with high rupturing capacity MCCBs and relay contactors and a changeover controller. The controller shall provide the following facilities:

#### **Auto Operation**

1. Monitor 'normal' source
2. Effect auto changeover in
  - i. 'normal' source failure
  - ii. phase failure
3. DG set control wherever shown and required.
4. Load shedding & Reconnection of non-primary circuits Changeover R
5. Replacement sources if one of the phase of 'Normal' source is absent.

#### **Position Switch & Indication**

1. Position selector switch with setting for Automatic/ forced operation on normal source/ force operation on Emergency source/ switch of both Normal & Emergency source operations.

#### **Other Facilities**

1. Manual transfer to 'second' source
2. Adjustable time set point from 1 to 30 sec
3. Option for communication bus.

The controllers should be self-powered & should not depend on any auxiliary supply. The common O/G bus bars should be insulated.

1.46

#### **Panel Construction**

- A. The Automatic Source Transfer Systems shall be incorporated as part of the panel concerned. The system shall become one vertical column with all the components including the auxiliary supplies and the other columns shall accommodate the outgoing feeders.
- B. Construction of panels shall conform to the specifications under section 'MV switchgear'. All panels with ASTS shall be front operating and totally maintainable from the front without accessing from the rear of the panel.
- C. The ASTS shall not be measured separately and it shall be regarded as a part of the panel in which it is incorporated. ACB or MCCBs as required are already considered in the panels accordingly the price of ASTS be quoted along with the panel cost.
- D. In the ASTS if electrical interlocking fails, the ASTS shall have an in-built permanent mechanism to prevent accidental paralleling of two sources of supply.
- E. The load bearing parts of the entire electrical panel assembly shall be 2 mm CRCA thick sheet whereas other partition parts shall be constructed of minimum 1.6 mm CRCA.
- F. Electrical panel shall have provision for top/bottom in-coming and bottom/top out-going to suit site conditions of cable entries.
- G. The Electrical Panels shall be mounted on a robust base frame made up of steel channel with a minimum height of 100mm and the maximum height of Electrical Panel shall not exceed 2.40 meter including base frame. The base frame shall be able to withstand the static and dynamic loads of the Electrical Panels. The steel Channel shall be painted with epoxy polyester paint. The main contractor shall ensure that the maximum height of the Electrical Panel at the site of installation shall not exceed 2.6 meter including foundation if any.
- H. The cubicle section shall be constructed of angle iron types frames or folded sheet steel or fully welded/bolted construction with all necessary removable covers. Removable lifting lugs shall be provided on the top of the cubicles. Cubicle sections shall be provided with bolts or devices for insuring that they are correctly aligned when being coupled together. The bus bar chamber shall be fitted with removable end cover plates secured by mild steel captive screws.

**1.47 Automatic Transfer Switch****1.48 Scope**

This covers scope to provide automatic transfer switches (ATS) comprising an ATS with a microprocessor controller for auto-operation and on-load manual operation with an operating handle or Allen key with amperage, voltage, number of poles (3 and 4 poles) and withstand values as per the Schedule of Quantities. The automatic Transfer switching equipment is designed to be used in low voltage power systems for Open transition transfer applications, with simultaneous closing of all 4 poles (three phases and neutral).

**1.49 Design Prerequisite**

The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a motorized unit or a double solenoid mechanism, momentarily energized. The switch shall be mechanically interlocked on a single shaft. The system shall incorporate switch position indicator, with provision of manual emergency operation, having 3 stable positions – Normal, Isolated and Emergency. To prevent source overlapping the transfer is operated through distinct isolated position. The sensing and logic shall be built-in microprocessor for maximum reliability and with option of serial communications feature. To facilitate flexibility of installation there shall be provision of Line/ Load reversibility.

ATS system shall have following characteristics: -

**1.50 Standard & Codes General Standard**

|                            |                |
|----------------------------|----------------|
| System Operational Voltage | 415 V          |
| Rated Insulation Voltage   | 1000 V         |
| Impulse withstand Voltage  | 12 KV          |
| Thermal Rating of Switch   | At 40 deg. C   |
| Storage temperature        | -20 to +70 ° C |
| Operating temperature      | -20 to +70 ° C |

|               |  |
|---------------|--|
| IEC 60947-1   | Low-voltage switchgear and control gear - General rules                                      |
| IEC 60947-6-1 | Multiple function equipment –Transfer switching Equipment                                    |
| IEC 60947-3   | Low-voltage switchgear and control gear – Switches & disconnectors Emission General standard |
| EN 55022      | Conductor Emission   |
| EN 55022      | Radiated Emission Immunity General standard  |
| EN 61000-4-2  | Electrostatic Discharge (ESD)  |
| EN 61000-4-3  | Radiated electromagnetic field   |
| EN 61000-4-4  | Electrical fast transient (EFT)  |
| EN 61000-4-5  | Surges   |
| EN 61000-4-6  | Conducted radio frequency field  |
| EN 61000-4-8  | Power frequency magnetic field   |
| EN 61000-4-11 | Voltage dips, short interruptions and variations   |
| EN 61000-4-13 | Harmonics and inter harmonics  |
| IEC 61010-1   | Electromagnetic compatibility  |

Normal / Emergency sequences must integrate following timers:

Loss of Mains Timer to validate Main source failure before starting loss of Mains sequence Delay to transfer Timer (Emergency source availability Timer) to validate emergency source stability before transferring Cool Down Timer in case of Genset application, to allow genset cooling down period after transferring back the load to the Main source It shall be possible to block the re-transfer operation (from Emergency to Main source) via programming.

**1.51 Safety**

An in-built Auto/Manual selector must inhibit any automatic command in manual position. It must also be possible to equip the product with a key selector to allow secure access to the operational mode selection Padlocking of the product in Isolation position must be included, and padlocking of the system in all 3 positions must be possible on request

**1.52 Construction And Design Requirements****A. Transfer Switch**

- i. The Switching contacts of ATS must be silver plated and of the self-cleaning type, which optimizes the quality of the contacts during operation and also to render a maintenance free system.
- ii. A manual operating handle made of one piece only shall be provided for emergency transfer purposes. The handle shall be located on the ATS itself to ensure ease of locating that and for quick operation for maximum efficiency during power outages. Manual transfer shall be possible on load
- iii. Manual retransfer function must be possible either locally or from remote.
- iv. The switch shall have simultaneous closing of all 4 poles of ATS to minimize effect of transient voltages
- v. The Neutral pole of ATS shall be fully rated (100% rating for all 4 poles).

**B. Controller**

- i. ATS Controller should have selectable Single phase or Three phase control on Sources
- ii. The control unit shall direct operation of the switch. The controller's sensing and logic shall be a built-in microprocessor for maximum reliability, minimum maintenance and to facilitate serial communication capabilities
- iii. It shall be possible to block the re-transfer operation when selected. The transfer back operation to the main source must be voluntarily validated
- iv. The Frequency setting shall be possible in steps of 0.10 % whereas Voltage to be settable in steps of 1%
- v. It shall be possible to have Voltage sensing on all three phases as well as for single phase
- vi. There shall be 300 distinct nominal voltage settings, for precise settings over a wide voltage band

**C. Settings**

- i. Both Voltage and Frequency settings shall be field adjustable either locally through display and keypad, or remotely through serial communication (voltage in 1% steps and frequency in 0.1% steps)

**D. Events & Alarms**

- i. It shall be possible to program the minimum and maximum voltage and frequency thresholds, and associated hysteresis levels to avoid any nuisance triggering of the switch operation. It shall also be possible to closely monitor Phase rotation of both the sources to check for any flaws. It shall be possible to configure unbalance level for both Mains and Backup source to ensure phase loss detection

**1.53 Specification for Contactor Based Auto Power Supply Changeover System**

This system ensures power supply availability to the load at all time from different incomers (two/three sources) by transferring the source supply from one to another depending on availability. Its control circuit shall be working on 230 volts, A C, single phase, 50Hz.

This system operates with MCCBs, power contactors, auxiliary contactors, timers, SPPR, UVR etc. This system should also have auto/manual selection option for operation in auto / manual mode. For manual switching ON/OFF, each supply source should be operated through ON/OFF push button and consists of ON/OFF /TRIP indications. There should be interlocking such that two supplies do not get parallel with each other, i.e., only one supply should be available for load.

In normal case priority of the power supply shall be available as follows: -

- i. EMDb: - Incomer-1 (MDB), Incomer-2 (MDB), DG
- ii. Rest panels with dual supply: - Incomer -1 (EMDb) & Incomer -2 (MDB)

## SECTION: E.02 DISTRIBUTION BOARDS

### 2.1 Scope

The scope of work shall cover the design, manufacture, supply, installation, testing and commissioning of distribution boards as specified and shown in respective drawings. Associated minor civil works required for the erection of the DB's such as niche in walls etc. are also included in the scope of this contract.

### 2.2 Standards

The following updated and current Indian Standard Specifications and Codes of Practice will apply to the equipment and the work covered by the scope of this contract irrespective of those listed.

|                   |   |
|-------------------|---|
| IS : 8828 – 1996  | Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations |
| IEC: 61439        | Specification for Low-voltage Switchgear and Control gear   |
| IS/IEC: 60947     | Specification for Low-voltage Switchgear and Control gear   |
| IS : 10118 - 1982 | Code of Practice for Selection, Installation and Maintenance of Switchgear and Control gear                   |
| IS: 2675 – 1983   | Enclosed distribution fuse boards and cut-outs for voltages not exceeding 1000 V Ac and 1200 V Dc             |
| IS: 5578 – 1984   | Guide for marking of insulated conductors   |
| IS: 11353 – 1985  | Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals                  |
| IS: 9926 – 1981   | Fuse wires used in rewirable type electric fuses up to 650 volts  |

All equipment, components, materials and entire work shall be carried out in conformity with applicable and relevant IS/BS/IEC Standards and Codes of Practice. In addition, relevant clause of Indian electricity act 2003 and Indian electricity rule 1956 amended up to date shall apply.

Necessary test certificates in support of the certification shall be submitted prior to supply of the equipment.

### 2.3 Miniature Circuit Breakers

- A. The MCBs shall be of the completely moulded design suitable for operation at 240/415 Volts 50 Hz, single phase/3-phase and neutral system. MCBs shall be quick make and break type conforming to IEC 60898 & IEC 60947 standards. Housing shall be heat resistant and have high impact strength. MCBs shall be flush mounting type and shall be provided with trip free manual operating lever with ON/OFF indications
- B. MCBs shall be provided with magnetic thermal releases for over current and short circuit protection with separate indications for short circuit.
- C. MCBs shall have quick make and break non-welding self-wiping silver alloy contacts rated for 10 kA or 15 kA (as applicable in BOQ) short circuit at 230/415 volts in accordance with IEC 60898 and IS: 8828 - 1996 as per the schedule & the drawing both on the manual and automatic operation. The MCB shall conform to Class 3 Energy Limitation. The MCB shall be conform to Class 3 Energy Limitation. Each pole on the breaker shall be provided with inverse time thermal over load and instantaneous over current tripping elements, with trip-free mechanism. In case of multi-pole breakers, the tripping must be on all the poles and operating handle shall be common.
- D. Breakers must conform to IEC 60898 and IEC 60947 with facility for locking using padlock with hasp in OFF position. Copper Pressure clamp terminals for stranded/solid conductor insertion are acceptable up to 10-sqmm size and for higher ratings, the terminals shall be suitably shrouded.
- E. MCB shall have a minimum life expectancy of 20,000 operations.

### 2.4 Residual Current Circuit Breaker with overcurrent protection

- A. RCBOs 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 or IS 12640.
- B. RCBOs shall meet the following requirements:
  - i. Number of poles: double-pole or four-pole as specified on the Drawings,
  - ii. Rated current (In): as shown on the Drawings,
  - iii. Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on the drawings or as per approval of the Engineer.
  - iv. Rated voltage: 240 / 415 V AC,
  - v. Rated frequency: 50 Hz,



- vi. Rated short-circuit capacity: not less than 10 kA unless otherwise specified,
- vii. Operating characteristics in case of residual currents with DC components: as specified,
- viii. Method of mounting: distribution board type,
- ix. Method of connection: connection shall be made with proper size of thimbles and number ferreting for circuit identification,
- x. I<sup>2</sup>t characteristic: suitable for equipment and circuit being protected,
- xi. Degree of protection: IP 2X to IEC 60529 or EN 60529
- xii. Reference ambient temperature: 50°C.
- C. 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.
- D. Provision shall be made for testing the automatic earth - leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage. There shall be separate indication on RCCB for earth leakage faults.
- E. REMOTE MONITORING:  
The following critical status and alarms for each Electrical Panels shall be sent to BMS for remote monitoring via volt-free contacts or serial interface over standard Protocol communication as approved but not limited to:
  - a) Individual ACB/MCCB open/close status,
  - b) Common alarm for ACBs/MCCBs trip on fault/lock out,
  - c) Common alarm for any local/remote or local/auto selector switch in local mode
  - d) Control supply failure,
  - e) ACB ready to close indication.
- F. Emergency push button (EPB) operated, and g) Busbar voltage, current, frequency and energy parameter h) Electrical Panels under voltage alarm and cause of tripping.

## 2.5 Construction of Distribution Boards

- A. The distribution equipment, as detailed in schedule of quantities and forming a part of the Distribution Boards, shall comply to the relevant Standards and Codes of the Bureau of Indian Standards.
- B. Distribution boards for miniature circuit breakers shall be of sheet steel construction with a minimum thickness of 1.6 mm, suitably braced to form a rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance. Hinged swing doors shall be fitted with gaskets and shall be easily removable to simplify installation. DBs shall be provided with suitable size of surge protection. DBs shall be fixed with bottom at 1200 mm from finished floors. DBs shall be fixed properly, fitted square with the frame and with holes correctly positioned. DBs shall be fastened to the walls with suitable grouted studs of not less than 12-mm diameter.
- C. All DB's should have minimum IP 54/65 construction. All Cut-outs/Conduit knockouts on top and bottom and covers shall be provided with PE sealed gaskets to provide minimum IP 54/65 degree of protection (as per requirement).
- D. Three phase boards shall have phase barriers and a wire channel on three sides generally as shown on approved working drawings. Neutral bars shall be solid tinned copper bars with tapped holes and cheese headed screws. For 3 phase DB's, 3nos independent neutral bars shall be provided. All DB's shall be internally pre-wired using copper conductor FRLSZH PVC insulated wires brought to a terminal strip of appropriate rating for outgoing feeders.
- E. Board shall meet with the requirements of IS: 2675 – 1983 and marking arrangement of busbars shall be in accordance with IS 5578 – 1984.
- F. Bus Bars shall be heat shrinkable PVC insulated electrical grade copper and suitable for the incomer switch rating and sized for a temperature rise of 30°C Over the ambient.
- G. Each board shall have two separate earthing terminals. One earthing terminal for single phase and two terminals for 3 phase DBs shall be provided with an earth strip connecting the studs and the outgoing earth bar.
- H. Circuit diagram indicating the load distribution shall be pasted on the inside of the DB as instructed. Each circuit shall be clearly numbered from left to right to correspond with wiring diagrams.



- I. All outgoing feeders shall terminate on a terminal strip which in turn is pre-wired to the MCB by means of insulated single conductor FRLSZH PVC insulated copper wires as follows:
 

|                        |          |
|------------------------|----------|
| Up to 10A              | 2.5-sqmm |
| Over 10A and up to 16A | 4.0-sqmm |
| Over 16A and up to 32A | 6.0-sqmm |
- J. Each DB shall have multiple LED type indicating lamps on the in-comer and all outgoing feeders denoting power availability in the board after the switch.
- K. All the internal connections shall be with solid/multi-stranded copper conductor PVC insulated wires with heavy duty ferrules of adequate temperature rating. All the internal connections shall be concealed by providing a hinged protective panel to avoid accidental contact with live points. All outgoing equipment mounted on a frame work for easy removal and maintenance shall be connected direct to the bus bar on the live side. Knock out holes of appropriate size and number shall be provided a top and bottom to facilitate conduit connection.
- L. MCBs shall be provided on the phases of each circuit. Individual banks of MCB's shall be detached. There shall be ample space behind the backs of MCB's to accommodate all the wiring. All the DB's shall be completely factory wired, ready for connections.
- M. All the terminals shall have adequate current rating and size to suit individual feeder requirement.
- N. All circuits shall be distinctly marked/ferruled with description of service installed.
- O. All the circuits shall have an independent neutral insulated wire, one per circuit, and shall be numbered and marked.
- P. Sample of the finished DB shall be got approved by the Employer/Engineer before bulk fabrication and supply.
- Q. Enclosure - The Enclosure system shall be IP54 duly provided with Neoprene gasket sealing arrangement with nut free assembly.

## 2.6 **Sheet Steel Treatment and Painting**

- A. Sheet Steel materials used in the construction shall undergo a rigorous rust proofing process comprising of alkaline degreasing, de-scaling in dilute sulphuric acid and a recognized phosphating process. The steelwork shall then receive two coats of oxide fill primer before final painting as specified or powder coated as per BOQ.
- B. All sheet steel as well as the angle iron frame shall after metal treatment be given powder coated finish painted with two coats of approved shade to on the outside and white on the inside. Each coat of paint shall be properly stove and the paint thickness shall not be less than 80 microns.

## 2.7 **Name Plates and Labels**

### A. **NAME PLATES**

Each Electrical Panels shall have permanently attached to it in a conspicuous position label upon which shall be engraved or stamped with the Station Name, Type and serial number, date of manufacture, designation of each Electrical Panels, details of the loading and duty at which the item of the Electrical Panels has been designed to operate. Such labels shall be of non-hygroscopic material. Detail of Name Plate shall be submitted for review and approval of Engineer.

### B. **LABELS**

- i. Labels shall be provided for every panel to describe the duty of or otherwise identify every instrument, relay or item of control equipment mounted externally and internally.
- ii. The designation on these labels shall be clear and shall, where applicable, incorporate the device number along with concise descriptive wording in English.
- iii. Externally fitted panel labels shall be of Perspex or other approved transparent plastic with letters and numbers rear engraved and filled with black.
- iv. Internally fitted panel labels shall be finished in white with engraved letters and numbers filled with black, laminated material such as Trifoliate or rear engraved and filled plastic may be used. Embossed materials and techniques will not be accepted or any latest technology which provides same result as mentioned above shall be applicable.
- v. Labels shall be provided in conformity with the above requirements or by other approved means wherever necessary to designate panels or panel sections. To describe or identify circuits or circuit components, to provide warnings or reminders of dangerous or potentially dangerous circumstances and wherever called for elsewhere in this Specification.

- vi. Safety labels "Danger 415 V" in both English and Hindi shall be provided on both the front and rear of the Electrical Panels. The safety labels shall have graphic symbols exactly as per IS standards. The design of all such signs shall be submitted for approval. Similar labels shall be provided for other panels at different voltages.
- vii. Labels shall not be less than 45 mm high. Lettering shall be of not less than 10 mm high. All labels shall be securely fixed to the panels by bolts and nuts.
- viii. Details of proposed inscription, including the English and Hindi wordings, and samples of the labels shall be submitted for approval before any labels are manufactured.
- ix. Circuit labels, one on the front of the panel and one on the rear of the panel suitably engraved.

## 2.8 **Material and Manufacturing:**

- A. All similar items of the Electrical Panels and their component interchangeable. Spare part shall be manufactured originals and shall fit all similar items of the Electrical Panels. Where machining may be needed before fitting renewable parts, the machining fits and the associated tolerances shall be shown on the drawings by Vendor accompanying the instruction manuals.
- B. All parts which are susceptible to wear or contaminated by dust shall enclosed proof housings.
- C. The style and finish of the workmanship shall be consistent throughout the Works. Unless otherwise specified, Engineer shall decide the final colours for all paint work and other finishes to be applied to the Electrical Panels

## 2.9 **Installation**

- A. Small wall mounted DBs shall be fixed with bottom at minimum 1200 mm from finished floors or depending upon the site condition. DBs shall be fixed properly, fitted square with the frame and with holes correctly positioned. DBs shall be fastened to the walls with suitable grouted studs of not less than 12-mm diameter.
- B. All distribution boards shall be mounted on wall or recessed, with necessary angle iron framework. All mounting frames shall have one prime coat and two finish coats after the completion of the work. All distribution boards shall be touched up for damaged painting.
- C. All boards shall be meggered phase to phase and to neutral using 1000/500V megger with all switches in closed position. The megger value should not be less than 2.5 MΩ between phases and 1.5 MΩ between phase and neutral.
- D. Fabrication drawings of all boards shall be approved by the Employer or his Engineer before fabrication and the boards will be inspected before dispatch unless waived in writing.

## 2.10 **Testing & Inspection**

- A. Copies of type tests and routine test as per relevant specification, carried out at manufacturer's work shall be submitted to the Employer / Engineer as required. Wiring and connections shall be checked for continuity.
- B. Tests as required shall be performed in presence of authorized Employer/Engineer for which the contractor shall give due prior notice.
- C. Test reports shall be furnished by the contractor in approved formats only.
- D. Pre-commissioning inspection:

The following checks shall be carried out before commissioning distribution boards certifying that:

- i. Erection is complete in all respect including earthing.
- ii. Opening in floor within and outside panels have been sealed off and all cover and door gaskets are intact to make the enclosure dust and vermin proof.
- iii. All metering instrument have been checked and calibrated.
- iv. Indicating lamps are healthy and in proper position.
- v. Ratio test of all the CTs is satisfactory.
- vi. Wiring continuity and correctness are ensured in the protection and metering circuits.
- vii. IR values have been found satisfactory and recorded for bus bars, circuit breakers, incoming and outgoing cables.
- viii. Resistance of bus joints has been checked and recorded as satisfactory.

## SECTION: E.03 MEDIUM VOLTAGE CABLING

### 3.1 Scope

- A. The scope of work shall cover supply, laying, connecting, testing and commissioning of low and medium voltage power and control cabling.

### 3.2 Standard

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

|                         |  |
|-------------------------|--|
| IS:1554 (Part-I) – 1988 | PVC insulated (heavy duty) electric cables 1.1kV insulated rating                      |
| IS:7098 Part-I 1988     | Cross-linked polyethylene insulated PVC sheathed cables 1.1kV insulated rating         |
| IS 8130 – 1984          | Conductors for insulated electric cables and flexible cords                            |
| IS 10418 –1982          | Drums for electric cables  |
| IS 10810                | Methods of test for cables (All latest)  |
| IS 3961                 | Recommended current rating for cables (All latest)                                     |
| IEC 60287-1993          | Calculation of continuous current rating of cables                                     |
| IS 5891–1970            | Recommended short circuit rating of high voltage PVC cables                            |
| BS:7671 – 2001          | Requirements for electrical installations. IEE Wiring Regulations - Sixteenth edition. |

- C. Codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian standards/British Standards Codes of Practice/IEC standards.
- D. Cables up to size 25-sqmm conductor size shall be copper conductor & beyond size 25-sqmm shall be aluminium. All conductors shall be stranded. Refer the BOQ for section of Cables for particular Use.

### 3.3 Abbreviations

| S. No. | Abbreviation | Description                            |
|--------|--------------|--|
| 1.     | PVC          | Poly-vinyl Chloride                    |
| 2.     | XLPE         | Cross-Linked Polyethylene              |
| 3.     | FRLSZH       | Flame Retardant Low Smoke Zero Halogen |
| 4.     | LV           | Low Voltage                            |
| 5.     | MV           | Medium Voltage                         |
| 6.     | HV           | High Voltage                           |
| 7.     | HT           | High Tension                           |
| 8.     | MS           | Mild Steel                             |
| 9.     | GI           | Galvanized Iron                        |
| 10.    | RCC          | Reinforced Cement Concrete             |
| 11.    | UPVC         | Unplasticized Polyvinyl Chloride       |
| 12.    | FR           | Flame Retardant                        |

### 3.4 Delivery, Storage and Handling

- A. All cables shall be new without any kinks or damage marked with K-RIDE, manufacturer's name, insulating material, conductor size and voltage class on cable surface at every 1000mm approx.
- B. Cable drum conforming to IS: 10418 shall be stored on a well-drained, well-ventilated area protected from sun and rain on hard surface, preferably of concrete, so that the drums do not sink in ground causing rot and damage to the cable drum.

- C. During storage, periodical rolling of drums, in the direction of arrow marked on the drum, shall be done once in 3 months through 90°. Both ends of cables shall be properly sealed to prevent moisture ingress. Storage and handling shall conform to section 7 of IS 1255.
- D. Drums shall always be rested on the flanges and not on flat sides. Movement of drums shall always be in direction of the arrow marked on the drum. For transportation over long distance, the drums shall either be mounted on drum wheels, trailers and pulled by ropes, unloaded preferably by crane and rolled down carefully on suitable ramps. While transferring cable from one drum to another, the barrel of the new drum shall have diameter not less than the original drum.

## 3.5

**Cables****A. PVC Cables**

- i. Medium voltage cables shall be aluminium/copper conductors PVC insulated, PVC sheathed with flame retardant Low Smoke Zero Halogen (FRLSZH) and armoured conforming to IS:1554 Part-I. Cables shall be rated for 1100 Volts. Conductors shall be insulated with high quality PVC base compound.
- ii. The conductor of all cables from shall be stranded. Sector shaped stranded conductors shall be used for cables of 50-sqmm and above.

**B. XLPE Cables**

- i. The cables shall be 1100 Volt grade XLPE insulated with PVC inner sheath steel armoring and with an outer protective sheath of flame-retardant low smoke zero halogen (FRLSZH) compound, conforming to IS: 7098 (Part I). Cables shall have high conductivity stranded aluminium or copper conductors and cores colour coded to the Indian Standards.
- ii. The maximum continuous current carrying capacity and the factors for determining such ratings and temperatures, for XLPE insulated cables shall be based on IEC 60287/ BS7671 and on the conditions available at Site.
- iii. The multicore XLPE insulated cables shall be rated for continuous operation at a maximum conductor temperature of 90° C and for a maximum short circuit temperature of 250 °C
- iv. A common covering (bedding) shall be applied over the laid-up cores by extruded sheath of unvulcanized compound. Armouring shall be applied over this extruded sheath. 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 PVC insulation

|             |                             |
|-------------|-----------------------------|
| 1 Core      | Red/Black/Yellow/Blue       |
| 2 Core      | Red and Black               |
| 3 Core      | Red, Yellow and Blue        |
| 3 ½ /4 Core | Red, Yellow, Blue and Black |

## 3.6

**Fire Survival Cables**

- A. All cables used for fire and life safety systems shall have a 3-hour fire survival capability. These cables may be Special Fire Cables as per BS 7629. Mineral insulated or EPR insulated with Glass Mica Taping or CWZ cables with special grade FRLSZH Inner and Outer sheath and overall Steel Braiding. The Minimum Withstanding Temperature of Glass Mica Tape during fire should not be less than 950°C and shall be double layered. (Manufacturer has to provide declaration on the usage of special mica tape of 950°C) Cables shall be tested for fire survival duty and should pass all the fire tests as per BS:6387-1994 and other relevant test certificates shall be furnished with each lot of supply.

## 3.7

**Installation**

- A. While shortest practicable route shall be preferred, cable runs shall follow fixed development such as roads, footpaths etc. with proper offsets so that future maintenance and identification are rendered easy.
- B. Whenever cables are laid along well demarcated or established roads, the LV/MV cables shall be laid further from the line than HV cables.
- C. Cables of different voltages and also power and control cable shall be kept in different trenches with adequate separation. Where available space is restricted, LV/MV cables shall be laid above HV cables.
- D. Where cables cross one another, the cables of higher voltage shall be laid at a lower level than the cables of lower voltage.

- E. 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 250 mm.
- F. Cables shall be laid in the routes marked in the drawings. Where the route is not marked, the contractor shall mark it out on the working drawings after deciding in consultation with Employer/Engineer. Cables shall be laid in masonry trenches, directly on walls / ceiling, inside shafts / cable trays, directly buried in ground or in pipes/ducts as elaborated below. Cables of different voltages and also 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, medium voltage cables shall be laid above HT cables as approved.
- G. Single cables laid shall be fixed directly to walls or ceiling and supported at not more than 600 mm. Cables laid in built-up trenches shall be on GI supports.
- H. Cables shall be so laid that the maximum bending radius is 12 times the overall diameter of the cable for medium voltage cables or in accordance with the manufacturer's recommendations whichever is higher.
- I. In the case of cables buried directly in ground, the cable route shall be parallel or perpendicular to roadways, walls etc. Cables shall be laid in an excavated, graded trench, over a sand or soft earth cushion to provide protection against abrasion. Cables shall be protected with brick or cement tiles as shown on Drawings. Width of excavated trenches shall be as per code of practice and drawings.
- J. The general arrangement of cable laying shall be as per drawings. All cables shall be full runs from panel to panel without any joints or splices.

### 3.7.1 Cables Laid in Masonry Trenches

- A. Wherever so specified, cables shall be laid in indoor/outdoor masonry/RCC trenches with chequered plate/RCC covers to be provided by contractor. Cables shall be laid on GI supports of approved design grouted in trench walls at intervals not exceeding 600 mm. If required, cables shall be arranged in tier formation inside the trench. Cables shall be dressed properly so that the clear spacing between the cables shall not be less than the diameter of the cable. Suitable clamps, hooks and saddles shall be used for securing the cables in position. Complete details of this support work shall be shown in working drawings to be prepared by the Contractors and submitted for approval of Employer / Engineer before execution. Works shall be carried out only as per approved working drawing. Wherever so specified, trenches shall be filled with fine sand.

### 3.7.2 Cable laid on Trays/Walls

- A. Where numbers of cables are run, necessary perforated cable trays shall be provided wherever shown. Ladder cable trays shall be galvanized MS as specified in the BOQ.
- B. After laying and securing the cables in a cut-out, suitable water tight sealant shall be applied as per requirement to prevent any ingress of water.
- C. Cables shall be secured in position and dressed properly by means of suitable clamps, hooks, saddles etc. Clamping of cables shall be at minimum intervals as below:
- D.

| Type of Cables  | Size                        | Clamping by  | Fixing intervals |
|---|-----------------------------|--|------------------|
| MV  | Up to and including 25-sqmm | Purpose made, approved GI clamp minimum 2 mm thick, 19 mm wide | 300 mm           |
| MV & HV   | 35-sqmm to 120-sqmm         | Clamps 3 mm thick 25 mm wide                                   | - 600 mm         |
| MV & HV   | 150-sqmm and above          | Clamps 3 mm thick 40 mm wide                                   | - 600 mm         |
| <b>Note:</b> The fixing intervals specified apply to straight runs. In the case of bends, additional clamping shall be provided at 30 cm from the center of the bend on both sides. |                             |  |                  |

### 3.7.3 Buried Directly in Ground

- A. Cables should be so laid that they will not interfere with underground structures.
- B. 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. Cables shall be laid and protected at such locations.
- C. Any telephone or other cables coming in the way are to be properly shielded as directed by Employer / Engineer.



- D. Surface of the ground shall be made good so as to conform in all respects to the surrounding ground to the satisfaction of Employer / Engineer.

### 3.8 Cable Trays

- A. Cable trays of sizes as per BOQ and drawings shall be of doubled bend channel design unless otherwise stated. Cable trays shall be fabricated from 2 mm thick (with tolerance as defined in IS) perforated hot dip galvanized sheet steel as specified in BOQ and shall be complete with tees, elbows, risers, and all necessary hardware. Trays shall be hot dipped galvanized (Galvanization as per latest IS 4759/6745). Cable trays shall be erected in perfect level and plumb and shall comply with the following:
  - B. Trays shall not have sharp edges, burrs or projections injurious to cable insulation. Trays shall include fittings such as bends, risers etc. for changes in direction and elevation. Each run of cable tray shall be completed before laying of cables. Cable trays shall be exposed and accessible. All bends & tees should be factory made.
  - C. Trays shall be supported adequately at around 1 m distance from the building structure by means of painted / galvanized (as specified) MS structural members secured to the structure by dash fasteners or by grouting. This support should be capable of withstanding the weight equivalent of 3m length of the cables that can be laid in the trays. At turns the support has to be double and at both ends of the bend. The entire cable tray system shall be rigid. Cost of support arrangement shall be included in the rates quoted for supply and installation of trays. Complete details of this support arrangement shall be shown in working drawings to be prepared by the Contractors and submitted for approval of Employer / Engineer before execution. Works shall be carried out only as per approved working drawing. Minimum support should be 40 X 40 X 5mm GI angle. Anchor fasteners of suitable size to be provided.
  - D. Cable tray shall be required to be painted for identification as approved by Employer / Engineer.
  - E. Each Cable Tray joint shall have 6sqmm tinned copper Cable (FRLSZH) /GI strip of suitable size bond bolted to each adjacent tray to ensure electrical continuity as approved by Employer / Engineer.
  - F. Cable tray shall be earthed.

### 3.9 Routing of the Cable Runs

- A. Before cable laying work is undertaken, the route of the cables shall be decided in consultation with the Employer/Engineer.
- B. While shortest practicable route shall be preferred, cable runs shall follow fixed development such as roads, footpaths etc. with proper offsets so that future maintenance and identification are rendered easy.
- C. Whenever cables are laid along well demarcated or established roads, the LV/MV cables shall be laid further from the kerb line than HV cables.
- D. Cables of different voltages and also 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.
- E. Where cables cross one another, the cables of higher voltage shall be laid at a lower level than the cables of lower voltage.
- F. Power and communication cables shall as far as possible cross at right angles. Where power cables are laid in proximity to communications cables the horizontal and vertical clearances shall not normally be less than 250 mm.

### 3.10 Width of Trench

- A. The width of trench shall be determined on the following basis:
  - (i) The minimum width of masonry trench for laying single cables shall be 350 mm or as specified in BOQ.
  - (ii) 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 one cable diameter.
- B. There shall be a clearance of at least 150 mm between axis of the end cables and the sides of the trench.
- C. The space between multiple cables laid in same trench shall be laid as prescribed by the manufacturer of the cable or as recommended in standards.



**3.11 Depth of Trench**

- A. Where cables are laid in single tier formation, in ground 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. 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.

**3.12 Excavation Of Trenches in Ground**

- A. The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature of 12 times the overall diameter of the largest MV cable shall be provided and 15 times the overall diameter for 11KV cable. Where gradients and changes in depths 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.
- B. 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 the approval of the Employer/Engineer. The Contractor shall use a cable detector along the route of excavation and identify existing live cables along the route and exercise caution during excavation.
- C. Existing property exposed during trenching shall be temporarily supported or propped adequately as directed by the Employer/Engineer. The trenching in such cases shall be done in short lengths, necessary pipes laid for passing cables therein and the trench refilled as required. If there is any danger of a trench collapsing or endangering adjacent structures, the sides shall be well shored up with timbering and / or sheathing as the excavation proceeds. Where necessary these may even be left in place when backfilling the trench.
- D. Excavation through lawns shall be done in consultation with the Employer/Engineer. Bottom of the trench shall be level and free from stone, brick, etc. The trench shall be provided with a layer of clean dry sand cushion of not less than 80 mm in depth before laying of cables.

**3.13 Laying of Cable in Trench in Ground**

- A. 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 bearings so as to prevent the drum creeping to one side while rotating.
- B. 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.
- C. After the cable is uncoiled and laid over the rollers, the cable 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.
- D. For short runs and cable sizes up to 50-sqmm 1.1 kV grade, the alternative method of direct handling can be adopted with the prior approval of the Employer/Engineer. 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 for continuity and insulation resistance. The cable shall be measured thereafter.
- E. Suitable moisture sealing compound / tape shall be used for sealing of the ends of cables laid in the trench. All the cables remaining in drums after laying shall be sealed in a dust and moisture proof manner.
- F. The trench shall be provided with a layer of clean dry sand cushion of not less than 80 mm in depth before laying of cables. Cable 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. If additional tiers are formed each of the subsequent tiers also shall have a sand cushion of 300 mm and 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 also to protect the cables against accidental mechanical damage. Such protection shall be with second class bricks of not less than 225 mm x 100 mm x 75 mm (normal standard size) laid breadth wise for the full length of the cable to the satisfaction of the Employer/Engineer. 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.

- G. The trenches shall then 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.
- H. 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 Employer/Engineer and all surplus earth and rocks removed to places as specified.

### 3.14 **Route Markers**

- A. Route markers shall be provided along straight runs of the cables at locations approved and generally at intervals not exceeding 25 meters. Markers shall also be provided to identify change in the direction of the cable route and also for location of every underground joint.
- B. Route markers shall be made out of 100mm x 100mm x 5mm GI/aluminium plate welded or bolted onto 35 mm x 35 mm x 6 mm angle iron 600 mm long duly painted with anti-corrosive paint/embossed. Such plate markers shall be mounted parallel to and 300 mm or so away from the edge of the trench/pipe/duct, or as directed at site.
- C. Markers shall be embedded in cement concrete 1:2:4 (one cement, 2 coarse sand: 4 graded stone aggregate of 30 mm normal size). The word "Cable" and other details such as voltage grading, size etc. as required shall be painted on the marker.
- D. Identification tags  
Plastic identification tags shall be provided at every 30m. Cables shall be identified at end terminations indicating the feeder number and the Panel / Distribution board from where it is being laid.

### 3.15 **Laying in Pipes / Closed Ducts**

- A. In locations such as road crossings, entry to buildings/poles in paved areas etc., cables shall be laid in pipes or closed ducts. Spun reinforced concrete/GI pipes or UPVC ducts shall be used for such purposes and the pipe shall not be less than 100 mm in diameter for a single cable and not less than 150 mm for more than one cable. These pipes shall be laid directly in ground without any special bed. Unless otherwise specified the top surface of pipes shall be at a minimum depth of 1000 mm from the ground level when laid under roads, pavements etc.
- B. 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.

### 3.16 **Laying Of Cables in Floors**

- A. Laying of cables directly in floors shall be avoided and GI pipes of adequate size shall be used wherever necessary. However, if the cables have to be laid direct in the floor specific written approval of Employer / Engineer shall be obtained and the Contractor shall cut chases, lay the cables and make good the chases to original finish. Also, heat shrinkable cable jointing kits shall be used wherever joints are unavoidable.

### 3.17 **Cable Entry into Buildings**

- A. 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. The Contractor shall submit a written request to Employer / Engineer cabling for inspection of works for the following:
  - i. On excavation and provision of sand bed at bottom of trench
  - ii. On laying of cables, and provision of sand bed over the cables
  - iii. On provision of protective cover & back filling
  - iv. On commencing termination of cable

These requests shall be serially numbered and shall be in an approved format out of one or two formats to be submitted by the Contractor.

### 3.18 Cable Joints

- A. 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 Employer/Engineer, and shall form a part of cable run / laying. Cable Jointing shall be done only of indicative make cable joints. Joints between dissimilar metals to be done by bimetallic conductor / plate or equivalent cross section. Heat shrinkable cable jointing kits shall be used wherever joints are unavoidable. No extra cost shall be paid for jointing of cables.

### 3.19 Cable Loops

- A. At the time of the installation approximately 3 meters of surplus cable shall be left as below or as directed by Employer/Engineer.
  - i. At each end of the cable
  - ii. on each side of underground straight through/tee/termination joints.
  - iii. at entries to buildings

This cable shall be left in the form of a loop.
- B. Wherever long runs of cable length are installed cable loops shall be left at suitable intervals as specified by the Employer/Engineer.

### 3.20 Termination / Jointing /Glands/ Ties of Cables

- A. All cable terminations should be nut-bolt type, irrespective of the cable size and shall have tinned copper compression lugs. The end terminations shall be insulated with a minimum of six half-lapped layers of PVC tape. Cable armouring shall be bonded at both ends.
- B. Soldered jointing/termination shall be totally avoided. Solder-less terminations by using crimping tools, suitable lugs and double compression brass glands shall be used. In the case of aluminium 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 termination.
- C. Armour Termination shall be by means of mechanical cable glands. For armoured cables the glands shall have an earth bond attachment. For cables with conductors larger than 35mm the earth termination shall be integral with the body of the gland. Glands used with aluminium armoured cables shall be of aluminium, but for all other situations they shall be of brass, unless otherwise indicated.
- D. The cables shall be tied through locking belts after 2 meters each for keeping the cables intact in case of trefoil formation. At locations, where there is change of level of laying, the cables shall be tied through locking belts after 1 meter each. These locking belts shall be strong enough to keep trefoil formation intact for entire life of cable. Heavy duty cable ties of width 30 mm (min) may also be used with the approval of engineer. The contractor can propose additional steps to ensure that cables remain in trefoil formation for life time.

### 3.21 Identification Tags

Plastic/Metal identification tags shall be provided at every 30m. Cables shall be identified at end terminations indicating the feeder number and the Panel/Distribution board from where it is being laid

### 3.22 Testing

- A. Tests at Manufacturer's Works
  - i. Type tests – Type test results as per the relevant standards mentioned herewith shall be submitted along with the vendor approval request. In case the engineers' desires, a repeat of the type test from the accredited lab may be asked for.
  - ii. FRLSZH, PVC insulated Cables shall be subjected to type tests and acceptance test at manufacturers work as per IS:1554 Part-1 1988 (Latest Amendment) carried out in accordance with appropriate parts of IS: 10810.FRLSZH, XLPE cables shall be tested as per IS: 7098 Part-1 (Latest Amendment) and IS: 10810. Copies of the type test reports shall be furnished by the contractor.
  - iii. Routine test - PVC Cables shall be subjected to routine test as per IS: 1554 and XLPE cables as per IS:7098 including:
    - a) Conductor resistance test

- b) High voltage test at room temperature.  
Copies of routine tests carried out at manufacturers works shall be furnished along with the cables.  
Acceptance Test for XLPE and PVC shall be carried as per the proforma given at annexure A of this specification. The prescribed values as per relevant IS and type results as available on record shall preferably filled by inspecting official before the inspection.
- B. Testing at Site
  - i. Before laying - All cables before laying shall be pressure tested for one minute with 1000 volts megger. Cable cores shall be tested for continuity, absence of cross phasing, insulation resistance to earth/sheath/armour and insulation resistance between conductors.
  - ii. MV cables shall be tested upon installation with a 500V Meggar and the following readings established:
    - a) Continuity on all phases
    - b) Insulation Resistance between conductors and between all conductors and ground
- C. All test readings shall be recorded and shall form part of the completion documentation.
- D. Underground Cable routes shall be got verified with the help of cable detector.
- E. Test at Site after receipt and installation shall be carried as per the proforma given at annexure B. All type, acceptance and site test readings records shall form part of the completion documentation. Underground Cable routes shall be got verified with the help of cable detector.

### 3.23 **Technical literature and test certificates to be furnished by Contractor**

- A. Contractor shall furnish following minimum technical particulars:
  - i. Name of manufacturer
  - ii. Standard governing specification
  - iii. Manufacturer's type designation
  - iv. Rated system voltage in kV
  - v. Rated continuous current in amps
  - vi. Max. permissible current in amps at 400C
  - vii. Short circuit current for 1 sec. in kA
  - viii. Minimum permissible bending radius in mm
  - ix. Overall diameter of cable/wire in mm
  - x. Max. permissible length of cable in drum
  - xi. Weight of cable and drum including cable
  - xii. Resistance of Conductor/100m length
  - xiii. High voltage with-stand test result in kV
  - xiv. Insulation resistance
  - xv. Thickness and material of
    - a. Insulation
    - b. Inner sheath
    - c. Armouring
    - d. Outer Sheath.
  - xvi. Compound used for FRLSZH properties
  - xvii. Chemicals used for protection against rodent and termite attack.
  - xviii. Shelf life of cable accessories for the ambient temperature specified.
  - xix. Catalogues and brochures giving technical and physical details of the cable such as current rating, de-rating factors, etc.
  - xx. Type test certificates and special test results for cables offered.
  - xxi. Shelf life of cable accessories for the ambient temperature specified.
  - xxii. Type test certificates for cable & accessories.
  - xxiii. De-rating factor with the proposed method of cable laying

**ANNEXURE A1: ACCEPTANCE TEST REPORT FOR XLPE CABLES**

| Acceptance Test Report                   |  |  |                  |  |  |             |                 |      |       |
|--|--|--|------------------|--|--|-------------|-----------------|------|-------|
| Customer Name:                           |  |  |                  |  |  |             |                 |      |       |
| P.O. No. & Date:                         |  |  |                  |  |  |             |                 |      |       |
| Description:                             |  |  |                  |  |  |             |                 |      |       |
| Specification: IS 7098 Pt-1 & Data Sheet |  |  | Specified Values |  | Type Test Values   |             | Observed Values |      |       |
| S.No.                                    | Test Descriptions                      |  | Unit             | (Specified Values shall be as per IS 7098 Pt-1 and the Cable selected) | Type test Values shall be the same as submitted at the time of Vendor approval | DRUM No.:   |                 |      |       |
|  | Core Identification                    |  |                  | Red, Yellow, Blue & Black  | Red, Yellow, Blue & Black  | Red         | Yellow          | Blue | Black |
|  | Color of Inner Sheath & Outer Sheath   |  |                  | Black/Black  | Black/Black  | Black/Black |                 |      |       |
| 1  | Dimensional Check                      |  | -                |  |  |             |                 |      |       |
|  | i)                                     | Thickness (Main)                         | mm               |  |  |             |                 |      |       |
|  |  | (Neutral)                                | mm               |  |  |             |                 |      |       |
|  | ii)                                    | Thickness of Inner Sheath                | mm               |  |  |             |                 |      |       |
|  | iii)                                   | Thickness of Outer Sheath                | mm               |  |  |             |                 |      |       |
|  | iv)                                    | Overall Dia of Cable                     | mm               |  |  |             |                 |      |       |
| 2  | Tests on Conductor (As per IS 8130)    |  | -                |  |  |             |                 |      |       |
|  | i)                                     | No. of Wires in Conductor (Class-2)(M/N) | -                |  |  |             |                 |      |       |
|  | ii)                                    | Conductore Resistance at 20 Oc (M/N)     | Ohm/K m          |  |  |             |                 |      |       |
|  | iii)                                   | Tensile strength (Before ageing)         | N/mm2            |  |  |             |                 |      |       |
|  | iv)                                    | Wrapping Test (Before ageing)            | -                |  |  |             |                 |      |       |
|  | v)                                     | Annealing Test (Before stranding)        | %                |  |  |             |                 |      |       |
| 3  | Test on Insulation (As per IS-7098-1)  |  | -                |  |  |             |                 |      |       |
|  | i)                                     | a) Volume resistivity (at 27 Oc)         | Ohm cm           |  |  |             |                 |      |       |
|  |  | b) Volume resistivity (at 90 Oc)         | Ohm cm           |  |  |             |                 |      |       |
|  | ii)                                    | a) Tensile strength (Before ageing)      | N/mm2            |  |  |             |                 |      |       |
|  |  | a. Elongation at break (Before ageing)   | %                |  |  |             |                 |      |       |
|  | iii)                                   | Hot set test (at 200+ 3 Oc for 15 min.)  | -                |  |  |             |                 |      |       |
|  |  | a) Elongation under load                 | %                |  |  |             |                 |      |       |
|  |  | b) Permanent Elongation                  | %                |  |  |             |                 |      |       |
| 4  | Test on Armoring (as per IS- 3875)     |  | -                |  |  |             |                 |      |       |
|  | i)                                     | Strip Dimension                          | mm               |  |  |             |                 |      |       |
| 5  | Test on Outer Sheath (as per IS- 5831) |  | -                |  |  |             |                 |      |       |
|  | i)                                     | a) Tensile strength (Before ageing)      | N/mm2            |  |  |             |                 |      |       |
|  |  | Elongation at break (Before ageing)      | %                |  |  |             |                 |      |       |
|  | Test on Complete Cable                 |  | -                |  |  |             |                 |      |       |

|   |     |   |   |              |  |  |  |                             |  |
|---|-----|---|---|--------------|--|--|--|-----------------------------|--|
| 6 | i)  | High Voltage Test (for each connection)   | - |              |  |  |  |                             |  |
|   |     | Visual Inspection                         |   |              |  |  |  |                             |  |
| 7 | i)  | Embossing over outer Sheath               |   |              |  |  |  |                             |  |
|   | ii) | Sequential Length Marking at every meters |   |              |  |  |  |                             |  |
|   |     |   |   |              |  |  |  |                             |  |
|   |     | Date and Signature:                       |   |              |  |  |  |                             |  |
|   |     |   |   |              |  |  |  |                             |  |
|   |     |   |   |              |  |  |  |                             |  |
|   |     | (Manufacturer)                            |   | (Contractor) |  |  |  | (K-RIDE Inspecting officer) |  |



**ANNEXURE A2: ACCEPTANCE TEST REPORT FOR PVC CABLES**

| Acceptance Test Report                              |  |  |                   |   |   |                        |        |      |       |
|---|--|--|-------------------|---|---|------------------------|--------|------|-------|
| <b>Customer Name:</b>                               |  |  |                   |   |   |                        |        |      |       |
| <b>P.O. No. &amp; Date:</b>                         |  |  |                   |   |   |                        |        |      |       |
| <b>Description:</b>                                 |  |  |                   |   |   |                        |        |      |       |
| <b>Specification: IS 1554 Pt-1 &amp; Data Sheet</b> |  |  |                   | <b>Specified Values</b>   | <b>Type Test Values</b>   | <b>Observed Values</b> |        |      |       |
| <b>S. No.</b>                                       | <b>Test Descriptions</b>                     |  | <b>Unit</b>       | <b>(Specified Values shall be as per IS 1554 Pt-1 and the Cable selected)</b> | <b>Type test Values shall be the same as submitted at the time of Vendor approval</b> | <b>DRUM No.:</b>       |        |      |       |
|   | Core Identification                          |  |                   | Red, Yellow, Blue & Black   | Red, Yellow, Blue & Black   | Red                    | Yellow | Blue | Black |
|   | Color of Inner Sheath & Outer Sheath         |  |                   | Black/Black   | Black/Black   | Black/Black            |        |      |       |
| <b>1</b>  | <b>Dimensional Check</b>                     |  | -                 |   |   |                        |        |      |       |
|   | i)   | Thickness (Main)                         | mm                |   |   |                        |        |      |       |
|   |  | (Neutral)                                | mm                |   |   |                        |        |      |       |
|   | ii)  | Thickness of Inner Sheath                | mm                |   |   |                        |        |      |       |
|   | iii)   | Thickness of Outer Sheath                | mm                |   |   |                        |        |      |       |
|   | iv)  | Overall, Dia of Cable                    | mm                |   |   |                        |        |      |       |
| <b>2</b>  | <b>Tests on Conductor (As per IS 8130)</b>   |  | -                 |   |   |                        |        |      |       |
|   | i)   | No. of Wires in Conductor (Class-2)(M/N) | -                 |   |   |                        |        |      |       |
|   | ii)  | Conductor Resistance at 20° C (M/N)      | Ohm/Km            |   |   |                        |        |      |       |
|   | iii)   | Tensile strength (Before ageing)         | N/mm <sup>2</sup> |   |   |                        |        |      |       |
|   | iv)  | Wrapping Test (Before ageing)            | -                 |   |   |                        |        |      |       |
|   | v)   | Annealing Test (Before stranding)        | %                 |   |   |                        |        |      |       |
| <b>3</b>  | <b>Test on Insulation (As per IS-1554-1)</b> |  | -                 |   |   |                        |        |      |       |
|   | i)   | a) Volume resistivity (at 27° C)         | Ohm cm            |   |   |                        |        |      |       |
|   |  | b) Volume resistivity (at 90° C)         | Ohm cm            |   |   |                        |        |      |       |
|   | ii)  | a) Tensile strength (Before ageing)      | N/mm <sup>2</sup> |   |   |                        |        |      |       |
|   |  | b) Elongation at break (Before ageing)   | %                 |   |   |                        |        |      |       |
|   | iii)   | Hot set test (at 200+ 3° C for 15 min.)  | -                 |   |   |                        |        |      |       |
|   |  | a) Elongation under load                 | %                 |   |   |                        |        |      |       |
|   |  | b) Permanent Elongation                  | %                 |   |   |                        |        |      |       |
| <b>4</b>  | <b>Test on Armouring (as per IS-</b>         |  | -                 |   |   |                        |        |      |       |

|   |     |   |                   |              |  |  |                             |  |  |
|---|-----|---|-------------------|--------------|--|--|-----------------------------|--|--|
|   |     | <b>3875)</b>                              |                   |              |  |  |                             |  |  |
|   | i)  | Strip Dimension                           | mm                |              |  |  |                             |  |  |
|   |     | Test on Outer Sheath (as per IS-5831)     | -                 |              |  |  |                             |  |  |
| 5 | i)  | a) Tensile strength (Before ageing)       | N/mm <sup>2</sup> |              |  |  |                             |  |  |
|   |     | b) Elongation at break (Before ageing)    | %                 |              |  |  |                             |  |  |
|   |     | <b>Test on Complete Cable</b>             | -                 |              |  |  |                             |  |  |
| 6 | i)  | High Voltage Test (for each connection)   | -                 |              |  |  |                             |  |  |
|   |     | <b>Visual Inspection</b>                  |                   |              |  |  |                             |  |  |
| 7 | i)  | Embossing over outer Sheath               |                   |              |  |  |                             |  |  |
|   | ii) | Sequential Length Marking at every meters |                   |              |  |  |                             |  |  |
|   |     |   |                   |              |  |  |                             |  |  |
|   |     | Date and Signature:                       |                   |              |  |  |                             |  |  |
|   |     |   |                   |              |  |  |                             |  |  |
|   |     |   |                   |              |  |  |                             |  |  |
|   |     | (Manufacturer)                            |                   | (Contractor) |  |  | (K-RIDE Inspecting officer) |  |  |

**ANNEXURE B: CABLE INSTALLATION CHECKLIST**

## c) Insulation Resistance (500 V) (in MΩ)

|      |  |
|------|--|
| R-Y  |  |
| Y-B  |  |
| B-R  |  |
| R-N  |  |
| Y-N  |  |
| B-N  |  |
| R-PE |  |
| Y-PE |  |
| B-PE |  |
| N-PE |  |

## d) Continuity Yes/No

|   |  |
|---|--|
| R   |  |
| Y   |  |
| B   |  |
| N   |  |
| PE  |  |
| 1. No cracks and physical damage observed on cable                                  |  |
| 2. Proper hook, clamp and saddle provided as per spec.                              |  |
| 3. Bending radius as per specification and provision of additional support at bends |  |
| 4. Proper offsets and loop provided for future maintenance                          |  |
| 5. Proper distance maintained between the control and LV cables                     |  |
| 6. Proper Phase sequence  |  |
| 7. Armour of the cable earthed properly at both ends                                |  |
| 8. Route Marker provided as per specification                                       |  |
| 9. Distance between the LV/MV and HV cables, if exists together                     |  |
| 10. Identification tags provided as per specification                               |  |
| 11. Cable termination has been completed as per the specification                   |  |
| 12. Underground cable routes verified with the help of cable detector               |  |

Checked By (Contractor)

Verified By(K-RIDE)

## SECTION: E.04 CONDUIT WIRING

### 4.1 Scope

The scope of work shall cover supply, installation testing and commissioning of all wiring in conduit and related works, earthing of distribution/sub-distribution boards, plug sockets etc. and protection against lightning.

### 4.2 Standards

The following standards and rules shall be applicable

|   |   |
|---|---|
| IS: 1554 Part-1 1988<br>(Amendment no. 1 of 1994) | PVC insulated (heavy duty) electric cables: For working voltages up to and including 1100 V                                 |
| IS: 694 – 1990 (Reaffirmed 2005)                  | PVC Insulated cables for working voltages up to and including 1100 Volts – specification                                    |
| IS 9537 : Part 1 : 1980                           | Conduits for electrical installations: Part 1 General requirements  |
| IS 9537 : Part 2 : 1981                           | Conduits for electrical installations: Part 2 Rigid steel conduits  |
| IS 9537 : Part 3 : 1983                           | Conduits for electrical installations: Part 3 Rigid plain conduits of insulating materials                                  |
| IS 9537 : Part 4 : 1983                           | Specification for Conduits for Electrical Installations - Part 4 : Pliable Self-recovering Conduits of Insulating Materials |
| IS 9537 : Part 5 : 2000                           | Conduits for Electrical Installations - Part 5 : Pliable Conduits of Insulating Material                                    |
| IS 9537 : Part 6 : 2000                           | Conduits for Electrical Installations - Specification - Part 6 : Pliable Conduits of Metal or Composite Materials           |
| IS 9537 : Part 8 : 2003                           | Conduits for Electrical Installations - Specification - Part 8 : Rigid Non-Thread able Conduits of Aluminium Alloy          |
| IS 3837: 1976                                     | Accessories for rigid steel conduits for electrical wiring  |
| IS 3480: 1966                                     | Flexible steel conduits for electrical wiring   |
| IS 4615: 1968                                     | Switch socket outlets (non-interlocking type)   |
| IS 3854: 1997                                     | Switches for domestic and similar purposes  |
| IS 1644: 1988                                     | Code of practice for fire safety of buildings (general): Exit requirements and personal hazard                              |
| IS 1646: 1997                                     | Code of practice for fire safety of buildings (general): Electrical installations   |
| IS 732: 1989                                      | Code of practice for electrical wiring installations  |
| IS: 1387-1993                                     | General requirements for the supply of metallurgical materials  |
| IS:800-1984                                       | Code of practice for general construction in steel  |
| IS:5-2004   | Colours for Ready Mixed Paints and Enamels  |
| IS:2551-1982                                      | Danger notice plates  |
| IS:5578-1984                                      | Guide for marking of insulated conductor  |
| IS:2675-1983                                      | Enclosed distribution fuse boards and cut-outs for voltages not exceeding 1000 V Ac and 1200 V Dc                           |
| IS: 2667-1988                                     | Fittings for rigid steel conduits for electrical wiring   |
| IS: 1255- 1983                                    | Code of practice for installation and maintenance of power cables up to and including 33 kV rating                          |
| IS:3961   | Recommended current ratings for cables  |
| IS: 1079  | Hot Rolled Carbon Steel Sheet and Strip Specifications  |
| IS: 209   | Zinc Ingot- Specifications  |
| IS: 2629  | Recommended Practice for hot-dip galvanizing of Iron and Steel  |

|                          |  |
|--------------------------|--|
| IS: 60529                | Degrees of protection provided by Enclosures (IP Code)   |
| IS: 60309 : Part 2       | Plugs, Socket-Outlets and Couplers for Industrial Purposes: Part 2: Dimensional Interchangeability Requirements for Pin and Contact-Tube Accessories |
| IS: 60309 : Part 1       | Plugs, Socket-Outlets and Couplers for Industrial Purposes: Part 1 : General requirements  |
| IS: 4736 : 1986          | Specification for Hot-dip Zinc coating on mild steel tube  |
| IS: 6745 : 1972          | Methods For Determination of Mass of Zinc Coating on Zinc Coated Iron and Steel Articles   |
| IS: 14772 : 2000         | General Requirements for Enclosures for Accessories for Household and Similar Fixed Electrical Installations –Specification                          |
| IS: 3854 : 1997          | Switches for domestic and similar purposes   |
| IS: 1293 : 2005          | Plugs And Socket-Outlets of Rated Voltage up to and Including 250 Volts and Rated Current up to and Including 16 Amperes                             |
| IS: 732 : 1989           | Code of practice for electrical wiring installations   |
| IS:14768 : Part 1 : 2000 | Conduit fitting for Electrical installations: Part 1 General requirements  |
| IS:14768 : Part 2 : 2003 | Conduit fitting for Electrical installations: Part 2 Metal Conduit fitting   |
|                          | Indian Electricity Act 2003 and IE Rules 1956 as amended from time to time   |
|                          | Regulations for the electrical equipment in buildings issued by the Tariff Advisory Committee of the Insurance Association of India                  |
|                          | National Building Code 2016.   |
|                          | Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010   |

All standards and codes mean the latest

#### 4.3 Abbreviations

| S. 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           | Galvanized Iron                        |

#### 4.4 Conduits

- A. Conduit shall be galvanized iron with wall thickness (with tolerance as defined in IS) of 1.6mm up to 32mm diameter and 2.0mm for sizes above 32mm diameter, 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 electric resistance welding. Welds shall be smooth and consistently of high quality to ensure crack proof bending. The conduit shall be galvanized according to IS 4736-1986. All conduits used in this work shall be marked according to IS: 9537 Part-2 and also with ISI certification mark. Other requirements for the conduits shall be as per IS: 9537, Part-1 and Part-2.
- B. Flexible conduit shall be restricted to only those areas where it is not possible to use Rigid Steel Conduits. Flexible GI conduits shall be as per latest edition of IS: 3480. Steel Conduit Connections.
- C. Connections between GI conduits shall be with screwed couplers of approved quality and finish, ensuring screwed metal to metal contact. Length of threads in all cases of joints shall be between 13 mm to 19 mm and sufficient to accommodate pipes to full threaded portion of couplers or accessories.

Threads and sockets shall be free from grease and oil. Connections between screwed conduits and sheet metal boxes shall be by means of G.I hexagon check nut fixed both inside and outside the box. Joints in conduits and terminations shall be free of burrs and bushes shall be provided to avoid damage to insulation of conductors while pulling them through the conduits. Connections between GI, if required, shall be through a junction box and never directly.

- D. Bends - As far as possible, the conduit system shall have minimum use of tees, elbows and sharp bends. A conduit length shall not have more than the equivalent of two quarter bends between two junction or draw boxes. These shall be galvanized. Right angle bends (as per IS: 14768 but more than 75mm radius) or non-right-angle bends (as per IS: 14768) 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). Facilities such as draw-in boxes must be provided so that cables are not drawn round more than two right-angle bends or their equivalent. The radius of bends must not be less than the standard normal bend. 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.
- E. Standard Conduit Accessories - Standard conduit accessories like bends, tees, junction boxes, pull boxes etc. shall be heavy duty, galvanized as specified in BOQ. The accessories shall conform in all respects to the relevant ISS. Samples shall be got approved through Employer/Engineer before use. Only galvanized accessories shall be used with galvanized conduits.
- F. Sheet Metal Outlet/Draw/Inspection/Junction Boxes
- G. Wherever required, outlet boxes of required sizes, approved quality, finish and manufacture, shall be galvanized and fabricated from 1.6 mm thick MS sheets excepting ceiling fan outlet boxes which shall be fabricated from minimum 2 mm thick sheets. All outlet boxes shall be provided with an earth stud. The boxes shall be protected from rust by zinc phosphate primer process. Where not galvanized as specified, for concealed conduiting work, boxes with primer only could be embedded while for surface conduiting work, the boxes shall be finished with minimum one coat of enamel paint of approved colour or electro galvanized. The outlet boxes shall be so protected at the time of fixing that no mortar find its way inside during concrete filling or plastering. For concealed conduiting work, outlet boxes shall be completely embedded in walls/ceilings leaving edges flush with finished wall/ceiling surface.
- H. Boxes suitable to house modular type switches/sockets of required ratings, and fan regulators as required shall be provided. In case the number of switches in one box is not tallying with that available in standard manufacture, the box accommodating the next higher number of switches shall be provided without any extra cost. In case fan regulator/regulators is /are to be provided at a later date, suitable provision for accommodating such regulators shall be made in the switch boxes and blank off covers shall be provided without any extra cost. The outlet boxes shall be of MS having external and internal surface true to finish. All boxes shall have adequate number of knock out holes of required diameter and earth stud. Unless otherwise stated boxes shall be located with bottom at 1200 mm above finished floor level.
- I. Circular type / square box as per required conduit sizes, and as per relevant IS of indicative makes shall be provided. For ceiling mounted LED fittings, the boxes shall be provided 300 mm off Centre for a 1200 mm fitting and 150 mm off Centre for a 600 mm fitting or to suit the fitting entry points so that the wiring is taken directly to the down rod. 3 mm thick Perspex / hylam sheet cover of matching colour shall be provided.
- J. Outlet boxes for ceiling fans shall be fabricated from minimum 2 mm thick MS sheet steel. The boxes shall be hexagonal in shape of minimum 100 mm depth and 60 mm sides. Each box shall be provided with one 'U' shaped 15 mm diameter rod inside securely tied to the top reinforcement of the concrete slab for a length of minimum 150 mm on either side. 3 mm thick Perspex / hylam sheet cover of matching colour shall be provided.
- K. Draw Boxes: Draw boxes of Circular type / square box as per required conduit sizes, and as per relevant IS of indicative makes as required shall be provided at convenient locations to facilitate drawing of long runs of conductors. These shall have covers of 3 mm thick Perspex / hylam sheet.
- L. Inspection Boxes / Junction Boxes: Inspection boxes of Circular type / square box as per required conduit sizes, and as per relevant IS of indicative makes shall be provided at suitable location in conduit runs to permit inspection and maintenance. These shall have covers of 3 mm thick Perspex / hylam sheet.



- M. Hardware and screws shall be cadmium plated brass with counter sunk heads, where as required.  
 N. In a galvanized conduit installation, only galvanized boxes shall be used.

#### 4.5 Laying of Conduits

- A. Conduits shall be laid either concealed in walls and ceilings or on surface on walls and ceilings or partly concealed and partly on surface, as required. Same rate shall apply for concealed and surface conduiting in this contract. Conduits shall be kept at a minimum of 100 mm from the pipes of other non-electrical services.
- B. 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.
- C. 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 8m or more than two right angle bends.
- D. 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.
- E. The entire conduit system including outlets and boxes shall be thoroughly cleaned after completion of erection and before drawing in of cables. For cast in-situ conduits, it shall be checked for freedom from blockage and continuity as soon as the shuttering is removed. All conduit shall be swabbed through before wiring is commenced and cables shall not be drawn into any section of the system until all conduits and draw boxes for that particular section are fixed in position.
- F. Fixing arrangement: The rigid steel conduits shall be fixed at an interval of 50 cm on the wall / ceiling by heavy gauge saddles secured to expansion fasteners on platforms and in service areas such as substation, S&T equipment room and pump house. The inter-saddle spacing shall not be more than 50 cm, but spacing from fittings shall not be more than 30 cm (measured from the Centre of the fitting). In passenger areas such as entrance hall, concourse, sub-way and in operational area at non false ceiling areas, the conduits shall be embedded in the ceiling at the time of construction, & shall be recessed in a chase in the wall which shall be filled up neatly after erection of the conduit.
- G. Conduit joints: Conduit pipes shall be joined by means of screwed couplers and screwed accessories conforming to IS: 2667. In long runs of conduit, inspection type coupler and accessories shall be provided at reasonable intervals. The threaded portion on conduit pipe shall be between 11 mm and 27 mm. The threaded portion shall be treated with anti-corrosive preventives. Cut ends on conduit pipes shall be bur-free to avoid any damage to insulation of conductor.
- H. Separate conduits / raceways shall be used for each of the following:
- Normal lights and 6A 3-pin sockets on lighting circuit
  - Power outlets - 16A 3-pin, 20A / 30A 2-pin + scraping earth metal clad sockets
  - Emergency lighting
  - Telephones
  - Fire alarm system
  - Public address system
- I. Conduit layout shall be generally as indicated on drawings and the layout shall be supplemented and complemented by contractor on site with the approval of the Employer/Engineer. Allowance for adjustments due to site conditions shall be provided with no extra cost.
- J. The conduits shall be of ample sectional area to facilitate simultaneous drawing of wires and permit future provision also. Conduit fill shall not exceed 40%. No wires installed in conduits shall be laced. Maximum number of PVC insulated 1100 Volt grade copper conductor wires shall be as per table given below:

| 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 |
|   |       |   |       |   |       |    |       |   |       |   |       |   |
| 1.5   | 5     | 4 | 10    | 8 | 18    | 12 | -     | - | -     | - | -     | - |
| 2.5   | 5     | 3 | 8     | 6 | 12    | 10 | -     | - | -     | - | -     | - |
| 4   | 3     | 2 | 6     | 5 | 10    | 8  | -     | - | -     | - | -     | - |
| 6   | 2     | - | 5     | 3 | 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 |

The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables. The columns headed 'S' apply to runs of conduits which have distance not exceeding 4.25 m between draw 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. Conduits sizes are the nominal external diameters.

## 4.6

**Concealed Conduiting**

- A. Concealed conduits in concrete members shall be laid before casting as specified in detail drawings, and as may be instructed, so as 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. All buildings with concealed conduiting unless specifically approved by the Employer/Engineer.
- B. Concealed conduits 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 sufficient width to accommodate the required number of conduits and of sufficient depth to permit full thickness of plaster over conduits. The conduits shall be secured in the chase by means of suitable clamps at intervals of maximum 1 meter. The chases shall then be filled with cement and coarse sand mortar (1:3) with 0.6-mm thick 10-15mm aperture galvanized chicken wire mesh for bonding.
- C. Entire concealed conduit work in concrete members and in brick work shall be carried out in close coordination with progress of civil works. Should it become 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 25 mm and outlet boxes of lesser depth than 50 mm could be used by the Contractor for such extensions only after obtaining specific approval from Employer/Engineer. 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.
- D. Cutting chases in finished concrete or finished plastered brick work for embedding conduits and outlet boxes etc. shall be done by the Contractors without any extra cost.
- E. All the chases, as specified shall be properly finished and lined (as specified in BOQ) and covered with suitable openable cover, flushed to the surface, screwed/hinged as specified in BOQ.

## 4.7

**Surface Conduiting**

- A. Conduits run on surfaces shall be supported through 1.6-mm thick metal saddles fastened on metal 6 mm thick steel bracket which in turn are properly screwed to the wall or ceiling. Saddles shall be at intervals of not more than 500 mm. Fixing screws shall be with round or cheese head and of rust-proof materials. Exposed conduits shall be neatly run parallel or at right angles to the walls of the building. Unseemly conduit bends and offsets shall be avoided by using fabricated galvanized steel junction/pull through boxes for better appearances. No cross-over of conduits shall be allowed unless it is necessary and entire conduit installation shall be clean and neat in appearance.

## 4.8

**Painting of Conduits and Boxes**

- A. All draw/switch/junction/fan-hook boxes shall be painted with red oxide/galvanized/zinc passivated in their manufactured form. All un-galvanized / un-plated boxes, conduits & accessories shall be again painted with red oxide paint as required before fixing. Boxes, conduits and associated accessories fixed on surface (if exposed) shall, in addition, be painted with finishing paint of approved colour and finish and make good the damages to the surface.
- B. All metallic accessories shall be painted/cold galvanized at such places where paint has been damaged due to vice/ wrench grip/handling or any other reason.

#### 4.9 Protection of Conduits

- A. 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. The entire conduit system including outlets and boxes shall be thoroughly cleaned after completion of erection and before drawing in of cables.
- B. Bends in conduit – All necessary bends in conduit system including diversions shall be done by bending pipes (by means of pipe bending machine) or by inserting suitable solid or inspection type normal bends, fittings / other accessories. Radius of bends should not be less than 7.5 cm. No length of conduit shall have more than equivalent of four-quarter bends from inlet to outlet.
- C. Earthing - Continuous earth wire shall be provided for all points, outlets and sub-mains. Earthing terminals shall be provided inside all switch boxes, outlet boxes and draw boxes etc. The minimum size of earth conductor shall be 2.5-sqmm stranded insulated copper wire.
- D. Wires

Wires for various purposes will be as follows:

|      |   |  |
|------|---|--|
| (i)  | Light and fan points  | 2.5-sqmm multi-strand copper conductors or as specified in BOQ |
| (ii) | 6/16A plug socket and group wiring of lighting and fan circuits | 4/6-sqmm multi-strand copper conductors or as specified in BOQ |

- E. Material - Wires shall be FRLSZH PVC insulated with stranded copper conductors, unless otherwise stated, of 1100 Volt Grade. Special parameters of FRLSZH PVC insulation like critical oxygen index, temperature index, smoke density and flammability test shall conform to relevant IS/IEC and ASTM standards. All wires shall bear manufacturer's label and shall be brought to site in new and original packages. Manufacturer's certificate, certifying that wires brought to site are of their manufacture shall be furnished as required.
- F. Bunching Of Wires - Wires carrying current shall be so bunched in conduits that the phase and neutral wires are drawn into the same conduit. Wires originating from two different phases shall not be run in the same conduit.
- G. Drawing Of Wires - The drawing of wires shall be executed with due regard to the following:
- H. No wire shall be drawn into any conduit, until all work of any nature that may cause damage to wires is completed. Care shall be taken in pulling the wires so that no damage occurs to the insulation of the wire. Bushes shall be provided at conduit edges.
- I. Before the wires are drawn, conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction by forcing compressed air through the conduits if necessary.
- J. While drawing insulated wires into the conduits, care shall be taken to avoid scratches and kinks, which could cause breakage of conductors. There shall be no sharp bends.

#### 4.10 Termination /Jointing of Wires

- A. Sub-circuit/ Sub-Main 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 of lights/fans/socket outlets. No joints shall be made inside conduits or junction/draw/inspection boxes.
- B. Wiring conductors shall be continuous from outlet to outlet. Joints where unavoidable, due to any specified reasons shall be made by approved connectors. Specific prior permission from Employer/Engineer in writing shall be obtained before making such joint.
- C. Insulation shall be shaved off for a length of 15 mm at the end of wire and it shall not be removed by cutting it square or wringing. Strands of wires shall not be cut for connecting terminals.
- D. Conductors having nominal cross-sectional area up to 10-sqmm shall be cage clamped.
- E. At all bolted terminals, brass flat washer of large area and approved steel spring washers shall be used. Brass nuts and bolts shall be used for all connections.
- F. The pressure applied to tighten terminal screws shall be just adequate, and should not dent or damage or cut any strand of the conductor.
- G. Switches controlling lights, fans, socket outlets etc. shall be connected to the phase wire of circuits only.
- H. Only certified and licensed wire-men shall be employed to do wiring / jointing work.

- I. Load Balancing - Balancing of circuits in three-phase installation shall be planned before the commencement of wiring and shall be strictly adhered to. Distribution of circuits in three phase installation shall be as per distribution chart indicated in drawings.
- J. Colour Code of Conductors - All wires shall be colour coded as follows:

| Phase                 | Colour of Wire |
|-----------------------|----------------|
| R                     | Red            |
| Y                     | Yellow         |
| B                     | Blue           |
| N                     | Black          |
| Earth control, if any | Grey           |

#### 4.11 Switches/Socket Outlets

- A. Switches - All 6- and 16-amps switches shall be of modular flush, grid plate mounting type, unless otherwise stated, suitable for 250-volt AC supply, made of poly carbonate and of indicative make. The switch moving and fixed contacts shall be of silver nickel and silver graphite alloy and contact tips coated with silver. Housing of switches shall be made from high impact resisting flame retarding and ultra violet stabilized engineering plastic materials. Switches shall be fixed inside the box on adjustable galvanized grid with tapped holes cadmium plated brass machine screws, leaving ample space at the back and side for accommodating wires.

##### Socket Outlets

- A. 6/16 amps socket outlets shall be of modular, universal type, flush grid plate mounting type, unless otherwise stated, and shall be switched, three pin type and fitted with automatic linear safety shutters to finger proof. Socket outlets shall be made from high impact resistant, flame retarding and ultra violet stabilized engineering plastic material.
- B. Switches and sockets shall be located in the same plate. Plates for 6 amp switched/ un-switched power and telephone outlets shall be of the same size and shape.
- C. An earth wire shall be provided along the wires 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. Flush Plates - Switches, socket outlets, receptacles etc. in walls shall be provided with polycarbonate moulded modular cover plates of approved colour, shape and size made from high impact resistant, flame retarding plastic and secured to the box with counter sunk /round head cadmium plated brass screws unless otherwise stated. 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.

##### Moulded Cover Plates

- A. Switches, receptacles and telephone system outlets in wall shall be provided with molded 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, 6/16 A sockets with switch 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 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 size of gang switch cover plate to be used and openings shall be provided with blank-off covers at no extra cost.

##### Industrial Socket Outlets

- A. Industrial plugs, connectors, socket outlets and appliance inlets shall be provided as per IS/IEC

60309-1&2. Heavy- duty single phase socket outlets shall be of 3 pin 32A, complying with IS/IEC 60309-2 and shall be IP54.

#### 4.12 **Lighting Fixtures**

- A. Light fixtures and fittings shall be assembled and installed complete as required and ready for service, in accordance with details, drawings, manufacturer's instructions and to the satisfaction of the Employer/Engineer.
- B. Wires brought out from junction boxes shall be encased in GI/PVC flexible pipes as required for connecting to fixtures concealed in suspended ceilings. Flexible pipes shall be provided with a check nut at both ends.
- C. Pendant fixtures specified with overall lengths are subject to change and shall be checked with site conditions and installed as required.
- D. All suspended fixtures shall be mounted on ball and socket joints and fixed in position in accordance with drawings, instructions and as approved by architect/ Employer/Engineer.
- E. Fixtures shall be suspended true to alignment, plumb, level and capable of resisting all lateral and vertical forces.
- F. All suspended light fixtures, fans etc. shall be provided with concealed suspension arrangement in the concrete slab/roof members. Making provisions for such arrangements at the appropriate stage of construction is deemed to be included in contractors' scope.
- G. Exhaust fans shall be fixed at locations shown on the drawings. They shall be wired to a plug socket at a convenient location near the fan.
- H. All switch and outlet boxes, and fan regulators shall be bonded to earth with PVC insulated stranded copper wire as specified.
- I. Wires shall be connected to all fixtures through connector blocks/cage clamped.
- J. Flexible conduits, wherever used, shall be of make and quality approved by Employer/Engineer

#### 4.13 **Drawings**

- A. Before execution of works, the Contractor shall submit the copies of drawings which are necessary to ensure correct supply of equipment, components, fittings and material and to enable correct erection of the installation for satisfactory and trouble-free performance as detailed in the specifications. All drawings for approval shall be prepared and submitted by the Contractor in standard size as approved by engineer and multiples thereof as required by the Employer/Engineer.
- B. Revision and modification: Approval for any revision and / or modification in job specifications shall be taken from the Employer/Engineer before implementation.
- C. Change in construction drawings: Any change required during and / or after approval of detailed construction drawings on account of functional requirements or in the interest of efficient running of the system, keeping the basic parameters unchanged, shall be carried out by the Contractor at no extra cost.



## SECTION E.05 Point Wiring

### 5.1 System of Wiring

- A. Group wiring shall be used for the lighting circuits except for individual rooms and other small cubicles where light points may be wired individually. Each group shall cater for a load of approx. 800 watts, not more than 10 point and wiring shall be done by looping - out at each fitting as per drawing.
- B. The wiring shall be carried out strictly as per IE Rules / Indian Standard Code of Practice for electrical wiring installation IS: 732-1989 clause 4.4. The wiring shall be done on distribution system with distribution and sub-distribution boards located at convenient points.
- C. FRLSZH PVC insulated, single core, multi-stranded copper conductor of nominal size 2.5-sqmm shall be used for wiring of single light points, fans and 6 A plug sockets, Or as specified for group wiring of light points. For 16 A/ 32A plug sockets, the conductor size used shall be 6-sqmm nominal for primary points and 4 sq mm for secondary.
- D. Parameters - Point wiring shall be carried out as per following parameters in concealed/surface conduit system unless otherwise stipulated.
- E. Only looping system of wiring shall be adopted through-out. All accessories shall be flush type unless otherwise stated.
- F. Light points, fan points and 6-amp socket outlet points may be wired on a common circuit. Each circuit shall not normally have more than a total of 10 numbers of light, fan or socket outlets and a load of 800 watts unless otherwise agreed by engineer. Wiring from DB to the first switch in each such circuit is defined as circuit wiring.
- G. Power circuits shall normally have maximum two 20-amps socket outlet unless otherwise stated. Separate circuit shall be run for each geyser, kitchen equipment, window air conditioners and similar appliances.
- H. Point wiring rates shall include painting of conduits and other accessories as required.
- I. Point wiring rates shall include cleaning of dust, splashes of colour wash or paint from all fixtures, fans, fittings etc. at the time of taking over of the installation.

### 5.2 Wiring / Cabling

- A. Wiring shall comprise of stranded copper conductor, for use at 415 V or less, volt grade 600/1100V will have FRLSZH /XLPE / FR type insulation and will be rated to carry the continuous current rating required by the various loads of the system. All cables up to 25 sq.mm will be of copper. Above 25 sq.mm will be of aluminium cored, complying with IEC 605021/2004, IS 6947098 P-1.
- B. Sizes of conduits, number/ type/size of wires and loop earthing shall be as stipulated in the schedule of quantities and/or drawings. Wires shall be drawn in the concealed or surface conduits as required, without being damaged. For this purpose, draw boxes shall be located at convenient locations.
- C. Every point wiring shall run in an independent conduit or otherwise specified by Employer/Engineer with an independent earth wire of PVC insulated stranded copper wire as specified running along the entire run of conduit. For single phase, one earth wire shall run and for three phase two earth wires shall run or as specified. Necessary provision of wire lengths entering and emerging from the conduit shall be made for connections.
- D. Designed life for wire should be minimum 10 years. The warranty for wires by the manufacturer shall be for a minimum of 60 months from the date of supply. Contractor will be responsible for any consequence related to replacement / reinstallation of cables within the warranty period if wires are not found in line with the requirements and Employer will not be responsible for such losses to the Contractor.
- E. The FRLSZH wires shall conform to BS EN 50525-3-31, for all internal wiring FRLSZH insulated cables of 600/1100 V grade, single core shall be used. Special Grade of 90°C High Temperature FRLSZH Thermoplastic Compound shall be used for insulation.
- F. The copper conductors shall be of Plain Annealed EC Grade, circular stranded and flexible conforming to Class V of BS EN 60228. The Geometrical Cross-sectional area of the conductor shall be better and propositional to the specified cross-sectional area with a tolerance of - 3%. This tolerance should be calculated only on the cross-sectional area of the conductor and not on the maximum conductor resistance requirement as per BS EN-60228.
- G. FRLS-ZH Insulated wires should have Anti Rodent and Anti Termite and UV Properties. Wires shall meet minimum test requirements for Oxygen Index test value of 32% and minimum Temperature



Index test value at 325°C. All tests procedure needs to be carried out as per ASTM D 2863-13 Smoke Density test, where the test requirement should not exceed above 10%. HCL Value should be within 0.2%. All the above tests will be carried out on the finished wires.

- H. As a special requirement, the wires should meet NES 713 Toxicity of Combustion gases test. The toxicity Index for the cables shall be less than 3.
- I. By using the formula which is related to specific resistivity, the manufacturer has to prove that the wires are not only meeting the requirements but also the resistance of copper conductor is better and lower than the maximum specified in BS EN 60228.
- J. FRLSZH wires meeting only the conductor resistance values of BS EN 60228 and not meeting the Geometrical cross-sectional area with tolerance will not be accepted. Tests will be carried out on Conductor Resistance properties on 1-meter samples drawn from the inspection lots. Conductor Resistance on Full Coil will be considered only for reference.
- K. **Conductor resistance and cross-sectional area calculation.**  
 Copper Conductor of 2.5mm<sup>2</sup> - 50 Strands of 0.253 Dia of each Strand.  
 Geometrical Cross-Sectional Area =  $(\pi) \times n \times d^2/4$   
 $3.142857 \times 50 \times (0.253 \times 0.253) / 4 = 2.5\text{mm}^2$   
 Tolerance on cross sectional Area = - 3% = 2.42 mm<sup>2</sup>  
 The specific Resistivity of Copper = Rho ( $\rho$ ) = 17.24  
 The D.C. Resistance for the Geometrical cross section of 2.5mm<sup>2</sup> on Minus 3% is 2.42 mm<sup>2</sup>  
 Formula -  $R = \rho / A = (17.24 / 2.42) = 7.12 \text{ } \Omega/\text{km}$  so 7.12/1000 meter = 0.00712  $\Omega/\text{m}$   
**So, the required Conductor Resistance Range for 2.5 Sq.mm will not be more than 7.12  $\Omega/\text{km}$ . Similar calculations has to be made by the manufacturer for other sizes of wires and cables.**

### 5.3 Inspection, Checks and Tests

- A. Prototype tests on electrical wire shall be submitted by the vendor seeking approval. Factory acceptance tests for wire shall be carried out by Contractor along with witness by Employer/Engineer.
- B. Checks before energization: On completion of works, the following checks shall be made before energization.
- C. A general inspection shall be carried out by the Engineer / Employer to verify that all works or parts thereof to be energized have been completed with high degree workmanship and all provisions of IE Rules-1956 (amended up-to-date) have been complied with.
- D. A check shall be made that all the equipment, fittings, accessories, cables, wires and materials are of adequate rating and conform to respective Indian Standards.
- E. A check shall be made for adequacy of earth connections and for compliance of the lightning protective system as per IS: 62305.
- F. Pre-commissioning tests – The following tests shall be carried out before putting the installation into service.
- G. Insulation resistance – The insulation resistance of the installation shall be tested. This shall not be less than 50 divided by the number of points in the circuit in mega ohms.
- H. 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
- I. 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 labeled or marked for connection to an outer or phase conductor or to the non-earthed conductor of the supply. In 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.
- J. Earth continuity – The earth continuity of various circuits shall be checked along with Earth resistance and electrical continuity of lightning protective system.
- K. Installation test of conduit wiring shall be carried out by Contractor along with witness by Employer/Engineer during the process of installation and completion of the installation as per the proforma given at annexure B as stipulated in special conditions of contract.

- L. 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.
- M. 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 particulars. Any test certificates etc., required by the local Inspectors Or any other Authorities 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 installation
- N. Lighting installation – The lighting installation shall be tested as per approved schedule and the instructions of the Engineer. The tests shall include but not be limited to the following:
- O. Insulation resistance of each circuit shall be measured without the lamps being in place. It should not be less than value specified in clause G above.
- P. Current and voltage of all the lighting circuits shall be measured at the sub-distribution board with all the lamps switched on to ensure that these are within designed values and in case of 3-phase circuits, the load shall be balanced, if required.
- Q. 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 Employer/Engineer for approval before final commissioning.
- R. 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.
- S. Before commissioning standby supply, its phase sequence should be tested to ensure correct phase sequencing (from main & standby sources in all possible combinations).

#### 5.4 **Conduiting and Accessories Only**

##### 5.5 **Scope**

- A. The scope of work shall cover supply and installation of conduiting and conduit junction boxes and accessories with pull wires (fish wires)
- B. The various systems and the complete wiring will be by others. These are public address telephone, signal and telecoms, CCTV, master & slave clock, data communications, signage, AFC, SCADA, Lift and Escalators, etc.

##### 5.6 **Conduits**

- A. Conduits shall be heavy gauge galvanized and shall generally be as specified under section "Conduit wiring".

##### 5.7 **Cables and Wires**

- A. The type of cables and the services shall be as follows: (By others)

##### 5.8 **Indoor**

- A. Laid on wall or cable tray – Multipair, PVC insulated & armoured and sheathed and of specified number of pairs.
- B. Inside conduit – Twin core or 1 pair PVC insulated wire of specified diameter of conductor, data communication wires, music system wires etc.
- C. Outdoor – Multipair PVC insulated jelly filled and armoured and with wires of specified diameter of conductor (by others).
- D. All Multipair cables and wires shall have tinned copper conductor and with wires of specified diameter and shall be colour coded in twisted pairs and with a rip cord (by others)

##### 5.9 **Tag Blocks**

- A. The telephone tag blocks shall be KRONE or equivalent suitable for the multicore telephone cables and shall accommodate tin-plated phosphor bronze connectors providing economical and reliable splicing. Connectors shall be spliced un-skinned cables up to 0.6mm diameter and shall terminate both "in" & "out" lines.
- B. The tag blocks shall be mounted inside fabricated galvanized sheet steel boxes with removable hinged covers and shall be fully accessible. The enclosure shall be powder coated.

##### 5.10 **Installation of Conduits and Accessories**

- A. The installation of conduits shall generally be as specified under section "Conduit Wiring".

- B. The final branch connections with single pair cables by others shall be in conduits and the maximum number of cables in each conduits shall be as per section 4 of IS 732: 1989. The contractor shall request for all necessary inputs on wiring and location of various systems before taking up conduiting works and prepare working drawings for approval.

| <b>Annexure A: Acceptance Test Report</b><br>(Format will be reviewed and approved by Engineer at the time of Conducting test) |   |                   |   |   |                 |
|--|---|-------------------|---|---|-----------------|
| <b>Customer Name:</b>  |   |                   |   |   |                 |
| <b>P.O. No. &amp; Date:</b>  |   |                   |   |   |                 |
| <b>Description:</b>  |   |                   |   |   |                 |
| Specification: Relevant IS to mention 'IS 694:2010 & Data Sheet  |   |                   | Specified Values  | Type Test Values  | Observed Values |
| S. 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 20 °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                |   |   |                 |
|  | Test on insulation (as per IS-5831-1984)          |                   |   |   |                 |
|  | Type of Compound                                  |                   |   |   |                 |
| 7  | i) a) Volume resistivity (at 27 °C)               | Ohm cm            |   |   |                 |
|  | Volume resistivity (at 90 °C)                     | Ohm cm            |   |   |                 |
|  | ii) a) Tensile strength (Before ageing)           | N/mm <sup>2</sup> |   |   |                 |
|  | b) Elongation at break (Before ageing)            | %                 |   |   |                 |
|  | Test on Outer Sheath (as per IS- 5831-1984)       | -                 |   |   |                 |
|  | Type of compound                                  |                   |   |   |                 |
| 8  | i) a) Tensile strength (Before ageing)            | N/mm <sup>2</sup> |   |   |                 |
|  | b) Elongation at break (Before ageing)            | %                 |   |   |                 |
| 9  | Routine High Voltage test at R. temp.             |                   |   |   |                 |

|                     |   |   |              |  |                            |
|---------------------|---|---|--------------|--|----------------------------|
| <b>10</b>           | <b>FR Test</b>                              | - |              |  |                            |
|                     | i) Oxygen Index Test                        |   |              |  |                            |
|                     | ii) Temperature Index Test                  | - |              |  |                            |
| <b>11</b>           | <b>Flammability test</b>                    |   |              |  |                            |
|                     | i) As per IS 10810 (Pt 53)                  |   |              |  |                            |
|                     | ii) Time of burning after removal the flame |   |              |  |                            |
| Date and Signature: |   |   |              |  |                            |
|                     | (Manufacturer)                              |   | (Contractor) |  | K-RIDE Inspecting officer) |

**Annexure B: CHECK LIST**

| S. NO.  | DESCRIPTION  | REMARKS |
|---|--|---------|
| <b>Checks to be done before Drawing of Wire in Conduits as per the Specification for supply &amp; installation of conduits, associated fittings &amp; accessories Specification</b> |  |         |
| 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  |         |
| 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 or via boxes  |         |
| 10  | Check the joints and terminations of the conduits, conduit-threads must not be exposed and if unavoidable then must be treated   |         |
| 11  | Check the conduit bends as per approval given by the Engineer at site.   |         |
| <b>In Recessed Conduit and Outlet Boxes</b>   |  |         |
| 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 1m.   |         |
| 14  | Check the space between the concealed conduits entering the draw-in box must be minimum 25mm   |         |
|   | <b>In Case Of Conduit Recessed In Brick</b>  |         |
| 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   |         |
| 16  | Check the Heavy-duty pressed steel clamps screwed to MS flat strip saddled at maximum 600mm must be provided where chase has been cut for conduiting                                   |         |
| 17  | Ensure Galvanized Chicken wire mesh of 0.6mm thick with 10 to 15 mm aperture must be provided for full length of the chase in the plaster  |         |
| 18  | Ensure that all boxes for accessories and draw/junction boxes must have outer rim flushed in the finished surface, in case of concealed conduits                                       |         |
| <b>In Case of Surface Conduiting</b>  |  |         |
| 19  | Check for indicative make spacer saddle at an interval not exceeding 600 mm and 300 mm from the fittings.  |         |
| 20  | Good quality of workmanship must be ensured in case of surface conduiting  |         |
| 21  | 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.                                      |         |
| 22  | 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. |         |
| 23  | Check entire conduit system including outlets and boxes must be thoroughly cleaned after completion of erection and before drawing of wires.   |         |

|  |   |  |
|--|---|--|
| 24   | Check loop earthing is provided by means of insulated stranded copper conductor wires of sizes as per BOQ laid along with wiring inside the conduits for all wiring outlets.  |  |
| <b>Checks to be done after Drawing of Wire in Conduits as per the Specification for Conduit Wiring of Elevated &amp; At Grade Stations</b> |   |  |
| 25   | Check the phase and neutral must be drawn in the same conduit.  |  |
| 26   | Ensure two different phases must not run in same conduit.   |  |
| 27   | 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.   |  |
| 28   | Check all bolted terminals, brass approved flat washer of large area must be used.  |  |
| 29   | Check that good quality heat shrinkable sleeves are used at the terminations.   |  |
| 30   | Check the switches controlling lights, fans, socket outlets etc. must be connected to the phase wire of circuit only.   |  |
| 31   | 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.   |  |
| 32   | 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)   |  |
| 33   | 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 3 phase 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 &amp; Sign

(Contractor)

K-RIDE representative)



## SECTION: E.06 INDOOR LIGHTING & FANS

### 6.1 Scope

The scope of work shall cover the supply, installation and testing, and commissioning of lighting system comprising light fittings (LED), Driver, control gear, fixing arrangement, fans (ceiling & exhaust), sockets etc. as specified.

### 6.2 Standards

The following standards and rules shall be applicable:

|                       |  |
|-----------------------|--|
| NBC 2016 INDIA VOL 2  | Code of practice for interior Illumination   |
| IS 3646 (All 3 parts) | Code of practice for interior Illumination   |
| IS 1913 – 1978        | General and safety requirements for luminaires: Part 1 Tubular fluorescent lamps   |
| IS 1777 – 1978        | Industrial luminaire with metal reflectors   |
| IS 374 – 1979         | Electric ceiling type fans and regulators  |
| IS 10322 (All Parts)  | Specification for Luminaires   |
| LM-79                 | Preforming measurement of LEDs   |
| IS: 16107-1 & 2       | General and particular requirements of LED luminaire performance.<br>Method of Electrical and photometric performance measurements of LED products   |
| IS: 16106             | (Performance requirements for DC or AC supplied electronic control gear for LED modules)   |
| IEC: 62384            | EMC Tests for drivers as per IEC61547, CISPR15, IEC61000-3-2 & Safety tests (LED Module luminaire & driver): IEC 62031, 61347-2-13 (Particular requirements of electronic control gear) and 60598-1. |
| IEC 62471             | Indian Electricity Act and Rules issued there under<br>Standard for Eye and Skin /Photobiological Safety.  |
| IEC 62031             | Safety Standard for LED Module.  |
| IEC 61347-2-13        | Standard for Led Drivers.  |
| IEC62560              | Standard for Self-Ballasted LED Lamps  |
| IEC 60838-2-2         | Standard for Particular Requirement on LED Connectors  |
| IEC 61000-3-2         | Electromagnetic compatibility (EMC)  |
| 61547-2-13            | Specifies particular safety requirements for electronic control gear for use on d.c. or a.c. supplies up to 1000 V   |

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.

Test reports shall be provided from a NABL accredited Laboratory adhering to all the relevant portions of the above standards and the general as well as BOQ specifications.

Manufacturer should have LM-80 report and IS file of the luminaries to be supplied for different applications areas. Manufacturer has to submit the test report along with relevant documents

### 6.3 General Requirements

- A. Generally, all the lighting fixture shall be supplied with 240V, 1 phase, 50 Hz power supply. The lighting system will be designed to achieve bright and aesthetic look, avoid any dark patches, afford easy access to all other areas and will be sufficient to avoid any unsafe situation. 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 lux level (Table is for reference) with dial Lux of latest software as approved by Engineer. **Contractor shall submit the proposal of Light Fixture to be installed in all rooms and area for Employer/Engineer review and approval.**





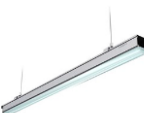



| S. NO. | ACTIVITY AREA                                  | ILLUMINATION |                 |
|--------|--|--------------|-----------------|
|        |  | NORMAL (LUX) | EMERGENCY (LUX) |
| 1      | Circulating area/Parking Area                  | 30-50        | 5 – 8           |
| 2      | Entrance hall                                  | 200          | 5 – 50          |
| 3      | Concourse                                      | 200          | 5 – 50          |
| 4      | Station Manager Room                           | 300          | 5 - 50          |
| 5      | EFO  | 300          | 25 - 50         |
| 6      | First Aid Room                                 | 300          | 5 - 50          |
| 7      | Security room                                  | 300          | 5-25            |
| 8      | Store Room                                     | 100          | 5 – 22.5        |
| 9      | Cleaner Room                                   | 150          | 5 – 25          |
| 10     | Refuse Store                                   | 100          | 5 – 22.5        |
| 11     | Staff and Locker Room                          | 150          | 5 – 25          |
| 12     | Toilets  | 150          | 5 – 25          |
| 13     | Staff Mess Room                                | 150          | 50              |
| 14     | Train Crew Room                                | 150          | 50              |
| 15     | Pump Room & Water Tank                         | 200          | 5-25            |
| 16     | Ticketing office/Cash & ticket supervisor Room | 300          | 5 - 50          |
| 17     | Passenger staircase / subway                   | 150          | 50              |
| 19     | Escalators                                     | 200          | 50              |
| 20     | Platform Supervisor Booth                      | 200          | 5-30            |
| 21     | Platforms (General)                            | 200          | 5-30            |
| 22     | Platforms (Edge)                               | 250          | 5 – 30          |
| 23     | Station Control room                           | 300          | 5-50            |


| S. NO.   | ACTIVITY AREA                     | ILLUMINATION |                 |
|--|-----------------------------------|--------------|-----------------|
|  |                                   | NORMAL (LUX) | EMERGENCY (LUX) |
| 24   | Signalling and PSD Equipment Room | 300          | 5-50            |
| 25   | Telecom Equipment Room            | 300          | 5-50            |
| 26   | S & T UPS Battery Room            | 300          | 25-50           |
| 27   | ASS                               | 200          | 25-50           |
| 28   | Station UPS/Battery Room          | 200          | 25-50           |
| 29   | DG set                            | 200          | 5-25            |
| Service illumination will be working condition level |                                   |              |                 |

All fixtures shall be complete with accessories and fixings 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. Fixtures shall be installed at mounting heights as detailed on the drawings or instructed on site by the Employer/Engineer.
- D. Fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the fixture tightly 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 herein specified shall be submitted to the Employer/Engineer for approval.
- E. Pendant fixtures within the same room or area shall be installed plumb and at a uniform height from the finished floor. Adjustment of height shall be made during installation as per Employer/Engineer.
- F. Flush mounted and recessed fixtures shall be installed so as 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 Lighting Fixtures, unless otherwise specified. Fixtures shall bear manufacturer's name and the factory inspection label unless otherwise approved.
- H. Fixture with visible frames shall have concealed hinges and catches. Pendant fixtures and lamp holders shall be provided with ball type aligners or similar approved means. Recessed fixtures shall be constructed so as to fit into an acoustic tile ceiling or plaster ceiling plaster rings/flanges shall be provided for plaster ceiling. Fixtures with hinged diffuser doors wiring all be provided with spring clips or other retaining device to prevent the diffuser from moving.
- I. Detailed catalogue for all fixtures, or, if so, required by the Employer/Engineer sample fixtures shall be submitted for approval to the Employer/Engineer before orders for the fixtures are placed. Shop drawings for non-standard fixture types shall be submitted for approval to the Employer/Engineer.
- J. Emergency lighting will be installed to ensure that all the escape routes, including walkway, from various areas can be safely and effectively identified in an emergency situation.
- K. Emergency lighting: 25% lighting shall be supplied from UPS, designed to meet the requirements of illumination
- L. All Large areas in station areas shall be sub-divided so the alternative luminaires are fed and switched on separate circuit to allow reducing lighting level and cater for local system failure.

M. Luminaires and accessories - The luminaires and accessories shall be as specified on drawings. However, a brief description of various type of fittings and there purpose is being given for the purpose of general understanding:

| Description of Light Fixtures  | Image   | Efficacy of LED Lighting | Area of Uses   |
|--|---|--------------------------|--|
| Recessed mounted 2' x 2' LED Luminaire, Luminaire should be with minimum system efficacy of 115 lm/Watt and minimum system lumen output of 3600lm. Similar to Philips <b>Full Glow LED</b> or equivalent make.     |    | 115 lm / watt            | 1) SCR, TER, SMR, and UPS. Presently Surface/suspended 4' length LED batten is suggested which doesn't give aesthetic look.<br>2) Motion sensor lighting in station area, concourse, and platform area.<br>3) Vertical gardening |
| Surface/suspended LED Luminaire, Luminaire should be with minimum system efficacy of 105 lm/Watt and minimum system lumen output of 2600lm. Similar to Philips <b>Pure line Slim LED</b> or equivalent make.       |   | 105 lm / watt            | Paid/Unpaid and Services Rooms Areas / Corridor  |
| Recessed mounted LED Down lighter, Luminaire should be with minimum system efficacy of 110 and minimum system lumen output of 2000. Similar to Philips Green Perform.  |  | 110 lm/watt              | Toilets/Corridor   |
| LED Bulkhead Luminaire, Luminaire should be with minimum system efficacy of 100lm/Watt and minimum system lumen output of 1000. Similar to Philips <b>Endura LED Bulkhead</b> or equivalent make.                  |  | 100 lm / watt            | Shaft, Utility Building  |
| Trunking LED, Luminaire should be with minimum system efficacy of 110 and minimum system lumen output of 4000. Similar to Philips <b>Optimus LED Trunking</b> .  |  | 110 lm / watt            | Platform Edge  |
| LED Luminaire, Luminaire should be with minimum system efficacy of >90 lm/Watt and minimum system lumen output of 5600. Similar to Philips <b>Claria</b> or equivalent make.                                       |  | >90 lm / watt            | Double Height Area   |
| LED Luminaire, Luminaire should be with minimum system efficacy of >90 lm/Watt and minimum system lumen output of 3300. Similar to Philips <b>Claria</b> or equivalent make.                                       |  | >90 lm / watt            | Ground Floor Entry   |
| Surface/suspended 4' length LED batten, Luminaire should be with minimum system efficacy of 120 lm/Watt and minimum system lumen output of 2000lm. Similar to Philips <b>Endura LED Batten</b> or equivalent make. |  | 120 lm / watt            | Emergency Staircase  |

| Description of Light Fixtures  | Image   | Efficacy of LED Lighting | Area of Uses   |
|--|---|--------------------------|--|
| Surface/suspended 4' length LED batten, Luminaire should be with minimum system efficacy of 120 lm/Watt and minimum system lumen output of 4000lm. Similar to Philips <b>Endura LED Batten</b> or equivalent make. |  | 120 lm / watt            | ASS ROOM, MESH ROOM, SECURITY ROOM, EL UPS ROOM, CORRIDOR, STORE |

| No. | LED FIXTURE DESCRIPTION                          | Proposed for   |
|-----|--|--|
| 1   | LED trunking system or equivalent                | Staircases, Corridor   |
| 2   | LED Batten surface mounted fixture or equivalent | Non false ceiling equipment rooms  |
| 3   | LED 2x2 recessed fixture or equivalent           | False ceiling equipment rooms& office area                                     |
| 4   | LED Bulkhead or equivalent                       | General purpose as required  |
| 5   | LED Down lighter or equivalent                   | Toilet Area  |
| 6   | Low wattage flood light or equivalent            | Road Level, Escalators   |
| 7   | Street light or equivalent                       | Road Level   |
| 8   | LED Linear fixture (Trunking) or equivalent      | Platform Edge, Platform (General), Concourse Public Area, Staircases, Corridor |

6.4

**Type of Light Fixture**

Actual make shall be as per Client approved vendor list

6.5

**L.E.D. Luminaire**

- A. 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 luminaire. In addition to the above luminaire shall adhere to and manufacturer should submit certifications relevant BIS standards IS 15885, 16101, 16102, 16103, 16104, 16105, 16106, 16107 (Part I & II) 16108 as per the application. The product supplier shall have proven design capabilities and should provide type test certificate / performance certificate from an NABL accredited laboratory. The product and its major components shall be state of art and of proven design.
- B. Information shall be marked on durable adhesive sticker as per IS code: Manufacturer name/ Manufacturing year and month/wattage /Lumen /Efficacy/ Type of fitting/IP/IK/ambient temp/CCT/CRI.
- C. Each luminaire and driver should be BIS certified and related "R" Number of BIS should be printed on the Luminaire/ driver.
- D. The KW loading and LPD (Light Power Density) in W/m<sup>2</sup> shall comply with the latest NBC/ECBC requirements.
- E. The tolerances in the wattage/efficacy/harmonics and other parameters shall be as per the latest IEC/IS.
- F. **Fixture**
  - i. The fixture shall be surface suspended or recessed type depending on the application area
  - ii. The fixture shall be suitable to work under following ambient conditions.
  - iii. Maximum ambient temperature of 50° C.
  - iv. Atmosphere – The outdoor product shall be designed to work in humid and corrosive atmosphere.
  - v. The fixture shall be tested under following ambient conditions conforming to relevant standards.

- vi. Indoor Luminaires tested under Temp – 45 °C
- vii. Outdoor Luminaires tested under Temp – 35°C
- viii. The Life Class of the fixture should be minimum of 50,000 hours @L70 and 50,000 hours @L70.

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.

Heat sink used should be extruded Aluminium or Pressure Die-Cast Aluminium having high conductivity preferably ADC 12 or LM 6.

Indoor luminaire should be covered with suitable Glass or diffuser with High Transitivity. Outdoor luminaire 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 and for Linear fixture used be at least IP-54 for the semi-indoor areas. However, down lighter and other internal fixture shall be provided with at least IP-20 protection or as specified in BOQ.

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.

- i. The luminaries shall have a high quality clear toughened glass or non-yellowish polycarbonate or PMMA diffuser with diffused reflection having a transmissivity of 85% with fire retardant feature
- ii. The Outdoor fixture shall be suitable to work in diverse atmospheric condition like humidity, dust, corrosive etc. The power factor of the overall system shall be >0.9.
- iii. All the Outdoor/High Bay luminaires should have potted driver
- iv. Provision shall be made for main connection preferably directly at the back of housing.
- v. The internal wiring of the fixture shall be of FRLSZH type, Copper conductor.
- vi. All screws should be SS 304 or higher grade.
- vii. Each fixture shall be provided with cable having FRLSZH, PVC insulated, PVC sheathed, minimum 1.5sqmm, 3 Core, Cu. Conductor with suitable gland and terminations.
- viii. SMD chip shall be in single length (PCB) for 4' fixtures. The solder shall be ROHS compatible for environment friendly. LED / LED PCB shall be mechanically fixed (not to be glue fixed).
- ix. Additional Reports to be submitted by the manufacturer, the reports have to be from NABL accredited third party lab/UL
- x. The luminaire should be tested as per IS 10322/IEC 60598 standards and following test reports should be submitted: Heat Resistance Test, Thermal Test, Ingress Protection Test, Electrical / Insulation Resistance Test, Endurance Test, Humidity Test.
- xi. Should be compliant to LM-79-8/IS 16106: approved method for the Electrical and Photometric Measurements of Solid-State Lighting Products LM-79 testing of the complete luminaire
- xii. Should be compliant to LM-80 IESNA: Approved Method for Measuring Lumen Maintenance of LED Light Sources and LED lumen depreciation time to L70 based on LM-80 data to estimate lifetime based on performance data collected from IESNA LM-80.

#### G. LED

##### i. General

- a. The scope of work shall cover the supply, installation and testing and commissioning of the lighting system. Relevant codes and standards up to latest revision shall be applicable. This specification covers the LED lighting that shall be used for general lighting.
- b. The lumen maintenance of the LED fittings (of the system not chip) shall not be less than 70% after 50000hrs i.e. [L70].
- c. The luminaries shall comply L-70 standards and the required illumination shall be maintained till the end of contract period.



- d. The product shall be of proven design, shall have type test certificate/performance certificate from the accredited laboratory.
- e. The lighting fixtures and accessories shall give continuous trouble-free operation and the material should not deteriorate with time.
- f. Luminaire shall have a warranty of 5 years after the delivery and the warranty will be seen in-line with L-70 and other standards, failing to meet the required lux level as mentioned in addition to complete failure of the fixture.
- g. Lighting layout with selection of approved light fittings to be submitted by the bidder/contractor for review by K-RIDE and based on the final layout dialux reports (with all parameters) to be submitted for the confirmation of the design meeting the lux level given in the lux chart. The lighting design shall also meet the best level of uniformity ratio.
- h. The KW loading and LPD (Light Power Density) in W/m<sup>2</sup> shall comply with the latest NBC/ECBC requirements.
- i. The tolerances in the wattage/efficacy/harmonics and other parameters shall be as per the latest IEC/IS.
- j. The light fittings or its paint shall not emit toxic/corrosive gases in case of fire and shall be non-combustible and fire-resistant type.
- k. The emergency lighting installation shall fully comply with NBC or other relevant safety standards.
- l. 25% of the total lights distributed uniformly shall be connected to emergency source i.e., UPS/DG.
- m. Luminaire shall be embossed with following legends:  
Type of fitting /Manufacturer name /Manufacturing year /wattage /Lumen /Efficacy

#### H. LED Standards

- i. The luminaries shall have conformation standard of luminaries as per IEC 60598/10322 and shall have electrical safety as per IEC 61000, 61547-2-13, 61347, 62471, 60958, 62560, 60838-2-2 and it.
- ii. IEC 62471-Standard for Eye and Skin /Photo biological Safety.
- iii. IEC 62031-Safety Standard for LED Module.
- iv. IEC 61347-2-13-Standard for Led Drivers.
- v. IEC62560-Stanadard for Self-Ballasted LED Lamps.
- vi. IEC 60838-2-2-Stanadard for Particular Requirement on LED Connectors.
- vii. EC DIRECTIVE 2002/95/EC and Related Commission.IEC61000-3-2" Electromagnetic compatibility (EMC)-part3-2: limits-limits for harmonic current emissions (equipment input current ≤ 16 a per phase)" is an international standard concerning the harmonics emitted by electric equipment.
- viii. 61547-2-13 "Specifies particular safety requirements for electronic control gear for use on d.c. or a.c. supplies upto1000V(a.c.at50Hzor60Hz) and at an output frequency which can deviate from the supply frequency, associated with LED modules.
- ix. CISPR15.Limits and Methods of Measurement of Radio Disturbance Characteristics Of Electrical Lighting And Similar Equipment
- x. IEC 61000-4-11.
- xi. LED Characteristics standards- LM79, LM-80 L-70 B-50TM-21.
- xii. IS 1239: Part 1: 2004S Steel Tubes, Tubulars and Other Wrought Steel Fittings - Specification - Part 1: Steel Tubes.
- xiii. IS 1239 : Part 2 : 1992 Mild steel tubes, tubulars and other wrought steel fittings, Part 2 Mild steel tubulars and other wrought steel pipefittings
- xiv. All codes and standards mean the latest. Where not specified otherwise the installation and requirements shall generally follow the Indian standards codes of practice or the relevant British Standard codes of Practice in the absence of standards.

#### I. LED Make And Specs

- 1. The indicative makes for the LED chips are as per Vendor list provided
- 2. Manufacturer should have LM-80 report and IS file of the luminaries to be supplied for

different applications areas.

3. Manufacturer has to submit the test report along with relevant documents.

**J. LED Chip Specification**

- i. LED efficacy at the chip level shall be  $> 120$  lumen/watt.
- ii. The system luminous efficacy (Actual lumen coming out of LED Luminaries) of the led luminaries (of the system) shall be as under
  - a. For Down lighter =  $\text{min} 100 \text{ Lm/W}$ .
  - b. For Platform edge type fittings =  $110 \text{ Lm/W}$
  - c. For any Tube or Module/Panel type Fixture =  $\text{min} 100 \text{ Lm/W}$ .
  - d. For Highbay/Flood Light/Pole Light/or any External lighting =  $\text{Min} 120 \text{ Lm/W}$ .
- iii. The minimum view angle of the LED shall not be less than  $120^\circ$ .
- iv. The product shall be available in the colour temperature range of  $4000\text{K}$ - $6000\text{K}$ .
- v. It shall have an SDCM (standard deviation in colour maintenance) of  $< 5$ .
- vi. The LED efficiency shall be more than  $85\%$  at a junction temperature of  $85^\circ\text{C}$ .
- vii. It shall have CRI  $> 80$  for indoor except tunnel, flood light and high bay and CRI  $> 70$  for outdoor applications.

**K. Led Driver and Control Circuit Specification**

- i. The led driver shall be constant current type.
- ii. The driver shall be able to withstand surge (EFT+ESD interference) of minimum  $4 \text{ KV}$  with a rise time of  $20$  nanoseconds. Luminaire with wattage  $> 50\text{w}$  and all external luminaire shall have surge protection devices of  $\text{min} 8 \text{ KV}$ .
- iii. The driver shall have under voltage, over voltage, short circuit and earth fault protection.
- iv. Output over voltage protection of  $125 \text{ VDC}$ .
- v. The high voltage test shall be done on the drivers as per the latest standards.
- vi. Output voltage ripple shall be within  $3\%$ .
- vii. Total harmonic distortion shall be  $< 15\%$ .
- viii. The LED driver should comply to CISPR 15 for limits and method of measurement of Radio Interference Characteristics.
- ix. The control gear shall be compliant to IEC 61347-2-13, IEC 62384.
- x. The driver shall have an efficiency  $> 85\%$ .
- xi. It shall have a power factor  $> .9$ .
- xii. It should give consistent performance in the input voltage range of  $165\text{V}$ - $270\text{V}$  at  $50\text{Hz}$ .
- xiii. The Current Waveform Shall Compliant To EN61000-3-2
- xiv. The equipment shall comply with IEC 61547 for EMC immunity requirements.
- xv. The control gear shall be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384.
- xvi. The Output Voltage of the Driver shall be designed to Meet the Power requirement of the System.

**L. Light Fixture Specs.**

- i. The fixture shall be surface suspended or recessed type depending on the application area.
- ii. The housing shall be made of Extruded aluminium/Pressure Die cast aluminium (PDCA)  $1.5\text{mm}$  thick CRCA conforming to relevant standards and shall have U.V. and corrosion resistance protection.
- iii. The luminaries shall have a high quality clear toughened glass or non-yellowish polycarbonate or PMMA diffuser with diffused reflection having a minimum transmittivity of  $85\%$ .
  - a. For the outdoor applications it shall have a clear toughened glass or clear U.V. stabilized polycarbonate cover.
- iv. It shall have a proper thermal management to dissipate heat. The heat sink should be made of extruded aluminium/latest trends as applicable having high conductivity.
- v. Reflector (if) shall be a high-quality aluminium reflector and shall have efficiency more than  $85\%$  to achieve a wide light distribution. The anodic film shall have a minimum thickness of

2.5micron.

- vi. The fixture shall be suitable to work in diverse atmospheric condition like humid, dust, corrosive etc.
- vii. The fixture shall have a minimum ingress (IP) and impact protection (IK) rating depending upon the area of application.
- viii. The power factor of the overall system shall be >.9.
- ix. The fixture shall be provided with separate wiring channel with cover plate and earth terminal.
- x. Provision shall be made for main connection directly at the back of housing.
- xi. The internal wiring of the fixture shall be of LSH type.

**M. Platform/Subway/Stairs/ Entrances**

- i. It shall have IP 54 protection or as specified in the BOQ.
- ii. It shall have impact protection of rating min 06 i.e., IK-06.
- iii. It shall have adjustable height arrangement provision and shall have easy installation and alignment feature.

**N. Enclosed Concourse/indoor/BOH**

- i. It shall have a minimum IP-20 protection.

**O. External/Pole/ High Bay lighting**

- i. It shall have minimum of IP-65 protection.
- ii. It shall have impact protection of rating min 05 i.e., IK-05.
- iii. It shall have a UV stabilized clear polycarbonate cover or clear toughened glass.

6.6

**Ceiling /Wall Fans & Exhaust Fans**

- A. Ceiling fans shall be of 1400 mm sweep conforming to IS:374-1979 complete with fan suspension stem, canopies and regulators. 30-cm suspension stem shall be standard accessory and stems shall be heavy-duty steel tubes to IS1239-2004. The stem shall be painted with enamelled paint. The fan shall have a junction box with MS hook of minimum size 150-mm diameter fixed in recess of ceiling and covered with sun-mica sheet of minimum 3-mm thickness. The fan clamp shall be fabricated from new metal and shall be as close fitting as possible. The suspension rod shall be seamless steel tube.
- B. Wall/bracket fans shall be propeller type with low noise levels and of diameters specified. Fans shall be mounted on a pre-embedded hook with hard rubber isolator. Regulators shall be no-step type mounted in the switch box. The box in all such cases shall be large enough to accommodate the regulator and switches. One sample box with top cover shall be got approved before procurement. Man, coolers of suitable size & sweep as specified, 1440 rpm, suitable for 415 V, 1-phase, Low noise level of 80-90dB or as specified and approved shall be provided at platform & concourse areas.
- C. Exhaust fan – The exhaust fan shall be of size 300/450-mm as specified and required and 900 rpm/1440 rpm and shall conform to IS: 2312-1967 (as reaffirmed in 2005). The fans shall be robust, having double ball bearings and low noise.
- D. Detail of Energy efficient HVLS: High volume and low Speed Fan as defined in BOQ shall be submitted for review and approval of Engineer

6.7

**Inspection & Tests**

Prototype tests/routine tests as required shall be carried out by the contractor.

## SECTION: E.07 EXTERNAL LIGHTING

### 7.1 Scope

The scope of work covers the 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.

### 7.2 Standards

A. The following standards and rules shall be applicable:

|   |   |
|---|---|
|   | General and safety requirements for luminaires: Part 1 Tubular fluorescent lamps  |
| IS: 3528 - 1966                         | Water proof electric lighting fitting   |
| <u>IS 1239 : Part 1 : 2004</u>          | Steel Tubes, Tubulars and Other Wrought Steel Fittings - Specification - Part 1: Steel Tubes                                  |
| <u>IS 1239 : Part 2 : 1992</u>          | Mild steel tubes, tubulars and other wrought steel fittings, Part 2 Mild steel tubulars and other wrought steel pipe fittings |
| <u>IS 10322 : Part 5 : Sec 3 : 1987</u> | Luminaires: Part 5 Particular requirements, Section 3 Luminaires for road and street lighting (superseding IS:2149)           |
| <u>IS 2713 : Parts 1 to 3 : 1980</u>    | Specification for Tubular Steel Poles for Overhead Power Lines  |
| <u>IS 1646 : 1997</u>                   | Code of practice for fire safety of buildings (general): Electrical installations   |
| <u>IS 1255 : 1983</u>                   | 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  |

B. 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.

### 7.3 Street Lighting

A. General - The steel tubular street lighting poles used for lighting of approach roads, traffic lanes and walkways in the circulating area, shall be erected at a distance of 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. Galvanized down pipes/sleeves of suitable diameter shall be embedded in the concrete for the incoming and outgoing feeder cables. Contractor should follow CPWD specification for mounting of MCBs.

B. Lighting Fixture

C. The luminaire should be made of pressure die cast aluminium housing and with toughened glass/PC cover.

D. Luminaire should have a system efficacy (not at chip level) of Minimum 125Lm/Watt.

E. It should have a CCT of 5700K, CRI>70 and THD<5%.

F. The electronic driver should have a power factor >0.9

G. Minimum Life class will be 50000 hrs. @L70B50.

H. The luminaire shall have an Ingress Protection of IP66 (without Glue) and Impact Resistance of minimum IK07.

I. Driver and Luminaire should be of different compartment.

J. Both the Luminaire and Driver should be BIS approved and Related "R" Number of BIS should be printed on both luminaire and Driver.

K. The driver should be fully potted and encapsulated and it should sustain 440V Stress Voltage protection for 8 Hrs.

L. Luminaire should have Minimum 4KV internal surge protection and there should be an additional surge protection device of minimum 10KV inside the driver Compartment.

**7.4 Street Lighting Poles**

- A. The lighting poles shall be octagonal / round type poles as per IS 2713 (PART 2) –1980, hot dip galvanized 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 48 mm diameter bent GI 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 before fabrication.
- B. The octagonal / round poles with single arm shall be made from steel of minimum tensile strength 490 N/mm<sup>2</sup>.
- C. Grade of foundation bolts shall be 6.8 & confirming to IS: 1367 (Part-III) – 2002.
- D. Foundation – adequate size M30 grade RCC foundation with 100mm 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.
- E. The pole shall be provided with a 20mm hole for wiring of street light pole and two nos. 20mm studs are to be welded for earthing.

**7.5 Junction Boxes and Connecting Cable**

- A. Each pole shall be complete with an MS junction box of fitted inside the pole, 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 (IP55) of size 300 x 100 mm. It shall be fitted with 16A 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 4C-mm<sup>2</sup> copper YWY drawn from the junction box to the luminaire terminal.
- B. Pole shall have a concrete coping of 200mm height and 300mm diameter in M30.

**7.6 Cable Laying**

- A. Cabling shall be generally as specified in the section 'CABLING.'
- B. Cables shall be terminated in a 6-way terminal block inside the pole or attached therewith as shown on drawings.
- C. 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.

**7.7 Earthing**

- A. All street light fixtures and poles shall be earthed as specified under section 'EARTHING.' In each pole a through hole of 14mm diameter shall be provided at a height of 300mm 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 7th pole shall be connected to locally provided earth electrode as per approved drawing.

**7.8 Feeder Pillars (As Applicable)**

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

**7.9 Testing And Commissioning**

- A. 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:
- B. Insulation resistance of each circuit shall be measured without the lamps being in place. It should not be less than 500000 ohms to earth.
- C. 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 if required.
- D. Earth continuity shall be checked for all the circuits.
- E. 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.

## 7.10 HIGH MAST

### 1. High Mast

a) Design, manufacture and performance of the masts should conform to:

- British code of practice CP3: Chapter V Part 2: 1972
- Technical Report No. 7: Second Edition, Section 2: 1996 by the Institute of Lighting Engineer
- Statutory rules and regulations as applicable
- The mast section lantern carriage and accessories should be hot dip galvanized as per B.S. 729:1971

b) **Mast Structure**

Masts should be continuously tapered of isogonal (20 sides) having no circumferential welding of any individual sections; capable of sustaining basic wind speed of 180Km/hr with 3 second's gust. Masts sections should be designed 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 1.15 Design Life of Mast structurally suitable for 25 years. The structure should be suitable for wind loading as per IS 875 part 3-1987.

The mast shafts should be manufactured with the best steel grade in compliance with BSEn10025 Fe 510C, having following guaranteed characteristics:

- Minimum yield strength = 335 N/Sq.mm for thickness < 30mm
- Tensile strength ranging from 490 to 630 N/Sq.mm
- Minimum elongation between 3mm to 30mm: 22%

The steel grade for accessories should be in compliance with BSEN 10025 Fe 430A having the following guaranteed characteristics:

- Minimum yield strength = 225 N/Sq.mm for thickness < 30mm
- Tensile strength ranging from 340 to 470 N/Sq.mm
- Minimum elongation between 3mm to 30mm: 26%

c) **Base Flange**

The base flange shall be manufactured from steel plate free from laminations. The base shaft should penetrate the full depth of the base plate and should be welded both above and below. Gussets shall be located between each hole position, for additional strength.

d) **Base Compartment**

i) Access

An access opening to the base compartment should be an aperture of dimensions 240 mm x 740 mm approximately and should be reinforced to maintain the strength of the mast.

ii) Door

The base of the lift-out door should be located on a substantial lug and secured at the top by means of a recessed socket head screw.

iii) Baseboard

Baseboard shall be provided for mounting electrical and control equipment.

- Base plates should be free from lamination and having single flange constructed with holes Jig drilled for anchor bolt passage. The bottom of the base mast section should be securely welded to the base plate by complete penetration.
- Base section should be having a hinged service door. Service door dimensions are 1400 mm x 300mm. It should be weather proof and equipped with a vandal resistant lock.
- Base plate dimensions, thickness and the number of holes to fix Anchor bolts should be determined based on Mast sections thickness. Shape and heights by calculation.

e) **Earthing terminal**

M12 hexagonal head bolt, complete with saddle bracket located on the left of the access opening



of the mast, shall be used as the earthing terminal.

f) **Head frame**

The head frame, designed to be a capping unit of the mast, shall be of welded steel construction and hot dip galvanized after assembly.

The suspension arrangement for the lantern carriage shall be with three wire ropes, running over three pulleys for superior stability.

The four pulleys, three for the hoist rope and one for electrical supply cables shall be in LMG aluminium alloy on stainless steel shafts. Close fitting removable guards shall be provided over the pulleys to ensure correct location of the ropes and cables in their grooves during operation. Additionally, a pair of rollers shall be fitted to guide the electric supply cables towards the centre of the shaft. The whole head frame assembly shall be covered and protected by a spun aluminium canopy, secured to the frame by stainless steel bolts.

g) **Lantern Carriage**

The lantern carriage shall be of mild steel construction and shall be hot dip galvanized after assembly. The carriage shall be in the form of a ring split on one diameter, enabling it to be assembled or removed from the shaft after erection.

The outside base of the ring shall be provided with spigots or supporting brackets, welded to it, depending on the form of lighting required. Guides on the inside of the ring, which engage with the head frame, shall be provided, to ensure that when the carriage is fully home, there is no movement between the carriage and the head frame.

The mast shall be supplied with mounting and dismounting arrangement of lantern carriage guide and latch assembly including double drum winch, reduction gear, 3 phase motor, control box for motor, pendent switch for lowering down / raising up the luminaries carriage ring, 12 core 2.5.Sqmm copper flat cable etc.

h) **Electrical Junction Box**

A cast aluminium junction box, located on the lantern carriage and housing connections to the lanterns, shall be provided. The junction box shall also have provision for connection of the flexible mast electric cable. The junction box shall be of gasketed construction, to ensure complete protection against weather.

i) **Wiring Duct**

A wiring duct shall be provided which should carry electrical wiring from the junction box to the lanterns.

j) **Electrical Cables**

Each high mast shall be provided with one flexible multicore cable. The conductor core shall be insulated with ethylene propylene rubber and the complete cable core shall be sheathed in heavy duty poly chloroprene.

k) **Electrical Disconnect**

An electrical disconnect shall be provided at the base of the mast, comprising socket with coupling ring and threaded plug.

It shall be possible that for lowering the lantern carriage, the electrical cable is disconnected at the base (and connected to the test lead) so that It Is free to travel within the mast and the power supply can be maintained.

l) **Winch**

Each mast shall be provided with double drum winch.

The double drum winch shall have a safe working load of 330 kgs for each drum i.e. 660 kgs for the winch.

The cast iron worm reduction gear boxes shall be provided, which shall be filled with lubricant in the factory and should require no further attention at site. The gears shall have a reduction ration

of 50.1 and provision shall be made for both manual as well as power drive.

To ensure correct rope stacking a minimum one full layer of rope shall remain on the drums, after the lantern carriage has been lowered to its lowest position. The winch shall have safety features including a disc brake and an automatic gravity latch. In normal use the gear box drives shall be linked to rotate both drums from a single drive shaft to raise and lower the lantern carriage. For leveling the lantern carriage, the lower rope drum shall be adjusted independently.

A 16A IP56 rated switch socket outlet for power to the winch shall be provided within the pole.

m) **Stainless Steel Wire Rope**

All wire ropes shall be made from stainless steel, having a tensile strength of 165 kgf/mm. The rope shall have a construction of 6/19 on a PVC core, to combine corrosion resistance with flexibility. The rope of 6 mm diameter shall provide a 330 kgs safe working load at a safety factor of 5:1. Test certificate for the wire rope shall be provided.

n) **Anchor / Foundation Bolts**

Based on structural requirement normally 1.2m length foundation bolts. Anchor plate (for fixing in casing inside) and template (detectable) should be provided. Quantity of bolts based on mast structural requirements.

Anchor bolts should be manufactured from deformed steel reinforcement bars having the following minimum guaranteed characteristics:

- Characteristic Strength = 410 N/Sqmm
- Tensile length = 430 N/Sqm

o) **Lighting Protection and Earthing Terminal**

Hot dip galvanized GI pipe along struts / spikes should be provided to attach on mast head frame (upper side) to provide lightning protection. There should be a provision along mast base plate / base section to fix bolts / nuts for earthing for mast structure lighting protection and for electrical switching cables, provided inside mast.

p) **Luminaries**

The lantern carriage shall be designed for 16 luminaries as follows:

- 16 Nos nonintegrated flood light luminaries' type BGENF 22 R with two nos 400 W SVT/MH (T) lamps.

The quantities of above lighting fixtures may undergo change as per site requirements or any change in design.

## 2. **Essential Spares for a Group of High Masts**

### A. **Power Drive**

The portable electric power drive shall be provided with reversible motor suitable for 240 V operations.

The power drive shall be connected to the winch via a matching coupler. To protect the hoist rope system against overload, the coupler shall incorporate a torque limiting clutch, pre-set at the factory.

A remote-control assembly shall be supplied to allow the power drive to be fixed to the mast and operated from up to 5 m away.

### B. **Test Lead**

Flexible multicore test lead shall be identical to the electric cable specified earlier. The conductor core shall be insulated with ethylene propylene rubber and the complete cable core shall be matching with the main electric cable. Each test lead shall be provided with locking type male plug at one end and female plug at the other end.

### C. **Winch Winding an Adjusting Handle**

For manual operation of the winch drum and for minor adjustment of the lantern carriage, suitable handles shall be supplied.

**3. Street Light Mast Swaged Steel Poles**

"The steel poles generally conform to IS: 2713-(Part I-III) 1980 or latest version and preferably carry IS marking to ensure quality of material.

The steel tubular poles single arm swages type shall be of circular cross section, of size as mentioned in the BOQ. They shall be manufactured out of steel with minimum tensile strength of 410 Mpa (42 Kgf/mm<sup>2</sup>).

Swaged poles shall be made of ERW or seamless tubes of suitable lengths swaged and joined together. Circumferential joints to be avoided in the individual tube lengths of the poles and for welded tubes only one longitudinal seam weld that to staggered at each swaged joints shall be used.

During the hot dip galvanizing process iron and steel components shall be heated and dipped in molten zinc bath, at 450°C. While the steel shall be immersed in the liquid zinc, layer of zinc-iron alloy will be formed on the surface by a process of diffusion, where the steel components shall be withdrawn from the bath, these alloy layers shall be covered with a coating of pure zinc. Zinc to be used shall confirm to minimum Zn 98 grade as per requirement of IS: 209-1992. Minimum weight of zinc coating for mild steel to be accordance with IS: 6745-1972.

**SECTION: E.08 MAINTENANCE FREE EARTHING AND / OR EARTHING****Part-A Maintenance Free Earthing****8.1 Scope**

- A. The scope of work shall cover earthing stations (earth mats and earth electrodes), laying copper/GI earth strips and connecting the power panels, DBs, switch boards and other equipment's such as pumps, PLCs of BMS etc.
- B. The earthing protection is an integral part of any electrical system and is required to:
  - (i) Protect personal and equipment from electrical hazards.
  - (ii) Achieve a reduction in potential to the systems neutrals.
  - (iii) Reduce or eliminate the effects of electrostatic and electromagnetic interference on the Signaling and Telecom equipment arising from auxiliary electrical systems.
- C. There are several types of earthing systems such as Earth Mat, Plate Earthing & Pipe Earthing which could be used in station. The selection of a particular type of earthing system depends upon several factors such as:
  - (i) Availability of Land.
  - (ii) Type of Soil.
    - a. **Normal soil**  
Black cotton soil field, 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).
    - b. **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.
    - c. **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
  - (iii) Resistivity of Soil.
- D. Indian TNS system of earthing as shown on IS: 3043 – 2018 shall be followed for the entire installation under the scope.
- E. All the non-current carrying metal parts of electrical installation shall be earthed properly. All metal conduits, cable trays, trunking, cable sheaths, switchgear, distribution fuse boards, light fittings and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system. All earthing shall be in conformity with Indian Electricity Rules.
- F. The Earthing System shall totally comprise the following:
  - (i) Earth mats and Electrodes as per IEEE 80: 2013 and IS: 3043 - 2018
  - (ii) Earthing Leads
  - (iii) Earth Conductors
  - (iv) Residual current earth leakage circuit breakers where applicable as per IE rules 61A
- G. All three-phase equipment shall have two separate and distinct body earths and single-phase equipment shall have a single body earth.
- H. Earthing of transformer neutral, DG set, S&T equipment's (clean earth electrodes only), BMS equipment, other items shall be carried out as per drawings.
- I. 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.

**8.2 Standards**

A. The following standards and rules shall be applicable:

- (i) IS:3043 – 2018 Code of Practice for earthing, 2<sup>nd</sup> revision  
Indian Electricity Act, 2003 and IE Rules, 1956 as amended
- (ii) IEEE 80: 2013 Guide for Safety in AC Substation Grounding

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

**8.3 Earthing Material**

- A. Materials of which the protective system is composed shall be resistant to corrosion or be adequately protected against corrosion. Adequate margin for corrosion should be taken for the selection of the size. The material shall be as specified in the schedule of quantities BOQ and shall comply to the following requirements:
- B. Copper - When solid or stranded copper wire is used it shall be of the grade ordinarily required for commercial electrical work generally designated as being of 98% conductivity when annealed, conforming to Indian standard specifications.
- C. The strips to be used shall be in maximum lengths available as manufactured normally avoiding unnecessary joints.

**8.4 Earth Stations****8.5 Earth Mats**

- A. Earth mat shall be constructed as per IEEE 80 – 2013 and IS 3043 2018. Cu. bonded MS round / flats should be used for constructing earth mat of adequate size (horizontal and vertical conductors) and at depth of 700 – 1000 mm from ground as per drawings. Adequate number of risers shall be brought from earth mat for further connection to ASS equipment and approved calculations and downstream equipment. Main earth terminals shall be provided in ASS, DG and pump room as required. The resistance of the earth mat should not be more than 1Ω.

**8.6 Earth Pit****8.6.1 Plate Earthing Station**

- A. The earthing station shall be as shown on the approved working drawing. The earth electrodes shall be 600 x 600 x 6.3mm GI plate / 600 x 600 x 3 mm copper plate electrode as required. The earth resistance shall be maintained with a suitable soil treatment and watering arrangement as per approved working shown on drawings or as directed at site. Excavated soft soil shall be thoroughly mixed with 6 percent by weight of common salt with 10 percent by weight of water and alternate layers of charcoal and filled in the earth pit. Independent earth shall have same specification subject to meeting the earthing value criterion for communication system. Pit details to be provided as per CPWD and relevant standards.
- B. The earth lead shall be connected to the earth plate through copper/brass bolts as per approved working drawings.

**8.6.2 Pipe Earthing Station**

- A. 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.
- B. The design of the electrode should be such as to have more than 15kA current carrying capacity for 1 second.
  - 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
- C. 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.
- D. Complete electrode shall be molecularly bonded by 99.99% pure, high conductivity copper on outer surface with copper coating thickness 300 micron or more.
- E. Its surface shall be clean and free from any visible oxide layer or foreign material.
- F. The outer pipe earth shall be as shown on the approved working drawing and shall be used for equipment earth grid. The earth electrode shall be 3.0m long, 25-100 mm diameter, 5mm thick galvanized iron pipe. The earth resistance shall be maintained with a suitable soil treatment as shown on approved working drawings and as per plate electrodes.
- G. The earth lead shall be fixed to the pipe with a clamp and safety set screws. The clamps shall be permanently accessible.
- H. In all cases the relevant provision of rule 33, 61 & 67 of the Indian Electricity Rules 1956 as amended shall be complied with. Metallic covers or supports of all medium or HT apparatus or conductors shall, in all cases be connected to not less than two separate and distinct earth electrodes.

#### 8.6.3 Masonry chamber

A masonry chamber of size 450x 450mm x 600mm with ductile iron/fabricated chequered plate hinged cover having locking arrangement set.

#### 8.6.4 Location of earth electrodes

- A. The following guidelines shall be followed for locating the earth electrodes.
- B. Where there is option, site should be chosen in one of the following types of soil in the order of preference given: -
  - ii. Wet marshy ground.
  - iii. Clay, loamy soil, arable land.
  - iv. Clay and loam mixed with varying proportions of sand, gravel and stones.
  - v. Damp and wet sand, peat.
  - vi. Dry sand, gravel chalk, limestone, granite, very stony ground and all locations where virgin rock is very close to the surface should be avoided.
- C. An earth electrode shall not be situated less than 3 meters from any building. The excavations for electrode shall not affect the column footings or foundations of the buildings. Entrances, pavements and road ways shall not be used for locating the earth electrode. In such cases electrode may be further away from the building.
- D. Earth mat locations – Earth mats shall be constructed at a suitable place in the area as near to ASS as possible.
- E. The location of the earth electrode / mats shall be such where the soil has reasonable chance of remaining moist, as far as possible.
- F. Electrodes shall be located in accessible locations. Entrances, pavements and roads shall not be used for locating earth electrodes

#### 8.7 Copper Bonded Steel Earthing Station

- A. Copper coated Mild steel rods shall be made of high tensile low carbon steel rod, 14/20/25 mm dia with molecular bonded 99.9% electrolytic copper having minimum coating thickness of 250 microns. The minimum length of the earth rod shall be 3 meters preferably UL listed. The electrode shall be tested for short circuit current test, Bend Test, Coating thickness test, Adhesion test etc. as per IEC 62561-2 or relevant standards. It should satisfy the requirements as per the above standards
- B. Interconnecting Strips / Earthing Conductor: Copper /GI strips shall be used to interconnect different earthing rods as well as horizontal earthing (Ring earthing). In case of GI strip, coating



thickness shall be minimum 70 microns and shall have minimum cross-sectional area of 90 sq.mm.

#### 8.8 **Method of Installing Watering Arrangement**

- A. In the case of plate earth electrode, a watering pipe of 15mm diameter of medium class GI Pipe shall be provided and attached to the electrode. A funnel with mesh shall be provided at the top of this pipe for watering the earth. The watering funnel attachment shall be housed in masonry enclosure of not less than 300 x 300 x 300 mm. A cast iron/MS frame with cover having identity mode "EARTH" and having locking arrangement shall be suitably embedded in the masonry enclosure.

#### 8.9 **Earth Leads and Connections**

- A. The strip earthing leads shall be connected to the Earth Electrode / Earth mat at one end and to the main equipment at the other end. The earthing lead shall connect to the earthing network in the installation.
- B. Earth lead shall be bare copper or galvanized steel as specified with sizes shown on approved working drawings. Copper lead shall have a phosphor content of not over 0.15 percent. Galvanized steel buried in ground shall be protected with bitumen and hessian wrap or polythene faced hessian and bitumen coating. At road crossings necessary Hume pipes or UPVC Pipes shall be laid. Earth lead run on surface of wall or ceiling shall be fixed on saddles or wall so that the strip is at least 8mm away from the wall surface.
- C. All earth strips shall be jointed as follows:
 

|            |  |
|------------|--|
| Copper     | : Copper riveting with 80mm fish plate and brazing with at least 80mm brazing as a lap joint along the length                              |
| Galvanized | : Lap joint & cross weld joints shall be of not less than 150mm overlapping and bitumen coat at every joint shall be provided as required. |
- D. Strip earthing leads shall be of copper/GI and as per specifications.
- E. The buried strip earthing lead shall be laid not less than 0.5 m deep. If conditions necessitate use of more than one earthing lead, they shall be laid as widely distributed as possible.
- F. In the case of plate earth electrode, the earthing lead shall be securely bolted to the plate with two bolts, nuts, check nuts and washers as required by IS 3043. All materials used for connecting the earth lead with electrode shall be GI in case of GI Pipe and GI plate earth electrodes or tinned brass in case of Copper plate electrode.

#### 8.10 **Connection of Earthing Conductors**

- A. Main earthing conductors shall be taken from the earth connections at the substation to the earth bar at the main switch boards in the TN-S configuration and the earth bar may also be directly earthed as in Indian TN-S.
- B. Sub-mains earthing conductors shall run from the earth bar at the main switch board to the sub-distribution boards and to the final distribution boards.
- C. Loop earthing conductors shall run from the final distribution boards and shall be connected to any point on the main/sub-main earthing conductor, or its distribution board.
- D. Metal conduits, cable sheathing and armouring shall be earthed at the ends adjacent to switch boards at which they originate, or otherwise at the commencement of the run by an earth bonding conductor in effective electrical contact with cable sheathing. Switches, accessories, lighting fitting etc. shall be effectively connected to the Loop Earthing Conductors. A metallic conduit shall not be considered as the only protective earth conductor.
- E. Point wiring for lights, fans, ceiling fans, exhaust fans, 6A & 16A sockets and the like and sub-main wiring, shall all have an earth continuity conductor (ECC) with the same cross section and type of wires used, the minimum in this case being 2.5-sqmm copper.

#### 8.11 **Prohibited Connections**

- A. Neutral conductor, sprinkler pipes, or pipes conveying gas, water, or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lighting protection system conductors shall not be used as a means of earthing an installation or even as a link in an earthing system. However, these are to be effectively earth bonded.

#### 8.12 **Resistance to Earth**

- A. The electrical resistance measured between earth connection at the main switchboard and any other point on the completed installation shall be low enough to permit the passage of current necessary to

operate fuses or circuit breakers. The combined earth resistance of the earthing system should not be more than 1 ohm.

#### 8.13 **Equipment Earthing**

- A. All apparatus and equipment transmitting or utilizing power shall be earthed as per the drawings.
- B. The earth continuity conductor may be drawn inside the conduit in which case, it should be insulated.
- C. Metallic conduit shall not be accepted as an earth continuity conductor. A separate insulated/bare earth continuity conductor of size related to phase conductor shall be provided. Non-metallic conduit shall have an insulated earth continuity conductor of the same size as above. All metal junction and switch boxes shall have an inside earth stud to which the earth conductor shall be connected. The earth conductor shall be distinctly coloured (green) for easy identification.
- D. Armoured cables shall be earthed by 2 bonding earth connections to the armouring at both the ends and the size of connection being as above. In multiple cables entering a panel/DB, the cable joints shall be bonded together using a bonding wire selected on the basis of the largest size of cable in the group. In the case of unarmoured cable, an earth continuity conductor shall either be run outside along the cable. Three phase power panels and distribution boards shall have 2 distinct earth connections of the size correlated to the incoming cable size. In case of single phase DB's a single earth connection is adequate. Similarly for 3-Phase and 1-Phase isolating switches there shall be 2 and 1 earth connections respectively, sizes being correlated to the incoming cable.
- E. Three Phase motors and other 3-Phase apparatus shall have 2 distinct earth connections of size equal to incoming feeder size. For 1-Phase motor and 1-Phase apparatus, the single earth connections shall be provided of the above size.

#### 8.14 **Manufacturing and Earth Enhancement Material**

- A. Quality Assurance and Controls: The Contractor's Management Systems shall emphasize quality assurance and controls. The program 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:
  - (i) Firm procurement and job performance specifications.
  - (ii) Firm procedures for transmission of information and data to their Subcontractors and ensuring their compliance.
  - (iii) Adequate testing to ensure repetitive product conformity to design requirements and Total program of surveillance and verification of physical performance and configuration accountability.
  - (iv) Adequate records shall be kept by the Contractor to provide evidence of quality and accountability. These records shall include results of inspections, tests, process controls, certification of processes and personnel, discrepant material, and other quality control requirements.
  - (v) The manufacturer shall ensure use of best manufacturing practice like quality of bends, no sharp corners, and no metallic parts with sharp edges, use of quality gasket at appropriate loss to damp vibrations and sealing etc.
  - (vi) The manufacturer shall study the environmental pollution data prevailing near the station where its equipment is going to be installed. The manufacturer shall take adequate precaution either during manufacturing or installation to prevent any damage to the equipment or loss of life arising due to prevailing pollution level.
- B. 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-
  - (i) It shall not depend on the continuous presence of water to maintain its conductivity.
  - (ii) 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.
  - (iii) 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.
  - (iv) 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.

- (v) 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.
- (vi) It should have water solubility < 5%. Test certificate from NABL approved lab be submitted for the composition so designed.
- (vii) It should be granular with granule size 0.1 mm to 3 mm.
- (viii) It should be nontoxic, non-reactive, non-explosive & non corrosive.
- (ix) It shall be thermally stable between -10 degree centigrade to +60-degree centigrade ambient temperature.
- (x) It shall not decompose or leach out with time
- (xi) It shall not pollute the soil or local water table and meets environmentally friendly requirement for landfill.
- (xii) It should expand & swell considerably and removes entrapped air to create strong connection between earth electrode and soil.
- (xiii) It should be diffusing into soil pores and creates conductive roots enlarging conductive zone of earth pit.
- (xiv) It shall be permanent & maintenance free and in its “set form”, maintains constant earth resistance with time.
- (xv) It shall not require periodic charging treatment or replacement.
- (xvi) It shall be suitable for any kind of electrode and all kinds of soils of different resistivity.
- (xvii) It shall not cause burns, irritation to eye, skin etc.
- (xviii) 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.
- (xix) 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.

#### 8.15 **Artificial Treatment of Soil**

If the earth resistance is too high and the multiple electrodes do not give adequate low resistance to earth, then the soil resistivity immediately surrounding the earth electrodes shall be reduced by adding sodium chloride, calcium chloride, sodium carbonate, copper sulphate, salt and soft coke or charcoal in suitable proportions.

#### 8.16 **Chemical Earthing**

Proposal of Chemical Earthing may be proposed by Contractor with suitable justification to Engineer for review and approval of Employer/Engineer.

#### 8.17 **Testing**

The following earth resistance values shall be measured with an approved earth megger and recorded.

- i. Each earthing station / mat
- ii. Earthing system as a whole
- iii. Earth continuity

#### 8.18 **Document Handover**

An original copy of the relevant manufacturer shall be provided to CLIENT upon completion and handover together with all generated site-specific data.

#### 8.19 **Part -B Earthing**

#### 8.20 **Scope**

- A. 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. The scope of work shall cover earthing stations (earth mats and earth electrodes), laying copper/GI earth strips and connecting the power panels, DBs, switch boards and other equipment's such as pumps, PLCs of BMS etc.
- C. Indian INS system of earthing as shown on IS:3043-1987 shall be followed for the entire installation under the scope.
- D. Earthing of transformer neutral, DG set, S&T equipment's (clean earth electrodes only), BMS equipment, and other items shall be carried out as per drawings.
- E. All the non-current carrying metal parts of electrical installations including metal conduits, Bus ducts, cable armour, switchboards, DBs, light fitting and all other non-current carrying parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system.
- F. All three-phase equipment shall have two separate and distinct body earths and single-phase equipment shall have a single body earth.
- G. Separate earth leads of appropriate size shall be provided for.
  - i. Main switchboards
  - ii. Computer system earth bus
  - iii. Telephone system earth bus

Wherever so specified the earth lead shall be PVC sheathed to provide a "clean" earth.
- H. All metallic components and pipes shall be connected to the earthing system by means of minimum 4 sq.mm PVC insulated (green/yellow) copper conductor wires.
- I. The Earthing system shall totally comprise the following:
  - i. Earth mats and Electrodes as per IEEE 80:2000 and IS:3043-1987
  - ii. Earthing Leads.
  - iii. Earth conductors.
  - iv. Residual current earth leakage circuit breakers where applicable as per IE rules 61A

#### 8.21 **Standards**

The earthing system shall be carried out in conformity with the updated and current edition of IS 3043: 1987, In addition, relevant clauses of Indian Electricity Act 1910, India Electricity Rules 1956 and IEE Wiring Regulations (16th edition), as amended up-to-date, shall also be applicable

#### 8.22 **Earth mats**

- A. Earth mat shall be constructed as per IEEE 80-2000 and IS 3040:1987 MS round/flats should be used for constructing earth mat of adequate size (Horizontal and vertical conductors) and depth of 700-1000 mm from grounds as per drawings. Adequate number of risers shall be brought from earth mat for further connection to ASS equipment and downstream equipment. Main earth terminal shall be provided in ASS, DG and Pump room as required. The resistance of the earth mat should not be more than 10.

#### 8.23 **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 mm and of GI electrodes not less than 6 mm.

##### **B. Pipe Earth Electrode**

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

#### 8.24 **Earth Pit**

##### **A. For plate electrodes**

Plate electrode shall be buried in ground with its face vertical and top not less than 3 m below ground level. The depth shall be increased if required so that permanently moist soil level is reached. 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 upto 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.

**B. For pipe electrodes**

Pipe electrode shall be installed with its stop not less than 200 mm below ground level. The top shall be provided with a 40 mm x 20 mm reducer to fix watering funnel with mesh on top. The entire length of pipe below the inspection chamber shall be surrounded by alternate layers of charcoal and sand. Earth lead shall be provided as for plate electrode and shall be terminated using a though bolt, nuts, check nuts, spring washers etc.

**C. 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.

**D. Location of earth electrodes**

Location of earth electrodes shall be based on the 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 located in accessible locations. Entrances, pavements and roads shall not be used for locating earth electrodes.

**8.25 Earthing Conductor**

**A. Main Earth Lead**

Interconnections between earth bus provided on the main switchboard inside the building for body earthing / neutral 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 die 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 pipe 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-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.
- Conduiting 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 of earthing conductors**

- Earthing conductors shall be provided in longest possible unbroken length to minimize jointing of the conductors in between terminations.
- 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.
- Copper earth strips shall be joined by butt welding /brazing or the mating surfaces shall be tinned, riveted and soldered.
- GI earth strips shall be joined by GI bolts, nuts, check nuts and spring washers of appropriate size.
- All exposed joints shall be provided with 2 coats of anti-corrosive paint.
- 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.

**8.26 Prohibited Connections**

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

**8.27 Resistance to Earth**

No earth electrode shall have a greater ohmic resistance than 3 ohms as measured by an approved earth testing apparatus. In rocky soil the resistance may be up to 5 ohms. The Electrical resistance measured between earth connection at the main switchboard and any other point on the completed installation shall be low enough to permit the passage of current necessary to operate circuit breakers, and shall not exceed 1 ohm

**8.28 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.

**C. In case the earth resistance is not achieved as per 8.1, necessary improvement shall be made by additional provision 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.**

**8.29 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 for rod type electrode and concentric pipe type electrode as per BOQ clause/Relevant standards.



- Physical check for copper bus bar for rod type electrode and concentric pipe type electrode as per BOQ clause/Relevant standards.
- Dimensional and construction feature tests of inspection chamber BOQ Clause/Relevant standards.
- Earth enhancement material as per BOQ/Relevant standards.
- Earth resistance measurements as per BOQ clause/Relevant standards.

#### 8.30 **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.

#### 8.31 **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.

#### 8.32 **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

## SECTION: E.09 LIGHTNING PROTECTION

### 9.1 Scope

- A. The scope of work shall cover supply, installation and testing of air and earth terminations and down conductors. Protection of buildings against lightning shall be done in accordance with IS 62305 – 2005/IEC 62305 and include the provision of a parallel path lightning system complete with air terminal conductors, ground terminals interconnecting conductors and other fittings required for the complete system.

### 9.2 Standards

- A. The following standards shall apply:
- |                          |   |
|--------------------------|---|
| IS: 3043 – 2018          | Code of practice for earthing.  |
| IS/IEC 62305             | Lightning Protection Standard   |
| IS 5216 : Part I : 1982  | Recommendations on Safety Procedures and Practices in Electrical Work - Part I : General                |
| IS 5216 : Part II : 1982 | Recommendation on Safety Procedures and Practices in Electrical Work - Part II : Life Saving Techniques |
|                          | Indian Electricity Act 2003 and IE Rules, 1956 as amended   |
- B. 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.

### 9.3 Air Terminations

- A. Air terminations: Air termination systems can be composed of any combination of the following elements:
- (i) Rods
  - (ii) Meshed conductors
- B. The air termination shall be multiple point type of copper/brass material with spikes generally as shown on approved working drawings. The stem and multi-point head shall be erected on the roof with a 150 x 150 x 6mm stainless steel (SS) base plate with a threaded socket of the same material welded to it. The base plate shall be embedded in a concrete block to hold the elevation rod in a vertical position. The elevation rod shall be one single rod without any joints.
- C. Positioning of Air-terminations  
Air termination components installed on a structure shall be located at corners, exposed points and edges in accordance with one or more of the following acceptable methods:
- a) Protection angle method
  - b) Rolling sphere method
  - c) Mesh method

### 9.4 Down Conductor

- A. The down conductor shall follow the most direct path possible between the air termination and the earth termination generally as shown on the drawings. The down conductor shall be free of sharp bends, upturns and kinks and clamped to the stem of the air termination by means of gun metal clamps. Each down conductor shall have an independent earth termination. Minimum size of the down conductor shall be 25 x 3 mm stainless steel (SS).
- B. The down conductor shall be clamped to the building outer wall at 600-mm centers. Joints in the down conductors shall be avoided as far as possible. However, in any case, joints shall not be made below ground level. Where joints are made care shall be taken so as to exclude any moisture. Bimetallic connectors shall be used where dissimilar metals are to be jointed. All joints shall be tinned, soldered or should be prepared & made in accordance as per IS 62305.
- C. A testing link shall be provided for each down conductor. Testing links shall be of gun metal or SS 304 or as specified.

### 9.5 Earth Termination

- A. The earth terminals and earth leads shall be as specified for earth station and earthing leads under section 'EARTHING'.
- i) **Testing**
- B. The entire installation shall be tested in accordance with the Indian Standard Code (IS 62305) and the ground resistance values shall be recorded for earthing Terminal (each) and earthing system (as a whole).

**i) Testing Points**

- C. 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 of GI.

**i) Design Considerations**

- D. The entire lightning protective system shall be mechanically strong to withstand the mechanical forces produced in case of a lightning stroke.
- E. The lightning protective system shall be so installed that it does not spoil the architectural or aesthetic beauty of the buildings.
- F. A vertical air termination where provided need not have more than one point and shall project at least 1.2m above the project, salient point or network on which it is fixed.
- G. Horizontal air terminations shall be so interconnected as per approved calculations / IS 62305 from the nearest horizontal termination.
- H. 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.
- I. 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.
- J. 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.

**9.6 Earth Terminations**

- A. Each down conductor shall have an independent earth pit. The interconnection of all the earth termination shall be done. It should be capable of isolation for testing purposes by "testing joints" of GI provided in suitable enclosures.
- B. Earth electrodes & earth pit shall be constructed and installed as specified for pipe earthing in Clause 8.8.2
- C. The whole of the lightning protective system shall have a combined resistance to earth not exceeding 10Ω before any bonding has been affected to metal in or on a structure or to surface below ground.

For lightning protection application, the rods should have a minimum diameter of 14.2 mm (fault current carrying capacity of 15 kA). In order to carry fault current, the earth rods used in power networks shall be of diameter 20 mm or 25 mm. In case of applications requiring fault current carrying capacity of less than 30 kA, multiple interconnected 20/25 mm dia rods shall be used as per requirements.

**9.7 Material and Manufacturing**

**Quality Assurance and Controls:** The Contractor's management system shall emphasize on the quality assurance and controls. The program shall be adequate to ensure the acceptance level of quality of the equipment supplied. The concept of total quality assurance shall be based on the principle that the quality is the basic responsibility of the contractor, and shall be visible by,

- A. Firm procurement and job performance specifications.
- B. Firm procedures for transmission of information and data to their subcontractor and ensuring their compliance.
- C. Adequate testing to ensure the respective product conformity to design the requirement and total program of surveillance and verification of physical performance and configuration accountability.
- D. Adequate records shall be kept by the Contractor to provide evidence of quality and accountability. These records shall include results of inspections, tests, process controls, certification of processes and personnel, discrepant material, and other quality control requirements.
- E. The Manufacturer shall ensure use to best manufacturing practice like quality of bends, no sharp corners, and no metallic parts with sharp edges, use of quality gasket at appropriate loss to damp variation sealing etc.

**9.8 Handing Over of Documents**

On completion of installation, The Manufacturer shall supply well bound handing over manuals duly approved by Employer/Engineer. Each set (As required by Engineers) shall include:

- A. As build drawings.
- B. Do's and Don'ts's for the maintenance and operating staff.
- C. Extract of warrant/DLP.
- D. Soft copy of the entire documents.
- E. FAT and SAT reports
- F. Tools and Spare list

**9.9 Training Requirement**

Workshop on lightening arrestor as per contract shall be conducted at customer's site by tenderer and including a combination of lecture and practical instruction.

## SECTION: E.10 UNINTERRUPTED POWER SUPPLY SECTION

This specification covers the supply, erection, testing and commissioning of requirements of 2 x 20kVA/2 x 30kVA/2x40kVA as required and mentioned in BOQ/drawing at unity output power factor i.e. kVA = kW, three-phase incoming three-phase outgoing operating in parallel redundant mode, UPS System units as per configuration defined in the Bill of Quantities.

1. The contractor shall supply the UPS meeting following requirement: -

Supply, Installation, Testing and Commissioning of parallel redundant 2 x 20kVA/ 2 x 30kVA/2 x 40kVA as required, online interactive UPS system suitable for providing power Supply to emergency lighting system.

UPS should be suitable for incoming 415V AC (-15% to + 10%), 3 phase, 50 Hz, Supply and three phase output voltage, variation  $\pm 1\%$ , including Transformer (input /output) and static Bypass, Rectifier/Dual converter, Static Switch, Inverter, Filter, Bypass & ATS (Auto Transfer Switch) of Standard MAKE as approved by Engineer/Employer, Automatic switch over without giving any break of power, maintenance bypass switch, Microprocessor/ software controlled annunciation, protection (including against input phase reversal), and menu run diagnostic module, associated cabling and connections/ terminations, erection including associated foundation/ masonry or RCC work for mounting on base channels etc. complete as per specifications and as required.

Supply, Installation, Testing and Commissioning of lead acid sealed Maintenance free (VRLA) suitable for 30 minutes to the UPS System. Battery shall comply with relevant standard & regulations and Standards/Code e.g., IEEE485. Battery Racks shall be made of acid resistant material. Battery bank shall be so organized that:

- (i) One set shall normally function to take up the entire load of UPS,
- (ii) The cells shall be grouped such that touch voltage does not exceed 72V,

A Separate Set shall consist of Six cell blocks each of the same voltage as in the Main Battery Bank, this set shall be maintained on charge from the charging unit such that one or more units from this set can replace faulty cell blocks of working battery bank.

Note-1: A contactor based ATS (Automatic Transfer Switch) suitable for terminating 2 nos. of suitable Size of Aluminium Conductor armoured cables on the incoming side of UPS. The automatic change over switch may be wall mounted in the UPS room. From automatic changeover switch to UPS, the connection should be through an adequately rated copper cable, and RS 485 port for display of ON/OFF status of UPS on BMS work station through MODBUS protocol is also included in the price.

Note-2: Should include a suitable size copper Conductor, armoured cable from UPS outgoing side to Emergency Power Panel (EPP).

Contractor shall submit the design and specification detail of the UPS meeting the above requirement and with design criteria: -

### 10.1 Design Prerequisite

The UPS shall be designed to meet the following parameters

INCOMING POWER SUPPLY - 3 phase 4 wire earth  
OUTGOING POWER SUPPLY - 3 phase 4 wire TP and N

In case the static bypass is required to be enabled a separate incoming power supply for only the bypass at 3 phase 4 wire TP and N shall be provided i.e. Dual Mains Input.

The neutral for the UPS output shall be created at the ups and shall not be interconnected or carried forward from the mains neutral by using isolation transformer at inverter output after the static switch.

|     |                            |   |                       |
|-----|----------------------------|---|-----------------------|
| 1.0 | Standards and Codes        | The equipment/ system shall conform to the latest version of following Standards and Codes<br>Indian Electricity Act 2003<br>Indian Electricity Rules 1956<br>IEC Standard 62040 for UPS<br>Safety:<br>Europe: EN 500091-1<br>IEC 62040<br>Emission and Immunity:<br>Europe: EN 500091-2 / IEC 62040-2<br>Performance: IEC 62040 – 3  |                       |
| 2.0 | Environmental Requirements |   |                       |
| 2.1 |                            | Storage ambient temperature.  | (-) 20° C to (+) 50°C |
| 2.2 |                            | Operating Ambient temperature Continuous operation  | Zero to (+) 40°C      |
| 2.3 |                            | Relative Humidity   | 0-95%, non-condensing |
| 3.0 | UPS Operation              | <p>The UPS shall be suitable for the following operational modes:</p> <p>1.0 Normal operation:<br/>The rectifier/ inverter combination shall operate to continuously regulate and supply power to the critical load. The Inverter/battery charger shall derive power from the AC Input source and supply DC Power to float-charge the battery.</p> <p>2.0 Battery:<br/>Upon failure of the AC Input source, the critical load shall continue to be supplied by the Inverter and battery without any switching. The Inverter shall obtain its power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the AC Input source.</p> <p>3.0 Recharge:<br/>Upon restoration of the AC input source, the Inverter/battery charger shall simultaneously recharge the battery and regulate and supply power to the critical load.</p> <p>4.0 Static by pass Mode<br/>Transferring the load to mains supply and vice versa without interruption in power to the critical load. No re-booting of microprocessor shall take place after transfer and retransfer of critical load.</p> <p>5.0 Maintenance by Pass mode<br/>For service and maintenance only and shall be used for supplying the load directly from the mains supply, while the UPS is isolated for maintenance.</p> <p>6.0 Parallel operation:<br/>UPS modules shall be capable of running in parallel operation for increased capacity or for redundant operation. The parallel board shall ensure proper control of parallel units and proper load sharing. One parallel board shall be provided for each unit connected in parallel and each load should have dual data cable to avoid single point of failure.<br/>The System should be capable of supplying power to Load without any break, in case of phase reversal at the input. The UPS should draw power from batteries or it should not transfer into bypass in case of input phase reversal. UPS should give a user notification in the display about phase reversal.</p> |                       |
| 4.0 | UPS safeties               | <p>Low Battery Voltage Protection:<br/>To prevent total discharge or damage to the battery, the UPS shall transfer to standby operation when the battery voltage reaches a set minimum voltage level (programmable). If AC input source has not returned within 10 minutes after “low</p>   |                       |



|     |  |  |
|-----|--|--|
|     |  | battery” shutdown, the UPS shall Electrically disconnect (using external battery circuit breaker) DC Power from the battery to avoid deep discharge.   |
| 5.0 | Technical Parameters                   |  |
| 5.1 | General                                | <p>The UPS Systems shall operate in conjunction with the building electrical system to provide power conditioning, back-up power protection, and power distribution for the critical loads.</p> <p>The UPS shall comply to the following parameters</p> <ul style="list-style-type: none"> <li>Double conversion online,</li> <li>Pulse Width modulation-based technology as defined in IEC standard continuous operation,</li> <li>Solid-state</li> </ul> <p>The system shall be classified as VFI-SS-III as per IEC 62040 such that UPS output is independent of supply mains voltage and frequency variations</p> <p>Suitable for parallel redundant system operation with separate DC for each unit, and shall provide proportional load sharing.</p>  |
| 5.2 | Technical performance                  | Technical parameters of the system are listed below. Bidders' confirmation of compliance or otherwise shall be filled and submit in against each item  |
| 6.0 | Construction and Design Specifications |  |
| 6.1 | Rectifier                              | <p>Power supply - public mains supply or from the standby generating set.</p> <p>Function to rectify input AC to DC and supply both the inverter and the battery system.</p> <p>The power section is constructed using IGBT technology to achieve system technical specifications as specified.</p> <p>Residual ripple of the battery charging current shall be reduced to &lt; 1% as per EUROBAT tolerances by appropriate smoothing devices in the battery link circuit.</p> <p>All rectifier regulation and control functions shall be digital to perform the following functions:</p> <ol style="list-style-type: none"> <li>i. Voltage regulation of the DC voltage link circuit with a constant voltage</li> <li>ii. Rectifier blocking during a mains failure and automatic restart on restoration of the mains supply or after starting the standby generating set; with adjustable soft start characteristic</li> <li>iii. Rectifier current limiting</li> <li>Battery Charging and monitoring</li> <li>iv. Automatic charger with I/U characteristic in accordance with DIN 41773</li> <li>v. Battery charging current limiting</li> <li>vi. Battery boost charge:</li> <li>vii. Automatic equalizing charge stage when the battery voltage falls below the set value</li> <li>viii. Temperature-dependent final charging voltage using an additional temperature sensor on the battery unit</li> <li>ix. Battery trip characteristic to prevent exhaustive discharge with very small battery currents</li> <li>x. Continuous battery- and battery-fuse-automatic</li> <li>xi. Monitoring of the battery and the mains voltage</li> <li>xii. Temperature-controlled battery charging extends the life of the battery</li> <li>xiii. Battery bank management /Monitoring</li> <li>xiv. The integral battery trip characteristic provides reliable protection against exhaustive discharge</li> <li>xv. Cyclical battery tests indicate the current status of battery bank</li> <li>xvi. Manual switch-off of battery charging from the operator control panel should be possible when running the standby generating set</li> <li>xvii. Manual equalizing charge stage for a period that is individually adjustable by UPS supplier under the recommendation of battery manufacturer</li> <li>xviii. The battery monitor indicates residual battery capacity and establishes for how long the load can be supplied. A message is generated if this is less than an adjustable residual run time.</li> </ol> |
| 6.2 | Inverter                               | Power Supply from rectifier in normal operation and battery in the event of a mains failure.   |

|       |                                  |   |
|-------|----------------------------------|---|
|       |                                  | <p>The inverter generates a three-phase system with controlled voltage and frequency and supplies the load.</p> <p>The power section shall be constructed using IGBT technology and output stages of the inverter shall be pulse-width modulated at high variable frequency in order to obtain an exact sinusoidal output voltage, even with a non-linear load, with a frequency accuracy of <math>\pm 0.25</math> with synchronization with bypass supply.</p> <p>Regulation shall be microprocessor-controlled achieve voltage tolerance as specified during 100% load changes.</p> <p>It shall be ensured that synchronicity between the reference sine signal and the bypass network is continuously available in the parallel standby position.</p> <p>The inverter comprises the following main components:</p> <ol style="list-style-type: none"> <li>Fully-transistorised three-phase inverter bridge employing IGBT technology</li> <li>Output filter capacitors for reducing the distortion factor to &lt;3% for a linear load and &lt;5% for a non-linear load.</li> <li>Outgoing isolator for connecting and disconnecting the inverter output</li> <li>Inverter controller for monitoring and control</li> </ol> |
| 6.3   | Static Switch (automatic bypass) | <p>Function automatically transfer load without a break to the mains supply in the event of a UPS rectifier/inverter failure or maloperation such that set tolerances are exceeded in any predefined parameter.</p> <p>On recovery to normal conditions, the bypass shall automatically return to inverter operation without a break.</p> <p>The static switch consists of 100% rated dual thyristor modules for uninterruptible changeover from inverter operation to bypass operation.</p> <p>Manual changeover shall be selectable if required and this too shall be without a break</p> <p>The rated output of the automatic bypass shall correspond to the total output of the UPS system.</p> <p>In the parallel mode with other UPS modules, each module shall have its own automatic mains bypass.</p> <p>The bypass mode must be capable of being disabled if required.</p> <p>It shall be possible to provide a separate in feed to the bypass circuit i.e. Dual Mains Input.</p>   |
| 6.4   | Maintenance Bypass               | <p>The maintenance bypass shall supply the load from the bypass source while the UPS is electrically isolated for maintenance. A UPS input, output maintenance bypass and bypass switch shall be housed in the UPS cabinet. Each switch shall be monitored and controlled by the UPS.</p>   |
| 6.5   | Display and Controls             |   |
| 6.5.1 | Displays                         | <ol style="list-style-type: none"> <li>A 320 x 240-pixel multi-language graphic LCD display unit shall be located at the front of the UPS cabinet.</li> <li>The display unit shall consist of an alphanumeric display with backlight, an alarm LED, and a key pad/Touch Screen</li> <li>The display unit shall display the following UPS operational status <ol style="list-style-type: none"> <li>Normal operation, load power xxx%</li> <li>Battery operation, time xxx minutes.</li> <li>Bypass operation.</li> <li>Standby</li> </ol> </li> </ol> <p>The display unit shall provide following indications</p> <ol style="list-style-type: none"> <li>LED indications for load level battery autonomy.</li> </ol>  |
| 6.5.2 | Metered parameters               | The unit shall display the metered parameters as listed out below   |
| 6.5.3 | Alarms                           | The unit shall display a log of all active alarms.  |
| 6.5.4 | Event Log                        | The unit shall display a time and date-stamped log of the minimum 256 most recent UPS status and alarm events.  |
| 6.5.5 | Controls                         | <ol style="list-style-type: none"> <li>Controls as listed out below shall be provided on the display unit:</li> <li>Inverter On and Off push Buttons: Momentary Inverter on and off push buttons shall be provided in a user accessible compartment. Upon activation of the on-push button, the UPS shall automatically connect to UPS output to the critical load. Upon activation of the off-push button, the UPS shall switch OFF Inverter and critical load shall receive standby Bypass Power.</li> </ol>  |

|        |  |   |
|--------|--|---|
| 6.5.6  | Potential Free Contacts                  | The UPS shall be equipped with two potential free contacts:<br>Additional potential free contacts as specified in the Schedule of Quantities shall be provided.   |
| 6.5.7  | Communications Interface                 | Communication ports listed out below. It shall be possible to use two or more ports simultaneously.   |
| 6.5.8  | Battery Charger temperature compensation | For units with external batteries, the battery charger temperature compensator shall monitor the temperature in the battery Racks.  |
| 6.5.9  | Remote UPS Monitoring                    | It shall be possible to remotely monitor the UPS via either RS-232 / RS-485 or TCP/IP or Modbus and an existing computer system. The UPS manufacturer shall have available interface kits to support remote monitoring systems listed out below.  |
| 6.5.10 | SNMP Adapter                             | A Web-Enabled SNMP adapter shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS & UNIX formats, The SNMP interface adapter shall be connected to the UPS via the RS232 serial port.  |
| 6.6    | Battery                                  |   |
| 6.6.1  | Battery Capacity and calculations        | Bidder shall provide support design calculations for selection of battery sizing and capacity.<br>For battery sizing, the following factors shall be considered unless specified otherwise in the data sheet: <ul style="list-style-type: none"> <li>i. Temperature correct factor as per IEEE-485</li> <li>ii. Design Margin as per IEEE-485</li> <li>iii. Battery Current as per IEEE-485</li> <li>iv. Aging factor as per IEEE-485</li> <li>v. Back up time of 30 minutes in case of mains power failure unless specified otherwise in data sheet</li> </ul> |
| 6.6.2  | Batteries type                           | <ul style="list-style-type: none"> <li>i. Batteries shall be VRLA type(2V)</li> <li>ii. Design Lifetime: minimum 10 years. Ageing factor &amp; Temperature correction factor @ 25°C should be considered for battery <u>sizing</u>.</li> <li>iii. DC ripple: Max. 2 %</li> </ul>  |
| 6.6.3  | Battery Function Monitor                 | Battery function monitor shall monitor and define battery capacity. It shall be possible to program the unit to perform an automatic battery test every 90 days to test the condition of the battery.   |
| 6.6.4  | Battery disconnects                      | For units with external batteries, an external MCCB Box shall be provided for protection and isolation of the battery bank from the rest of the system.   |
| 6.6.5  | Quality Control                          | During manufacture, each battery cell shall be clearly identified as to the cell type, voltage, and capacity. All cells in the battery should have been tested during manufacture to verify 100% system capacity. Design and manufacture of the batteries shall be done under a quality assurance program controlled and documented by written policies procedures or instruction.  |
| 6.7    | Fault Diagnosis                          | For rapid and efficient fault diagnosis an electronic diagnostic system shall be provided comprising <ul style="list-style-type: none"> <li>i. Event recorder which stores the last 2000 events in plain text in chronological order with date and time</li> <li>ii. Status LEDs on the controller board</li> </ul> <p>The information shall remain permanently stored, even with the power supply switched off.</p>  |
| 6.8    | Enclosure                                | The UPS shall be housed in a freestanding enclosure with provision for cable entry for all incoming and outgoing cables from top/ Bottom<br>All service accesses shall be from the front.<br>The UPS cabinet shall be powder coated with the manufacturers standard colour.<br>The cabinet shall be equipped for fork truck lifting.<br>Dust Filters shall be provided inside the UPS<br>IP 20 Rated  |
| 6.8.1  | Forced Ventilation                       | Details of forced ventilation if required shall be furnished along with the tender.   |
| 6.8.2  | Dimensions and weights                   | Overall dimensions of the UPS systems as also the battery banks shall be furnished. The weight of the UPS units and battery banks shall also be furnished for checking structural floor loading.  |

|     |                                      |  |
|-----|--------------------------------------|--|
| 7.0 | General Specifications               |  |
| 7.1 | Mean time between failures           | MTBF shall be Field-proven minimum of 50,000 hours. MTBF calculation for parallel redundant system shall be furnished along with the tender.   |
| 7.2 | Modular Sub-assemblies               | For ease of maintenance and service, UPS units shall have field replaceable modular sub-power module assemblies. Individual UPS Frame shall have minimum of one power module and failure of one shall not impact the capacity of other parallel redundant frame modules.   |
| 7.3 | Materials                            | All materials comprising the UPS units shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing.   |
| 8.0 | Testing at Manufacturers Works       | <p>The tests indicated below but not limited to shall be carried out on the final product at the manufacturers works. The Owner/ Consultant reserve the right to witness these tests and appropriate notice shall be given by the manufacturer. The UPS shall be give specific dispatch clearance by the Owner. Consultant after satisfactory completion of all desired tests</p> <p>8.1 Load Tests<br/>Measurement of the following parameters para 8.1.1 under varying loads para 8.1.2 indicated below</p> <p>8.1.1 Parameters<br/>Voltage Regulation Output Line to Neutral voltages (R, Y, B)<br/>Voltage Regulation Output Line to Line voltages (R-Y, Y-B, B-R)<br/>Line Currents (R, Y, B)<br/>Phase Shift (R, Y, B)<br/>Voltage Distorsion (R, Y, B)<br/>Input Power and power factor (R, Y, B)<br/>Output Power and Power Factor (R, Y, B)<br/>Percentage Efficiency</p> <p>8.1.2 Load Conditions<br/>Load 25% Power factor Unity<br/>Load 50% Power factor Unity<br/>Load 100% Power factor Unity</p> <p>8.2 Transfer Power from Mains to Inverter and vice versa</p> <p>2.0 Output Voltage, Output Current and Bypass current oscillograms during Full load Manual Transfer from Mains to Inverter</p> <p>3.0 Output Voltage, Output Current and Bypass current oscillograms during Full load Manual Transfer from Inverter to Mains</p> <p>4.0 Output Voltage, Output Current and Bypass current oscillograms during Full load automatic Transfer from Mains to Inverter</p> <p>5.0 Output Voltage, Output Current and Bypass current oscillograms during Full load Automatic Transfer from Inverter to Mains</p> <p>8.3 <b>Dynamic Step Loads</b><br/>Output Voltage and Current oscillograms during dynamic step load from 0% to full load 100%<br/>Output Voltage and Current oscillograms during dynamic step load from full load 100% to 0% load</p> <p>8.4 Overload Test<br/>The following overload tests shall be carried out</p> <ul style="list-style-type: none"> <li>i) Load Rate 110% - Duration 60 minutes</li> <li>ii) Load Rate 125% - Duration 10 minutes</li> <li>iii) Load Rate 150% - Duration 1 minute</li> </ul> |
| 9.0 | Installation and After Sales Service | <p>The Bidder shall have a service organization available consisting of factory trained field service personnel to</p> <ul style="list-style-type: none"> <li>i. Perform installation, testing, commissioning and start-up of the equipment at the site.</li> <li>ii. Perform preventive maintenance, and servicing</li> <li>iii. offer service support 24 hours a day, 7 days a week, 365 day a year</li> <li>iv. provide spare parts 24 hours a day, 7 days a week, 365 days a year</li> <li>v. SLA shall be 2 hr response time and 4 hr resolution time for all the UPS units.</li> </ul>   |

|      |             |  |
|------|-------------|--|
| 10.0 | Training    | The Bidder shall provide training of the Clients operating and maintenance staff at no extra price. A UPS training workshop shall be conducted at the customers site by the Bidder and shall include a combination of lecture and practical instructions. The service training workshop shall include instruction about safety procedures, UPS operational theory, subassembly identification and operation, system controls and adjustment, preventive maintenance, and trouble shooting. |
| 11   | Instruments | DC voltmeter, Safety Gloves, Shoes, Glass, Spanner, Screw driver supplied with battery.  |

### 10.2 **Electromagnetic Compatibility (EMC)**

The Contractor shall ensure and demonstrate that the System is adequately protected against electromagnetic interference (EMI) among the systems of the K-RIDE. All equipment shall comply with IEC 62040 – 3 and EN 50091 – 2 and the following standards for the requirements of electromagnetic compatibility.

#### (1) **Electromagnetic Compatibility – Immunity**

IEC 62040-2

IEC 61000-2-2, IEC 61000-4

#### (2) **Electromagnetic Compatibility – Emission**

IEC 62040-2

All equipment shall confirm with the objective of the European Directives on EMC (EN 62040-2, EN 55011/EEC) and where appropriate shall be fixed with the CE mark.

### 10.3 **Environmental Conditions**

All equipment shall be capable of withstanding any combination of the following external environmental conditions:

(1) Operating ambient temperature 0 to 40°C

(2) Relative humidity. Up to 95%

(3) Storage temperature: - 20°C to 50°C

The equipment shall be designed to provide rated output at 40°C.

#### **Annexure-I**

#### 1. Electrical Characteristics and UPS Performance

##### a) **Mains Supply**

(i) Input Voltage: 415/240 Volts AC (-15% to + 10%)

(ii) Wiring: 3-phase: 4 wire and earth

(iii) Input Frequency 50Hz  $\pm$  10%

##### b) **Input Power Factor**

The total power factor to UPS as a load shall be from 0.99 lagging to unity, with rated load, fully charged battery, and input voltage within +10% & -15% of the nominal value.

##### c) **System Efficiency**

The efficiency of the proposed UPS shall be at least 90% from half load to full load with the fully charged batteries and 85% minimum for rated load while recharging the battery.

##### d) **Harmonics on Input Voltage**

Relative harmonic content on the input voltage shall not exceed 3% of the RMS value for 100% linear load & 5% of the RMS value for 100% nonlinear load of the rated input voltage and harmonic components shall not exceed values given in IEC 62040-3, Clause 5.2.1 d.

##### e) **Reflected Input Harmonics**

The rms value of all harmonics in the input current waveform contributed by the rectifier shall not exceed 4% for linear load and 5% for nonlinear load with input THDv < 1% for both condition of the fundamental frequency with the UPS operating at rated voltage and current.

##### f) **Load unbalance capacity**

The UPS shall have the capability to accept up to 100% load unbalance

##### g) **Overload capabilities**

The UPS shall be able to supply 125% rated load for at least 10 minutes and 150% rated load for at least 1 minute.

**h) Output Voltage**

- (i) Rated voltage: 415 volts, 3-phase, 4-wire.
- (ii) Steady state voltage regulation:  $\pm 5\%$  for a load between 0 and 100% of full rated value, irrespective of the normal mains supply voltage and DC voltage, provided these voltage are within the limits specified.
- (iii) Transient voltage regulation: Output voltage transients shall not exceed the limits of classification 1 specified in IEC 62040-3 clause 5.3.1 and ENV 50091-3 clause 3.2.1 during change in operating mode, 100% step change in load or fault clearing.
- (iv) Output voltage selection :380/400/415V.
- (v) Steady state, voltage unbalance (difference between phase voltage and the arithmetic average of the three phase voltage) :  $\pm 1\%$  maximum for balance load,  $\pm 3\%$  maximum for 50% unbalance load.
- (vi) Phase displacement:  $120^\circ \pm 1^\circ$  for balanced load;  $120^\circ \pm 3^\circ$  for 50% unbalanced load.
- (vii) The output voltage shall not dip more than 20% in case of any fault on the load side of UPS.
- (viii) (H) Total Harmonic Distortion content: less than 4% with linear load, less than 6% with non-linear load (Crest Factor of 3 :1)

**i) Output frequency**

- (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 variation exceeding these limit, the inverter shall switch over to free – running mode, with regulation, providing an output frequency to within  $\pm 0.1\%$  of the rated value without switching to batteries.
- (iv) Frequency slew rate: 0.1 to 0.3 Hz/second settable.

**j) Load Current Crest Factor**

**A crest factor up to 3 :1 for the load current shall be anticipated.**

**The converter should meet with the following specification in addition to other requirement stated herein:**

|                                     |  |
|-------------------------------------|--|
| Nominal Voltage                     | 415V, 3 PHASE ,4 WIRE  |
| Voltage range                       | $\pm 15\%$ / -15% AC   |
| Nominal frequency                   | 50 Hz $\pm 10\%$   |
| Input Power Factor                  | 0.99 lagging or more at Full load  |
| Input Harmonic Current THD          | 3% with linear load and 6% nonlinear load  |
| Duty                                | Continuous   |
| Cooling                             | Forced Cooling   |
| Ambient operating temperature range | 0 to 40°C  |
| Operating Relative Humidity         | 0 – 95 %   |
| Operating Altitude                  | Sea level to 1000 meter  |
| Magnetizes Sub cycle inrush         | Typically 8 times normal full load current   |
| Converter Walk in Timer             | 1 through 7 Seconds (every 1 second selectable<br>0 to 100% rated load) ,Default setting 2 seconds Input |

Suitable terminals shall be provided for termination of cables from the AC Distribution Board.

The inverter should meet the following specification in addition to other requirement stated herein.

|                                 |  |
|---------------------------------|--|
| Voltage Input                   | Three phase UPS                                    |
| Range as per manufacture design |  |
| Nominal Voltage Output          | 415/240V, 3Phase 4WIRE / Single Phase respectively |

**Inverter Capacity**

**As per specification**

**Voltage Regulation**

- (A) For 0 to 100% loading  $< \pm 1\%$
- (B) Inverter DC Input Voltage  $< \pm 1\%$



(C) Environmental Conditional Given below  $< \pm 1 \%$

#### **Transient Voltage Regulation**

(A) At 100% Step Load Change  $< \pm 5 \%$

(B) At loss or return of AC Input  $< \pm 3 \%$

(C) At load transfer from Bypass to inverter  $< \pm 3 \%$

Time to recover from transient to normal voltage 20 milliseconds

#### **Waveform**

Normal frequency 50Hz

Frequency regulation for all  $< \pm 1 \%$

Condition of input supplies, Loads and temperature occurring Simultaneously or in any combination (Automatically controlled)

Synchronization limits for synchronism 48.5 to 51.5 Hz

Between the inverter and standby AC Sources

Field adjustment range for above  $50 \pm 0.25 \text{ Hz to } 50 \pm 1.5 \text{ Hz}$

Phase Voltage Displacement  $120.0^\circ \pm 1^\circ$

Total voltage Harmonic Distortion  $< 3 \%$  THD for 100%

linear load  $< 5\%$  for nonlinear load

Cooling Forced cooling using fans

Ambient Operating Temperature Range 0 to  $40^\circ \text{C}$

Operating Relative Humidity 95 %

Operating Altitude Sea Level to 1000 meters

The static switch should also conform to the following minimum requirements

Continuous Capacity Equal to the 100% continues rating of the inverter

Overload Capacity Equivalent to the overload characteristics of the inverter

#### **UPS**

Nominal Bypass input Voltage 415V, 3-Phase

Voltage Range  $\pm 10\%$  nominal

Nominal Frequency 50 Hz

Frequency Range  $\pm 3\%$

Current 1000%

Duty Continuous

Colling Natural Convection

Ambient Operating Temperature Range 0 to  $40^\circ \text{C}$

Operating relative Humidity 0 – 95%

Operating Altitude Sea Level to 1000 meters

#### **10.4 System Earthing and Equipment Earthing**

Two independent and distinct earth electrodes connectivity shall be provided for equipment earthing of UPS connections comprising suitable GI strips/copper strip to withstand fault current or as required/ approved. Each of these earth electrodes shall comprise a GI plate as per Code of Practice for Earthing IS 3043 (latest version).

#### **10.5 Finish**

All cubicles shall be fabricated from cold rolled closed annealed mild steel sheet 1.5 – 2.00 mm with dead-front access and load bearing members of 1.0 mm to 1.2 mm thickness. The sheet steel shall be pre-treated for rust inhibition through a 7-tank process of degreasing and phosphating and adequately treated before being powder coated in an approved colour. All modules shall be designed for front access for ease of maintenance.

#### **10.6 Testing and Commissioning**

The UPS shall be thoroughly checked for correct operation and load tested in supplier works before dispatch. All faults, control functions and site load conditions shall be simulated, checked and proved. The

equipment shall be dispatched after testing in presence of authorized representative of purchaser. Site Acceptance test shall be done by the UPS supplier @ 100% loading condition with inbuilt/external load bank along with requisite cables and breakers.

10.7 **Documents Handover**

O & M manual shall be prepared by contractor and handed over to client.

## SECTION: E.11 DIESEL GENERATOR SET

### SECTION-I

#### 11.1 Scope of Work

The offer should cover Design, Manufacture, Supply, Installation, testing and commissioning including Integral testing & commissioning with systems of Diesel Engine Alternator sets including AMF Panel, Power and Control Cabling from DG set to AMF Panel (with necessary cable end terminations), all the necessary meters & Relays, Control wiring, Earthing, Day Oil Fuel Tank along with fuel piping, Exhaust Piping, Silencer(s), Sound proof Enclosure and Fire Safety system, etc.

Models of DG sets offered should be strictly as per latest CPCB norms and IGBC guidance and relevant guidelines and Codes (latest prevalent at the time of supply of the DG sets).

All minor civil works, electrical and other works associated with erection, installation and commissioning of the set shall be carried out by the contractor. The contractor should quote for the complete lot to be executed under Indivisible works contract.

#### Scope of work under this tender will include: -

- A. Design, Manufacture, Supply, including all transportation, arranging access to site, storage, loading/unloading, insurance, installation, testing, commissioning, including Integral testing & commissioning with systems and safe custody till handing over of the following of each sound attenuated Diesel Generator set: -
  - i. Sound attenuated weather proof enclosures.
  - ii. Ventilation and illumination system for acoustic enclosure.
  - iii. Alternator and Engine with Radiator.
  - iv. Residential/Critical/Hospital grade silencer.
  - v. Bank of starting batteries along with battery charger for trickle and boost charging of battery bank.
  - vi. Auto-Main Fail (AMF) Panel for DG set operation.
  - vii. Power cable from Generator to AMF Panel (with necessary cable end terminations).
  - viii. All necessary control wiring from Generator to AMF Panel.
  - ix. Approval of the Installation from EIG for its operation.
  - x. Anti-vibration mounting pads.
  - xi. All piping system between engine and radiator.
  - xii. Piping system for fuel line from Engine to Day Oil fuel tank. The pipes shall be Mild Steel (MS) pipes of 25 mm dia or braided flexible.
  - xiii. Calibrated Day Services Tank minimum capacity of 990 liters for operation of DG sets. 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.
  - xiv. Provision of necessary signals for Local and remote monitoring and recording of parameters through Building Management System (BMS).
  - xv. Provision of making earth stations as per IS 3043:2018 complete in all respect including masonry enclosure, and connecting the Earth strips to the Earth stations / Station Earthing.
  - xvi. Provision of making cable trenches / or supplying and laying of GI/HDPE pipes to accommodate all cables, earthing strips and fuel pipe lines as utility to DG set.
  - xvii. Supply and fixing of hot air exhaust duct of 22 SWG GI sheet with DG canopy to remove hot air (if required).
- B. Exhaust piping system including MS pipes, specials, bends, flanges, reducers etc. connection to silencers and lagging the exhaust pipe as per specifications.  
 All the MS supports for the Exhaust pipe should be bolted type instead of being welded, so as to facilitate easy removal /replacement.  
 As per the CPCB guidelines the Chimney / Stack height has to be higher than the building height, therefore suitable Lightning protection system on the Exhaust pipe, duly approved by K-RIDE has to be provided.
- C. All wiring and connections including but not limited to between:

- i. Engine control panel and AMF Panel.
  - ii. Starting battery bank and engine control.
  - iii. Engine mounted alternator to static battery charger.
  - iv. Electrical panel and Fuel pumps etc.
  - v. Battery charger to batteries.
- All necessary wirings & connections to make DG Set system fully functional.
- D. Supply laying and commissioning of earthing from Earth stations (or existing station earthing system) to D.G. Body and neutral and AMF panel separately by Cu/GI earthing Strips (suitable design calculations to be submitted for review and concurrence by K-RIDE). The fixing arrangement of Earth strips should ensure all safeguards against vandalism and theft.
  - E. Alarms and Protection system should be got approved from K-RIDE. It should include all parameters for safe operation and safety of equipment & personnel. AMF should be PLC or microprocessor based with suitable interface for monitoring and recording of all parameters by BMS.
  - F. Interfacing with Station Building Contractor and Electrical contractor.
  - G. Testing and commissioning (including arranging suitable consumables and testing equipment) of the DG sets at site.
  - H. All other work, not specifically mentioned but required for satisfactory completion of work.
  - I. Automatic Gas flooding of AMF Panel, using linear heat sensing tubes Fire tube or equivalent.
- Note: - All Cables (Power and Control cables) for Elevated & At Grade stations will be FRLSZH.**
- J. K-RIDE may need operation of DG sets before Revenue Operation date. For such sets, all consumables, maintenance of DG set and the DG set operator will have to be arranged by the DG set contractor. For this, K-RIDE will make the payments as per the items provided in Bill of Quantities.
  - K. The contractor should go through all the site conditions of the DG set installation before submitting the installation approval of the section/schedule. The DG sets are being installed at the Elevated & At Grade SUB URBAN STATION stations of the K-RIDE project. The requirements for the installation at the above sites may vary & contractor has to coordinate with the different Civil contractors for the foundation and other requirements for the DG set Installation. The contractor has to make all the arrangements for the movement of the inventory and his equipment's for Karnataka region, has to make arrangements along with all the approval requirements as per the place of installation of the DG sets.
  - L. Mechanical foam type extinguisher shall be provided in DG room.
- 11.2 Tender Conditions, Specification and Schedule.**
- A. For any discrepancy between Technical Specifications and Bill of Quantities, provision of Bill of Quantities shall prevail.
  - B. Any item shown in Bill of Quantities and not called for in the Specifications or vice versa shall be provided as if called for in both.
  - C. Wherever it is mentioned that the Contractor shall perform certain work or provide certain facilities, it implies that the Contractor shall do so at his cost.
  - D. Wherever the Technical Specifications stipulate requirements in addition to those contained in the applicable Indian Standard Specifications/Codes these additional requirements shall also be satisfied the Contractor shall do so at his cost.
  - E. At some Elevated & At Grade stations the DG sets are required to be installed below the staircase (Road to Concourse level Staircase) as per the layout. The contractor has to co-ordinate with the civil contractor for its requirements of Air circulation/Exhausts, cabling and foundations etc. The contractor should study each location of installation and submit the detail report for approval to the Engineer before the installation of DG set. The space and access requirements for the DG set transportation, de-loading, access to the room, installation etc. should be interfaced with the Civil contractor at the time of the construction of the Staircase by the DG set Contractor.
- 11.3 Interfacing with Designated Contractor**
- A. The employer has appointed a DDC for civil works, Electrical works of K-RIDE stations. The contractor will be required to interface with the DDC for all the design related activities, associated with this tender.
  - B. Civil works are being executed by Station Civil Contractor. The contractor will be required to interface with the Station Civil Contractor for ensuring provisions, required for installation of DG sets at stations. While the foundation will be done by Station Civil Contractor, minor civil works like grouting, chipping etc are in the scope of the contractor.

- C. Contractor shall interface with Civil plumbing works contractor to ensure that a water outlet (controlled by suitable Valve) shall be provided near the Acoustic Enclosure for meeting the water requirement of DG set radiators.
- D. Contractor shall provide at least Six Potential Free Contacts for Station BMS.
- E. Employer may provide Building Management System at all the stations or in few stations. Contractor is required to provide signals for the BMS. All signals (digital as well as continuous/ analogue) should be available from PLC of AMF panel or microprocessor through RS – 485 ports. All the information for the BMS should be compatible with MOD – BUS protocol. All energy related parameters shall be made available through a RS 485 port.
- F. DG sets are expected to run at light load/No load. The DG set offered, shall be suitable for operation under light load/No load, without any adverse impact on the service performance or life of the equipment. The Bidder should clearly explain that the DG set proposal meets the above requirements.
- G. Stations are provided with independent reliable sources for power supplies 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.
- H. Approximately 60 percent of the load may 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.  
(Requirements of EMI/ EMC due to Single – phase A.C. traction should be taken care)  
**During the Integrated, Testing and Commissioning of the DG set, the set will be tested for the actual linear and non – linear loads at site and the test report furnished.**
- I. Equipment offered shall comply with latest pollution norms as notified by the Government and other statutory bodies at the time of delivery of the DG sets at the site.  
All drawings and other documentation shall be submitted in hard copy format as well as in soft copies in latest version of MS word and PDF formats.

#### 11.4 Approval of Prototype Rating

- A. Contractor will manufacture one prototype DG set of ratings as decided by engineer, with complete equipment (DG set inside the Sound proof enclosure and with AMF Panel) for capacity / rating as specified of the Engine Alternator set. The proto type will be inspected and tested at factory premises by the Employer. Once the Prototypes is approved by the Employer, the firm will subsequently, manufacture and supply the DG sets.
- B. Complete DG Sets of each capacity size shall be made available for prototype testing at Manufacture works.
- C. A complete DG Sets system in addition to the controller shall be assembled on a test bench to undergo a comprehensive running and functional testing in accordance with the accepted test specification to verify compliance with the Specification.
- D. Prototype DG sets shall be tested at varying loads at manufacturers works prior to dispatch of DG sets to site. The performance tests at the works shall be carried out in presence of the authorized Employer/ Engineer. Due notice for the program of performance testing at works shall be given to the Engineer to enable them to arrange for the Employer/ Engineer for this inspection to be at manufacturers works for this inspection & testing.

The performance test on the DG sets shall be of minimum 8 hours duration.

All instruments, material, consumables (fuel oil, lube oil etc.) load and labour 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 manufacturers works tests shall be used as the basis of calculation of specific fuel consumption ratio. |
| 2. | Voltage regulation from no load to full load   | ± 0. 5%  |
| 3. | Frequency regulation from no load to full load | ± 0. 5%  |
| 4. | Maximum water temperature                      | ± 5 % of guaranteed performance  |
| 5. | Maximum lube oil temperature                   | ± 5 % of guaranteed performance  |
| 6. | Maximum lube oil pressure                      | ± 5 % of guaranteed performance  |

- E. The tests shall include the following minimum requirements.
  - i. Verification of the suitability of the system, its efficiency, etc.
  - ii. Performance testing of DG set for 8 hours.
  - iii. Capacity testing of the DG set.
  - iv. Any additional testing as required as per relevant standards.
  - v. Fuel consumption of the DG set.
  - vi. Complete functional tests.
  - vii. Testing of the Sound Acoustics enclosures.
  - viii. Fault Simulation and testing of control & protection devices.
- F. Copies of all the documents of routine tests & type test certificates of the equipment carried out at the manufacturer premises shall be furnished to the Employer/Engineer along with the supply of the equipment's and these are as below.
  - a) Routine Test: -
    - i. Engine separately
    - ii. Alternator Separately
    - iii. DG Set
  - b) Type Test Certificates.
    - i. Engine.
    - ii. Alternator.
    - iii. Pumps.
    - iv. Meters.
    - v. Governors.
    - vi. All major components.

## SECTION-II

### TECHNICAL SPECIFICATIONS

#### 11.5 Operating Conditions

The Engine Alternator are to be installed in Bengaluru of Karnataka Region and shall be **capable** of working at any ambient temperature between 0°C and 50°C and relative humidity up to 95%.

#### 11.6 Performance Requirement

- A. The working kVA rating at site condition after accounting for de – rating shall be obtained at 0.8 power factor.
- B. **Period of Operating:** - The set may be idle for a long period except for routine test periodically. When there is an electrical supply failure it will be required to work **continuously** at variable load with average load factor of 80% as per ISO 8528.
- C. **Overload:** - The set shall be capable of taking 10% overload for a period of one hour during any 12 hours period while operating as per above conditions.
- D. **Shaft Speed:** -Rotational speed shall not exceed 1500 rpm.
- E. **Loads:** - The set shall be capable of operating in conjunction with non-linear and harmonics generating electronic loads including the UPS System.

#### 11.7 Standards

- A. The set shall conform to following standards with latest amendments.
  - Diesel Engines : BS : 5514 BS : 649
  - Alternator : IS : 4722
  - Sound Insulation : IS : 8183
  - Fuel Filters : BS 4552
  - Air Filters : BS 7226
  - Earthing System : IS 3043
  - Latest CPCB norms for Noise Level, Height of Stack/Chimney & Emission levels.
  - Genset : ISO 8528

#### 11.8 Diesel Engine: Construction

- A. 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.

- B. Engine shall be built to comply with BS 5514. The engine shall be complete with cooling fan drive, lubricating oil filters, air cleaners, starter motor/exciter, fuel injector, fuel control solenoid, fuel lift pump, engine speed adjustment, other standard / operational accessories and protective devices including Genset controller.
- C. The Diesel Engine are designed for operation on HSD oil Grade A conforming to IS –1460. DG sets will be operated on Diesel, commercially available in the Bengaluru region, this aspect should be duly taken care in the DG sets being offered and any variation in the performance of DG set on account of this should be clearly indicated / brought out.
- D. The engine shall be fitted with a heavy, dynamically balanced flywheel suitable for constant speed generator duty to meet the cycle variation requirements. An electronic speed governor shall be fitted to maintain engine speed at all conditions of load in line with the requirements of BS: 5514.
- E. Cylinder Housing and heads shall be provided along with other accessories.
- F. Crankshaft shall be truly balanced.
- G. Pistons shall be of aluminium alloy and provided with necessary compression and scrapper rings and a fully floating dudgeon pin.
- H. Connecting rods shall be H-section steel stampings. Camshaft shall be gear driven (fly-wheel end) and easily removable.
- I. Lubrication system shall be complete with necessary gear pump, piping and drilled oil passage strainer, oil cooler and relief valve, etc.
- J. 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 30 seconds (wake up time) of failure of normal supply.
- K. DG set shall be designed for low specific fuel consumption. Specific fuel consumption at rated load should not be more than as per ISO 3046 / BS 5514. During testing of DG set, consumption will be checked and recorded at 25%, 50%, 75% and 100% of rated loads.
- L. The DG set shall be suitable for continuous operation inside the acoustic enclosure under all the ambient conditions without any adverse effect on its performance.
- M. The DG set shall be suitable for continuous operation inside the acoustic enclosure under all the ambient conditions up to 50°C ambient without any adverse effect on its performance.
- N. 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.

#### 11.9 **Cooling**

- A. The engine shall be complete with suitable radiator for cooling the machine in tropical ambient temperatures of 50°C, with engine-driven blower type heavy duty cooling fan and radiator core.
- B. 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 and coolant supplied by manufacturer. Need of corrosion inhibitors shall be examined during design stage, based on recommendations of engine manufacturer.
- C. A thermostatic valve should by-pass the coolant in the primary circuit until a pre-set operating temperature is reached.
- D. The design shall take into account compensation for possible ingress of dirt, which may normally clog the fins. The choice shall take into account the place of installation and the flexibility available for locating cooling system, air circulation and smoke exhaust.

#### 11.10 **Fuel Tanks**

- A. Fuel Day tank of not less than 990 liters Diesel Storage Capacity complete with mechanical fuel oil level indicator to indicate ‘High’ and ‘Low’ levels and isolation valves. Rotary hand pump with flexible hose shall be supplied for pumping and storing Fuel oil from barrels to ‘Day Tank’ as necessary. The tank shall be complete with a floor stand such that the tank is installed at the optimum height which allows correct suction pressure to the Fuel lift pump of the Generator set when the fuel in the tank is at any level between low level and high level.
- B. The tank shall be constructed from Mild Steel of not less than 16 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 be free from leakage and airlocks. The fuel tank shall be supplied with a level gauge to indicate the oil level in the tank in litters. The following fittings shall be included:

- i. Direct reading level indicated (gauge),
- ii. Drain pipe situated at lowest point in tank complete with isolating valve,
- iii. Outlet pipe complete with manually operated isolation valve and mechanically operated isolation valve (for fire shut-down),
- iv. Fuel inlet pipe from the filling point at the top of the tank,
- v. Fuel return inlet pipe connection (from the generator set),

#### **Filtration**

- A. The engine shall have replaceable fuel oil filters. Lube oil filtration, air filtration shall also be through replaceable filters.

#### **Fuel Filters**

- A. supply line fuel filters shall be fitted and shall be of twin replaceable elements type.

#### **Air Filters**

- A. The engine shall be fitted with dry type air filters with replaceable elements.
- B. Twin heavy duty air intake filters in accordance with BS 7226 suitable for operating in dust-laden atmospheres shall be fitted. Breathers shall be fitted with washable filters, which are easily accessible for maintenance.

#### **Engine Exhaust**

- A. The engine exhaust piping shall be amply sized for minimum back pressure 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 / critical / hospital – grade silencers so as to achieve sound attenuation of more than 25 dBA from the DG set as per CPCB norms.
- B. 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 rock wool insulated with 50 Mm thick 64 Kg/cum density. The insulation shall be held in position with 0.63 mm dia, 20 mesh, galvanized steel wire mesh and finished neatly with 24SWG Aluminium cladding.
- C. The generator set shall be provided with an exhaust system incorporating residential/critical/ Hospital – grade silencers. If possible, the silencers shall be contained entirely within the Generator building / on acoustic enclosure.
- D. As per the CPCB guidelines for DG sets the Stack Height / Height of Chimney shall be worked out as per the formula given below: -
  - i.  $H = h + 0.2 \times \text{SQROOT}(KVA)$ .
  - ii. H = Total height of Stack in meter.
  - iii. h = Height of the building in meters where the generator set is installed.
  - iv. KVA = Total Generator capacity of the set in KVA
  - v. Based on the above formula the minimum stack height to be provided with different range of Generator sets may be categorized as follows: -

#### **Capacity of Generators Sets**

1. 50 KVA
2. 50 – 100 KVA
3. 100 – 150 KVA
4. 150 – 200 KVA
5. 200 – 250 KVA

#### **Total Height of Stack in meter.**

- Ht. Of the building + 1.5 meter.
- Ht. Of the building + 2.0 meter.
- Ht. Of the building + 2.5 meter.
- Ht. Of the building + 3.0 meter.
- Ht. Of the building + 3.5 meter.

Similarly for higher KVA ratings a stack height can be worked out using this formula.

The Exhaust Pipe is to be provided keeping in view the CPCB guidelines. Nothing extra shall be paid on account of the suitable support structure to be provided for the Exhaust pipe (suitable support structure should be part of DG set exhaust pipe item).

- E. 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.
- F. 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 & vermin. Exhaust emission control shall be as per CPCB norms.
- G. 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 schedule of quantities shall be checked by the Bidders 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, the measurement of the back pressure will be checked during proto type testing. 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 spirelet 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.

#### 11.11 Sound Attenuating Acoustic Enclosure

##### Design

- A. The sound attenuation enclosure should be designed keeping into account the latest norms of the CPCB as applicable at the time of Delivery
- B. Sound Attenuating Acoustic Enclosure should have pleasant and aesthetic looks and should be designed to achieve the Final sound level of 75 dB (maximum) at a distance of one meter from the Acoustic enclosure as per ISO 8528 part 10 (The latest CPCB guidelines will have to be complied, during the execution of the contract). For testing, the measurement of dB shall be done at different points all along the enclosure and then averaged as per ISO 8528 part 10 mentioned in CPCB compliance procedures.
- C. The sound attenuating enclosure shall be meticulously designed and its design, construction etc. should be decided based on ventilation requirement and should be completely weather proof.
- D. In design, 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 temperature rise of the enclosure with respect to the ambient is less than 7°C.

##### Construction Features:

- i. STRUCTURE: Enclosure shall be made in modular design and can be dismantled/assembled at site. It shall be made out of heavy gauge mild steel sections and reinforced with fabricated super structure, the supporting frame work shall be of 1.6 mm thickness. Outside covers & doors shall be fabricated in 1.6 mm thick CRCA sheet. Inside cover or perforated sheet should be used. The base of Acoustic Enclosure shall be made from suitable size of M.S. sheet / Channel. There should be provision of lifting-hooks on the enclosure to ensure easy lifting. "CAP – ON" type Acoustic Enclosure shall not be accepted.
- ii. ACOUSTIC INSULATION (walls, Roof and Doors): Fire retardant Foam/Mineral rock wool slab of minimum density & thickness confirming to IS 8183 and with covered by fire resistant fiber tissue confirming to AWWA C – 203 specifications.
  - i. For DG sets up to 250 KVA Fire retardant Foam can be used & above 250 KVA Mineral Rock wool can be used as per the requirement, and confirming the Latest CPCB norms as applicable at the time of delivery.
- iii. AIR INLET & AIR OUTLET: Specially designed sound attenuators at Suction & Exhaust ends.
- iv. PAINTING: Outer surface of Acoustic Enclosure shall be painted with Polyurethane paint or powder coated but painting should be done after corrosion treatment of sheet by 7 tank treatment process (or latest available) & synthetic enamel paint on the internal surface. All nuts & bolts shall be zinc coated. The colour of the Enclosure should be got approved from the Employer. Enclosure should be suitably coated to withstand arduous temperature conditions in Bengaluru of Karnataka region.
- v. WIRING AND LIGHTING: Suitable lighting arrangement to be provided in all compartments of Sound attenuating Acoustic Enclosure i.e., E/A set, Fuel tank, AMF Panel with PVC FR copper wire of minimum 2.5 mm<sup>2</sup>, 1100 V grade concealed in flexible conduit / channel & MCB.

- vi. **EXHAUST OF ENGINE:** The Engine Exhaust shall consist of suitable dia 'B' class M.S pipe (Insulated) along with smooth bends & supported. This pipe shall be suitably brought out at the top of enclosure with suitable arrangement at the outer end for preventing water to enter in pipe as required. The Exhaust Muffler with insertion loss of 25 dB shall be provided. For the Engine Exhaust detailed specifications as per clause 5.5. are to be complied.
- vii. **PROVISION FOR NEUTRAL/BODY EARTHING:** Suitable bus bars have to be provided outside sound Attenuating Acoustic Enclosure for neutral/Body earthing separately. The neutral terminals shall be connected to the neutral of Alternator with flexible copper wire insulated braided strip. All the equipment inside the Acoustic Enclosure shall be connected together with suitable size strip and then connected to the Body Earthing busbars.
- viii. **VENTILATION & AIR CIRCULATION:** The system shall be designed to provide air inlet/exhaust acoustic louvers for efficient air circulation under all loading conditions. The ventilation may be natural/forced cooling. The temperature rises of the enclosure with respect to the ambient should be less than 7°C. In case of forced ventilation there should be specially designed circuitry to ensure that the fan(s) starts when the Genset is in operation and when the Genset has been switched off the fan(s) automatically switches over to main supply and runs for 5 – 15 minutes (programmable) before stopping to ensure that set is ready to start in case of another failure.

**Special Feature:**

- i. Fuel tank shall be provided at suitable place (nearest to E/A set) inside or outside the sound attenuating enclosure. Provision should be there to fill this tank from outside as in automobiles and this should be with a lockable cap.
- ii. The batteries shall be accommodated in the sound attenuating enclosure in battery tray.
- iii. Control Panel as well as engine instruments panel shall be inside the sound attenuating enclosure with free frontal access.
- iv. The control panel may be placed inside / outside the sound attenuating enclosure. Alternatively, if it is located outside in the DG room, the equipment layout for each DG room is to be got approved from the employer, prior to the extension of work. As far as possible the control panel shall be placed adjacent to the enclosure to have minimum length of cable.
- v. The sound attenuating enclosure shall be provided with residential/critical/hospital – grade silencers insulated from inside with rock wool having minimum insertion loss as specified in the Latest CPCB norms.
- vi. The sound attenuating enclosure should be as compact as possible with good aesthetic look.
- vii. From continuous running of engine, temperature rise of the enclosure with respect to the ambient is less than 7°C and canopy shall be provided with temperature safety device to shut down engine if canopy temperature exceeds 60°C. The measurement of difference of temperature shall be as per the prescribed procedure specified by the C.P.C.B.
- viii. The sound attenuating enclosure shall be complete with ducting & radiator bellow.
- ix. The sound attenuating enclosure shall have built in receiving tray at base of the Genset for any oil spillage.
- x. The sound attenuating enclosure shall have provision of emergency shut down from outside the container.
- xi. The sound attenuating enclosure door shall be gasketed with high quality EPDM gaskets to avoid leakage of sound. The door handles should be provided with durable weather – proof locking system.
- xii. All the doors of the sound attenuating enclosure shall be lockable and theft proof.

**11.12 Safety Systems**

**Governor**

- A. 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:

- i. Steady state speed band: + 1% or + 0.25% of nominal speed,
- ii. Transient frequency change on application or rejection of 60% load: ± 5%,
- iii. Recovery time to steady state speed band on application of 60% load: 10 seconds,
- iv. Maximum speed drop: 5%

The electrical over speed trip provided shall operate at 120% of the rated speed and shall be reset only by hand.

Other safety controls and indicating instruments shall be as shown in Data Sheet.

**Engine Starting**

- A. The starting system shall comprise a 12/24 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 Five consecutive starts of the engine at 0°C to 50°C. The starting system shall be complete with necessary relays, solenoid valves for fuel, control and indicating panels as specified and required.
- B. A main powered battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfil the starting requirements.
- C. The mains powered charger shall be suitable for operating on 240 V, single phase, 50 HZ supply and shall be complete with the following indications and features:
  - i. Battery charge / discharge current,
  - ii. Boost charge / trickle charge selector,
  - iii. On / Off switch,
  - iv. Fault indication.
  - v. Protection Auto cut off feature to safeguard batteries from over charging.
  - vi. DC ammeter and voltmeter
  - vii. Annunciation panel for battery charging indication
- D. The input voltage to battery charger may vary between 180 V to 240 V, therefore the battery charger should be capable of charging the battery to the desired voltage level with the above input Voltage range.
- E. The battery charger shall have a selector switch by which the rate of charging the batteries can be selected.
- F. If the equipment does not start within three starting cycles with appropriate interval between each attempt, the starting circuit shall be located and audio-visual alarm shall be given.

**Mounting and Installation**

- A. 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.
- B. A common rigid bed plate 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.
- C. The entire set shall be housed in sound attenuating enclosure mounted on suitable Rubber-in-shear type vibration mounts with 6mm static deflection for isolating the building floor/foundation. 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. It is to be ensured that minimum vibrations are transmitted to the surface on which set is resting.
- D. Radio Interference: All equipment, 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.
- E. The installation of DG set be strictly in compliance with manufacturer's recommendations.

**11.13 Alternator****Type & Rating**

- A. Alternator shall be 3 phase, 4 wire 50 cycles 415 volt, totally enclosed, brush-less screen protected drip proof with self-contained excitation system and self-regulating and conforming to IS 4722 & continuously rated. 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 [to adjust nominal voltage over a range of approximately (+) or (-) 5%] and low speed protection, to reduce voltage proportional to the driven speed in order to protect both alternator and V/ F sensitive loads.
- B. 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.
- C. The alternator shall be tropically insulated with class H 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.
  - i. The neutral point shall be brought out separately and earthed permanently.



- ii. The band of voltage regulation shall be  $\pm 0.5\%$  from no load to full load and under varying load conditions.
- iii. The overload capacity shall be 150 – 300 % for 10 seconds limitation, if any, shall be highlighted by the manufacturer.
- iv. The Alternator shall be suitable for taking unbalanced load, limitation, (if any), shall be highlighted by the manufacturer.
- D. The alternator shall be of fabricated steel construction conforming to minimum IP-23 class specified (test certificates conforming to the specified IP class should be produced by the contractor), 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.
- E. Alternator rotor shall be salient pole type with a damper cage and dynamically balanced. Insulation shall be to class 'H' (BS 2757/1957). All winding shall be fully impregnated for tropical climates with high quality or epoxy varnish.
- F. Ventilation to the alternators shall be by means of fans fitted on the rotor.
- G. 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.

#### 11.14 **Excitation System**

- A. 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, overload 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.
- B. Voltage regulation shall be within half 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 wave form shall be as true as possible with a total harmonic distortion not exceeding 3% on 3-Ph load.
- C. 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.
- D. The neutral of each generating set shall be earthed solidly to ground with facility for isolation through a fully rated contactor.

#### 11.15 **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 Emergency main distribution board 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 30 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 DG set Contactor or breakers shall have 4 poles (3 phase and 1 neutral) electrically interlocked. The interlock logic will be got approved from K-RIDE and necessary interfacing with E&M contractor will be done by DG set contractor.
- C. The AMF logic must be achieved through a PLC or 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.
- D. The sequence of Automatic Mains Failure (AMF) operation shall be as follows:
  - i. Upon main power failure, the generator shall receive 3 kick-starts and the generator breaker shall close only after building up of requisite voltage.



- ii. Hold the Mains Contactor or Breaker open.
  - iii. On restoration of power, AMF logic should make change over from DG set to main supply and trip the engine after a pre-set time delay.
  - E. The AMF Panel should therefore comprise:
    - i. 4 Pole MCCBs & 3 pole breakers / contactor and One Neutral Isolating contactor of adequate rating, electrically and mechanically interlocked.
    - ii. Battery charger with normal and trickle charging facility and an isolating switch.
    - iii. Over load and E/F protection for the generator set.
    - iv. For DG sets of Elevated & At Grade stations, 2 outgoing breakers shall be provided – one for Panel of Firefighting system & one to extend power supply to Main distribution panel.
  - F. The contractor shall provide a flame proof Portable Oil Filling pump- Electrical Type with 40 lpm capacity to deliver the oil up to height of 10mtrs.
- 11.16 Protection / Annunciation**
- A. 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: -
    - i. Overload and short circuit trip for main in-comer
    - ii. Overload and short circuit trip for the DG set
    - iii. Over and under voltage protection
    - iv. Over and under frequency protection
    - v. High temperature for cooling water trip
    - vi. Alarm in case the DG set is not run for 1 week at a stretch.
    - vii. Earth fault
    - viii. Loss of sensing
    - ix. Low battery voltage
    - x. Fault indication alarm through suitably designed Annunciator within built hooter
    - xi. High Temperature in Canopy / DG room.
    - xii. Over speed Trip.
    - xiii. Field overload
    - xiv. Over current
    - xv. Any other alarm as specified.
- 11.17 Meters and Indicators as Follows:**
- A. Meter Generator as given in Specifications and data sheets
    - Battery
      - 0 - 24V Voltmeter
      - 0 - 5A Ammeter for charge.
      - 0 - 75mA ammeter for trickle charge.
    - a) Indication and Alarm annunciation
 

| Engine side                  | as given in Specifications and data sheets |       |
|------------------------------|--|-------|
| Additional                   | Indication                                 | Alarm |
| Battery Charger ON           | Yes  |       |
| High/Low battery voltage     | Yes  |       |
| Failed to start              | Yes  | Yes   |
| Lack of Fuel oil             | Yes  |       |
| Low lubricating oil pressure | Yes  | Yes   |
| High oil temperature         | Yes  |       |
| Gen. On                      | Yes  |       |
| Mains On                     | Yes  |       |
| Enclosure Temperature. High  | Yes  |       |
| Over speed                   | Yes  |       |
    - b) Auto-Manual selector switch
      - Start-Stop Reset Buttons
      - Alarm Reset Buttons
      - Lamp testing Buttons

**11.18 Battery System**

There shall be a 12/24V lead acid stationary battery with an AH capacity suitable for minimum 5 (five) cranking attempts of (10 seconds each) (suitable design to be submitted by the firm for each capacity of DG set and to be got approved from K-RIDE plus all indicating lamps and alarm before the cell voltage

goes down by 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. The battery stand and the canopy failure should be provided with suitable safeguards against battery Acid.

#### 11.19 **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 so as to enable it to extend alarm and operation status to station control center. 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:

- A. Metering/Indication
  - i. Voltmeter
  - ii. Phase sequence indication
  - iii. Ammeter
  - iv. KW Meter
  - v. Frequency Meter
  - vi. Battery Voltmeter
  - vii. Common Fault Alarm Signal
  - viii. KWH meter
  - ix. Power factor meter
- B. Counters
  - i. Hours Run Counter
- C. Controls
  - i. Emergency Stop Button
  - ii. Run/Off-Reset/Auto Control Switch
  - iii. Lamp Test/Reset Push Button
  - iv. 3 Attempt Start Timer
  - v. Terminals for Remote/Emergency Stop
  - vi. Interface to Remote Annunciator
  - vii. Voltmeter Phase Selector Switch,
  - viii. Ammeter Selector Switch

**Note: For Metering, Indication and Control, above or equivalent system shall be designed & provided as per the latest industrial standards, after getting explicit approval of the Employer.**

The annunciation alarm shall be repeated to the station control room.

#### 11.20 **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.

#### 11.21 **Testing & Commissioning**

- A. The complete Diesel generator set shall be thoroughly checked for correct operation and load tested in supplier works 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 the Employer/ Engineer of purchaser.
- B. After installation each DG set shall be tested and the specific fuel oil consumption will be checked. The values of the oil consumption noted at the time of testing will be the basis for the penalty. Each DG set shall be run for a minimum period of 30 minutes continuously on no load. On satisfactory completion of the no-load run the set shall be run for a period of 6.5 hours at 100% full load and followed by 60 minutes operation at 10% overload. All consumables including fuel, lubricating 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.
- C. The trial shall be conducted in the presence of the Employer/Engineer / Project Manager 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, labour, instruments, materials and consumables including fuel and lubricating oil required for the test shall be provided by the contractor at his cost.
- D. Tests proving the satisfactory performance of all operating gear, safety functions and controls shall be carried out.

- E. Performance test at site shall include (but not limited to) the following test acceptance criteria:
- |  |   |  |
|--|---|--|
| 1. Voltage variation                           | ± | 1% or ± 0.25%  |
| 2. Voltage regulation                          | ± | 0.5%   |
| 3. Frequency regulation                        | ± | 1% or ± 0.25%  |
| 4. Maximum water temperature                   | ± | 5% of guaranteed performance.  |
| 5. Minimum lube oil pressure                   | ± | 5% of guaranteed performance.  |
| 6. Temperature rises in the Acoustic Enclosure |   | temperature rise of the enclosure with respect to the ambient is less than 7°C as per CPCB guidelines. |
| 7. Noise Measurement                           |   | as per CPCB guidelines.  |
| 8. Muffler / Silencer Test                     |   | Test certificate from independent lab to be submitted  |
| 9. Fuel Consumption at 50%, 75% & 100% load    | ± | 5% of guaranteed performance.  |

Measurement of Vibration around the DG set Enclosure.

Testing of all Trips and Alarms, and data logging and monitoring systems.

Contractor shall be required to carry out any further tests / trials that the K-RIDE Engineer's may desire to satisfy themselves that the Generator Sets and Associated equipment's fully comply with the conditions as set out in these Specifications. Co-ordination with EIG for inspection shall be the responsibility of contractor.

#### 11.22 Fire Safety Measures for The Diesel Engine AMF Panel.

##### 11.22.1 Scope

- A. Compare with ASS Spec. The scope covers supply, installation, testing and commissioning of automatic Clean Agent flooding system complete for AMF panels with fire tube, cylinder, valves, integration with fire alarm control panel for annunciation. The work shall cover: -
- Providing fire tube system inside the AMF panel.
  - Arrangement of Clean Agent for flooding of the AMF panel.
  - Audio-visual annunciation devices for indicating incidence of fire.
  - Wiring from alarm initiating devices to the AMF panel with required conduits as per direction of Employer/Engineer
  - Any other item required for the successful commissioning of the system.
  - Providing manual arrangement outside the sound attenuating enclosure for discharge of gas inside the AMF panels.
- B. The AMF panel fire suppression system shall be complete with Clean Agent gas storage cylinders of 10lb capacities, extinguishing agent as specified, polymer fire tubing system, 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.
- C. 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.

##### 11.23 Standards

- A. Clean Agent used should be clean agent The design and installation of the Clean Agent gas based High Temperature Polymer tube system is based on the latest applicable codes and also as per the manufacturer's recommendations, the required Clean Agent gas quantity is arrived as per the volume of the respective panels to be protected. In addition, the following standards and rules and regulations shall be applicable:
- Fire protection manual of the tariff advisory committee, Fire Insurance Association of India*
  - IS : 15493 – 2004 Gaseous Fire Extinguishing Systems- General Requirements*
  - NBC Part-IV National Building Code Part-IV: Fire Safety System*
  - NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems.*
  - Local Fire Brigade/Authority.*
- B. All standards mean the updated standards with latest amendments.
- C. UL Listed & FM approved system Description
- D. The Clean Agent Pre-Engineered automatic direct fire suppression system shall be approved by Underwriters Laboratories/Factory Mutual/.
- E. Each clean agent pre-engineered automatic system is equipped with its own detection/discharge Fire tubing. The pre-engineered concept minimizes the amount of engineering involved in system design.

When the detection/Discharge tubing is installed within the limitations stated in the manufacturer manual, no hydraulic calculations are required to determine the pressure drop, agent flow or discharge time.

- F. Each Clean Agent extinguishing unit, when installed, is a self-contained system, meaning that it is equipped with its own automatic (non-electric) detection system, which when actuated, automatically releases the suppression agent into the Electric panel.
- G. The Clean Agent Automatic Direct System consists of the following major components:
  - i. Clean Agent Cylinder/Valve Assembly.
  - ii. Cylinder Mounting Bracket.
  - iii. Fire tubing Detector, Actuation and Discharge Fire Tubing and Fittings (No Substitute).
  - iv. Pressure Switch
- H. The Clean Agent Automatic Direct System utilizes unique Fire flexible tubing that is attached to the top of the cylinder valve. This Fire tubing is pressurized with dry nitrogen, is temperature sensitive and acts as a continuous linear thermal detector that ruptures upon Flame impingement. Once the detector tubing is ruptured forming a nozzle at the rupture point, it allows the Clean Agent to flow through, distributing the extinguishing agent into the protected area. Upon system actuation, the pressure switch can be used to indicate system discharge, shutdown ventilation, shut-off electrical power etc. may be required.
- I. The Clean Agent Automatic Direct System is designed and listed as an Automatic unit. No manual or electric means is provided for simultaneous actuation of multiple systems. Only one (1) unit can be used to protect one hazard. These extinguishing units cannot be combined to protect a larger size hazard, since they are not designed to provide for simultaneous actuation of two or more units.
- J. The Clean Agent is stored in DOT steel cylinders as a liquefied compressed gas, super-pressurized with Dry Nitrogen to 150 psig at 70°F. The ambient operating temperature range for all system components is: +32oF to 130 of (0oC to 54.4oC).
- K. Each container is equipped with a nickel-plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the Detection Tubing. The ball valve must be kept closed always when the container is not in service. In addition, the container valve is equipped with a pressure relief (rupture disc) device in compliance with DOT requirements.
- L. A wall-mounted painted steel bracket is used to mount the container/valve assembly in a vertical (upright) position. Each bracket is equipped with two integral quick-clamp straps.
- M. For the direct Clean Agent systems, the tubing performs three functions: Heat Detection, System Activation, and Clean Agent discharge. The tubing is installed throughout the Electrical Panel volume, with one end connected to the top of the Clean Agent container valve. The tubing is pressurized with Dry Nitrogen to 150 psig and maintains the system in the "OFF" position. An optional pressure gauge or pressure switch can be connected to the other end of the detector/discharge tube to monitor system pressure and/or signal of system actuation, etc. The detector/discharge tubing is heat sensitive and, in a fire, situation is designed to rupture at any point upon flame impingement. The rupture of the tube results in a formation of a discharge nozzle that will perform a complete discharge of the Clean Agent. Location and spacing of the tubing should be placed above the hazard areas being protected.
- N. A pressure switch is connected at the end of line of the Detection Tubing to monitor system pressure, system actuation or to energize/de energize electrically operated equipment. Manufacturer recommends that all systems use a pressure switch coupled with some other devices to alert personnel in the event of a system discharge.
- O. 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.

#### 11.24 Design Requirements

- A. Provide sufficient amount of Clean Agent liquid to convert into Clean Agent vapor. Considering the following when computing volume to verify suitability and to establish design limitations:
  - i. Volume of hazard area.
  - ii. Specific volume of Clean Agent.
  - iii. Discharge time and flow rates.
  - iv. Design concentration and design factors.
  - v. Detector/discharge tubing placement.

- B. Locate Clean Agent supply near each hazard area.
- C. Interface system with main control fire alarm system and BMS
- D. Provide total flooding of 7 percent Clean Agent concentration by volume as per NFPA-2001.
- E. The pre-engineered automatic system concept minimizes the amount of engineering required when evaluation is design for a specific application.
- F. No calculations are required for pressure drop, flow rates or discharge time as long as the discharge/detection tubing is installed within the limits as specified by this manufacturer.
- G. When the additional limitations of hazard volume, area coverage, maximum height, design concentration, agent quantity, detection tubing arrangement etc. are also met, the system installation shall be understood to comply with the design requirements, NFPA-2001, and FMRC approval.
- H. Therefore, no discharge tests or concentration measurements shall be required.
- I. All doors and holes in the enclosed/equipment should be closed or sealed to maintain the tightness of enclosure.
- J. The system should have means to close the exhaust fans if installed in the panel at the time of system activation.
- K. As desired by the engineer-in-charge the main supply of panel can be shut off with the system.

#### **TECHNICAL SPECIFICATION OF FIRE TUBE SYSTEM.**

- A. The High Temperature Polymer tube should be a flexible tube made of special polymer.
- B. The High Temperature Polymer tube should be red in colour to indicate it is part of fire protection system.
- C. The tube should be non – conductive, non- corrosive and flexible.
- D. The automatic system shall become a self-contained; self-actuating unit does not require an external source of power or electricity.
- E. The System shall utilize unique flexible tubing that shall be attached to the top of the container valve. The tubing shall be pressurized with Dry Nitrogen to 150 psig at 70°F (1.034 KPA @21°C) is temperature sensitive and shall act as a continuous linear thermal detector that shall rupture upon flame impingement.
- F. Once the detection tubing is ruptured, forming a nozzle at the rupture point, it shall allow the Clean Agent through the Nozzle into the protected area.

#### **11.25 Operation and Maintenance Documentation**

##### **11.25.1 General**

- A. The Contractor shall provide Interactive Training and Operation and Maintenance manuals, bi –lingual (i.e. in Hindi and English both) and Interactive Video CD, for use by supervisory, operating and technical staff of Employer. In addition, contractor shall provide Computer Based training program for the Trouble shooting and Operation and Maintenance of the DG Set.

##### **Requirements of Interactive Manual**

The contractor shall submit in English language Interactive Electronic Technical Manuals (IETMs) to manage technical documentation. IETMs shall compress volumes of text into CD-ROMs which may include sound and video, and shall allow readers to locate needed information rapidly than in paper manuals.

This IETM shall follow the structure and format of a printed book, with indexes and table of contents that are hyperlinked into the content of the document. All figures, tables and section references shall be linked.

The data to be stored in a relational database, obtaining benefits of data integrity and removal of data redundancy. Relationships in the content that are presented as hyperlinks, are mapped directly to relations in the database scheme. The IETM shall be able to change the content dynamically based on users' navigation and input through the content; the content may now be user specific.

- B. Each and every manual shall be divided into indexed sections explaining the subject matter in logical steps. Most manuals shall consist of A4-size printed sheets bound in stiff-cover wear-resistant binders clearly and uniformly marked with the subject matter and reference number. Where alternative sizes are proposed, (e.g. A5/A6 pocket books of schematic wiring diagrams) these shall be submitted for review of "Engineer". The binding shall allow for all subsequent changes and additions to be readily effected.
- C. Information shall be provided in pictorial form wherever possible and shall include step-by-step instructions and views of the particular equipment including exploded views. Programmable



equipment shall be supplied with sufficient flow charts and fully documented programmed to enable faults to be quickly identified and system modification to be undertaken at any time.

- D. The Contractor shall provide clarifications and amendments to the Operation and Maintenance manuals as necessary during the Defects Liability Period. Updates shall be provided for the originals and all copies.
- E. The first draft of operation & maintenance manuals is to be provided at least 60 days before the installation commences. These should be corrected as per employer's comments and finally be submitted during installation and commissioning.
- F. Hard copy as well as electronic copy should incorporate colour photos, colour sketches and drawings in pictorial form wherever possible.

#### 11.25.2 **Operation Manuals**

- A. The Contractor shall provide operation manuals explaining the purpose and operation of the complete system together with its component subsidiary systems and individual item of equipment. The characteristics, ratings and any necessary operating limits of the Equipment and Sub-systems shall be provided. The Operation Manuals shall focus on operation aspects under normal and emergency conditions.

#### 11.25.3 **Maintenance Manuals**

- A. The Contractor shall provide particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing program.
- B. The maintenance manual shall also include an illustrated parts catalogue of all plant supplied and shall contain sufficient information to identify and requisition the appropriate part by maintenance staff. The catalogue shall comprise 2 sub-sections.
- C. The first shall be an alphanumeric parts list, which shall include the following information:
  - i. Part number
  - ii. Description
  - iii. Name of manufacturer
  - iv. Quantity and Unit
  - v. Part number of next higher assembly (usually a line replaceable unit).
  - vi. Cross-reference to figure number.
  - vii. Category: e.g. consumable, line replaceable unit, repairable.
  - viii. Life-expected life, Mean time between failure or mean distance between failure where available, Mean time between repair, Mean time between maintenance, Reliability.
  - ix. General or specific purpose
- D. The second is a series of illustrations to indicate the location of each replaceable item which shall be clear and progressive with exploded views to enable parts to be identified easily by cross-reference with the alpha-numeric list.
- E. Maintenance manual should cover the following;
  - i. Maintenance planning, Maintenance management, Maintenance Requirement
  - ii. Analysis like Reliability centered maintenance, FMCEA etc.
  - iii. PM, CM, CBM & condition monitoring techniques i.e. during installation, vibration levels are required to be noted down which becomes reference for vibration limits.
  - iv. Maintenance infrastructure
  - v. Man power requirement
  - vi. Job description, Comprehensive annual maintenance.

#### 11.25.4 **Scope of Training**

The training shall be provided by the Contractor to the Employer's personnel in operation, maintenance, schedule maintenance, breakdown etc. maintenance installation practices related to DG Sets. This will cover training in India and abroad including training at manufacturing facilities.

##### **Training Program**

Contractor shall submit a training program for imparting training to K-RIDE employees with batches of approximately 20 trainees for DG Sets systems.



## Section F.01- FIRE ALARM AND DETECTION SYSTEM

### 1.1 General

- A. This Section specifies the scope of work, manufacture, supply, design and installation, Testing, commissioning of the Fire Alarm and Detection System.
- B. The system shall be an intelligent addressable fire alarm and detection system. NFPA 130,2020 shall be used as the guiding standard for the fire alarm and detection system. The system shall be designed in an integrated manner in accordance with NFPA-72, 2019 or latest Edition, British standard BS 5839, BS EN 60701, BS EN 60702-2, BS 8434, or ISO 7240, as appropriate or other internationally recognized and local code of practice.

### 1.2 List of Abbreviation

|        |  |
|--------|--|
| FACP   | Fire Alarm Control Panel               |
| FRLSZH | Fire Retardant Low Smoke Zero Halogen  |
| SCADA  | Supervisory Control & Data Acquisition |
| SCR    | Station controller room                |
| SD     | Smoke detector                         |
| SWG    | Steel Wired Gauge                      |

### 1.3 Scope of Work

- A. The scope of the work is to supply, installation, testing and commissioning of intelligent addressable fire alarm and detection system in compliance with codes and standard mentioned in this specification, Outline design Criteria and International best practices for all station areas not limited to platform level, concourse area, Ancillary building, back of houses etc. The Addressable Fire alarm system will comprise of the following:
  - i. Micro-processor based Main MAPs and RPs.
  - ii. Analogue addressable smoke detectors, heat detectors, combined optical and heat detector.
  - iii. Addressable manual call-point.
  - iv. Alarm bell & beacon lights
  - v. Colour mimic panels with LED indicators
  - vi. Batteries and charges
  - vii. Electrical wiring, conduits, trucking and accessories
  - viii. Flow switches of the sprinkler system.
- B. Voltage free fire alarm signals through voltage free normally close contacts from the fire alarm system to the ITBs: the contractors shall supply and install all ITBs (except for BMS/SCADA interface) and connecting cables between the fire alarm system and ITB for all interfaces.
- C. A main alarm panel shall be provided in each station to indicate the location where the alarm is being activated. The MAP shall be placed at a location within the station where the Fire & Safety Department Personnel have first access when responding to a fire call.
- D. For all stations, the MAP shall be located in the firemen staircase, Station Control Room or as directed by the FRSD. The firemen staircase shall have access to every level of the station.
- E. A FACP (Fire Alarm Control Panel) shall be provided in each SCR and repeater panel in each entry near fire exit as required by the FRSD. Colour mimic panels with LED indicators shall be provided next to each MAPs, RP and at specific locations indicated in the Drawings.
- F. The fire alarm system shall have the capability to process and evaluate incoming signals from addressable devices such as smoke detectors, heat detectors, combined optical & heat detectors, manual call-points, flow switches etc. via Class "A" twisted pair screen cables addressable loop in separate galvanized steel conduits. The individual addressable loop shall comply with UL 864 and shall be monitored for open and short circuit fault. In the event of open or short circuit, all devices connected along the affected loop must be fully operational. Fault isolators shall be provided with every detector in base/device or as per latest UL requirement.
- G. Each addressable loop shall constantly scan to check the operation and status of all the field devices. In a fully loaded system, the average time to detect an alarm shall not be more than 5 seconds in case of alarm from detectors and 3 seconds in case of alarm from manual call points. Separate loops shall be provided for the alarm bells.

- H. MAPs and RPs installed at outdoors or exposed to weather shall be of double layer enclosure weatherproof construction and rated to at least IP55 for the station Areas.
- I. Detectors shall not be located too close to the air-conditioning outlets or diffuser, which may cause condensation and false activation. Detectors shall be visible and accessible for maintenance.
- J. The following operational requirements shall be automatically instituted when any detector, manual break-glass call-point, clean gas system, panel flooding system or sprinkler system is activated: -
  - The alarm signal shall be automatically transmitted direct or through clean gas
  - Panels or Panel gas flooding system panel to the MAP and RP giving both visual and audible indications at the MAP and RP

## 1.4

**Standards**

- i. Relevant Codes and Standards
- ii. BS 4683 / BS EN 60079: Electrical Apparatus for Explosive Atmospheres
- iii. BS 5445: Components of Automatic Fire Detection Systems
- iv. BS 5839: Fire Detection and Alarm Systems for Buildings
- v. BS 6387: Performance Requirements for Cables required to Maintain Circuit Integrity under Fire Conditions
- vi. BS EN 55104: Electromagnetic Compatibility
- vii. BS EN ISO 9000: Quality Management and Quality Assurance Standards
- viii. BS EN ISO 9001: Quality Systems Model for Quality Assurance in Design, Development, Production, Installation and Servicing
- ix. BS EN ISO 9002: Quality Systems Model for Quality Assurance in Production, Installation and Servicing
- x. BS EN ISO 9003: Quality Systems Model for Quality Assurance in Final Inspection and Test
- xi. BS EN ISO 9004: Quality Management and Quality Assurance Standards
- xii. BS 7846 / BS EN 60702-2: – Code for Fire Survival Cables.
- xiii. IS 2189: 2008 Selection, Installation and Maintenance of Automatic Fire Detection and alarm system – Code of practice
- xiv. Codes and regulations of the jurisdictional authorities.
- xv. NFPA 72: National Fire Alarm and Signaling Code.
- xvi. Mandatory Approvals  
**UL Listing/FM Approved**

**TECHNICAL AND INSTALLATION REQUIREMENTS****A. QUALITY CONTROL**

- (i) Provide equipment which are products of manufacturers who have made these products for a period of at least ten years, except that the console and the intelligent analogue type detectors and modules shall be the latest developed products which is UL listed/FM approved. The system components such as control panel, detectors, line break isolator and modules shall be of the same manufacturer and under one family design.

**B. CONTROL PANEL**

- (i) The automatic and manual Fire Alarm Control Panel (FACP) shall be multi-zone control panel of the intelligent analogue addressable type, complete with power supply, battery charger, batteries.
- (ii) The main Fire Alarm Control Panel shall be located within the Station Control Room (SCR), with an interface to the Workstation for the Fire Detection & Suppression system. All the fire detectors, alarm devices and interfaces to other systems shall be connected via this panel.
- (iii) The Cabinet of FACP will be fabricated from Minimum 2mm thick electro-galvanized steel sheet, epoxy powder coated minimum thickness of 60 microns. All angles and channels will also be hot dip galvanized and painted signal red. The cabinet will be fitted with a lockable door of hardened tempered glass panel. All group indicators and associated switches shall be visible behind the locked door without opening door. The door shall be provided with appropriate hinges and lockset and shall not stay when opened. The FACP shall be analogue addressable in a lockable housing with illuminated function keys and capable of full “stand-alone” operation. The FACP housing shall be to a minimum protection rating of IP 30 or NEMA 1 (Whichever is applicable)

- (iv) The FACP shall be at least 4 loops control panel with loops expandable feature for all Elevated & At Grade stations and of intelligent addressable type with a loop capacity of minimum 250 devices, complete with all alarm loop cards and input / output control interface, at least 120 LCD character display, easily operable with acknowledgement, reset and silence facility with 21 Inches LED monitor and appropriate with latest configuration printer with software. Intel core i7 Processor with 3.0 GHZ or higher, 4 GB RAM or above. 1 TB SATA HDD, Integrated Sound & Graphics Media Accelerator, optical scroll mouse, multimedia keyboard .52x CVO Read / Write, Dual LAN card, 2 Serial port, 1 parallel port. 4 USB Ports, all hardware driver as required for smooth operation, Windows 10, 32/64-bit Desktop preloaded operating system with standard MS Office package, & along with latest antivirus version with updated security pack and minimum 3-year product license validity. Auto recovery and auto archive software and suitable for operation on 230 volts A/C. 50 Hz
- (v) Detection devices shall be connected via loops with a maximum acceptable length of 3km. The FACP shall have indicators for information, isolation (including device isolated), alarms and faults (including system fault, device fault, and external fault and processor fault).
- (vi) Activation of manual call points or detectors shall be identified on the FACP identifying the loop number and detector address number including the associated Fire Alarm zone. This information shall be provided via a textual message on a separate screen integral to the FACP. Fire alarm panels shall be lockable with alarm/reset functions; On/Off controls and alarm disable controls. A facility shall be provided to allow operating access to authorized personnel. This shall be via key or password access.
- (vii) The FACP shall be self-checking and shall have the facility to identify faulty/ contaminated devices or system malfunction such that faulty status/condition shall not be confused with fire alarms. The loss or failure of any detector or alarm device shall be identified and displayed within 60 seconds.
- (viii) The processor shall be capable of polling all field devices on a loop within Three seconds.
- (ix) A facility shall be provided to isolate a single device on a loop or a group of devices on a loop on a temporary basis. An illuminated warning indication shall be provided on the FACP, which shall remain lit until the isolation is removed.
- (x) The FACP shall have an integral clock, which shall be synchronized with the Station centralized clock system (provided by others). A facility shall be provided to allow for an external logging printer to be connected. The printer shall be located within the SCR. The station FACP shall be equipped with monitoring/relay points to relay status and alarm messages to the SCADA system.
- (xi) The following function shall have on the FACP with LED indicators:
  - a) Fire pump and Jockey pumps "ON/OFF/TRIP" status
  - b) Fire water tank high and low-level alarm
  - c) Control valve status
  - d) Electricity supply per phase failure indication alarm zones "ALARM/FAULT/ISOLATE"
  - e) Electricity supervised gate valve "Closed"
  - f) Clean gas panels "ALARM/FAULT/ISOLATE"
  - g) Mute switch status
- (xii) Relays points shall be provided for:
  - a) FAP healthy signal,
  - b) Fire alarm condition,
  - c) Fire zone of such alarm condition,
  - d) Fire condition link to PA automatic messaging,
  - e) Non-synchronizing clock.
- (xiii) These relay signals shall be connected to the station communications equipment under the signaling and communications contract.
- (xiv) The FACP shall interface with other systems including but not limited to:
  - a) Ventilation Control System. The FACP shall send signals to the Ventilation Control Panel advising of zones in FIRE condition.
  - b) Sprinkler Systems. The system shall monitor water flow for wet stand pipes etc. as required. The FACP shall receive signals from the sprinkler flow switches to identify activation,

- c) Gas Suppression System. Total flooding/panel flooding system shall interface with fire alarm control panel through interface module.
- d) FACP shall also interface with public address and voice alarm system, lifts, escalators, AFC gates, electrical rooms, fire pumps, and all other systems as per requirement.
- (xv) The response to alarms from various combinations of the detectors, flow switches, or manual call points shall, via the dedicated microprocessor, initiate performance of such other functions as required like:
  - a) Alert Station staff,
  - b) Alert Line controller,
  - c) Initiate operation of Fire Suppression Equipment,
  - d) On confirmation of Station Manager, initiate operation of Automatic Public-Address System message,
  - e) Release Smoke stop doors held open,
  - f) Allow any emergency exit fastenings to open on transmission of the Evacuation signal,
  - g) Initiate illumination of Station No – Entry signs on transmission of the Evacuation signal (via SCR and Telecommunications),
  - h) Initiate closure of Fire shutters,
  - i) Initiate smoke extraction measures.
- (xvi) All detector and bell circuits shall be continuously monitored and a fault on any of these shall be indicated in the Main Fire Alarm Panel.
- (xvii) The FACP shall also control and monitor the flow switches for Fire sprinkler system and Gas suppression system.
- (xviii) Each system shall provide at least 25 % spare capacity for future expansion as per UL 864 latest edition.

#### **C. BATTERY CHARGER AND BATTERIES**

- (i) A 24 V DC trickle type battery charger and batteries shall be provided. The unit shall incorporate the following components: -
  - a) Trickle charger assembly.
  - b) Rotary type selector switch.
  - c) One incoming double pole control fuse holder with suitably rated fuse.
  - d) Sealed type Ni-Cd batteries
  - e) Rectifiers and DC output voltage stabilizer
- (ii) The unit shall be suitable for use on a 240 V AC single phase power supply and shall automatically maintain the 24 V DC batteries in a state approximate to full charge and at the same time to compensate for the standing load. The charger shall cater for re-charging the battery from fully-discharged condition to fully-charged condition in not more than 24 hours.
- (iii) Batteries shall be of 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 operating in the "alarm" condition continuously for at least one hour.
- (iv) 72 hours back up shall be provided to the indication lamp of the "power loss".
- (v) In selection of battery capacity, a deterioration factor of 0.9 minimum shall be applied

#### **D. MANUAL CALL POINT**

- (i) Manual call point shall be addressable type. Manual call points shall be arranged to operate automatically upon breaking of the glass and shall commonly with the requirements of NFPA, BS and acceptable to the local authorities. The cover shall have sealing facilities to prevent vandalism and locked in position with a special key with the flash panel being clipped firmly into place. It shall be manufactured in bright red compliant material, measuring 65 x 85mm with 50mm overall depth or as approved / required by engineer. Operation shall be via a plastic membrane (non-breakable) with wording on method of operation in white lettering. The cover shall be etched in black lettering in Hindi and English "FIRE", the letters measuring not less than 10mm high.
- (ii) The surface of the Manual call point shall be provided with a LED indicator. It shall light up upon activation of the Manual call point. The operation of any call point connected to the system shall cause the station FACP to enter the alarm state within three seconds.

- (iii) Contacts shall be of silver or approved non-deteriorating alloy, for normally close/open system. The voltage and current ratings of the contacts shall be marked within the unit.
- (iv) The units shall be of the flush mounting type and suitable for direct connection to the type of wiring system therein specified without the addition of unsightly surface boxes, glands and adaptors. Special boxes compatible with the conduit system shall be provided where necessary for installation of the call points.
- (v) Manual call point shall be positioned at a height of 1.4m at strategic points throughout the station such that they are clearly visible from front and sides as practicable and Manual call point shall be located so that one is within 30 meters of any point in the station. Provide flush plates for the recess mounting units.
- (vi) Each Manual call point shall be accompanied by an alarm bell except those installed in concourse and platform areas where no alarm bell is required. The alarm bells and flashing light units shall actuate upon receipt of a fire alarm signal from any of the Manual call points or detection systems.
- (vii) Manual call points installed outdoor shall be of weatherproof type complying with IP55.
- (viii) Each Manual call point shall be complete with built-in testing slot, such that testing can be carried out by insertion of the test key without removing the glass front cover of the unit.

## 1.5

**Detectors****General**

- A. Unless otherwise specified, smoke detectors shall be of multi-criteria type.
- B. The internal circuits shall be of solid-state device and shall be hermetically sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock. All circuitry shall be protected against typical electrical transients and electromagnetic interference based on BS EN 55104 to include IEC 801-2, IEC 801-3 and IEC 801-4.
- C. Each detector shall carry a built-in address via easily understood decade switch.
- D. There shall be a built-in magnetic test switch in each intelligent device.
- E. Built-in testing facility shall be provided based on NFPA 72/ Latest Edition requirements.
- F. The detector base shall have a positive mechanical means to hold the removable portion of the device. However, such provision shall provide a simple means to remove the detector from the base, either by hand or by the use of a special tool that can plug-in and/or remove the detector head from a distance of up to 6 m above floor level.
- G. Detector base shall be compatible for connection of all types of analogue addressable detectors and shall have the facility to drive a remote visual alarm indicator which shall be provided for all concealed detectors. Remote indicator shall be compatible with the detector so that the operation of the indicator will not impair or affect the brightness of the detector's built-in LED.
- H. There shall be LEDs on the detector head so that alarm condition of the detector can be seen clearly from any direction or angle.
- I. There shall be at least 3 levels (high, medium and low) of sensitivity, as approved by the agency listed or by Fire service, which can be selected at any time at the Fire alarm control panel or by automatic day/night sensitivity change over program which shall be built into the Fire alarm control panel.
- J. Detector shall be low profile, no more than 60mm in height including the base to minimize dust accumulation at detector head, resulting from the pattern of airflow.
- K. The response indicator with labelling shall be provided for all detectors installed above false ceiling as specified in clause 1.15 of this Technical Specification.
- L. Labels shall be provided adjacent to all detectors with appropriate letters indicating the corresponding address and letters shall be of not less than 20mm high.
- M. Should Include a built-in fault isolator (Base/Sensor Head)

## 1.6

**Heat Detectors**

- A. Heat detector shall be an analogue addressable type and combined rate of rise of 10°C per minutes and fixed temperature suitable for 24V DC operation.
- B. All electronic circuitry in the detecting head and base unit shall be hermetically sealed to prevent their operation from being impaired by dust, dirt or humidity. The detectors shall be capable of performing accurately when subjected to relative humidity up to 90%.
- C. A LED visible alarm indication of sufficient brightness shall be provided on detectors to identify the unit in alarm.



**1.7 Addressable Multi Criterion Detector**

- A. The detector shall operate on light scattering principle, containing an emitter and photo sensor. The scattered light reaching the photo sensor shall be proportional to the smoke density inside the detection chamber. It shall combine both optical and heat detector technology to detect clear burning fire products, which hitherto could only be easily detected by ion-chamber detectors. The detectors shall not operate on a rate of rise of temperature alone.
- B. The detector shall be fully operable between 0°C and 38 °C and up to 90% relative humidity non-condensing or as per UL listed operating temperature range.

**1.8 Interfacing Relay**

Addressable relay modules shall be available for system control and other building functions. Signals to control other systems by means of dry contacts shall be equipped with a 24V DC relay, with dry contact rated at not less than 2A 240 VAC. The relay and terminal block shall be housed in a covered galvanized steel or stove enamel steel box with adequate size to house all relays but in no case smaller than 110mm X 100mm X 50mm. Terminals shall be labelled clearly by means of silk screened or engraved lettering in metal or plastic plate.

**1.9 Printers**

- A. The fire alarm control panel shall comprise a system printer which shall have a 96 ASCII character set.
- B. The printer shall have an indicator to alert the operator that paper has run out.
- C. The printer shall have a self-test feature to verify printer operability even when off line.

**1.10 Monitor Modules**

- A. Addressable contact monitoring module shall communicate via the detection cable loop with the FA control panel for continuous monitoring of any NO or NC dry contacts connected including break glass, flow switch and repeating dry contact signals from gas flooding system and gas detection system. LED indication shall be provided to show the status of the module.

**1.11 Control Modules**

- A. Addressable control modules shall be provided to supervise and control the operation of one conventional NAC's of compatible, 24 Vdc powered, polarized audio/visual notification appliances. Shall be UL listed (latest edition). Audio/visual power shall be provided by a separate supervised power circuit from the main fire alarm control panel or from a supervised UL listed remote power supply.
- B. The control module shall provide a supervised indicating circuit where indicated on the Drawings. Any open/short circuit fault shall be detected/highlighted/displayed at the FA control panel. Subsequent fire alarm signals shall activate the appropriate controls and signaling devices despite of the fault conditions.
- C. The control module shall act as a control relay where required.
- D. The control module shall contain a LED which blinks upon being scanned by the FA control panel. Upon activation of the module, the LED shall be latched on.
- E. Status of control module shall be fed back to FA control panel and print out automatically (if printer is available) once it is activated.

**1.12 Repeater Panels**

- A. The Cabinet will be fabricated from Minimum 2mm thick electro-galvanized steel sheet, epoxy powder coated minimum thickness of 60 microns. All angles and channels will also be hot dip galvanized and painted signal red. The cabinet will be fitted with a lockable door of hardened tempered glass panel. All group indicators and associated switches shall be visible behind the locked door without opening door. The door shall be provided with appropriate hinges and lockset and shall not stay when opened.
- B. The Repeater Panel shall have its own micro-processor, software, and memory capability and provide indication for alarmed and troubled/faulted condition in each loop. All software (i.e. programs and data system configuration) shall be held in non-volatile ROM/EPROM. The signal display at each SAP shall be means of LCD with back-lighting capability and sufficient display characters which are user definable. All alarm signal display shall include zone location and point location in English text.
- C. Remote repeater panels for repeating all alarm status indication with LCD display shall be provided at the specified location and shall be fire service approved.
- D. The repeater panel shall have identical zoning and colour display for all alarms and shall fully correspond to those in the FA control panel.



- E. The repeater panel shall be provided with warning buzzer which shall activate when an alarm occurs in the fire control room and a push switch shall be provided for silencing the warning signal. Lamp test control switch shall also be provided in the panel.
  - F. The panel shall contain an integral backlit LCD display of minimum 80 characters. LCD display shall be viewable through the panel door.
  - G. The repeater panel enclosure shall be flush mounted, and all electronics shall be contained in the enclosure. Access to the repeater panel switches shall be protected by key-switch.
  - H. The panel construction shall be as per Specification.
- 1.13 **Fire Zone Mimic Panel**
- A. An LED Fire Zone Mimic Panel shall be located in the Fireman's Staircase adjacent to the auxiliary FAP.
  - B. This panel shall provide a LED indication of the stations layout and details relating to the alarm zones, breeching inlets, standby hoses, call points, electrically supervised butterfly valve, landing valves, flow switches and sprinkler control valves, MAPs, SAPs and RP Locations Etc. the fire zonings for the viaduct shall be indicated with the distance markings in meter for the location detected along the line type detectors with reference from the nearest connected SAP. Pictorial representation of the Station favour identifying the zone boundaries and is intended to aid the fireman in the later identification of the area of the station in fire condition.
  - C. In the event of a detector in a particular zone going into fire condition the associated Zone LED shall illuminate on the mimic panel.
- 1.14 **Sounder Cum Strobe**
- Annunciation, Sounder cum Strobes has also been provided. Sounder cum strobe shall be used for audio to alert people in case of fire and shall be fully solid state with audio output sufficient to be heard. Sounder cum strobe shall be preferably be connected to the detector loop using addressable control module and shall be powered from the panel using same detector loop.
- 1.15 **Response Indicator**
- Response indicator of LED type shall be provided for above false ceiling and below false floor detectors and these shall be mounted outside/ inside the rooms wherever asked for by the Contractor/ Employer/Engineer for indication of fire through detector in the room. The design & colour shall be as per the standard as approved by Employer.
- 1.16 **Wiring & Signal Transmission**
- A. Transmission shall be hard-wired using separate individual circuits for each zone of alarm operation, as required or addressable signal transmission, dedicated to fire alarm service only.
  - B. System connections for initiating device circuits shall be Class A.
  - C. Initiating device circuits/detection loop shall be wired with 2-core, Copper Conductor, 1.5 sqmm (16 AWG), twisted pair FRLSZH cable of approved makes.
  - D. Notification Appliance Circuits shall wired with 2-core, Copper Conductor, 1.5 sqmm (16 AWG), twisted pair FRLSZH cable of approved makes.
  - E. The Fire Fighter Telephone line, Notification Appliance Circuit and Voice Evacuation cum Public Address Pathway shall be wired with 2-hour fire rated shielded cable of mentioned specification & approved make.
  - F. Terminations shall be done with proper ATC lugs with insulated sleeves.
  - G. Circuit faults shall be indicated by a trouble signal at the FACP. The system shall provide a distinctive indicating audible tone and alphanumeric annunciation.
  - H. Fault Isolators shall be provided in every Detector's as inbuilt capability either in base or sensor head. However, it shall be ensured that a single short circuit or open-circuit fault on an automatic fire detector circuit/detection loop shall neither disable protection within an area of more than 3,000m<sup>2</sup>, nor on more than one floor of the building plus a maximum of five devices (automatic detection, manual call points, sounders or a combination of these) on the floor immediately above and five devices on the floor immediately below that floor.
  - I. Circuit faults shall be indicated by a trouble signal at the FACP. The system shall provide a distinctive indicating audible tone and alphanumeric annunciation.
  - J. When provided, audio notification appliance circuits shall be supervised during standby by monitoring for DC continuity to end-of-line resistors.

## 1.17 Data Sheet Fire Alarm System

| DATA SHEET FIRE ALARM SYSTEM |                         |  |
|------------------------------|-------------------------|--|
| 1.0                          | SYSTEM                  |  |
| 1.1                          | GENERAL                 | Networked Fire Alarm System  |
| 1.2                          | CAPACITY & ARCHITECTURE | Number of loops as shown in drawings.<br>Signal initiating devices per loop as shown in drawings. Control devices per loop as shown in drawings.<br>Auto dialling facility to the nearest fire brigade station.  |
| 1.3                          | PANEL DISPLAY           | Adequate LED alarm display - Minimum requirements are as under:<br>Type of point/loop in alarm.<br>Alarm acknowledge<br>All-clear, clear acknowledge<br>Trouble/ disable condition<br>Trouble acknowledge<br>Loop location<br>System location<br>Loop activated<br>Open circuit<br>Short circuit<br>Wire grounding<br>Maintenance need   |
| 1.4                          | System Testing          | Manual test switch : Re- commissioning testing as specified.   |
| 1.5                          | System Power            | System power with 24V DC sealed lead-acid batteries with 220 VAC 50 Hz battery charger with trickle and quick charge capability of 24 hours from fully discharged to fully charged condition.<br>Batteries to be capable of maintaining the system for 12 hours and then for 1 hour in alarm mode.<br>Fault indication in panel.<br>Low cell voltage –<br>High cell voltage<br>Charger faulty<br>(Charger - metering as follows: AC voltage & amps)<br>DC charge voltage & amps DC discharge voltage & amp |

## SECTION: F.02 FIRE FIGHTING SYSTEM

### 2.1 General

The scope of this section comprises the supply, installation, testing and commissioning and Training to Employer/Engineer (Training plan Shall be submitted to Engineer for Approval and its implementation) of the entire firefighting system.

- A. 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 as per BOQ.
- B. The contractor shall get the Fire Fighting System approved by the Fire Authority having Jurisdiction.
- C. All items provided in this specification shall be provided by the Contractor and no extra payment shall be made.
- D. All power and control cables in the fire system shall be Fire Retardant Low Smoke Zero Halogen cables.
- E. The Contractor shall obtain initially and final NOC / approval from Local Fire Department. No extra amount shall be paid for this work and price may be included in the rates.
- F. All nuts, bolts, washers etc. shall be of Galvanized iron for fitment of pipes, valves and other accessories unless and otherwise specified.
- G. Data sheet shall be submitted for Materials and equipment for approval of Employer/Engineer before conducting FAT. The approved data sheet shall be verified at factory from Employer / Engineer during FAT.

### 2.2 Scope of Works

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:

- i) Fire Fighting Pumps & Accessories and related electrical works
- ii) External & Internal Fire Hydrant System.
- iii) Sprinkler system in store building.
- iv) Hand appliance

The firefighting system covering the entire complex and consisting of the following:

- A. Fire Hydrant electric pumps as shown in the BOQ, drawings and as required.
- B. Jockey pump, electric driven as shown in the equipment schedule, drawings and as required.
- C. Hydrant mains, and yard hydrants.
- D. Wet risers in the station as specified and shown on drawings.
- E. Landing valves, hose reels, hose cabinets etc.
- F. Fire brigade breaching, Siamese connections and connections to pumps and appliances.
- G. The Fire Suppression System shall comprise the Fire Hydrants System, the Sprinkler System (Wet type), Fire extinguishers, Gas flooding system etc.
- H. The Hydrant System and the Sprinkler System, under normal conditions, shall be pressurized by means of the electric motor driven Jockey Pump.
- I. The Hydrant System and Sprinkler System shall be provided with one common electric motor driven main pump (1Working + 1 Standby).
- J. The starting and stopping of the Jockey pump shall be automatic based on the pressure switches at preset low and high pressure.
- K. The electric motor driven Hydrant & sprinkler Pump starts automatically at preset pressure by means of a pressure switch. As soon as the Hydrant & sprinkler Pump starts, the Jockey Pump stops. If for any reason the electric motor driven Hydrant & sprinkler Pump does not start at the preset pressure or is unable to maintain the pressure, the stand by electrical driven Hydrant Pump starts at the preset pressure.
- L. The hydrant & sprinkler pump, electric motor driven shall be stopped manually.
- M. Contractor shall ensure that all false ceiling voids greater than 800 mm are provided with sprinklers.
- N. Contractor shall ensure Hydro Testing for the complete system.
- O. 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.

- P. The contractor shall get the Fire Fighting System approved by the 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.
- Q. Prepare and submit the As-Built-drawings after completion of Site Work
- R. Work shall be carried out by Authorized Agency and Contractor shall take prior approval from Employer/Engineer before Agency mobilization at Site

## 2.3

**Standards**

- A. The fire hydrant installation shall conform to and meet with the requirements set out by the following:

| STANDARDS          | DESCRIPTION   |
|--------------------|---|
| IS: 3844-1989      | Code of practice for installation of internal fire hydrant.                                       |
| NBC Part-IV (2016) | National Building Code Part-IV: Fire Safety System  |
| IS: 5290 – 1993    | Specification for landing valves  |
| IS : 12585         | Specification for Thermoplastic Hoses   |
| IS 8442            | Stand port type water and Foam monitor for Fire Fighting  |
| IS: 2871           | Specification for branch pipe, universal for firefighting purposes.                               |
| IS: 5714           | Specification for coupling, branch pipe, nozzle used in hose reel tubing for firefighting.        |
| IS 15105           | Design and installation of fixed automatic sprinkler fire extinguisher system – Code of Practice. |

- B. All the standards mentioned above as well as referred to in the document elsewhere shall be latest.

## 2.4

**Pumps Capacity -**

As per NBC 2016 Part IV, Annexure J Clause No. J-9.1.8 & J-9.1.9

- A. One is Main Pump and another Standby pump with minimum discharge details shown below:
  - i. 2280 LPM if the commercial area in the Station is up to and including 300 sq.mm.
  - ii. 2850 LPM if the commercial area in the Station is more than 300 sq.mm and up to 1000 sq.mm.
  - iii. 2850 LPM if the commercial area in the Station is more than 1000 Sq.mm with an additional requirement for electric and jockey pump of same capacity for sprinkler system.
  - iv. Jockey Pump of 180 LPM also to be provided.

## 2.5

**Fire Pump**

- A. The fire pump shall be multi stage suction centrifugal type with split casing type and direct driven by electric motor. The pumps should be with mechanical seal of reputed make.
- B. 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, lubricants, head and flow at duty point and any other pertinent information required by MFS or the Engineer. The pump construction shall meet the maximum required working conditions, liquid temperature, test pressure and nature of the liquid to be handled, as specified.
- C. 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.
- D. Pump casing shall be of close-grained cast iron with bronze impeller. The shaft sleeve shall be brass or SS 304 and the trim shall be brass or bronze.
- E. 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.
- F. 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.
- G. The pump shall be electrically driven with direct flexible coupling.

- H. Equipment shall be selected for minimum noise and vibration, and rotating machinery shall be fully statically and dynamically balanced.
- I. 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. Starters shall conform to relevant IS standard and rated for AC-3 duty conditions. High efficient Class IE-3.
- J. Drive rating shall be based on the largest of the following:
  - i. Rated pump discharge at rated head
  - ii. 150% of rated discharge @ 65% of rated head
  - iii. Maximum power absorbed by the pump in its operating range i.e. no-delivery to free discharge.
- K. Pump Foundation - Foundation of pumps in Fire Pump rooms should be of considerable height so that these are not submerged in case of overflow as shown in drawings.

## 2.6 Jockey Pump

- A. Provision of Jockey Pump shall be vertical inline type and of detail as per schedule of quantity. Contractor shall verify that the capacity of the Jockey pump which shall not be less than 3% (Minimum 180 LPM) and not more than 10% of the installed pump capacity.
- B. The pump casing shall be of cast iron and parts like impeller, sleeve, wearing ring etc. shall be of noncorrosive metal like bronze, brass or gunmetal. The shaft shall be of stainless steel.
- C. Bearings of the pump shall be effectively sealed to prevent loss of lubricant or entry of the dust or water. The pump casing shall be designed to withstand 1.5 times the working pressure.
- D. The motor shall be squirrel cage A.C. induction type suitable for operation on 415 volts 3 phase 50 Hz, system. The motor shall be totally enclosed fan cooled type confirming to protection clause IP 55 of IS 4691.
- E. The pump shall be directly driven from the electric motor. Flexible coupling and coupling guard shall be provided.
- F. The class of insulation shall be B, synchronous speed shall be 3000 RPM. The motor shall conform IS 325-1978 and rated for continuous duty.
- G. The motor starter shall be automatic star delta type with overload trip, but without under voltage/no volt trip. Starter shall conform to IS 1822-1967.

## 2.7 Accessories

- A. The Fire Pumps shall be complete with the following accessories:
  - i. Suction side Reducers shall be Eccentric to avoid air pockets and Discharge side shall be Concentric, as may be required to match the sizes of the connected pipe work.
  - ii. Pump coupling guard
  - iii. Common base frame, fabricated mild steel or cast iron.
  - iv. Vibration Isolator
  - v. Sluice valves on suction and discharge.
  - vi. Non-return valve at the discharge.
  - vii. Expansion bellow at both side of suction and discharge
- B. Each pump shall have independent set of 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. Each pressure switch shall be provided with a pressure gauge in parallel as shown on the drawings and all gauges and pressure switches shall be mounted in an instrument panel with necessary control piping and drainage facility.
- C. Vibration isolators shall be selected (as per IS 15301) in accordance with the weight distribution so as to produce reasonably uniform deflection during pump running following: -
  - i. The allowable bearing pressure shall be specified by the manufacturer. For preliminary designs, however, linear variation in allowable bearing pressure between 0.8 N/mm<sup>2</sup> and 1.6 N/mm<sup>2</sup> may be assumed in the range of shore hardness values between 40° and 70° degrees.
  - ii. The allowable shear stress is also required to be specified by the manufacturer. As in the earlier case, a linear variation in allowable shear stress between 0.3 to 0.5 N/mm<sup>2</sup> may be assumed for preliminary designs for shown hardness values lying between 40° deg. and 70° deg.

- iii. From stability considerations. the thickness of the rubber pad shall be limited to one-fifth of its width.
- iv. The dynamic characteristics of rubber pads exhibit a non-linear character. Further, the stiffness of the rubber pad depends on the level of the static stress and the amplitude of vibration (or dynamic strain).

## 2.8 Rubber Mat

Rubber mat shall be provided in front to cover the full length of all panels. Where back space is provided for working from the rear of the panel, rubber mat shall also be provided to cover the full length of panel. 1000 mm wide of required length as required for 1100 voltage.

## 2.9 System Operation and Control Panels

The fire pump shall be started automatically on loss of pressure and the operation sequence of the booster and fire pumps shall be as follows:

### A. Main Hydrant Pumps:

- i. It shall be manually operable from the Local motor control panel (LMCP).
- ii. Automatically started by actuation of Pressure switch.
- iii. There shall be one pump in operation at any time.
- iv. Automatic change-over facility shall be provided. The standby pump shall automatically start if the duty pump fails to operate at pre-set pressure (pressure switch setting), when there is a pressure drop.
- v. Manual / Automatic selection switch for the duty and standby pump shall be provided.
- vi. The Fire Pump shall start when the system pressure drops by 1.0 kg/cm<sup>2</sup> and shall continue to run till manually switched off.
- vii. Pump operation status shall be provided inside the Station Control Room by potential free NO/NC contact in the Local Motor Control Centre and provisions shall be made for interface with BMS.

### B. Jockey Pumps:

- i. Jockey pump shall cycle ON/OFF automatically to maintain the system pressure. Pump shall cut in through the pressure switch when the system pressure drops to 0.5 Kg / cm<sup>2</sup> below the designed system pressure and stop when the system pressure restores to the designed value.
- ii. It shall be manually operated on the Fire & Water Pump Panel (FWP).
- iii. It shall be automatically stopped when the fixed fire pump (duty or standby) starts to run.
- iv. Jockey and fire pump starting shall be indicated on the panel with a red indication lamp.
- C. The motor starters (direct on line or star-delta) 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.
- D. The starter along with isolator shall be housed in a 14 SWG MS box duly rust inhibited through a process of degreasing and phosphating.
- E. All cabling to and from the pumps to starter and control switch shall be carried out through armoured PVC cables of indicative makes. Cables shall be laid in accordance with section "MV CABLING". The pump motors and panels shall be double earthed in accordance with IS 3043-2018 or as shown on drawings and as approved.

## 2.10 Installation

- A. Fire pumps and appurtenances to the space provided and make readily serviceable.
- B. Provide hot-dipped galvanized steel framework, hangers, anchor bolts and vibration isolators for pumps.
- C. Pump bases mounted on the inertia blocks shall be fixed on the concrete plinths by means of the approved spring isolators.
- D. Provide flanges and flexible pipe connectors to the suction and discharge connections of pumps.
- E. Provide supports to both sides of the flexible connection to prevent undue strain on pumps. Such support shall be mounted so as not to transmit vibration to the structure.
- F. Each pump shall be fitted with air cocks, drain plugs and a pressure gauge on both suction and discharge sides of the pump.
- G. Except in the case of glandless pumps, provision shall be made for collecting gland leakage via a copper drain pipe fitted from the pump to the nearest gully or drain point. A copper Tundish shall be used to collect the drips at the gland packing.



- H. Provide galvanized angle iron wire mesh guards to all exposed shafts, couplings and moving parts. The guard shall be stoutly constructed with lifting lugs for easy removal.
- I. 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 run-ways and hoists shall be provided to the Engineer.
- J. Pipe connections to the pump should not impose any load on the pump which is liable to disturb shaft and bearing alignment. The pump/pipework connection ends shall be of final closure joints, and thus ensuring the pipework is independently supported.
- K. Demonstration of free pump rotation before and after pipe connection shall be provided.
- L. The pump Heads Specified on the Drawings and/or equipment Schedules are for guidance and information only. Contractor is required to calculate based on equipment pressure drops before execution with the prior approval from Employer/Engineer. 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.
- M. All necessary steps shall be taken to ensure that noise and vibration are not transmitted from any part of the installation to any part of the structure at such a level as deemed to be objectionable.
- N. Pumps shall be isolated from their associated pipework by means of flexible pipework vibration isolators, of suitable stiffness, and mounted with the isolator's axis at right angles to the direction of maximum vibration amplitude. These isolators shall be mounted as close as possible to the pump, and as such may be used as the final closure joint. However, the isolators should not be used to compensate for misaligned pipework.
- O. Automatic priming equipment shall be included where necessary to ensure that the pumps are primed at all times.
- P. Long radius reducing elbows or reducers at the locations where pipe size decreases shall be provided. Contractor to ensure sufficient supporting system to pipework adjacent to pumps so that no weight is to be carried on pump casings. Provide supports under elbows on pump suction and discharge line of 100 mm diameter and over.
- Q. The straight pipe length for the suction side shall be a minimum length of 5m of the suction pipework size.
- R. Motor starter for all pumps shall be provided as specified.
- S. Shaft Coupling Alignment
  - (i) Carefully and accurately align shafts of all machinery, utilizing shaft couplings between drivers, speed reducers and the equipment. Test the direction of rotation of the driver before final shaft coupling connection is made.
  - (ii) Type of Shaft Misalignment:
  - (iii) All necessary corrections to eliminate both types of shaft misalignment defined as below shall be made at no extra cost to the Employer.
  - (iv) Angular Misalignment - Shafts having axis concentric but not parallel.
  - (v) Parallel Misalignment - Shafts having axis parallel but not concentric.

## 2.11 Testing and Commissioning

### Operating Sequence for the Fire Fighting pumps

- A. The operating pressure in the mains is to be maintained at 8.0 kg/cm<sup>2</sup>.
- B. The jockey pump shall start automatically the moment pressure drops to 7.5 kg/cm<sup>2</sup> due to any leakage or minor draw-off from the system and stop when the pressure reaches 8.0 kg/cm<sup>2</sup> again.
- C. In the event of electrical or mechanical failure of main fire pump (hydrant & sprinkler) to start, the standby electrical driven pump shall cut in when the pressure in the mains fall down to 7.0 kg/cm<sup>2</sup>. The main electric pump shall then be locked out.
- D. If within a pre- set period the standby pump fails to start or fails to develop adequate pressure, the control system shall shut down the standby pump and lock it out and given an audio-visual indication to that effect at the control panel.
- E. The control panel shall have status selection for each of the pumps for "automatic" as well as "manual" operation.
- F. Pumps when under "manual" status shall be operated manually through relevant push buttons.

- G. Once tripped the electric fire pump shall remain locked out for operation irrespective of the position of its operational status selection switch. Look out indication shall be available on the panel.
- H. Return to normal operational availability shall be feasible only by manual re-set of locked out units by operation of appropriate push buttons.

#### **Interlocking Table**

The following inter-locking shall be followed between the one main fire pumps (i.e. wet riser pump & sprinkler), the jockey pump and the common standby pump.

Only one category of pumps will work at a time i.e. either jockey pump or main fire pumps or common standby pump.

| SL.NO. | JOCKEY PUMP | ELECTRICAL MAIN PUMP (SPRINKLER & HYDRANT) | COMMON STANDBY PUMP |
|--------|-------------|--|---------------------|
| 1      | ON          | OFF  | OFF                 |
| 2      | OFF         | ON   | OFF                 |
| 3      | OFF         | OFF  | ON                  |

**The Jockey & fire pump starting and stopping shall be tested by opening the test valve and record the following and the valves should be as furnished below:**

| S. NO. | TAG NO..DESCRIPTION |   | HEAD | CAPACITY       | PRESSURE SWITCH | SETTING IN BAR | SIGNAL                                      | MODE                            |
|--------|---------------------|---|------|----------------|-----------------|----------------|---|---------------------------------|
| 1      | F1                  | JOCKEY PUMP (COMMON)                      | 80m  | 180LPM         | PS-01           | 7.5 Bar        | TO START JOCKEY PUMP                        | AUTOMATIC                       |
|        |                     |   |      |                | PS-02           | 8.0 Bar        | TO STOP JOCKEY PUMP                         | AUTOMATIC                       |
| 2      | F2                  | MAIN HYDRANT & SPRINKLER PUMP             | 80m  | 2850/ 2280 LPM | PS-03           | 7.0 Bar        | TO START HYDRANT & SPRINKLER PUMP           | AUTOMATIC START & MANUALLY STOP |
| 3      | F3                  | COMMON STANDBY PUMP (HYDRANT & SPRINKLER) | 80m  | 2850/ 2280 LPM | PS-04           | 5 Bar          | TO START STANDBY PUMP (HYDRANT & SPRINKLER) | AUTOMATIC START & MANUALLY STOP |

- A. Maintained system pressure while discharging the landing valve at the highest point.

1. Highest Outlet 3.5 kg/cm<sup>2</sup>

- B. All the operating tests shall be carried out to the satisfaction of Authority having Jurisdiction.

#### **2.12 Mode of Measurement**

- A. Hydrant pump with mounting frame excluding concrete foundation shall be measured per unit.
- B. Jockey pump - same as hydrant pump.
- C. Instrument panel with pressure gauges, pressure switches, control piping etc. shall be measured as one unit.
- D. Control cabling from pressure gauge panel to the respective starters shall be measured in running meter and paid at unit rates.

#### **2.13 Data Sheet**

| Data Sheet |              |                    |
|------------|--------------|--------------------|
| Sl. No.    | Description  |                    |
|            | <b>Pumps</b> | <b>Jockey Pump</b> |
| 1          | Make         |                    |

| Data Sheet |   |  |
|------------|---|--|
| Sl. No.    | Description                             |  |
| 2          | Pump Model No.                          |  |
| 3          | Pump Type                               |  |
| 4          | Duty of Pumps                           |  |
| 5          | Discharge (LPM)                         |  |
| 6          | Head (Mtrs.)                            |  |
| 7          | Efficiency                              |  |
| 8          | Speed (RPM)                             |  |
| 9          | Power Absorbed at duty point (kw)       |  |
| 10         | No. of Stages                           |  |
|            | <b>Pump performance at 150% of D.P.</b> |  |
| 11         | Capacity (LPM)                          |  |
| 12         | Head (Mtrs.)                            |  |
| 13         | Efficiency                              |  |
| 14         | Power absorbed                          |  |
|            | <b>Material of Constructions</b>        |  |
| 15         | Casing                                  |  |
| 16         | Impeller                                |  |
| 17         | Shaft                                   |  |
| 18         | Shaft sleeve                            |  |
|            | <b>Prime Mover</b>                      |  |
| 19         | Make                                    |  |
| 20         | Type                                    |  |
| 21         | H. P.                                   |  |
| 22         | Full load speed (RPM)                   |  |
| 23         | Full load current (amp.)                |  |
| 24         | Design Standard                         |  |
| 25         | Supply Voltage & Variations             |  |
| 26         | Frequency & Variations                  |  |
| 27         | Cooling Type                            |  |
| 28         | Protection Class                        |  |
| 29         | Insulation Class                        |  |
| 30         | Duty                                    |  |
| 31         | Colour Shade of Paint                   |  |
| 32         | Terminal Connection                     |  |
|            | <b>Pump Accessories</b>                 |  |
| 33         | Base Plate                              |  |
| 34         | Coupling                                |  |
| 35         | Coupling Guard                          |  |
| 36         | Foundation bolts, nuts & washers        |  |
| 37         | Mechanical Seal                         |  |

## SECTION F.03 PIPING FOR FIRE FIGHTING SYSTEM

### 3.1 Scope

- A. The scope of work covers supply, fabrication, laying, testing, painting and commissioning of the entire piping system for the Fire Fighting installation i.e. fire hydrant and sprinkler systems.

### 3.2 Standards

- A. The following standards shall be applicable:

|       |   |  |
|-------|---|--|
| i.    | IS: 554 – 1999                          | Dimensions for pipe threads where pressure tight joints are required on the threads. |
| ii.   | IS: 638 – 1979                          | Sheet rubber jointing and rubber insertion jointing.                                 |
| iii.  | IS: 778 – 1984                          | Copper alloy gate, globe and check valves for water work purposes.                   |
| iv.   | IS: 901 – 1988                          | Couplings, double male and double female, instantaneous pattern for fire fighting    |
| v.    | IS: 1239 – 2004 (Pt-I) and 1992 (Pt-II) | Mild steel tubes, tubulars and other wrought (Part I & II) steel fittings.           |
| vi.   | IS: 884 – 1985                          | Specification for first-aid hose reel for fire fighting                              |
| vii.  | IS: 444 – 1987                          | General purpose rubber water hose  |
| viii. | IS: 4038 – 1986                         | Foot valves for water-works purposes.  |
| ix.   | IS: 5290 – 1993                         | Landing valves   |
| x.    | IS: 10221 – 1982                        | Code of practice for coating and wrapping of underground mild steel pipelines        |
| xi.   | IS: 5312 – 2004 (Pt-I) & 1986 (Pt-II)   | Swing check type reflux (non-return) valves.   |
| xiii. | IS: 1879 – 1987                         | Malleable cast iron pipe fittings  |
| xiv.  | IS: 1537 – 1976                         | Vertically cast-iron pressure pipes for water, gas and sewage                        |
| xv.   | IS: 1538 – 1993                         | Cast iron fittings for pressure pipes for water, gas and sewage                      |
| xvi.  | IS: 7181 – 1986                         | Horizontally cast-iron double flanged pipes for water, gas and sewage                |

- B. All the standards mentioned above as well as referred to in the document elsewhere shall be latest

### 3.3 Technical and Installation Requirements

- A. G.I Pipe (C-class) conforming to IS: 1239 up to 150 mm pipe dia and above sizes are confirming to IS: 3589 Grade 410. Hydro testing after welding, complete Fire Protection Piping System shall be wire brushed and applied with two coats of red oxide and then painted with 2 coats of Post office red enamel paint.
- B. The installation shall be neat and tidy, with accurate spacing between pipes, valves and joints, whether running in straight routes or turning through bends.
- C. Particular care shall be taken that all pipework is erected and secured truly parallel with the building structure, clear of obstructions, preserving headroom and keeping passageways clear and that all vertical drops are plumb.
- D. No bends or curves in any pipe shall be made so as to diminish the waterway or alter the internal diameter of the pipe.
- E. Wherever possible, horizontal pipes shall be fixed to 'fall' to aid venting and draining down of the pipe work. Eccentric reducing sockets shall be used on horizontal runs of pipe to prevent the formation of air pockets. On vertical pipes, concentric reducing sockets shall be used.
- F. Drain outlets shall be provided at all low points of the system to enable emptying and to facilitate maintenance of the pipe work.
- G. Automatic or manual air vents shall be placed at each high point of each water line and discharge pipe shall be terminated at 50 mm above floor drain.
- H. Pipe runs, where exposed, shall be positioned at least 100 mm from the finished wall surfaces to enable subsequent cleaning and painting of all surfaces. Where pipe runs are installed at an angle, they shall be positioned 40 mm from the finished surfaces.
- I. All pipes shall be fitted clear of the floor to permit cleaning beneath the pipes. Where possible, a 125 mm clearance shall be provided between the underside of the pipe and the finished level of the floor and in no case shall the pipe be less than 100 mm clear of the floor.

- J. Site welding shall be applied with pipe work unrestrained and each joint hydraulically tested at 1.5 times working pressure plus 350 kPa for 60 minutes without loss of pressure followed by application of appropriate protective coating, both internally and externally, prior to final installation.
- K. Qualified welder (Certificate Holder with minimum 3 years of experience) shall be mobilized at site.
- L. All GI pipe runs when buried underground shall be tested and approved before being covered.
- M. Where it is not possible to install the pipe work with setting out dimensions as shown on the Drawings, minor deviations will be allowed, subject to prior Approval.
- N. Where pipes pass through walls and floors, steel pipe sleeves shall be provided to allow free axial movement of the pipes. Sleeves passing through walls shall be of sufficient length to fully enclose the pipe, from one side of the finished wall to the other side. Sleeves passing through floors shall protrude at least 50 mm above and below the finished floor and soffit to enclose the pipe.
- O. All pipes passing through the roof shall be provided with at least 2.0 mm lead flashing sandwiched between the layers of waterproofing roofing membrane, and secured to the pipe with a galvanized spring clip.
- P. Where pipes pass through water-containing chambers, puddle flanges of Approved design shall be provided.
- Q. Accessible pipes shall be flanged or with grooved coupling connected in sections of three nominal lengths for dismantling. Embedded pipe work shall be in straight lengths as far as possible. Pipes with screwed joints shall be installed with grooved couplings at suitable positions for easy removal of equipment.
- R. All pipe installations shall be provided with removable sections to facilitate pipe-cleaning operations.
- S. Pipework shall rest freely upon supports and be carefully aligned prior to final connection.
- T. All pipes on straight runs shall be lined up with facilities for pipes to be rotated for the process of welding joints to avoid welding from the bottom as far as possible.
- U. During storage, all pipes shall have end covers fitted to prevent the ingress of any unwanted particles or waste.
- V. During installation, all open ends of pipes shall be blanked off with blank flanges or pipe caps. These shall be removed only immediately prior to connecting to adjacent sections. As soon as pipes have been installed, all open ends shall be covered to prevent entrance of materials that would obstruct the pipes. Covers shall be left in place until removal is necessary for completion of the installation.
- W. Damage to coatings or linings during material transport or handling on Site shall be repaired to the Engineer-in-charge's satisfaction before installation of the pipe work and fittings commences.
- X. The Engineer-in-charge reserves the right to reject any material deemed to be unsuitable for installation and such material shall be removed from the Site and be replaced with Approved material at no extra cost to the Employer.
- Y. Manufacturer's data sheets shall be provided for all materials and equipment for approval before purchase or installation. Data sheets shall describe the type of material, capacities, manufacturer Date, and part numbers of equipment and give information necessary for checking equipment approval.
- Z. Work shall be carried out by Authorized Agency and Contractor shall take prior approval from Employer/Engineer before Agency mobilization at Site

#### 3.4 **Pipe Wrapping and Coating**

- A. Minimum requirement of a suitable coating and wrapping for underground steel pipelines shall be confirm with IS 10221.
- B. All the above ground protection pipes (external fire hydrant system, wet riser system piping, etc.) shall be painted with two coats of red oxide primer for G.I. pipe and two coats of synthetic enamel paint of shade 'Fire Red' (shade no: 536) conforming to IS: 5. The total thickness of painting shall not less than 120 microns
- C. Surface Preparation - The pipe surface shall be cleaned by a wire brush.
- D. Application of Primer - Primer is to be applied on pipes immediately after cleaning. This is to prevent any further accumulation of rust on the pipe. This is a cold applied primer and is applied by brush.
- E. Application of 4 mm bitumastic Tape - After the primer is applied on the pipe, it is allowed to dry for about 30 min. till it becomes touch dry. Before adhering the tape to the pipe, it is advisable to gently heat the primer coated pipe by a run of LPG torch. Remove the bottom polyethylene from the tape & then heat bottom surface of the tape by LPG torch or any heat source & start wrapping the tape to the

pipe by heating the primer coated pipe & by removing the bottom polyethylene from the tape before wrapping better adhesion between the tape & pipe is obtained. Overlaps are maintained with a minimum of 15.0 mm.

- F. Tape coating of weld joints - The tape is applied over the weld joints after the necessary welding & testing methods of the joints is completed. The procedure for application of tape shall be the same as bare pipe procedure. Overlaps on each side of the weld joints shall be 50 mm.
- G. A final coat of White wash with water-based cement paint is done immediately over the entire coated pipe.
- H. Testing of pipes: Adhesion test, holiday test, direct Impact test, Corrosion Resistance Test & Identification of tape shall be confirmed with IS 15337.
- I. Fire Fighting Color Codes

| S.No. | Equipment                           | Color                                |
|-------|-------------------------------------|--------------------------------------|
| 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                             |

### 3.5 Pipe Joint

- A. All pipe jointing systems used shall comply with the requirements of this clause and the Particular Specification.
- B. Pipes shall be cut in a neat manner without damaging the pipe. Unless otherwise approved by the Engineer-in-charge, cutting shall be done with an Approved type of mechanical cutter. Wheel cutters shall be used when practicable. Pipe ends shall be reamed to remove burrs.
- C. Flanges and bolting for pipes, valves and fittings shall comply with IS 6392 PN 1.6 (16 kg/sq cm), or to other higher ratings as required by the system for which they are used.
- D. Electric welding joints shall be provided in the G.I. pipe work. Flanged joints shall be provided for connections to valves, pumps, air vessels etc. and also on straight lengths at suitable points to facilitate erection and subsequent maintenance
- E. Mild Steel 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.
- F. All hardware items such as Nuts, Bolts and Washers shall be of G.I and appropriate size. Washers shall be used on both sides of the bolt.

| Pipe dia          | Flange Thickness |
|-------------------|------------------|
| 300 mm            | 28 mm            |
| 250 mm            | 26 mm            |
| 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            |



### 3.6 Pipe Support Installation

- A. The installation work shall be carried out in accordance with the detailed drawings prepared by the contractor and approved by the Engineer.
- B. 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.
- C. 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.
- D. Open ends of piping shall be blocked as soon as the pipe is installed to avoid entrance of foreign matter.
- E. No pipe shall be installed at low level across route of egress or maintenance access routes causing obstruction to access. All angle support brackets installed at low level shall be padded and warning signs shall be provided. All angle brackets and supports for pipes shall have all sharp edges padded. The direction of flow shall be painted onto the pipe with white arrows at suitable intervals. Angle shall be MS steel and conform with IS: 808.
- F. Piping installation shall be supported on or suspended from structure adequately. The contractor shall provide clamps and hangers etc. Proper lines and levels shall be maintained while installing exposed pipes.
- G. Support spacing. Unless otherwise specified, pipe supports shall be provided at intervals in accordance with the following table: -

| Size of Pipe(mm) | Maximum Intervals for<br>Vertical Runs (m) | Maximum Intervals for<br>Horizontal Runs (m) |
|------------------|--|--|
| 15               | 2.5  | 1.8  |
| 20-25            | 3.0  | 2.5  |
| 32               | 3.0  | 2.7  |
| 40-50            | 3.6  | 3.0  |
| 65-80            | 4.5  | 3.6  |
| 100              | 4.5  | 4  |
| 150 and above    | 5.5  | 4.5  |

- H. Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress on the pipes.
- I. 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 project engineer-in-charge.
- J. 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.
- K. (a) Vertical risers shall be parallel to walls and column lines and shall be straight and in plumb. Risers passing from floor to floor shall be supported at each floor by clamps.
- L. (b) 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.
- M. (c) Riser shall have suitable supports at the lowest point.
- N. Underground pipe shall be laid 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/Hume pipe with removable covers.
- O. 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.
- P. Pipe over ground shall be painted in red colour as 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.

- Q. 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.

### 3.7 Hanger Rods

- A. Hanger rods of steel threaded and fitted with two removable nuts at each end for positioning rod and hanger and locking each in place shall be provided.
- B. Unless otherwise specified, hanger rods shall be of the following sizes: -
- | Size of Pipe (mm)   | Single Rod Dia (mm) | Double Rod Dia (mm) |
|---------------------|---------------------|---------------------|
| 15 to 50, inclusive | 10                  | 10                  |
| 65 and 80           | 13                  | 10                  |
| 100 and 125         | 15                  | 13                  |
| 150                 | 20                  | 15                  |
| 200, 250 and 300    | 22                  | 20                  |
- C. Secure hangers from metallic inserts cast into concrete. When these inserts are not available, attachment by anchor bolts to be placed with fast setting high strength grout shall be used.
- D. Hanger shall be placed close to the point of change of direction of a pipe in either a horizontal or vertical plane.
- E. Supports and hangers for ductile iron pipe shall be placed as close as possible to joints. When hangers or supports are not within 300 mm of a branch line fitting, additional hangers or supports shall be provided.

### 3.8 Pipe Anchors

- A. Anchors shall be positioned in association with pipe work change in direction, expansion joints and loops so as to absorb stresses due to pipe work expansion and internal pressures by transmission of such forces to the structure at appropriate points.
- B. Anchors shall be constructed to withstand the highest thrust during piping hydraulic pressure testing.
- C. All details, calculations and sizes of anchors shall be submitted for Approval prior to installation.

### 3.9 Welding

- A. Preparation for welding shall comply with the following requirements: -
- B. Welding of MS piping shall be mild-bevelled on both ends before welding, bevelled to  $37\frac{1}{2}^{\circ}$ .
- C. Weld spacing on all butt welds shall comply with the following table:-

| Nominal Pipe Wall Thickness | Spacing | Bevel Angle             |
|-----------------------------|---------|-------------------------|
| 6.35mm or less              | 3mm     | $37\frac{1}{2}^{\circ}$ |
| Over 6.35mm to 19.5mm       | 5mm     | $37\frac{1}{2}^{\circ}$ |

- D. Backing rings shall be used on all butt-welded joints.
- E. Before starting any welding, all corrosion products and other foreign material from surfaces to be welded shall be removed by scraping, brushing, chipping and swabbing.
- F. Welding process: butt-welding and 10% of the welded joints shall be radiographically tested and found in order. The welded joints shall be random selected for testing in consultation with the Engineer-in-charge. All flanges shall be slip-on welded type to IS: 6392 – 1971 with a 3mm fibre-reinforced EPDM gasket and rated for 2.0 N/ mm<sup>2</sup>.
- G. Welding operation: Electrodes, voltage, current, thickness and number of passes or beads, shall be as previously specified. After deposition, each layer of weld metal shall be cleaned to remove all slag and scale by wire brushing and grinding and chipped where necessary to prepare for deposition of the next layer. Welded reinforcement shall be not less than 1.6 mm nor more than 3.18 mm above the normal surface of sections being welded. Reinforcement shall be crowned at centre and tapered on each side of surfaces being jointed. Exposed surfaces of weld shall present workmanlike appearance and be free of depressions below surface of jointed members.
- H. Weld metal shall be thoroughly fused with base metal at all sections of weld. Penetration of weld shall include unbevelled portion and extend to inside walls of pipe.

- I. Inspection: All welds shall be inspected visually and non-destructively by the Engineer-in-charge. The Engineer-in-charge reserves the right to order at random the examination of 2 % of the number of the welded joints for ultrasonic test by an independent firm nominated and paid by the Contractor. Should any one of the above welds prove faulty in materials or workmanship, further test of welds will be ordered up to a total of 4 % of the welded joints. If the number of welds failing the tests within the above 4 %, it is sufficient to suggest that an operative is not consistent in standard, the Engineer-in-charge may order any number of that welds to be removed and rectified at no extra cost to the Employer.

### 3.10 **Pressure Testing**

- A. 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/sqcm 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.
- B. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
- C. System may be tested in sections and such sections shall be securely capped.
- D. Pressure gauges may be capped off during pressure testing of the installation.
- E. **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.

- (1) Split pipe support clamps with rubber lining for vertical, horizontal and roof hanging.
- (2) Clevis Hangers for horizontal supports to adjust varying heights.
- (3) Sprinkler Hangers for horizontal supports for pipes from 15 mm dia. to 150 mm dia

## SECTION F.04 VALVES AND OTHER ACCESSORIES

### 4.1 General

- A. This Section specifies the manufacture and installation requirements for gate valves, check valves, butterfly valves, Sluice valve, gauge cocks, automatic air valves, strainers, stopcocks, pressure reducing valves, ball float valves, safety and pressure gauges, pipe sleeves, expansion loops, expansion joints, pipe anchors, gaskets for pipe separation and water closet connector.
- B. All valves, taps and cocks shall be of the types and working pressures suitable for the systems to which they are connected and shall be approved by the Engineer. Valves shall be rated to withstand the system hydraulic test pressure.
- C. Brass, bronze or cast-iron valves shall generally be of 16 bar working pressure rating type. In addition, all valves at discharge side of transfer water pumps shall be of minimum 16 bar pressure rating.
- D. Wheel head valves shall be arranged for clockwise operation of the handle to close the valve.
- E. Connections shall be made between each valve and the adjoining pipe work or equipment with flanges for 65mm size pipe work and above. Flanges shall be selected to suit working pressure and temperature.
- F. Screwed connections shall be made between each valve and the adjoining pipe work or equipment for 50 mm size pipe work and below. A union shall be fitted on each side of all screwed valves.
- G. All valves shall be suitably located in accessible positions for operation and maintenance purposes.
- H. All drain outlets and manual air vents shall have connection pipes leading to the nearest drain.
- I. Valve packing shall be suitable for the service intended. Valve packing consisting of asbestos or asbestos based materials shall not be used.
- J. Inverted mounting of valves shall not be permitted without prior approval of Engineer-in-charge.
- K. All valves provided for manual operation shall have a hand wheel or other suitable device which shall be fixed to the valve. Hand wheels shall be rotated clock-wise to close the valves and shall be clearly marked with the words "OPEN" and "CLOSE" and arrows pointing in the appropriate directions. The rims of hand wheels shall be machined to a smooth finish.
- L. Valves of identical make, size, type and duty shall be fully interchangeable.

### 4.2 Butterfly Valve

- A. Butterfly valve (wafer Type) conforming to IS: 13095 shall be provided. All valves shall be suitable to with-stand the pressure in the system and rating shall be PN 1.6 (16 kg/sq cm). All valves shall be right-handed (i.e. handle or key shall be rotated clock wise to close the valve), the direction of opening and closing shall be marked and an open/shunt indicator fitted.
  - (1) The material of valves shall be as under:
 

|        |   |                                   |
|--------|---|-----------------------------------|
| Body   | - | Cast iron                         |
| Disc   | - | Cast Bronze or Stainless Steel    |
| Seat   | - | Either integral or Nitrite rubber |
| O-ring | - | Ring- Nitrite/ Silicon            |

### 4.3 Non-Return Valve

- A. Non-Return valves (wafer type) shall be cast iron double flanged with cast iron body and gunmetal internal parts conforming to IS: 5312 and IS: 778.
- B. Non return valves shall be swing check type in horizontal run and lift check type in vertical run of pipes.

### 4.4 Pressure Switch

- A. 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. It shall be suitable for line pressures up to 15 kg / cm<sup>2</sup>. The scale range for cut in and cut out shall be from 0 to 10 kg / cm<sup>2</sup>.
- B. 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.
- C. 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.

#### 4.5 Gate Valves

- A. Gate valves generally shall be used on service pipe work, and shall be fitted as necessary. Valves shall be rated, designed and tested in accordance with BS 5154/ BS EN 12288:2003/ IS 778 for bronze valves and BS EN 1171:2002 / BS 5163 for those of cast iron manufacture. Valves shall be of non-rising stems and same size as the nominal bore of pipeline in which they are installed.
- B. Bronze bodied valves shall be cast to BS 1400/ BS EN 1982. Valves with cast iron bodies shall be made to BS 1452/ BS EN 1561/IS 318 Gr. LTB 2. The bodies shall be of an even thickness throughout, clean and free from scale flaws. Valves up to and including 50 mm nominal bore shall be bronze bodied, 65 mm nominal bore and larger may be bronze or cast iron.
- C. Valve wedges may be of cast iron, bronze, nickel alloy or stainless steel. Cast iron wedges shall have bronze trim and seating. Slide valves shall be fitted with stainless steel springs. Wedges shall be renewable and free to rotate on the valve spindle.
- D. Valves shall have packed stuffing boxes, or alternatively shall be fitted with 'O' rings.
- E. Gate valves of 80 mm nominal bore and above for use in water supply system shall be of cast iron body with nickel alloy faces and stainless-steel spindle or with nitrite resilient facing wedge gate and aluminium bronze stem and shall be entirely suitable for use with sea water.
- F. The Valve shall be PN 1.6 rated and shall be tested in accordance with relevant BS/IS/API standard. The ends shall be flanged. The batch number of the valve shall be punched on the top of the flange. The spindle shall be removable type, and shall be easily rotated.
- G. Gate valves shall be tested as follows at the place of manufacture prior to dispatch to Site: -
  - (i) Body Test  
With both ends closed and the gate in the open position, the body shall be tested to 1.1 times the maximum working pressure for a minimum of 30 minutes. There shall be no visible leakage.
  - (ii) Seat Test  
With one end open to the atmosphere and the gate in the closed position, the seat of the valve shall be tested for tightness when 1.1 times the maximum working pressure is applied to the other end of the valve for a minimum of 30 minutes. The seat test shall be carried out in both directions. There shall be no visible leakage past the gate.

#### 4.6 Automatic Air Release Valve

- A. Automatic air release valve shall be provided at all high points of the system as directed by the Engineer or as indicated on the Drawing. Connections to the service pipes shall be made at the highest point to ensure complete venting. Automatic air vents shall be mounted so that the inlet connection is in an exact vertical plane. A lock shield valve shall be located between the service pipe and the automatic air vent.
- B. Automatic air release valve for water systems shall have bodies of brass, gunmetal or malleable iron, non-ferrous or stainless-steel floats and guides, and non-corrodible valves and rubber seats.
- C. All automatic air release valve shall be 20 mm diameter unless otherwise specified and shall be of the single large-orifice type suitable for the release or admission of air during system filling or draining. Automatic air vents bodies shall be constructed of cast iron to BS 1452 Grade 14 and float guides from grade 316 stainless steel. Connections to the pipe work shall be via a screwed BSP connection.
- D. A gate valve shall be provided between the automatic air vent and the connected pipe work to enable isolation of the automatic air vent for maintenance.
- E. Units shall be designed to facilitate dirt removal while in service.
- F. Automatic air vents shall be designed to open to discharge air or air / fluid mixture and to close firmly against fluid.

#### 4.7 Automatic Pressure Relief Valve

- A. Each pump shall be provided with an automatic pressure relief valve set slightly below the shut-off pressure of the pump. It shall provide circulation of sufficient water to prevent the pump from overheating when operating with no discharge. Provisions shall be made for a discharge back to the sump. The relief valve shall be labelled with the setting pressure.
- B. When the jockey pumps have a shut-off pressure exceeding the working pressure of the fire protection equipment, a suitable relief valve shall be installed on the pump discharge to prevent damage to the fire protection system. An orifice plate shall be installed at the discharge pipe of the jockey pump.

**4.8 Expansion Joints**

- A. Provide expansion joint (axial, hinged and gimbal type) wherever expansion loops or change in direction of pipework expansion and contraction of pipework where otherwise expansion and contraction of pipework is not feasible. It shall conform to relevant BS or equivalent standard.
- B. Provide expansion joint at all building expansion joints, and wherever else expansion joints are specified, additional allowance shall be made by the provision of stainless-steel articulated bellows type expansion compensators complete with all necessary guides as recommended by the manufacturer. Each compensator shall maintain at least the same cross-sectional area as adjoining pipework for its entire length.
- C. Ensure the expansion joints are adequately tied, anchored or removed to avoid damage to the bellows during sectional testing.
- D. Expansion joints shall have stainless steel membrane and carbon steel fittings.
- E. Design working pressure shall be as specified on the Equipment Schedules and/or Drawings while the testing pressure shall be at least 1.5 times of the working pressure. Designed life to be 12,000 (minimum) complete cycles of movement over the entire working range without failure.
- F. Joint shall be securely held by guides on both sides.

**4.9 Strainers**

- A. Strainers shall be provided in pump suction pipes, water tank outlets and in the locations specified in the drawing. Strainers shall be of the same nominal bore as the pipeline in which they are fitted. Strainers shall be installed in a plane to ensure that filtered matter is retained within the screen.
- B. Strainers shall be full line size, "Y" or "BASKET" type as specified and readily removable for cleaning.
- C. Strainers of up to and including 50 mm shall be bronze bodied and have screwed end caps with a brass drain plug. Strainers of 65 mm and over shall be cast iron bodied to the requirements of IS 210 Gr FG 200 with cast iron cover and mild steel stud bolts. The cover shall be complete with a 25 mm bronze drain valve, the outlet of which shall be capped with a brass plug.
- D. Strainer connections shall be as for the pipeline in which they are installed.
- E. Screens and baskets shall be of brass or stainless steel to suit the service intended. The total free area of the installed screen shall not be less than 5 times of the internal cross-sectional area of the inlet pipe. Openings in the screen or basket shall be less than 1.2 mm in diameter.
- F. Strainers for flushing water systems shall be of cast iron body and filtering medium of the strainer of stainless-steel grade 316.
- G. Strainers shall be of adequate strength to withstand the working pressure.
- H. Strainers at the pump suction inlet shall be fitted with removable channel magnets, secured to the screen or basket by stainless steel retaining lugs and threaded rods, and placed to provide a continuous magnetic field around the entire circumference of the screen. They shall be fitted with a breech-locking arrangement to maintain the screen in place when removing the cover plate. The screen cover plate shall be bolted using studs with hexagonal headed nuts and shall be fitted with a special hinge. Initially each strainer shall be fitted with mesh lined baskets, reinforced on both sides with an open bottom. After initial cleaning, the baskets shall be replaced with a standard basket, suitable for the service required. All Y type strainers shall be complete with magnetic rod and screw plug for drain or blow-off.

**4.10 Orifice Plates**

- A. Orifice shall be used to restrict the hydrant discharge pressure within 3.5 kg/sq.cm.
- B. 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.
- C. The orifice plate shall fitted not less than two pipes internal diameters downstream of the outlet from any elbow or bend.
- D. Contractor shall submit the design and identify location on drawing before installation.



**4.11 Pressure Gauge Instruments**

- A. Stainless Steel Dial Type Pressure gauge of appropriate range and 100 mm. dia size shall be provided.
- B. The Pressure Gauge shall be constructed of die cast aluminium and stove enamelled. It shall be weather proof with an IP 55 enclosure. It shall be a stainless steel Bourden tube type Pressure Gauge with a scale range from 0 to 16 Kg / cm<sup>2</sup> and shall be constructed as per IS: 3624 - 1987. Each Pressure Gauge shall have a siphon tube connection. The Shut off arrangement shall be by Ball Valve.
- C. 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. Stainless Steel bourdon type with gun mental isolation ball valve, tapping and connecting pipe and nipple. The gauge shall be installed at appropriate height for easy readability.

**4.12 Ball Valve**

- A. The Ball Valve shall be made from die cast brass and tested to 14 Kg/cm<sup>2</sup> pressure. The valve shall be internally threaded to receive pipe connections.
- B. 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.
- C. 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 / cm<sup>2</sup> pressure.
- D. The handle shall also be provided with a lug to keep the movement of the ball valve within 90 degrees. The lever shall be operated smoothly and without application of any unnecessary force.

**4.13 Sluice Valve**

- A. Cast iron double flanged sluice valve shall be of indicative make conforming to IS 14846 with PN 1.6 (16 kg/sqcm)
- B. Sluice valve shall be provided with wheel when they are in exposed positions and with a cap top when they are located underground. Flange end as per IS 1538.
- C. Contractor shall provide suitable operating keys for sluice valves with cap tops
- D. The material of valves shall be as under:
 

|              |                                 |
|--------------|---------------------------------|
| Body         | - Cast iron (IS 210 Gr. FG 200) |
| Gland Flange | - Cast Iron                     |
| Hand wheel   | - Cast Iron                     |
| Seat ring    | - Bronze                        |
| Gasket       | - Rubber (IS 638-2)             |
| Sheet Ring   | - Bronze (IS 318 Gr. LTB2)      |

**4.14 Flow Meter**

- A. Flow meters shall be the latest "state-of-art" microprocessor based electromagnetic type, having flanged connections with integral sensor, transmitter, processor & indicator suitable for measurement of water flow. Water contains silt and sand particles. Meters shall be lined with Polyurethane (PU) liners.
- B. Flowmeter should have Multi line backlit LCD display with facility to show flowrate indication with Unit (LPM) and flow totalizer. The display shall be programmed to show readings in LPM prior to dispatch.
- C. The meter shall have flanged connection to confirm to IS 6392 or equivalent.
- D. The material of flow meter shall be as under:
 

|                     |                      |
|---------------------|----------------------|
| Flow Tube           | - SS 304             |
| Liner               | - Neoprene           |
| Flange              | - MS                 |
| Electrode           | - SS 304             |
| Body                | - MS                 |
| Electronics housing | - Aluminium die cast |

**4.15 Air Vessel Tank**

- A. Air vessel tank shall be provided in the pump room connected with discharge line of hydrant and sprinkler and shall be fabricated out of 8mm thick M.S. sheet. The ends shall be dished fabricated out

of 8 mm thick M.S. sheet. This shall be of 250 mm dia., 1.2 m high 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. The legs shall be grouted in CC foundation. Flange connection shall be provided for connection with wet riser pipe. Contractor to ensure capacity before execution in prior approval from Employer/Engineer.

- B. It shall be normally partly full of water, the remaining being filled with air, which will be under compression when the system is in normal operation. The air vessel shall be tested at 25 kg/cm<sup>2</sup> pressure before installation.
- C. Air vessel tank shall be provided with air release valve, stop cock flanged inlet connection and drain arrangement with 25 mm dia valve, The Pressure Switches and pressure gauge shall be mounted on the drain end of each Vessel complete with all accessories as required and conforming to IS 4736-1968 painting the vessel piping etc. with two coats of anticorrosive primer inside and outside, epoxy paint inside, two coats of postal red enamel outside of indicative make.

#### 4.16 **Installation Control Valve**

Installation control valves shall comprise of the followings:

- A. One-man stop valve of full way pattern with gunmetal pointer to indicate where open/shut.
- B. One automatic alarm valve fitted with handle & cover.
- C. One hydraulic alarm motor and gong for sounding a continuous alarm upon out-break of fire. One combined waste and testing valve including 5mtr of tubing and fittings.
- D. Alarm stops valve.
- E. Strainer
- F. Drain plug
- G. Padlock and strap
- H. Wall box for installation of valve.

#### 4.17 **Alarm Gong**

- A. Water motor alarms of approved type shall be supplied and fitted close to the sprinkler control valve set. Each water motor alarm shall comprise a fire alarm gong with a turbine to operate whenever the alarm check valves are being operated. The water motor alarms shall be suitably mounted on the wall above the alarm valves and all pipe connections shall not be less than 20mm diameter.
- B. Each water motor alarm shall be arranged to drain through a non-ferrous fitting with an orifice. Drain lines shall be connected to water drain or sump pit in which the water will ultimately be discharged to surface water drains.

#### 4.18 **Flow Switches**

- A. Flow switch shall have a paddle made of flexible material of the width to fit within the pipe bore. The terminal box shall be mounted over the paddle / pipe through a 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 seat shall be of stainless steel. The Flow switch shall have IP: 55 protections
- B. Flow switches shall be provided on sectional mains and branch lines of sprinkler system, with each fire hydrant valve and hose reel connections as indicated on the drawings or required and directed by Engineer. The logic of the flow switches shall indicate the following:
  - i. When both the switches operate: Area covered by the downstream switch is in distress.
  - ii. When only the upstream switch operates: Area covered between downstream switch and the upstream switch is in distress.
  - iii. Contact rating shall be 230V, 5A. Single compression cable gland shall be suitable for 1.5 sq.mm copper, armoured, fire survival cables confirming to BS 7846 (F-2, CWZ).
  - iv. Each flow switch shall be suitably earthed.
- C. All the cables from the flow switches shall be led to a junction box located on each floor. Each junction box shall be provided with outgoing terminals with 20% spare for the following:
  - i. Lead from the junction box to local control panel to indicate the status of each flow switch which identifies a particular area of the floor;
  - ii. A visual red bulb, one for each flow switch shall be provided on each junction box to indicate that the flow switch is in operation.

**4.19 Measurement**

- A. Measurements of piping work shall be on following basis: -
  - a. Piping shall be measured along the centre line of installed pipes including all pipe fittings and accessories but excluding valves and other items for which quantities are specifically indicated in the schedule of work. No separate payment shall be made for fittings and accessories.
- B. The measurements for piping work shall include all wastage allowances, flanges pipe supports, hangers, excavation, refilling, testing, nuts and check nuts, vibration isolators, suspension where specified or required, and any other item required to complete the piping installation. None of these items will be separately measured.

**4.20 Excavation**

- A. Excavation for pipe lines shall be in open trenches to levels and grades shown on the drawings or as required at site. Pipe lines shall be buried with a minimum cover of 1 meter or as shown on drawings.
- B. Wherever required Contractor shall support all trenches or adjoining structures with adequate timber supports, shoring and strutting.
- C. On completion of testing in the presence of the Engineer and pipe protection, trenches shall be backfilled in 150 mm layers and consolidated.
- D. Contractor shall dispose of all surplus earth within a lead of 200 m as directed by the Engineer. After completion of work the area will be properly dressed up.

**4.21 Anchor/ Thrust Block: -**

- A. Contractor shall provide suitably designed anchor blocks in cement concrete/steel support to cater to the excess thrust due to work hammer and high pressure.
- B. Thrust blocks shall be provided at all bends, tees and such other location as determined by the Engineer in charge.  
Exact location design size and mix of the concrete blocks/steel support shall be as shown on the drawings or directed by the Engineer in charge prior to execution of work

## SECTION: F.05 FIRE HYDRANT AND HOSE REEL SYSTEM

### 5.1 Scope

- A. This chapter covers supply, installation, testing and commissioning landing valves, first aid hose reels, hose pipes, branch pipes etc., which are vital tools for firefighting.

### Hose Cabinet

#### 5.2 Internal Hose Cabinet to be installed at Concourse and Platform Level

- A. Hose cabinet shall be of double flap, 5 mm thick plain glass fronted with hinged door and lock & Breakable acrylic window with key inside. The cabinet shall be made of 2 mm thick SS sheet stove enameled fire red paint (shade No. 536 of IS: 5) with "FIRE HOSE" written on it prominently (size as given in the schedule of quantities).
- B. The hose cabinet shall be of suitable size to accommodate the following:
- (i) Landing valves (Single outlet).
  - (ii) Hose pipe (2 length of 15m).
  - (iii) Hose reel (25 dia., 45 mtr. long).
  - (iv) Branch pipes, nozzles (1 set).
  - (v) Fire man's axe and hand appliances as per IS926.
  - (vi) Universal locking arrangement.

#### 5.3 External Hose Cabinet 750x600x250 mm

- A. External Hose cabinets shall be fabricated from 2 mm thick stainless-steel sheet (SS 304) sheet for fully welded construction with hinged double front door partially glazed (5.5 mm glass panel) with locking arrangement, stove enameled fire red paint (shade No. 536 of IS: 5) with "FIRE HOSE" written on it prominently (size as given in the schedule of quantities).
- B. The hose cabinet shall be of size to accommodate the following:
- (i) Single headed yard hydrant valve.
  - (ii) Hose pipe (2 length of 15 m).
  - (iii) Branch pipes, nozzles (1 sets).

#### 5.4 Installation

- A. 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.
- B. 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 M from any part of the room.
- C. There shall be no obstruction in swinging the hose reel and should be installed above landing valve where provided.
- D. The inlet valve-shall be at 900 mm above floor level.
- E. Hose reel bracket should be firmly grouted on the wall with the help of rawl bolts.

#### 5.5 Landing Valve

- A. Landing valves are provided in the system for connection of hose pipes for discharging water for fighting fire by fire brigade or trained personnel.
- B. The landing valves shall be as per IS: 5290
- C. The landing valves are of single head outlet types.

#### 5.6 Material of Construction

- |                               |   |  |
|-------------------------------|---|--|
| (i) Body, outlet and cap etc. | - | Stainless steel                          |
| (ii) Spindle                  | - | Stainless steel for stainless steel body |
| (iii) Hand wheel              | - | Cast iron.                               |

The water discharge shall be not less than 950 lpm for single head and 1900 lpm for double head valves at 7 kg/cm<sup>2</sup> pressure.

#### 5.7 Installation

- A. The landing valve shall be fitted to a Tee or Elbow 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 m. from floor level.
- B. The valve base shall be vertical and the valve facing outside. There should be no hindrance in operation of the handle.

**5.8 First Aid Hose Reel**

- A. 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 degrees. The water inlet is connected to the riser pipe by means of 40 mm socket and valve. The hose tube can be pulled out easily for the purpose of discharge of water on fire.
- B. First aid hose reel shall be as per IS: 12585 Type-II. The coupling, branch pipe and nozzle shall be as per IS:8090

**5.9 Material of Construction:**

- (i) Hub and sides : Mild steel
- (ii) Wall Bracket : Mild steel.
- (iii) Hose tube (25 mm) (Nominal Internal dia ) : Thermoplastic (Textile Reinforced)
- (iv) Type-2. as per IS-12585
- (v) Nozzle with branch Pipe : Stainless Steel.
- (vi) Stop Valve (Ball Valve) : Gun metal.
- (vii) Drum : Mild Steel (IS: 884)

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 6m.

**5.10 Fire Hose (External)**

- A. Hose shall be made of jacket of synthetic material. The jacket shall be traded internally with any suitable coating agent to ensure controlled percolation and confirm to IS 8423. Hoses shall be tested and certified by the manufacturer to withstand an internal water pressure of not less than 35 kg/cm<sup>2</sup> without bursting. The hose shall also withstand a working pressure of 7-kg/ cm<sup>2</sup> without leakage.
- B. Two numbers of 63 mm diameter, 15 m long, synthetic hose pipe with stainless steel male and female instantaneous type coupling IS 903, machine wound with copper wire and SS branch pipe with nozzle for external Fire Hydrant.

**5.11 Fire Hose Delivery Coupling, Branch Pipe and Nozzles: -**

- A. These are important accessories used for firefighting operations.
- B. Material of Construction: Stainless Steel.

**5.12 Delivery Hose Couplings**

- A. 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 (Le. 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.
- B. Sizes: - 63 mm

**5.13 Branch Pipe and Nozzle**

- A. 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.
- B. 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).

**5.14 Fire Water Tank**

- A. The Contractor shall construct the reinforced concrete sprinkler tank in all stations. The Contractor shall coordinate to achieve the required effective storage capacity. All pipe works and embedded items within the tank wall shall be provided,
- B. The Contractor shall also include in his scope, provision of the incoming water pipe up to the stop valve just outside the tank,
- C. Air vents and overflow fittings shall be provided for each compartment,
- D. The ladders, concrete platforms hand railings and access doors shall be supplied and installed,
- E. Visual water level indicators, with the necessary levels and lettering neatly and clearly marked, shall be provided. The indicator shall show high level at the upper end and low level at the lower end. Visual

- water level indicators shall not be glass tube type. Electrode type high/low water level sensors shall be provided and these shall be wired back to the pump control panels and map by the Contractor,
- F. Anti-vortex device for the sprinkler tank shall be incorporated so that the effective capacity can be maximized,
  - G. All pipe penetrations provided shall be complete with puddle flanges and cast in the tank wall,
  - H. The Contractor shall co-ordinate to determine the pipes penetration through the tank wall and the position of the cat ladders and concrete platforms so as to avoid any clashes with the fire protection system and to ensure that they are suitable for their intended purposes
  - I. All exposed openings for the tank and pipe ends shall be completed with insect screen,
  - J. A draw-off connection point from the fire water storage tank shall be provided for the use of Fire Brigade
- 5.15 Fire Service Inlet and Fire Service Connection**
- A. 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.
  - B. Fire service inlet shall be provided with each wet riser/down comer and the ring main. These are fixed to 150 mm dia. pipe and located in fire hose Box made of 16g MS sheet with 3 mm thick glass cover.
  - C. These shall be as per IS: 904.
  - D. Material of Construction – MS
  - E. The fire Brigade connection shall be fitted with four numbers of 63 mm instantaneous inlets in glass fronted wall box at a suitable position at street level, so located as to make the inlets accessible from the outside of the building. The size of the wall box shall be adequate to allow the hose to be connected to inlets, even if the door cannot be opened and the glass has to be broken.
  - F. Gun metal Fire Brigade draw-out connection shall be fitted into the water tank with 100 dia. foot valve and confirm with IS 4038
- 5.16 Hose Pipes**
- A. Hose pipes shall be synthetic non-percolating hose confirm with IS 636 Type-B and 63 mm in diameter. They shall be flexible and capable of being rolled. Length of hose pipe will be 15 m.
  - B. The hose pipe shall be complete with male and female coupling at the ends.
  - C. Besides keeping hose pipe with internal hydrant and yard hydrant spare hose pipes along with branch pipes shall be kept in fire hose box.
- 5.17 Earthing And Isolation**
- The Wet Mains, Hose Reels and Sprinkler systems shall be electrically earthed using appropriately sized copper conductors. The earthing continuity across pipe joint shall be maintained using copper tape with proper metal to metal contact. The maximum allowable earth impedance shall be 10 ohms. Each Wet Mains system shall be independently earthed at the breeching inlet.



## SECTION: F.06 SPRINKLER SYSTEM

### 6.1 Scope of Work

- A. The scope of work shall cover supply, installation, testing and commissioning and Training to Employer/Engineer (Training plan Shall be submitted to Engineer for Approval and its implementation) of the sprinkler system.
- B. The contractor shall get the Sprinkler System approved by the Authority having Jurisdiction.
- C. As per IS 15105, Sprinkler System shall be under ordinary Hazard.
- D. Prepare and submit the As-Built-drawings after completion of Site Work
- E. Work shall be carried out by Authorized Agency and Contractor shall take prior approval from Employer/Engineer before Agency mobilization at Site

### 6.2 Standards

- A. The sprinkler system shall conform to and meet with the requirements set out by the following:

|                  |  |
|------------------|--|
| NBC-2016,        | National Building code: Part IV Fire Protection  |
| IS: 9972-2002    | Specification for Automatic Sprinkler Heads for Fire Protection Service.                             |
| IS: 15105 - 2002 | Code of practice for design and installation of fixed automatic sprinkler fire extinguishing systems |
|                  | Compliance with the local fire brigade and the fire enforcing authorities.                           |

### 6.3 Sprinklers

- A. Sprinklers shall be provided internally in the commercial area depending on the floor area as shown on the drawings.

### 6.4 Pendant type Sprinkler Head

- A. Sprinkler heads shall be of quartzoid bulb type with valve assembly, yoke and the deflector.
- B. The bulb shall be made of corrosion free material strong enough to withstand any water pressure likely to occur in the system. The bulb shall shatter when the temperature of the surrounding air reaches at 68° C /79° C (rooms with cooking/heating appliances).
- C. The sprinkler shall be of indicative make and type with 15mm nominal diameter outlets and colour of liquid shall be Red/Yellow.
- D. The sprinkler head shall be approved by UL/FM.

### 6.5 Upright type Sprinkler Head

- A. Upright sprinkler heads shall be similar to Pendent type in material construction and performance but designed to throw water droplets upwards in umbrella fashion, to cool the underside of ceiling and extinguish any fire involving combustibles on the floor below.
- B. The sprinkler head shall be approved by UL/FM. The nominal bore shall be 15mm dia and the colour of the liquid shall be red.

### 6.6 Installation Control Valve for Sprinkler

- A. The installation control valve shall be double-seated clapper type check valve. The body and cover shall be made from cast iron to IS: 210 Grade FG 200. The seat and seat clamp shall be made from bronze to IS: 318, LTB II grade. The sealing to the seat shall be neoprene gasket. The hinges pin and ball shall be from stainless steel.
- B. It shall be vertically mounted and the direction of water travel shall be indicated on the surface. It shall be rated to 12 Kg / cm<sup>2</sup> and tested to 25 Kg / cm<sup>2</sup> pressure.
- C. A Bye-pass check valve shall be fitted to adjust minor and slow variations in water pressure for balancing so as to avoid any false alarm.
- D. The valve shall also be provided with a Test Control Box. The Box shall house a lever to test and operate the ICV. A brass strainer shall also be provided at the point of water supply to the alarm gong. A Retarding Chamber shall also be provided. The Chamber shall be able to balance the water pressure in case of water line surges.
- E. Each installation control valve shall have two sets of Pressure Gauges with brass ball type shut off.
- F. Water Motor Alarm shall also be provided. This shall be mechanically operated by discharge of water through an impeller. The drive bearing shall be weather resistant. A strainer shall be provided on line before the nozzle. The Gong piece shall be constructed from bronze to IS: 318, 2TB II Grade and base of cast iron. The Motor Housing, rotor and Housing cover shall be pressure die cast aluminium.

**6.7 Flow Switch**

- A. Flow switch shall have a paddle made of flexible material of the width to fit within the pipe bore. The terminal box shall be mounted over the paddle / pipe through a 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 seat shall be of stainless steel. The Flow switch shall have IP: 55 protections
- B. The Flow switch shall work at a minimum flow rate of 100 LPS. Further it shall have a Retard to compensate for line leakage or intermittent flows.

**6.8 Test & Commissioning**

- A. Pressurize the sprinkler system by running the jockey pump and after it attains the shutoff pressure of the main pump then come to operation.
- B. The Sprinkler pump starting and stopping shall be tested by opening the test valve.
- C. Open by pass 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 by pass valve.
- D. Discharge test of sprinklers shall be carried out at least once in six months.
- E. All sprinklers shall be inspected for proper positioning or test, external loading and corrosion and cleaned, if necessary, based on experience but at least once in six months.
- F. The entire system shall be drained out at least once a year and testing recorded shall be check and get approval by the engineer / employer.
- G. Check all annunciations by simulating the alarm conditions at site.
- H. The firefighting system shall be maintained and manned from the very first day of its commissioning.
- I. After completion, all operation checks - Sprinkler System shall be carried out for automatic operation of the systems. For this purpose, sprinklers may be opened at different locations. The exercise shall be repeated couple of times to ensure trouble free operation of the system.
- J. Flow Test: - The design flow of sprinklers shall be checked. The sprinklers shall be operated after opening of Installation control valves and shall be monitor through BMS.
- K. 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/sqcm or 1.5 time the rating pressure. The drop of pressure up to 0.5 kg/sqcm shall be accepted.
- L. All the operating tests shall be carried out to the satisfaction of Engineer-in-Charge.

**6.9 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.

All the fire authority submission drawing & document to be provided by contractor for fire for approval from local fire officer/authority.

## SECTION: F.07 PORTABLE FIRE EXTINGUISHERS

### 7.1 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:

- a) Dry powder / ABC type extinguisher
- b) Carbon-dioxide extinguisher
- c) Mechanical Foam Type Extinguisher
- d) Water type CO2 extinguisher.

### 7.2 Standards

The following standards and rules and regulations shall be applicable:

|     |                               |   |
|-----|-------------------------------|---|
| (a) | IS: 15683                     | Portable Fire Extinguishers                       |
| (b) | IS : 15683 -2018              | CO2 fire extinguisher above 4.5 Kg                |
| (c) | IS : 16018 -2012              | Mechanical Foam fire extinguisher above 50 Litres |
| (d) | Local Fire Brigade/ Authority |   |

### 7.3 Extinguishers

#### 7.3.1 Dry Powder / ABC Type

- A. The extinguishers shall be of 4, 6 and 9 kg capacity, cartridge type unless otherwise specified.
- B. The body shall be of cold rolled carbon steel grade D, made up of 1.8 mm for 4 kg and 2 mm for 6 & 9. The construction shall be similar as per IS 15683:2018 but of the following dimensions:

| Capacity (kg) | Outside diameter (mm) | Filler opening (mm) |
|---------------|-----------------------|---------------------|
| 4             | 140±5                 | 74                  |
| 6             | 150 ±5                | 74                  |
| 9             | 180±5                 | 74                  |

- C. The discharge fitting shall be with min 450mm, 12.5mm diameter hose for 4 & 6kg and min 500 mm, 12.5 mm diameter for 9 kg with open type nozzle capable of discharging 85% of the contents as follow:

| Capacity (kg) | Time (sec) | Throw (m) |
|---------------|------------|-----------|
| 4             | Min 15 Sec | Min. 2 m. |
| 6             | Min 15 Sec | Min. 2 m. |
| 9             | Min 15 Sec | Min. 2 m. |

- D. A carbon dioxide cartridge conforming to IS: 4947 shall be fitted in a cartridge holder. A spring-loaded piercing device shall be provided in the cap for piercing the seal of the gas cartridge. A siphon tube of aluminium or PVC shall be provided for upright operation. The cap and neck ring shall be similar with M74 threads.
- E. All internal and external components and surfaces shall have anti-corrosive coating of not less than 12 microns applied uniformly as indicated below:

|     |                                 |                        |
|-----|---------------------------------|------------------------|
| (a) | Body                            | Zinc Phosphate treated |
| (b) | Cage for acid bottle and spring | Not Applicable         |
| (c) | Discharge fittings              | Zinc Plating           |
| (d) | Strainer                        | Not applicable         |

#### 7.3.2 Carbon Dioxide Type

- A. 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.
- B. 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/mm<sup>2</sup>. A siphon tube of copper or PVC shall be

fitted. A non-conducting discharge horn and a high-pressure hose (27.5 N/ mm<sup>2</sup> pressure) shall be fitted with each extinguisher.

- C. For CO<sub>2</sub> 4.5 kg hose length shall not be less than 1 meter & CO<sub>2</sub> 2 kg provided with bend pipe.
- D. The discharge system shall be designed to expel 95% of the contents in continuous discharge as within Min. 8 sec for 2 kg & 9 sec for 4.5 kg.
- E. Carbon dioxide trolley mounted type.
- F. 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/mm<sup>2</sup>. A siphon tube of copper or Aluminium shall be fitted. A non-conducting discharge horn and a high-pressure hose (27.5 N/ mm<sup>2</sup> pressure) shall be fitted with each extinguisher.
- G. The Cylinder shall be fabricated MS steel Body and confirm with IS: 7285
- H. Hose length shall not be less than 5m for 22.5kg
- I. The discharge system shall be designed to expel 95% of the contents in continuous discharge as within min. 15 sec

#### 7.3.3 Water CO<sub>2</sub> Fire Extinguishers

- A. 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.
- B. The capacity of the cylinder when filled shall be 9 liters  $\pm$  5 %.
- C. 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 MS neck ring.
- D. The cap shall be of leaded tin bronze. The siphon tube shall be PVC/Aluminium. 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 EPDM rubber braided, of 12.5 mm diameter and min 500 mm length with a PVC nozzle.
- E. 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 35-bar pressure for 1 minutes. The Extinguisher shall be IS 15683:2018 marked.
- F. Wheeled foam type fire extinguisher shall conform to IS 16018:2012. Foam fire extinguishers shall be rated in accordance with IS Standards, Class B with a capacity up to 45&60 litres of AFFF biodegradable foam agent, rated 20A:233B.

#### 7.3.4 General Requirements

- A. All extinguishers shall be standard products, approved by the 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.
- B. All extinguishers shall have a structurally designed galvanized steel handle and a suitable wall-mounting bracket.

#### 7.4 General Requirements of Breathing Apparatus

- A. The set shall be self-contained open circuit type compressed air Breathing Apparatus set fully confirming to EN 137:1993, standard.
- B. Mass
  - (i) The mass of the ready to use set with facemask and fully charged compressed air cylinder shall not exceed 12.0Kg.
- C. Back Plate (Body Harness):
  - (i) Anti-static back plate made from glass-filled polyamide material for resilience and impact resistance, with carbon fiber for strength.
  - (ii) Fitted with a rubber shocker at the base.
  - (iii) Should be orthopedically designed.
  - (iv) Should be chemical, heat & flame resistant, lightweight, water resistant, anti-static & should have incorporated moulded carrying handles.
  - (v) It shall be ergonomically designed with two integrated carrying handles.
  - (vi) All securing buckles shall be of the 'quick-release' type, designed for accessibility and easy handling with gloved hands without compromising security.
  - (vii) Cam-lock universal cylinder strap which can be adjusted to accommodate all standard cylinder sizes from 4-liter 200 bar to 12 liters 300 bar.

- (viii) Cylinder strap shall be made from a material which allows flame retardancy and heat resistance and includes divider to accommodate twin cylinder configurations.
- D. Face Mask:
  - (i) Full mask assembly shall be with reverted edge seal and made of EPDM material with flame resistance requirement meeting EN 136 standards.
  - (ii) Visor shall provide wide-angle, panoramic vision and be made of replaceable shock and heat-resistant polycarbonate material.
  - (iii) Visor shall be self-demisting type through special control of inspire air.
  - (iv) It shall be fitted complete with a speech device (stainless steel speech diaphragm) which should give excellent clarity and voice reproduction. Integral inner mask shall reduce dead-space and eliminate misting of visor.
  - (v) A single size double reflex seal on the outer mask shall be provided to enable excellent sealing to the wearer's face.
- E. Air Cylinder:
  - (i) The air cylinder shall have a minimum water capacity of 6.8 liters and free air capacity of min. 1800 liters when filled at a pressure of 300 bar and the test pressure shall be 1.5 times the working pressure.
  - (ii) Cylinder valve to be in line type.
  - (iii) The cylinder shall be aluminum lined, fully wrapped carbon composite material.
  - (iv) The weight of the cylinder when fully charged shall not be more than 8 Kg.
  - (v) The cylinder shall be approved by CCOE and certificate to that effect shall be submitted along with the tender.
  - (vi) The cylinder shall be supplied with valve made from nickel plated brass and shall comply with EN 12245.
- F. Pressure Reducer:
  - (i) Small, light, sturdy & encapsulated pressure reducer with high air delivery (enough for 2 users).
  - (ii) The reducer must be able to accommodate optional attachments such as airline belt manifold or decontamination hose / 2nd lung demand valve connection.
  - (iii) The pressure reducer valve shall have a provision of safety pressure relief valve.
  - (iv) The pressure reducer valve shall comply with all the safety requirements stipulated under EN 137 – 1993.
  - (v) The reducer shall be capable of supplying air at the rate 1000 lit/min at an input pressure of 180 bars.
  - (vi) The reducer shall be of the 'balance' type, ensuring that output pressure to the demand valve is stable and constant with varying input pressure down to 20 bars.
- G. Lung Demand Valve:
  - (i) The set shall be provided with plug-in quick removable type lung demand valve with rubber hose having a quick connect coupling connected to the low-pressure side of pressure reducing valve.
  - (ii) The LDV should be connected from the front side of the mask.
  - (iii) The LDV shall be servo assisted, tilting diaphragm/ a balance piston design lung demand valve offering stability, quiet operation & first breath activated with a centrally located switch off button & tough wrap around silicone cover incorporated in an elegant streamlined shape for easy handling – even when wearing gloves.
  - (iv) The LDV shall have flow not less than 500 liters per minute and shall activate at first breathe at 20 – 30 mbar.
- H. Pressure Gauge:
  - (i) Should be connected to the pressure reducer by a high-pressure hose (Non-Metallic outer surface).
  - (ii) Should have a luminescent dial.
  - (iii) Should be encased in a rubber cover.
  - (iv) Should be integrated with the warning whistle in a streamlined hose without any manifold block.
  - (v) Warning whistle should be a self-actuating of 90Db intensity.
  - (vi) Warning Whistle should be positioned on the shoulder in front of the user & close to the ear of the user.
  - (vii) Warning whistle should be high-pressure activated & medium pressure driven.

- (viii) Warning whistle must operate at a residual cylinder pressure 5 +/-5 bar.
- I. Hoses:
  - (i) All the hoses used in the set shall be flexible and non-kinking type and shall permit the free movement of the head.
  - (ii) The design of the hose shall be such that it shall not restrict or close the supply at any time and shall not collapse.
  - (iii) The hose connected to the lung demand valve from the pressure reducer including the connector shall withstand twice the operating pressure of pressure reducer safety valve or at least 30 bar whichever is higher for minimum of 15 minutes.
  - (iv) The hoses shall be provided with necessary end connections for connecting the various parts of the set.
- J. Carrying Case:
  - (i) Set should be supplied in a single moulded tailor-made LLDP Carrying Case made for the set so that all components fit in proper space within the case & cylinder does not move about.
- K. Operation and Maintenance Manual:
  - i. The manufacturer should supply operation and maintenance manual with each set +2 additional set in English language.
  - ii. A Cabinet made from Stainless Steel with Glass front shall be provided for keeping the Breathing Apparatus. The cabinet design shall be approved by Engineer.



## SECTION: F.08 CLEAN AGENT GAS BASED PANEL FLOODING TUBE SYSTEM

### 8.1 Scope

- A. The scope covers supply, installation, testing and commissioning and Training to Employer/Engineer (Training plan Shall be submitted to Engineer for Approval and its implementation) of automatic Clean agent flooding system complete for electrical panels (Main distribution panel, essential power panel, Main Lighting Panel, Water Pump Panel, Fire Pump Panel and any other panel as decided by Employer/Engineer with fire detection tube, cylinder, valves, integration with fire alarm control panel for annunciation. The work shall cover:
  - i. Providing fire detection tube inside the above-mentioned panels.
  - ii. Arrangement of Clean Agent for flooding of the above-mentioned panels.
  - iii. Audio-visual annunciation devices for indicating incidence of fire.
  - iv. Wiring from alarm initiating devices to be above-mentioned panels with required conduits as per direction of engineer-in-charge.
  - v. Any other item required to the successful commissioning of the system.
  - vi. Providing manual arrangement for discharge of gas inside the above panels.
- B. The electrical panel fire suppression system shall be complete with clean agent gas storage cylinders of required capacities, extinguishing agent as specified, polymer fire detection 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.
- C. The panels to be protected shall be determined as per the approval of the engineer-in-charge.
- D. Prepare and submit the As-Built-drawings after completion of Site Work
- E. 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.
- F. Work shall be carried out by Authorized Agency and Contractor shall take prior approval from Employer / Engineer before Agency mobilization at Site

### 8.2 Standards

- A. The design and installation of the clean agent gas-based Fire detection tube system is based on the latest applicable codes and also as per the manufacturer's recommendations, the required clean agent gas quantity is arrived as per the volume of the respective panels to be protected. In addition, the following standards and rules and regulations shall be applicable:
  - (i) Fire protection manual of the tariff advisory committee, Fire Insurance Association of India
  - (ii) IS: 15493 - 2004 Gaseous Fire Extinguishing Systems- General Requirements
  - (iii) NBC-2016 National Building Code, volume-1, Part-IV: Fire Safety System
  - (iv) NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems.
  - (v) Local Fire Brigade/ Authority
- B. All standards mean the updated standards with latest amendments.

### 8.3 System Description

- A. The Clean Agent Pre-Engineered automatic direct fire suppression system shall be approved by Underwriters Laboratories/Factory Mutual/.
- B. Each clean agent pre-engineered automatic system is equipped with its own detection/discharge Fire detection tubing. The pre-engineered concept minimizes the amount of engineering involved in system design. When the detection/Discharge tubing is installed within the limitations stated in the manufacturer manual, no hydraulic calculations are required to determine the pressure drop, agent flow or discharge time.
- C. Each Clean Agent extinguishing unit, when installed, is a self-contained system, meaning that it is equipped with its own automatic (non-electric) detection system, which when actuated, automatically releases the suppression agent into the Electric panel.
- D. The Clean Agent Automatic Direct System consists of the following major components:
  - (i) Clean Agent Cylinder/Valve Assembly (As Approved).
  - (ii) Cylinder Mounting Bracket.
  - (iii) Fire Detection Detector, Actuation and Discharge Fire detection Tubing and Fittings.
  - (iv) Pressure Switch

**8.4 Design Requirements**

- A. Provide sufficient amount of Clean Agent liquid to convert into Clean Agent vapor. Considering the following when computing volume to verify suitability and to establish design limitations:
  - (i) Volume of hazard area.
  - (ii) Specific volume of Clean Agent.
  - (iii) Discharge time and flow rates.
  - (iv) Design concentration and design factors.
  - (v) Detector/discharge tubing placement.
- B. Locate Clean Agent supply near each hazard area.
- C. Interface system with main control fire alarm system and BMS.
- D. Provide total flooding of 7 percent Clean Agent concentration by volume as per NFPA-2001.
- E. The pre-engineered automatic system concept minimizes the amount of engineering required when evaluation is design for a specific application.
- F. No Calculations are required for pressure drop, flow rates or discharge time as long as the discharge / detection tubing is installed within the limits as specified by this manufacturer.
- G. When the additional limitations of hazard volume, area coverage, maximum height, design concentration, agent quantity, detection tubing arrangement etc. are also met, the system installation shall be understood to comply with the design requirements, NFPA-2001.
- H. Therefore, no discharge tests or concentration measurements shall be required.
- I. All doors and holes in the enclosed/equipment should be closed or sealed to maintain the tightness of enclosure.
- J. The system should have means to close the exhaust fans if installed in the panel at the time of system activation.
- K. As desired by the engineer-in-charge the main supply of panel can be shut off with the system.

**8.5 Technical specifications of fire detection tube.**

- A. The High Temperature Polymer tube should be a flexible tube made of special polymer.
- B. The High Temperature Polymer tube should be red in colour to indicate it is part of fire protection system.
- C. The tube should be non – conductive, non- corrosive and flexible.
- D. The automatic system shall become a self-contained; self-actuating unit does not require an external source of power or electricity.
- E. The System shall utilize unique flexible tubing that shall be attached to the top of the container valve. The tubing shall be pressurized with Dry Nitrogen to 150 psig at 70°F (1.034 KPA @21°C) is temperature sensitive and shall act as a continuous linear thermal detector that shall rupture upon flame impingement.
- F. Once the detection tubing is ruptured, forming a nozzle at the rupture point, it shall allow the Clean Agent through the Nozzle into the protected area.

**8.6 Clean Agent Containers**

- A. Fill containers with required Clean Agent. Pressurize with dry nitrogen to 1.034 kPa (150 psig) at 21°C (70° Fahrenheit).
- B. Each storage container is equipped with a nickel-plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the detection tubing. The quarter-turn ball valve shall be kept closed always when the container is not in service.
- C. All container valves shall be equipped with a pressure relief valve (rupture disc) device in compliance with PESO requirements.
- D. The containers shall be located as close as possible to be protected enclosure. In some cases, the containers shall be mounted inside the protected enclosures. The container assemblies shall be located in a ready accessible location to allow for ease of inspection service and maintenance.
- E. Each container shall be equipped with a straight siphon tube. Each container can only be mounted in a vertical upright position. The container discharge valve shall be capable of releasing the Clean Agent in a vertical direction, so that the discharge force is perpendicular to the floor.
- F. The pressure gauge shall permit a quick visual inspection of the container pressure.

**8.7 System Operation**

- A. Designed for simple installation, often very near the source of a potential fire, fire detection is a self-activating detection & suppression system that reliably suppresses fires in few seconds. In the event of fire contacting the fire detection 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 Clean agent gas stored in the cylinder will get released through the tube at the burst point into the panel.

- B. The drop of pressure in the tube followed by reduction in the weight of the clean agent 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.

#### 8.8 **Design Criteria**

- A. Clean Agent gas-based fire detection 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.

#### 8.9 **Main components of the system**

- A. The main features of the system are:
  - (i) Automatic detection of fire
  - (ii) Automatic flooding of clean agent
  - (iii) Activation of audio-visual alarm unit
  - (iv) Manual release valve option
  - (v) Indication & alarm in main fire alarm & control panel
- B. 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.
- C. 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 detection 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.
- D. Pressure switch is connected to the end-of-line adaptor, which is electrically connected to an audio-visual alarm unit.
- E. In the event of fire contacting the fire detection 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 clean agent cylinder open out instantaneously and the clean agent stored in the cylinder will get released through the tube at the burst point into the panel.
- F. The drop of pressure in the tube followed by reduction in the weight of the clean agent in cylinder due to the discharge will activate a local audio-visual alarm both at the audio-visual alarm unit located in the respective zones as well as it will give direct indication on Fire Alarm Panel.

#### 8.10 **Accessories**

- A. The system shall include but not limited to the following:
  - (i) Fire detection tube
  - (ii) Indirect high-pressure valves
  - (iii) Pressure switches
  - (iv) Spring top
  - (v) Auto weigh measurement system
  - (vi) Alarm units
  - (vii) Clean agent cylinder
  - (viii) Hardware items
  - (ix) Pressure switch to sense the drop in pressure.
  - (x) Filling in adapter to change the tube.
  - (xi) Ball valve for closing and releasing.
  - (xii) The spring top to protect the Fire detection tube at the cylinder end.
  - (xiii) Straight fitting for connecting Fire detection tube in case of need.
  - (xiv) Cross fittings
  - (xv) T fittings.
  - (xvi) Cross panel fittings with external insulating jacket.
  - (xvii) End of line adapter.
  - (xviii) Non return valves.

## SECTION V01: VENTILATION & AIR CONDITIONING SYSTEM (VAC)

### 1. INTRODUCTION

#### 1.1 Scope and Purpose

- A. Scope of work under this contract shall include but not limited to the design, manufacture, testing at manufacturer's works, supply, storage, erection, site testing and commissioning of the Air-conditioning.
- B. System mainly comprising of:
  - i. Outdoor and indoor units of VRV / VRF / High performance air-conditioning system along with refrigerant piping and drain piping etc.
  - ii. Ventilation fans
  - iii. Air distribution system
  - iv. Drain Piping
  - v. Electrical works
- C. 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.

#### 1.2 List of Abbreviation

|        |  |
|--------|--|
| A/C    | Air Conditioning   |
| ACPH   | Air Changes Per Hour   |
| AMCA   | Air Movement and Control Association (U.S.A.)                                      |
| ANSI   | American National Standard Institute (USA)   |
| AHRI   | Air-conditioning, Heating and Refrigeration Institute (USA)                        |
| ASHRAE | American Society of Heating and Refrigerating and Air Conditioning Engineers (USA) |
| ASME   | American Society of Mechanical Engineers (USA)                                     |
| ASTM   | American Society of Testing Materials  |
| ATCS   | Automatic Temperature Control System   |
| BIS    | Bureau of Indian Standards   |
| BS     | British Standards  |
| CFM    | Cubic Feet per Minute  |
| FAT    | Factory Acceptance Test  |
| IGBC   | Indian Green Building Council  |
| ISHRAE | Indian Society of Heating and Refrigerating and Air Conditioning Engineers         |
| ISO    | International Organisation for Standardisation                                     |
| LPS    | Litre per Second   |
| NBC    | National Building Code   |
| NFPA   | National Fire Protection Association   |
| OCC    | Operations Control Centre  |
| PSD    | Platform Screen Door   |
| QA     | Quality Assurance  |
| QC     | Quality Control  |
| SCR    | Station Control Room   |
| V      | Voltage  |
| VAC    | Ventilation and Air Conditioning   |
| VRF    | Variable Refrigerant Flow  |

**1.3 Quality control / Assurance (Standards and Codes)**

The following standards shall be applicable in general to each equipment and component of the VAC.

|             |  |
|-------------|--|
| ISHRAE      | Indian Society of Heating, Refrigerating and Air-Conditioning Engineers Handbook             |
| ECBC        | Energy Conservation Building Code  |
| NBC         | National Building Code of India  |
| NFPA        | National Fire Protection Association (USA)   |
| ASHRAE      | American Society of Heating, Refrigerating and Air-Conditioning Engineers                    |
| ASHRAE 62.1 | Ventilation for acceptable indoor air quality  |
| ASHRAE 90.1 | Energy Standard for Building Except low rise residential Building                            |
| NFPA 130    | Standard for fixed Guide way transit and passenger Rail System                               |
| NFPA 204    | Standard for smoke and heat venting  |
| IGBC        | Indian Green Building Council  |
| HVCA        | Heating and Ventilation Contractors Association  |
| DW/144      | Specification for Sheet Metal Ductwork Low, Medium and High Pressure or Velocity Air Systems |
| IS 277      | Galvanised Steel Sheet (Plain and corrugated)  |
| AHRI        | Air-Conditioning, Heating and Refrigeration Institute  |
| AHRI-410    | Forced-Circulation Air-Cooling and Air-Heating Coils   |
| AHRI 1230   | Performance rating of VRF Multi split Air-Conditioning & Heat pump equipment                 |
| BS          | British Standards  |
| ISO         | International Organization for Standardization   |
| EN 799      | Particulate air filters for general ventilation. Determination of the filtration performance |

**1.4 Service Life of the Equipment**

The quality of the material, equipment's, shall be so as to secure a service life as shown below:

|                           |          |
|---------------------------|----------|
| VRF Units & Split Units   | 10 years |
| Axial fans                | 15 years |
| Ductwork & Insulation     | 30 years |
| Automatic Dampers         | 15 years |
| External Louvers & Grills | 20 years |

Above service life of the equipment is the normal life expectancy of the equipment subject to its maintenance and preservations as per the recommended maintenance practice. Contractor shall furnish manufacture's certificate for secured service life of the equipment.

**2. KEY CHALLENGE, PERFORMANCE AND GENERAL REQUIREMENTS****2.1 Air-Conditioned Spaces in Sub Urban Station**

The following rooms of the stations shall be generally air-conditioned: -

| S.NO. | ROOM DESCRIPTION                       |
|-------|--|
| 1     | STATION CONTROL ROOM(SCR) + EFO        |
| 2     | TICKET OFFICE MACHINE ROOM (TOM)       |
| 3     | SIGNALLING EQUIPMENT & PSD ROOM (SPER) |
| 4     | TELECOM EQUIPMENT ROOM (TER)           |
| 5     | UPS ROOMS FOR ELECTRICAL AND S&T ROOM  |
| 6     | STATION MANAGER ROOM(SMR)              |
| 7     | SIGNALLING & TELECOM MAINTAINANCE ROOM |
| 8     | E&M MAINTAINANCE ROOM                  |
| 9     | CREW CONTROL ROOM                      |
| 10    | STAFF ROOM                             |

The rooms shall be served by Hi-wall units, wall Mounted, duct-able units or cassette units, depending on the type of room and its usage.

Any other room may be envisaged with air-conditioning, if there is a specific requirement from the client.

## 2.2 Design Parameters:

The following parameters are being considered for the design.

|                 |   |
|-----------------|---|
| <b>Summer:</b>  | <b>41.2 °C Dry Bulb Temperature (DBT), 22.9 °C Wet Bulb Temperature (WBT)<br/>(@1 % criteria)</b> |
| <b>Monsoon:</b> | <b>32.7 °C Dry Bulb Temperature (DBT), 28.1 °C Wet Bulb Temperature (WBT)<br/>(@1 % criteria)</b> |

Design temperatures to be maintained for Air conditioning rooms:

- **24+/-1°C Dry Bulb (DBT), 55+/-5% RH – For Back of House Room & Technical Rooms**

|            |  |
|------------|--|
| Occupants: | 75 W/person sensible, 55 W/person latent for technical room, Office areas<br>(from ASHRAE 2009 Fundamentals) |
| Lighting:  | 1.1 Watt/sqft. for Technical/Operational Room<br>1.1 Watt/sqft. for Offices<br>(From ISHRAE Table 1.38)      |

## 2.3 Air Conditioning System with VRV/VRF - GENERAL

The scope of work related to Variable Refrigerant Flow Air-conditioning System shall generally comprise of but not limited to the following:

- Manufacturing
- Testing at manufacturer's works
- Supply and storage
- Installation at station
- Site testing and commissioning

A. The VRF type air-conditioning system shall generally consist of:

- Outdoor and Indoor units along with refrigerant piping, its nitrile insulation with aluminium cladding and cable tray/ raceway. The cable tray/raceway used for refrigerant pipe (if applicable) and electrical cables will be a part of the VRF system and no separate payment is to be made. Each refrigerant circuit from Outdoor Unit to Indoor Unit will run on separate cable tray.
- Air distribution system when ducting is provided as per Drawing.
- Drain Piping.
- Electrical works.
- Materials and components not specifically stated in the specifications and/or noted on the drawings but which are necessary for satisfactory installation and operation of the system.

B. Governing Specifications

The VRF type air-conditioning system shall comply with standards mentioned particularly in the table below unless otherwise stipulated in the specifications. The latest version of standards shall be applicable.

|  |
|--|
| AHRI-1230 (or the latest)                |
| ASHRAE latest standard and guidelines.   |
| UL-94- V0                                |
| Indian Electricity Rules- 2005           |
| ASTM B 280                               |
| Japanese Industrial Standard JIS H :3300 |
| ASHRAE & ISHRAE                          |

## 2.4 System Description

A. The Variable Refrigerant Volume VRV / Variable Refrigerant Flow VRF -R410a refrigerant System should be air-cooled, air-conditioning systems consisting of modular condensing units connected to multiple indoor units, each having the capability of individual set point control



- B. The manufacturer shall take a note of the ambient air pollution prevailing in Karnataka and shall provide proven protection against corrosion to all the components of VRF module.

#### **Outdoor Back up**

- C. Equipment rooms having Back up system on Outdoor and Indoor shall have Back up system.  
For example, out of any 3 Outdoor units, 2 ODU shall be in continuous cyclic operation of 16 hours for each day with 3rd ODU working as Stand-by system i.e. for 1st 8 hours ODU-1 & ODU-2 shall be in working condition while ODU-3 shall be kept in Stand-by mode, for another 8 hours ODU-1 & ODU-3 shall be in working condition and ODU-2 shall be kept in Stand-by mode and for next 8 hours ODU-2 & ODU-3 shall be in working condition while ODU-1 will be in stand-by mode.
- D. ODU 1,2,3 Working periods shall also be rotated weekly(accordingly).
- E. UPS(S&T), SER, TER, OCC and other Equipment/Technical rooms etc. shall be fed by any of the ODU's in continuous operation of 24 hours.
- F. In case of failure of any ODU the stand-by units shall automatically starts through central system controller.
- G. After a unit has been brought on line, a timer starts to prevent from cycling ON and OFF through Schedule timer.
- H. Indoor unit capacity can be changed depending on actual A/C heat load.

### **2.5**

#### **Variable Refrigerant Flow System**

- A. The Variable Refrigerant Volume VRV / Variable Refrigerant Flow VRF - R-410A. A refrigerant System should be air-cooled, air-conditioning systems shall be consisting of modular condensing units connected to multiple indoor units, each having the capability of individual set point control. Each modular condensing unit should incorporate at least one inverter compressors (Scroll / Rotary) to obtain 10% to 100% stepless capacity control for enhanced Power saving. The indoor units should be provided with Corded Remote Control as a standard accessory.
- B. The VRV / VRF units shall be capable of delivering rated capacity within a wide range of ambient temperatures. The Condensing units should be capable of provide cooling within an ambient range of -5 °C to 50 °C DB and heating in the range. -10 °C to 15 °C DB.
- C. The refrigerant piping shall be extendable minimum 165 m with 50 m level without any oil trap.
- D. 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.
- E. Units shall be suitable to use R 410a (or any zero ODP refrigerants or equivalent), factory tested, evacuated, dehydrated and pressurized with refrigerant holding charge for field installation.
- F. The complete units shall be protected from damage, corrosion, weather etc., during transportation and storage until ready for installation.
- G. Fins, casing and all sections shall be protected from damage during installation.
- H. Highly energy efficient and latest / best space saving VRF indoor and outdoor unit model shall be provided.
- I. Contractor to provide a functional system having an **ISEER (Indian Seasonal Energy Efficiency Ratio)** value of 4.5 and above.

### **2.6**

#### **Outdoor Unit**

- A. The outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing constructed from rust-proofed mild steel panels coated with a baked enamel finish. The ODU must deliver 100% cooling capacity at 50°C Ambient Temperature.
- B. The outdoor unit shall have multiple scroll compressors preferable one with inverter compressor and be able to operate even in case of breakdown of one of compressors.
- C. The noise / sound pressure level shall be limited to 60 to 65 dB(A) at normal operation measured horizontally 1 Meter away and 1.5 Meter above ground level for single and modular type of multiple outdoor units.
- D. The outdoor unit shall be modular in design and shall be allowed for side-by-side installation.
- E. The outdoor unit must have feature of record running parameters of last 3 minutes before failure, for fault analysis and easy, faster trouble shooting.
- F. In case of trouble occurs in one indoor unit, continuous operation of safe system and other indoor units should be possible.

- G. The unit shall be designed in such a way the cleaning of drain pan, inspection and replacement of compressor should be easy. Drain pan shall be of SS 316 with 0.8 mm thickness and CPVC pipe shall be connected from the drain pan to nearest drain location.
- H. Electricity characteristics for outdoor unit shall be 415 Volts / 3 Phase / 50Hz.
- I. The dip switch shall available in ODU to check correct amount of refrigerant charged.

#### **Compressor**

- A. The compressor shall be of highly efficient hermetic Inverter Scroll / Rotary capable of capacity modulation by time averaging method and Vapour injection Technology. Each ODU should have minimum 1 no. variable compressor up to 16 HP capacities, 2 variable compressors up to 32 HP capacities, 3 nos. Variable compressors up to 48 HP capacity & 4 nos. variable compressors up to 64 HP capacities.
- B. Each module of outdoor unit must have minimum 1# Inverter scroll/DC Twin Rotary with multiple compressors in each module compressor, suitable to operate at heat load proportional to indoor requirement / or by change in compressor configuration or capacity as per load.
- C. The inverter compressor shall be capable of changing the speed to follow variations in cooling load requirement.
- D. Thermal casing shall be provided for compressors to minimise the noise level. In addition to that, compressors shall be mounted on vibration isolators on the unit housing to minimise the noise level.
- E. Compressor shall be equipped with internal overload (overheated) protectors for safe operation.
- F. Starter for the outdoor unit compressor shall "Direct on Line" type. Inverter compressor / or equivalent system of the unit shall start first & at the minimum frequency / capacity, to reduce the in-rush current during starting.

#### **Heat Exchanger**

- A. Condenser coil shall be seamless deoxidized copper tubes with mechanically expanded into aluminium fins to form a cross fin coil.
- 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. Manufacturing of copper tubes shall comply with ASTM B280-03/JIS 3300.
- D. The copper tubing shall be inner grooved type for better heat transfer.
- E. The system should have sub-cooling heat exchanger further to condenser to increase refrigerating effect in indoor units.
- F. Terminal box for power input shall be water protected with IP54.

#### **Fan Motor Speed Control**

The condensing unit fan motors to have at least two speed operations to maintain constant head pressure control at all ambient temperatures and modes of operation.

#### **Refrigerant Circuit**

- A. The refrigerant circuit shall include an accumulator, liquid and gas shut off valves and a solenoid valves or pulse width modulation valve. All necessary safety devices shall be provided to ensure the safety operation of the system.
- B. The IDU Shall be connected in each confirmed spaces through a redundant refrigerant piping network connecting IDU with the Network alternatively.

#### **Safety Devices**

The following safety devices shall be part of the outdoor unit;

- i. High Pressure Switch,
- ii. Low Pressure Switch,
- iii. Fan Motor Safety Thermostat,
- iv. Over Current
- v. Relay,
- vi. Fusible Plugs,
- vii. Fuses.

#### **Oil Recovery System**

Each unit shall be equipped, with an oil separator to ensure stable operation with long refrigerant piping.

## 2.7 Indoor Unit

Each area shall have independent indoor units of ceiling/wall mounted type. Each unit shall be supplied with the corded remote controller and one nos. relay. The contractor shall make the control power available in case of emergency failure of a single unit the system working shall be ensured.

- A. Indoor unit shall be either ceiling mounted or wall mounted cassette type / Ductable type as specified in BOQ. It shall have electronic control valve to control refrigerant flow rate in response to load variations of the room. The fan shall be of the dual suction multi blade type and statically and dynamically balanced to ensure low noise and vibration free operation.
- B. The address of the indoor unit shall be set automatically in case of individual and group control. In case of centralized control, it shall be set-by liquid crystal remote controller.
- C. **Electronic Expansion Valve** - Each indoor unit shall be fitted with an electronic expansion valve to control the refrigerant flow in response to the load variations in the room. The electronic expansion valve is to be controlled via 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.
- D. The minimum dehumidified CFM delivered by the unit shall be as given below: -

| TR      | CFM      |
|---------|----------|
| 1.0 TR  | 335 CFM  |
| 1.65 TR | 530 CFM  |
| 2.0 TR  | 635 CFM  |
| 3.3 TR  | 1130 CFM |
| 4.13TR  | 1377 CFM |
| 4.75 TR | 1624 CFM |

The above capacities are approximate and these may be variation of 5% on either side.

- E. The enclosure of all indoor units shall be galvanized sheet steel with powder coating.

### High wall mounted unit:

- i. Casing shall be of ABS / polypropylene with minimum 1.0 mm thickness and standard finish.
- ii. Unit shall be provided wired remote controller and it should facilitate on/ off function, change of temperature settings, fan speed setting, operation mode setting, swing setting, clock function and error code display.
- iii. The minimum length cable from controller to unit should be 3 m and maximum length of cable as per site condition. Necessary Casing arrangement to fix the controller at wall to be provided.
- iv. The minimum length cable from controller to unit should be 3 m and maximum length of cable as per site condition. Necessary Casing arrangement to fix the controller at wall to be provided.

### Cassette type unit:

- i. Casing shall be made of Galvanised steel sheet (G.S.S) with minimum 0.8 mm thickness. Zinc coating thickness on G.S.S shall be of minimum 220 GSM.
- ii. All parts of housing, which are in direct contact with water, are made from moulded ABS / Polypropylene and lifetime against corrosion.
- iii. Cassette panels shall be of ABS / polypropylene with standard finish.
- iv. Unit shall be provided wired remote controller and it should facilitate on/ off function, change of temperature settings, fan speed setting, operation mode setting, swing setting, clock function and error code display.
- v. The minimum length cable from controller to unit should be 3 m and maximum length of cable as per site condition. Necessary Casing arrangement to fix the controller at wall to be provided.
- vi. Independent vane control facility and angle swing flap shall be possible with remote controller.

### Filters:

- i. Filters shall be provided with EU-4/G4 rating as per EN 779/ISO 16890. The filter shall be insertable type. It shall be possible to clean with either compressed air or water.
- ii. Air face velocity shall be limited to 2.5 m/s maximum.
- iii. VRF units shall be supplied with inbuilt filters. The same shall be used for testing commissioning only.
- iv. One set of extra filters shall also be provided along with delivery of units and the same shall be fixed prior to handing over of the system.

**Indoor Unit Fans**

- i. Shall be direct driven of the DIDW multi-blade type, statically and dynamically balanced to ensure low noise and vibration free operation.
- ii. The noise level shall not exceed 42 dbA for non- ductable type unit & shall not exceed 49 dbA for ductable type unit.
- iii. Each unit shall have an individual corded remote controller for local control of the indoor unit.

**Cooling Coils**

- A. Shall be direct expansion, constructed from copper tubes expanded into aluminum fins to form a rigid mechanical bond.

**Unit Control Board**

- A. It shall include in the indoor unit a printed circuit board complete with, address switches for a variety of operation controls, emergency operation switch and fault / operation indication LED's. The fan motors shall be thermally protected.

**Unit Casing**

- A. The indoor unit casing shall be fully insulated and sealed to prevent condensation.
- B. Each Indoor unit shall be provided with one no. of relay and control supply shall be made available to the PCB of unit by the contractor.
- C. In case of failure of a single unit because of fault shall not affect the operation of the entire circuit. Electric circuit should follow the scheme as shown in the standard details drawing for HVAC.

2.8 **Centralized System Touch Screen Remote Controller**

- A. A multifunctional compact Touch Screen centralized controller shall be provided with the system.
- B. The System Controller shall act as an advanced air conditioning management system to give complete control of VRV / VRF air conditioning equipment. It shall have ease of use for the user.  
It shall be able to control up to 256 groups of indoor units with the following functions: -
  - i. Starting/stopping of Air conditioners as a zone or group or individual unit.
  - ii. Temperature setting for each indoor unit or zone.
  - iii. Switching between temperature control modes, switching of fan speed and direction of airflow, enabling/disabling of individual remote controller operation.
  - iv. The address of the indoor unit shall be set automatically in case of individual and group control.
  - v. Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble-shooting information.
- C. The controller shall have wide screen user friendly colour LCD Touch screen display and can be wired by a non-polar 2 wire transmission cable to a distance of 1 km. away from indoor unit.
- D. In case of power fluctuation or power failure, the addressing and other settings such as temperature of individual indoor units should not be affected. Alpha- numeric addressing of each indoor unit should be possible to facilitate the location of individual indoor unit.
- E. Each VRF shall have a built-in control panel to control the machine compressors and provide the mechanical protection. Dedicated VRF controller panels are supplied and installed (by others) for the control and monitoring of VRF outdoor units. These panels shall communicate with VAC over a software links Modbus over TCP/IP. These panels shall communicate with DMS over a software links Modbus RS 485 over TCP/IP such that the system can be easily programmed for individual unit fully controlled by O & M team

2.9 **Cabling Between Indoor and Outdoor Units**

- A. The cable between indoor and outdoor units shall run in GI conduit.
- B. The work will include supply, installation, testing, commissioning of control cum transmission wiring of 2 core x 1.5 sq.mm FRLSZH XLPE insulated in suitable GI conduits and accessories between indoor and outdoor units. Necessary securing arrangement of conduit shall be made by contractor. Provision of supply and laying of GI conduits shall be in the scope of work.

3. **PIPING**3.1 **Refrigerant Pipework:**

- 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 are kept to a minimum. Necessary securing arrangement of Refrigeration Piping shall be made by contractor.
- 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 -25° C up to 150° C
- F. The polymer shall be obtained by the mixing of base / monomer with a hardener / polymerise. It may be brush applied or with the use of a suitable gun.

**Y-JOINT ORIENTATION:**

- A. Proprietary Distribution refrigeration pipe Y-Joints and headers shall be installed in an appropriate orientation to enable correct distribution of refrigerant.
- B. The Distribution joints shall be factory insulated with pre-formed sections of expanded Polystyrene / equivalent.

**CLEANLINESS OF PIPING:**

- A. All pipe-work must be kept clean and free from contamination to prevent breakdown of the system.
- B. All pipe ends shall be kept sealed until immediately prior to making a joint.

**PRESSURE TESTING:**

- A. After complete installation of refrigerant piping, it shall be pre-pressure tested and repaired if necessary and further pressure tested to 3,800 KPa, to hold for a minimum 24 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 one to four hours depending on the pipe length.

**REFRIGERANT CHARGE**

- A. Refrigerant charge must be calculated based on the actual length of the refrigerant pipe work.
- B. The refrigerant charging process must be carried out with an appropriate charging station and under supervision of the contractor & contractor shall submit the calculations for Additional refrigerant for each circuit separately

**PIPING INSULATION**

- A. All suction & liquid lines of the Refrigerant pipe work shall be insulated with Nitrile rubber /expanded polyethylene class O pipe sections clad with aluminium foil to avoid condensation. The exposed piping insulation shall be painted with UV paint.
- B. Insulation for nitrile rubber shall be Class O as per BS 476 Part 6 and for Class 1 as per BS 476 Part 7
- C. Thickness of refrigerant insulation shall be 13 to 25mm as specified in BOQ for individual pipe size
- D. Sample of insulation shall be submitted to Engineer for notice of no objection.

**REFRIGERANT COPPER TUBES INSULATION INSTALLATION REQUIREMENT**

- A. Method statement of installation for insulation for copper pipes, fittings / Y-branch joins / header joints shall be submitted as recommended by the manufacturer.
- B. Always insert / push the insulation over the copper pipes according to their sizes prior to brazing and place the insulated copper pipes on the support.
- C. The insulation manufacturer shall supply adhesive for joining / bonding of copper tubes.
- D. Inside and outdoor application: Water based protective paint shall be applied over the insulation. To provide UV protection two complete coats shall be applied. The first coat (0.13 mm dry film thickness) shall be applied immediately after the insulation has been installed. The second coat (0.13 mm dry film thickness) shall be applied within 7 days. Total dry film thickness shall of minimum 0.26mm.
- E. The insulation joint shall be closed with self-adhesive nitrile rubber gasket size is 5mm thickness and 50mm width.
- F. Place the nitrile rubber gasket (5mm thickness X 50mm width) while joining the insulation tubes and tight it with plastic tie to provide protection.
- G. The minimum gap between the copper pipe insulation top and the concrete slab is 100 mm.
- H. The minimum gap of 100 mm shall be provided between gas and liquid line copper pipe insulation (both horizontal & Vertical) to ensure free convection and provides a safeguard against condensation on cold pipes.



- I. The insulated pipes shall be laid with perforated cable tray and fully covered with top plain cover sheet. Perforated cable tray and top plain cover sheet shall be made of hot dip galvanised steel sheet with minimum of 1.2 mm thickness. Refer installation drawing for more details.

OEM of VRF units or authorised vendor of the OEM shall verify, validate and certify the installation and testing / commissioning of copper piping insulation and complete VAC System **REFRIGERANT PIPING CAPABILITY:**

The unit shall be capable of long length of piping and for providing of refrigerant due to level difference between the outdoor unit and indoor unit within the specified capacities of system.

- A. The size of the pipe may vary depending on the site conditions.  
B. Test certificates for copper pipes used in the refrigerant circuit (as per JIS H 3300) from an accredited laboratory should be submitted.

#### **Installation**

- A. The power/control/communication cable between indoor and outdoor units shall run in GI conduits or armoured cable to be used.  
B. The insulated refrigerant piping and cable between indoor and outdoor unit shall run in a Galvanized Steel raceway/Cable tray with proper supporting arrangement.  
C. All galvanized support beams, galvanized legs, galvanized hangers, anchor bolts, vibration isolators, and ductworks shall be provided for the installation of the units, assembly and its sub-assembly.  
D. The VRF 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.  
E. The centralized system Controller shall be located in a properly sized box with lock and key facility along with its battery/adaptor unit. The power supply cable for the controller shall be taken in a conduit from the nearest 230V socket. A guidance manual of the controller shall be located in this unit.  
F. Joints in refrigerant piping should be kept as minimum as possible, for this following consideration to be taken into account:  
i. One end expanded copper tube should be preferred over plain ended copper tube.  
ii. If possible, bending of semi-hard/hard copper pipe should be preferred instead of using elbow.  
G. Metal cladding to be provided for exposed pipes in maintenance areas for mechanical protection

#### **3.2 Testing at Manufacture's Premises**

The units shall be tested for capacity and COP as per AHRI conditions at manufactures premises before delivery, Owners / their representative reserve the right to witness the tests.

#### **3.3 Insulation for Copper Tubes:**

All suction & liquid lines of the Refrigerant pipe work shall be insulated with Nitrile rubber /expanded poly ethylene pipe sections clad with aluminium foil as specified to avoid condensation. The exposed piping insulation shall be painted with UV paint.

- i. It shall have the following properties:

|  |   |  |
|--|---|--|
| Temperature Range  | Minimum surface temperature<br>Maximum surface temperature<br>Maximum temperature for flat surfaces | -40 °C<br>+105 °C<br>+85 °C  |
| Thermal Conductivity as per DIN EN ISO 8497              | Mean temperature °C<br>Thermal Conductivity, W/m°K  | 0, +20, +40<br>0.035, 0.037, 0.039   |
| Water vapour permeability as per DIN EN 13469 / EN 12086 | Moisture resistance factor  | > 7,000<br>2.48x10 <sup>-14</sup> kg/(m.s.pa)<br>8.91x10 <sup>-11</sup> kg/(m.hr.pa) |
| Water absorption as per ASTM D 1056                      | By volume after 28 days   | 0.9% average<br>1.5% maximum   |
| Fire performance   | —   | Class 0  |
| Surface spread of flame as per BS 476 Part 7.            | —   | Class 1  |



|   |   |             |
|---|---|-------------|
| Fire Propagation as per BS 476 Part 6   | Total index performance<br>Sub index performance                      | < 12<br>< 6 |
| Reaction to fire - Physical performance | Self-extinguishing does not drip<br>flaming droplet up to 180 minutes | –           |
| Safety and Environment                  | Zero ODP, Zero GWP, dust and<br>fibre free.                           | –           |

### 3.4 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 openable GI covers.

Refrigerant copper piping shall be as per ASTM: 8280. 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) | 1.1 mm    | 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) |

### 3.5 Drain Piping

- A. The indoor/Outdoor units shall be connected to drain of insulated GI pipe/uPVC.
- B. The pipes shall be laid in proper slope for efficient drainage of condensate water.
- C. Drain Pipe Insulation (Pre-Insulated)
  - i. Drain pipes carrying condensate water shall be insulated with 9 mm Nitrile rubber having a 'K' value of 0.037 W/mk at a mean temperature of 20° C and a minimum density of 55 Kg/Sqm.
  - ii. The joints shall be properly sealed with synthetic glue to ensure proper bonding of the ends. Entire drain piping should be included in the scope of work.
- D. Drain pipe for Wall mounted indoor unit shall be installed to have the proper aesthetic look as per site condition.

## 4. AIR CONDITIONING SYSTEM WITH SPLIT AIR CONDITIONERS

### 4.1 General

The contractor shall supply and install split /FCU Metallic type with **5-Star rating** (with Grilles at supply openings of the units) system air conditioner wherever indicated and capacity shall be as per the requirement. The system shall be complete in all respects and comply with the specifications as given. The system will work at 240V, 1-Phase, 50 Hz, AC supply. The unit shall be operated by remote control and should show temperature on the cooling units.

### 4.2 Condensing Units

- A. Each condensing unit shall be complete Inverter type unit with EER hermetically rotary/scroll compressor/s, air cooled condenser, condenser fans with motors, internal piping, switches and internal wiring and shall be enclosed in a weather proof outdoor type housing.
- B. The compressor shall be hermetic, with enclosed gas cooled motor. The compressor shall be suitable for R-410A, R32 or R134A or Environment Friendly Refrigerant in terms of "**Ozone Depletion**" potential and energy efficiency.
- C. The condenser coil shall be air cooled type with aluminium sine wave fins and copper tubes and necessary refrigerant connections. The copper tubes diameter shall be as per manufacturers standard.
- D. The condenser air fans shall be propeller type direct driven, each complete with motor.
- E. The casing shall be fabricated from galvanized steel and finished with powder coated paint. The casing shall make the whole unit fully weather proof suitable for outdoor installation.

- F. The unit shall include a remote-control assembly with thermostat and starter and speed switches.
- G. The necessary charge of refrigerant gas and lubricated oil shall be provided to run the system.

#### 4.3 **Cooling Unit**

- A. The cooling unit shall be matched to the respective condensing unit and shall consist of cooling coil, blower, filters, outer casing, drain pan, accessories etc.
- B. The cooling coil shall have copper tubes & the dia. shall be as per manufacturers standard and continuous aluminium sine fins with integral collars. The tubes shall be staggered in the direction of the air flow.
- C. The fan section shall comprise of 1 No. statically and dynamically balanced centrifugal blower, motor, drive package, mounting arrangement etc.
- D. The unit shall include a remote-control assembly with thermostat and starter and speed switches.
- E. The unit casing shall be made of galvanized steel, the casing shall be insulated to lower the noise level and eliminate condensation.

#### 4.4 **Refrigerant Piping**

- A. The condensing unit and evaporator unit shall be interconnected by type 'L' seamless copper refrigerant liquid and suction lines using flared or brazed fittings. Necessary accessories shall be incorporated in the circuit. This includes the entire piping work as required.
- B. The suction and liquid line shall be insulated with 13 mm thick expanded polyethylene/ Nitrile rubber insulation.
- C. Necessary chases and holes in walls and floor etc. for laying the piping work shall be done by contractor, after completion of work necessary repair work shall be done by contractor and brought to its original finish.

#### 4.5 **Miscellaneous**

- A. The unit shall have control panel, housing the starting switches, contractor, relays etc.
- B. Isolation pads shall be provided under the units.
- C. Insulated drain line shall be provided from indoor unit up to drain trap.
- D. Suitable M. S. channel supporting frame shall be provided for the condensing unit and supporting arrangement for the indoor units.
- E. Interconnecting power and control cabling shall be provided between condensing unit and evaporator unit.
- F. PVC flexible sleeves shall be provided to cover the insulated refrigerant piping and electrical cabling from indoor to outdoor units.
- G. Compressor current should not flow through indoor unit.
- H. In-built protection in indoor unit against electric fault to be provided.

#### 4.6 **Installation**

- A. 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.
- B. Refrigerant pipes that exposed to outdoor shall be covered with UV coating to protect insulation from direct UV exposure.
- C. Anti-corrosion protective coating on refrigerant pipes, Bents, Joints of indoor & outdoor unit to be done to avoid leakages.
- D. All galvanized support beams, galvanized legs, galvanized hangers, anchor bolts, vibration isolators, ductworks and shall be provided for the installation of the units.

### 5. **TESTING OF AIR-CONDITIONING SYSTEM**

This is applicable for testing of all HVAC system.

- A. Routine and types tests for the various items of equipment shall be performed at the contractor's works and test certificates furnished. Functional tests shall be conducted at site.
- B. The performance tests to determine whether or not the full intent of the specification is meant shall be conducted by the contractor. After notification to the employers that the installation has been completed and the plant has run continuously for a period of at least two weeks, the contractor shall conduct under the direction of the consultants and in the presence of the employer's representatives tests such tests as specified to establish the capacity of various equipment supplied and installed by the contractor.

- C. The contractor shall operate, test and adjust the air conditioning appliances including adjustment of regulators, dampers, etc.
- D. All test equipment, labour, operating personnel, oil and refrigerant required for these tests shall be furnished by the contractor to enable the plant to be put in continuous running test for a period of two days after all other tests and adjustments have been made.
- E. The performance tests shall be conducted during peak summer and peak monsoon.

## 5.1

**Procedure****A. Design Conditions:**

The inside and outside conditions will be recorded for 24 hours duration on hourly basis. The outside and inside dry bulb and wet bulb temperatures shall be recovered by means of a sling spectrometer with mercury thermometers. The relative humidity shall be computed from the psychometric chart. The inside dry bulb temperature and relative humidity shall fall within the specified limits.

**B. Capacity of the Air-conditioning System**

The following aspects shall be checked before conducting the performance tests:

- i. The outside conditions shall be as close to the design values as possible. The tests shall be arranged during the peak summer and monsoon
- ii. The internal loads of various spaces shall be close to the design values as far as possible. Otherwise, internal loads shall be simulated to a value required to satisfy the design condition.
- iii. Hourly readings of pressure, temperature, electrical current, voltage and power factor shall be properly recorded. The capacity of the system and various other equipment and accessories shall be ascertained.

**C. Cooling Coils of Indoor units**

- i. The flow of air over the cooling coil will be measured by recording the velocity of air across each filter placed before the cooling coil. The velocity shall be measured by means of an anemometer.
- ii. The wet bulb temperature of air entering the coil and that leaving the coil shall be measured. The enthalpy of entering and leaving air shall be noted from the psychometric chart, corresponding to the WB temperature recorded. Single thermometer shall be used.
- iii. Same pressure gauge and thermometer shall be used for different measurement of pressure and temperatures. The capacity of the compressor shall be computed from the performance chart supplied by the manufacturer. Bhp/ton of the compressor shall be computed from above readings.

**D. Air Balancing**

After the desired inside conditions are achieved the quantity of air through every outlet shall be measured.

## 5.2

**Functional Tests****A. Electrical Equipment:**

- i. All the cables shall be tested for continuity and absence of cross phasing. Insulation resistance between the phase conductors and the earth shall be measured shall with the help of a 500-V megger.
- ii. Motors:
  - a. Starting current shall be recorded every time the motor is started.
  - b. Starter operation shall be checked for single phasing by removing one of the phases.
  - c. Overload protection shall be checked by altering the starter thermal overload setting.

## 5.3

**Test Reading**

The following readings shall be recorded hourly during the tests and capacity of the plant shall be computed.

| Indoor Units:         |                          |
|-----------------------|--------------------------|
| Air velocity          | M/Hr (FPM)               |
| Coil face area        | M <sup>2</sup> (SFT)     |
| Air quantity          | M <sup>3</sup> /Hr (CFM) |
| Entering air temp. DB | ° C (°F)                 |
| Entering air temp. WB | ° C (°F)                 |
| Leaving air temp. DB  | ° C (°F)                 |
| Leaving air temp. WB  | ° C (°F)                 |
| Cooling capacity      | K Cal./ Hr (TR)          |

| Motor             |       |
|-------------------|-------|
| Rated horse power | HP    |
| Rated volts       | Volts |
| Rated current     | Amps  |
| Actual current    | Amps  |
| Actual volts      | Volts |

Control, Interlocks etc.

The observations of the test shall be recorded for each item separately.

#### 5.4

##### **Noise Control**

A. The testing of all noise control equipment and the methods used in measuring the noise rating of air conditioning plant and equipment shall be in accordance with the relevant sections of the following British Standards, unless otherwise stated:

|                             |   |
|-----------------------------|---|
| BS 4718 : 1971              | Methods of Test of Silencers for Air Distribution Systems.  |
| BS 2750 :<br>Parts 1-9:1980 | Laboratory and Field Measurement of Airborne Sound Insulation of Various Building Elements.<br>Recommendations for Field Laboratory Measurement of Airborne and Impact Sound Transmission in Buildings. |
| BS 3638 : 1987              | Methods of Measurement of Sound Adsorption in a Reverberation Room.   |
| BS 4773 : Part 2: 1976      | Acoustic Testing.   |
| BS 4856 :Part 2: 1976       | Acoustic performance without additional ducting of forced fan convection equipment.   |
| Part 5: 1976                | Acoustic performance with additional ducting of forced fan convection equipment.  |
| BS 4857 :Part 2:1978 (1983) | Acoustic Testing and Rating of High Pressure Terminal Reheat Units.   |
| BS 4954 :Part 2:1978 (1987) | Acoustic Testing and Rating of Induction Units.   |
| BS 5643 : 1984              | Glossary of Refrigeration, Heating, Ventilating and Air Conditioning Terms.   |

### General

Mechanical services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source where illustrated on the tender drawings and plant and equipment schedules to achieve acceptable noise rating specified for occupied areas.

- A. In addition to the provisions specified in the Specification, particular attention must be given to the following details at time of ordering plant and equipment and their installation:
  - i. Where duct work and pipe work services pass through walls, floors and ceilings, or where supported shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure and minimize the outbreak of noise. from rooms.
  - ii. The reduction of noise breakout from rooms and the selection of externally mounted equipment and plant to meet ambient noise level requirements of the Specifications.
- B. Electrical conduits and connections to all moving plant and equipment shall be carried out in flexible conduit and cables to prevent the transmission of vibration to the structure and nullify the provisions of anti-vibration mountings.
- C. All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units.
- D. Duct work connections to the fan inlets / outlets shall be concentricity aligned so that the flexible connections are not subjected to any strain.
- E. All resilient acoustic absorbing materials shall be non-flammable, vermin and rot proof and shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.
- F. Where practicable, silencers shall be built into walls and floors to prevent the flanking of noise the duct work systems and their penetrations sealed in the manner previously described.

Where this is not feasible, the exposed surface of the duct work between the silencer and the wall subjected to noise infiltration shall be acoustically clad as specified.

| DATA SHEET FOR AIR CONDITIONING SYSTEM |   |            |
|--|---|------------|
| S. No                                  | Item  | Parameters |
| <b>1.1</b>                             | <b>Outdoor Units</b>                                  |            |
| a                                      | Make and Model  |            |
| b                                      | Type (Cooling or heat pump)                           |            |
| c                                      | Dimension of unit (Overall)                           |            |
| d                                      | Actual capacity (TR) at specified conditions          |            |
| e                                      | Permissible length of refrigerant piping (m)          |            |
| f                                      | Type of compressor                                    |            |
| g                                      | No. of compressor (each unit)                         |            |
| h                                      | No. of digital compressor                             |            |
| i                                      | Electrical characteristics                            |            |
| j                                      | Power consumption at ARI conditions for each capacity |            |
|  | 100%  |            |
|  | 75%   |            |
|  | 50%   |            |
|  | 25%   |            |
| <b>1.2</b>                             | <b>Indoor Units</b>                                   |            |
|  | Manufacturer  |            |
|  | Type  |            |
|  | Nominal capacity (TR)                                 |            |
|  | Airflow Min/Max (CFM)                                 |            |
|  | Sound level (Hi/Lo)                                   |            |
|  | Overall dimensions (L x W x H)                        |            |
|  | Unit weight (Kg)                                      |            |
|  | Remote controller for each indoor unit (Yes/No)       |            |
| <b>1.3</b>                             | <b>Centralized Controller</b>                         |            |

| DATA SHEET FOR AIR CONDITIONING SYSTEM |  |            |
|--|--|------------|
| S. No                                  | Item                                       | Parameters |
|  | No. of controllers                         |            |
|  | Features                                   |            |
|  | Power consumption                          |            |
|  | Technical brochures to be attached.        |            |
| <b>2.0</b>                             | <b>GALVANISED STEEL SHEETS</b>             |            |
|  | Make                                       |            |
|  | Thickness/Gage                             |            |
|  | Class of Galvanizing                       |            |
| <b>3.0</b>                             | <b>GRILLES / DIFFUSERS / DAMPERS</b>       |            |
|  | Make material and gauge of the following   |            |
| <b>a)</b>                              | Fire damper, rating, make of damper motor  |            |
|  | Smoke damper, rating, make of damper motor |            |
|  | Grilles/Diffuser                           |            |
|  | Slot Diffuser                              |            |
|  | Duct Damper                                |            |
|  | FA Damper                                  |            |
|  | Access Panel.                              |            |
| <b>4.0</b>                             | <b>INSULATION</b>                          |            |
|  | Manufacturer                               |            |
|  | Duct acoustic lining material & density    |            |
|  | Duct insulation material & density         |            |
|  | Pipe insulation material & density         |            |

## 6. VENTILATION

### 6.1 General

- A. This Section specifies the manufacture and installation of all ventilation fans as shown on Drawings.
- B. The fan external total pressure resistance figures specified on the Equipment Schedules and/or Drawings are for guidance and information only. The exact fan total pressure based on the duct run and the offered equipment shall be carefully checked and re-calculated for each fan before ordering the equipment. Calculation shall be submitted for Approval. No modification to the ductwork system shall be allowed without prior Approval. Any additional cost for the modification of the system (fans, motors, switchgears, cables, panel boards, switchboards, etc.) necessary to meet the specified duties, spatial conditions and the offered equipment shall be provided.
- C. Allowance shall be made for the effects on fan performance of all installation conditions including coils, eliminators, sound attenuator, plenums, enclosures, inlet and discharge arrangements so that actual installed fan performance equals that specified.
- D. Proprietary bell mouth and wire guard shall be provided for fans without ductwork connection. Bell mouth is not required for propeller fans.

### 6.2 Standards and Codes Used for Fans

The design and manufacture of Ventilation System shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The items covered shall also confirm to latest applicable Indian Standards. Nothing in this specification shall be construed to relieve vendor of his responsibility. In particular the items shall generally confirm to the latest edition of following standards:

| IS No.            | Description   |
|-------------------|---|
| IS: 655           | Specification for Metal Air Ducts   |
| IS: 277           | Specification for Galvanized Steel Sheet                                  |
| IS: 737           | Specification for Wrought Aluminium and Aluminium Alloy sheet and Strips. |
| UL: 555           | Fire Damper   |
| UL: 181           | Safety of Air Ducts   |
| SMACNA            | HVAC Duct Construction Standards Metal and Flexible.                      |
| AMCA Standard 210 | Laboratory Methods of Testing Fans for Rating                             |



|                     |  |
|---------------------|--|
| BS 848              | Fans for General Purpose   |
| IS / IS / IEC 60034 | design, performance and efficiency of motors                     |
| ISO 5801            | Industrial Fans – Performance Testing using Standardized Airways |
|                     | ASHRAE & ISHRAE  |

The Ventilation for different areas of the Station is summarized as follows

| S.NO. | ROOM DESCRIPTION        | ACPH REQUIREMENTS |
|-------|-------------------------|-------------------|
| 1.    | TOILETS & CLEARNER ROOM | 6 – 10            |
| 2.    | PUMP ROOM               | 15 – 20           |
| 3.    | ASS / TSS ROOM          | 16 – 20           |
| 4.    | DG ROOM                 | 10 - 15           |

All toilets/ventilated rooms shall be provided with exhaust air system. Replacement / makeup air shall be done by fresh air duct through fresh air fan / door transfer grille (DTG) / air transfer grille (ATG)

### 6.3

#### **Performance / Functional Requirements**

- A. Technical rooms will be served by dedicated Variable Refrigerant Flow (VRF) indoor and outdoor units considering 24-hour operation.
- B. Ductwork
  - a. Duct velocity: Maximum velocity: 10.2 m/s for all ducts in normal application.
  - b. Frictional pressure drop: 0.81 Pa / Meter for all ducts.
- C. Louver Design Criteria
  - a. Maximum Face velocity in Intake Louver: 2 m/s
  - b. Maximum Face velocity in exhaust Louver: 2.5 m/s
- D. Individual propeller/axial type fans shall be provided for each area viz, TSS/ASS Room, Toilet-M, Toilet-F, Toilet-H/C, Staff, Cleaners, Room and DG Room The fresh air intake shall be through Fresh Air Louvers including the wire mesh, filter, volume control damper (all factory fabricated and assembled) for the TSS and ASS Room.
- E. For rest all of the areas other than the pump room mechanical extraction system shall be provided. The odorous /polluted air shall be extracted and exhausted by the wall mounted propeller/axial fans.
- F. Pump room below the ground shall be envisaged with the push pull type ventilation system via the ducted inline fan. The air intake shall be through the supply air inline fan.

**Note:** In-line type exhaust fans shall be envisaged/ provided for ventilation only if the ventilation via the Axial or propeller fan is not feasible.

### 6.4

#### **Propeller Fans**

- A. The scope will include supply, Installation, testing and commissioning of the propeller fan.
- B. Propeller fans shall be direct driven, three or four blade type, mounted on a steel mounting plate with orifice ring.
- C. 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%.
- D. Mounting plate shall be of steel construction, square with streamlined venturi inlet (reversed for supply application) coated with blacked enamel paint. Mounting plate shall be of standard size, constructed of 12-to-16-gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.
- E. Fan blades shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.
- F. Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed through the full range of specified fan speeds.
- G. Motor shall be standard (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 1000 rpm for fans 38 cm dia. or larger and 1440 rpm for fans 30 cm dia. and smaller. Motors for larger fans (More than 450 dia.) shall be suitable for 415 volts, 50 Hz, 3 phase power supply and for smaller fans shall be suitable for 220/240 volts, 50 Hz single phase power

supply. Motors shall be suitable for either horizontal or vertical services as indicated on Drawings and as required. All motors shall have B-class insulation.

- H. Accessories: The following accessories may be required and provided with propeller fans, as indicated in Schedule of Quantities.
- i. Wire guard on inlet side and bird screen at the outlet.
  - ii. Fixed louvers built into a steel frame.
  - iii. Regulators for controlling fan speed for single phase fan motors.

#### 6.5 **Inline Exhaust Fans**

- A. Inline fan shall incorporate direct driven Centrifugal Fan with TEFC motor. The fan assembly shall be encased in a sheet metal housing of powder coated 22-gauge GSS and with necessary inspection cover with proper gasket assembly. The fan material shall be galvanized sheet steel. Flanges shall be provided on both sides of the Inline fan to facilitate easy connection. Flexible anti-vibration joints shall be provided to arrest vibration being communicated to other equipment connected to the Inline fan.
- B. Motor shall be single phase/three phase as per duty conditions and shall have B-class insulation. All single-phase fans shall be provided with speed regulators while all three phase fans shall be provided with opposed blade damper in GSS construction at fan outlet for air balancing. Necessary attachment with duct shall be made.

#### 6.6 **Axial Fans**

Fans shall be direct driven vane axial type. Fans shall be complete with motor, drive arrangement, motor mount, and vibration isolation arrangement.

Fans shall be licensed to bear the AMCA Air and Sound Certified Ratings Seal.

- A. Casing shall be constructed of 14-gauge sheet steel. Fan casing and motor mount shall be of welded steel construction. Motor mounting plate shall be minimum 12 mm thick and machined to receive motor flange. Casing shall be provided with wide hinged doors which should open easily for removal of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be primed and finish coated with enamel paint.
- B. Rotor hub and blades shall be cast aluminium construction. Blades shall be die formed air foil shaped for maximum efficiency and shall vary in width from hub to tip to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5 mm. Rotor blades shall be whirl tested to a speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow values as specified and quoted.
- C. Motor shall be squirrel cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, suitable for  $415 \pm 10\%$  volts 50 cycles, 3 phase power supply as per latest IS specifications. Motor nameplate horsepower shall exceed brake horsepower by a minimum of 10%. Motors shall be quiet operation and motor speed shall not exceed 1500 rpm. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible conduit.
- Motor starters shall be automatic direct on line for rating up to 7.5 H.P. and automatic Star Delta for motors 10 HP & above. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventer and are to be included in the prices of starter panels.
- D. Drive to fan shall be direct driven.
- E. **Vibration Isolation:** The assembly of fan and motor shall be suspended from the ceiling or mounted on walls by vibration isolators.
- F. **Accessories:** The following accessories shall be provided with all fans:
- i) Outlet cone, if required.

- ii) Inlet cone, if required.
- iii) Fan silencers, if required.
- iv) Wire guards on fan outlet / inlet not connected to duct work and shall be made freely accessible for maintenance.

Fans shall be factory assembled and shipped with all accessories factory-mounted.

| DATA SHEET FOR AXIAL FLOW FANS  |  |
|---|--|
| Type  | Vane/Tube Axial (Long Casing Type)   |
| Reference Code / Standard   | AMCA 210, ISO5801, BS848   |
| Capacity  | As per Drawing   |
| Flow  | Unidirectional   |
| Noise   | 85 dBA at 1 meter  |
| Total Pressure  | As per Drawing   |
| <b>FAN</b>  |  |
| Blade   | Aerofoil Construction, Dynamically Balanced                                  |
| Material  | Aluminium alloy  |
| Bearings  | Totally sealed type Ball Bearing   |
| Hub   | Cast Aluminium Alloy   |
| Casing  | Rolled Steel Sheet, Heavy Gauge  |
| Shaft   | Solid Steel  |
| Mounting  | Shaft Key And Positive Locking Device  |
| Drive Arrangement   | Direct Drive   |
| <b>Motor</b>  |  |
| Type  | TEFC, IE-3, Induction Motor, Continuous Duty                                 |
| Design  | As Per IEC 60034   |
| Power Supply  | Three Phase, 415 V, 50 Hz, AC Power Supply IP 55 Protected                   |
| Mounting Arrangement  | Suitable Bracket for Ceiling Suspension                                      |
| Lifting Arrangement   | Lifting Eye at Suitable Location And Number or as per manufacturer standard. |
| Paint   | Synthetic Paint (Not required in case of 275 GSM or above, as per standard)  |
| a) Lifting eyes / Flanges shall be provided for the lifting of fans.<br>b) Should be provided for spring isolators & to install fans as per manufacturer standard.<br>c) Flanges on the fans have sufficient strength to lift the fans.<br>d) Fans shall be provided with Flexible connections (Fire Rated in case of Fire Rated) with spring washers on both the side. |  |

## 6.7

### Anti-Vibration Mountings

- A. All items of rotating and reciprocating plant and equipment shall be isolated from the structure by the use of anti-vibration materials, mountings or spring-loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.
- B. Centrifugal fans and motors within air handling units shall be isolated from the frame of the air handling unit by suitable anti-vibration mountings. Fan discharge air connections shall be fitted with approved flexible connections internally isolating the fan scroll from the air handling unit casing.
- C. Axial flow fans shall be mounted on steel legs as diaphragm plates supported on neoprene in shear

anti-vibration mountings, or suspended using spring loaded hangers to suite the application.

- D. The construction of the anti-vibration mountings shall generally comply with the following: - Enclosed Spring Mounting(Caged or Restrained Springs)
- E. Each mounting shall consist of castor fabricated telescopic top and bottom housing enclosing one or more helical steel springs as the principal isolation elements, and shall incorporate a built- in levelling device.
- F. The springs shall have an outside diameter of not less than 75% of the operating height, and be selected to have at least 50% overload capacity before becoming coil bound.
- G. The bottom plate of each mounting shall have bonded to its neoprene pad designed to attenuate any high frequency energy transmitted by the springs.
- H. Mountings incorporating snubbers of restraining devices shall be designed so that the snubbing damping or restraining mechanism is capable of being adjusted to have no significant effect during the normal running of the isolated machine.

#### 6.8 **Description: Ducts & Dampers**

- A. This Section specifies the manufacture and installation of ductwork, diffusers, registers, grilles, dampers, guide vanes, cleaning of air system, access panels and accessories.
- B. All ductwork and distribution accessories delivered to Site shall be new and indelibly stamped to identify different grades, materials and manufacturers.
- C. Provide all ductwork, diffusers, registers, dampers and grilles generally in accordance with the Drawings to be performed during final design stage.
- D. Diffusers, registers and grilles shall be selected to meet the requirements of noise control as described elsewhere in this Specification.

#### 6.8.1 **Duct Standards**

- a) Relevant Codes and Standards
  - i. HVCA, DW/144: Specification for Sheet Metal Ductwork, Low, Medium and High Pressure / Velocity Air Systems
  - ii. IS 277: Galvanized steel sheets (plain and corrugated) - Specification
  - iii. BS 476: Fire Tests on Building Materials and Structures
  - iv. BS 729: Hot Dip Galvanised Coatings on Iron and Steel Articles
  - v. UL 555: Fire Dampers
  - vi. UL 555S: Leakage Rated Dampers for Use in Smoke Control Systems
- b) SMACNA: HVAC Duct Construction Standards, metal and Flexible and Rectangular Industrial Dust Construction Standards (Note: SMACNA standards shall be applied only if any part of the duct installation standards are not covered by DW/144).
- c) Technical and installation requirements.

#### 6.8.2 **Raw Materials**

The material shall be Galvanised Iron and Galvanizing shall be Class VIII – light coating of zinc, nominal 270 gm/sq.m surface area and Lock Forming Quality prime material along with mill test certificates. In addition, samples of raw material, selected at random by employers representative shall be got tested for thickness and zinc coating by the contractor.

All ducts shall be fabricated from galvanized steel / aluminium of the following thickness, as indicated as below:

| Rectangular Ducts G. S. | PRESSURE 500 Pa PSI |                        |                 |
|-------------------------|---------------------|------------------------|-----------------|
|                         | Duct Section Length |                        | 1.2 m           |
| Maximum Duct Size       | Thickness (SWG)     | Joint Type             | Bracing Spacing |
| 1-600 mm                | 24                  | Cleat& tending S Cleat | Nil             |
| 601-750 mm              | 24                  | Angle Iron 25x3        | Nil             |
| 751-1000 mm             | 22                  | Angle Iron 25x3        | Nil             |
| 1001-1200 mm            | 22                  | Angle Iron 40x3        | Nil             |
| 1201-1300 mm            | 20                  | Angle Iron 40x3        | Nil             |
| 1301-1500 mm            | 20                  | Angle Iron 40x3        | Nil             |
| 1501-1800 mm            | 18                  | Angle Iron 40x6        | Nil             |
| 1801-2100 mm            | 18                  | Angle Iron 40x6        | Nil             |

|              |    |                 |     |
|--------------|----|-----------------|-----|
| 2101-2250 mm | 18 | Angle Iron 40x6 | Nil |
| 2251-2400 mm | 18 | Angle Iron 40x6 | Nil |
| 2401-2700 mm | 18 | Angle Iron 40x6 | 600 |

Note: Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

### 6.8.3 Duct Construction

- All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA/DW144 codes.
- Ducts so identified on the Drawings shall be acoustically lined and insulated from outside. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where required. The fabricated duct dimensions should be in accordance with approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.
- Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button in accordance with IS/BW144 practice, to ensure air-tightness.
- All ducts up to 75 cm width within conditioned spaces shall have slip and drive (C & S/SS) joints. The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that S/SS Cleats are mounted on the longer side of the duct and Cleats on the shorter side. Ducts and accessories within ceiling spaces, visible from air-conditioned areas shall be provided with two coats of mat black finish paint.
- Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.
- All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.
- All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18-gauge GSS / 16 gauge aluminium, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.
- Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.
- Self-adhesive Neoprene rubber / UV resistant PVC foam lining 5mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.
- Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality expanded polystyrene around the duct and totally covered with fire sealant such as fire barrier mortar for complete sealing.
- All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, ductable units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of flame retardant, water proof, silicon rubber impregnated flexible connection at least 10 cm long securely bonded and flange bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

| DATA SHEET FOR NON-FIRE RATED DUCT MATERIAL AND DUCT WORK |   |
|---|---|
| Duct Material   | Galvanized Sheet Steel of Lock Forming Quality                          |
| Reference codes / Standards                               | Duct Construction DW 144 / SMACNA (only for parts not covered in DW144) |
| Duct  | All Duct Sections Will Be Cross Broken                                  |

| DATA SHEET FOR NON-FIRE RATED DUCT MATERIAL AND DUCT WORK |  |
|---|--|
| Guide Vanes   | At All the Bends to Be Made From The Same Material As The Duct   |
| Thickness Of Sheet and Type Of Joint for Rectangular Duct | As per DW144   |
| <b>Traverse Joint</b>                                     |  |
| Large side up to 1000mm                                   | TDF type Flange  |
| Large side 1000mm and above                               | Slip On Flange   |
| <b>Bracing/Support</b>                                    | Indicative support arrangement is given in tender drawing, final drawing shall be approved by engineer in charge |
| <b>Duct Accessories</b>                                   |  |
| For Joints  | Hexagonal Nuts – Bolts / Washers Zinc Coated   |
| Rivets  | Galvanized Iron / Magnesium Aluminum Alloy   |
| Gaskets   | Fire retardant– size as per flange requirement   |
| Screws  | Self-Tapping Screws Will Not Be Used   |
| Support Arrangement                                       | As Per SMACNA/DW144  |
| Support From Wall / Ceiling                               | Anchor Fastener of Required Rating Not Less Than 2.5 Times the Load of the Duct                                  |
| Paint   | Flanges And Supports Treated for Corrosion And Painted With Zinc Rich Paint Of Approved Quality                  |
| Flexible Connection circular Spigots                      | Fire Proof Material to Be Screwed Or Clip Band With Adjustable Screw Or Toggle Fitting                           |
| Flexible Connection Rectangular Ducts                     | Fire Proof Material to Be Flanged And Bolted With Backing Flat Or Bolted To Mating Flange With Backing Flat      |
| Flexible Connection                                       | 150 Length Between Two Faces (Minimum)   |

#### 6.8.4 Dampers

- All duct dampers shall be opposed blade louver dampers of robust 16 SWG GSS construction and tight fitting.
- Dampers shall be placed in ducts at every branch supply or return air duct connection as required.

#### 6.8.5 Volume Control Dampers (VCD)

- The manufacturer shall provide opposed blade type VCD. Frame and blade shall be provided with minimum 1.6 mm thickness marine grade aluminium extruded material.
- Blade shall be of double skin aero foil type (each skin to be 1.2 mm thick).

#### 6.8.6 Grills

- All grills and diffusers shall be designed and rated in accordance with ASHRAE 32- 7/ASHRAE 70.
- All grills and diffusers shall be of pure polyester finish aluminium unless otherwise specified. Colour of grills and diffusers shall be selected by the Engineer. Samples of finishes shall be submitted for approval.
- All supply, return and exhaust diffusers shall be complete with opposed blade dampers, suitable for mounting with appropriate diffuser and shall be fitted with concealed adjustment devices. Straightener grids are required before diffusers except for the last diffuser on the route. Each supply air grille shall be complete with an opposed blade multi-leaf damper. One set of tool for every 10 grilles or diffuser shall be provide for volume adjustment.
- The inside of all components and surfaces of all diffusers and grilles shall be painted matt black. The drawings show provisional locations of diffusers and grilles but in each instance, outlets shall be installed in accordance with the final detail drawings and reflected ceiling plans.
- Velocities, net airways and distribution patterns shall give satisfactory air distribution and temperature equalisation, be free of draughts stratification or noise nuisance. The contractor shall make final adjustments to air patterns when balancing.
- The sizes of the grilles (including linear grille) indicate on drawings imply the neck sizes of the fittings.



Whereas the sizes of ceiling diffusers on drawings imply overall external dimensions.

**G. Supply and Transfer Air Grilles and Register for general use.**

- Double deflection supply air grilles/register shall be tapped from top or bottom of ducts with provision for tamper proof adjustment of air pattern spread along its width. Adjusting tool shall be provided by the manufacturer. Grilles/register shall have a minimum of 80% free area.
- Provide grilles/registers to meet the size and capacities as shown in the drawings required to connect ducts to grilles and registers.
- Grilles and register shall be factory assembled with opposed blade volume control dampers operable through the grilles face. The adjustment shall be by a key through the face of the register and the volume control damper shall be group operated or opposed blade type. The operating mechanism shall not project through any part at the register face.
- Diffusers constructed of the extruded aluminium shall be pure polyester finish of a colour approved by the Engineer.
- All grille cores shall be capable of being removed easily from the duct work of access to dampers.
- All edges exposed to view shall be rolled or otherwise stiffened and rounded. All edges shall be equipped with air tight, non- combustible neoprene or sealing stripes to prevent leakage. The register ring of frames shall be compatible with ceiling construction in which they are installed.
- Multi-blade volume extractors shall be of the air deflecting and air straightening type with blades spaced a maximum of 50mm apart.
- Supply air registers shall comply with the following performance requirements at design flow as:
  - a) Maximum pressure drop: 30 Pa
  - b) Throw: 4m
  - c) Noise criteria: NC 30

**H. Return/Exhaust Grilles and Registers for General use**

- Grilles shall have single set of fins which shall be vision proof to effectively mask the return opening. Grilles shall have 45° inclined fins spaced approximately 19 mm apart.
- Free area of grille core shall be at least 80%.
- Grilles and registers will be fixed type.
- Return air diffusers shall match the supply diffusers in appearance and shall be constructed of the same material and identical in surface finish as approved by the Engineer.
- Register rings or frames shall be compatible with the ceiling construction in which they are installed.

**I. Linear Air Diffusers**

- Each diffusers shall be of single/multi-slotted vertical/horizontal discharge, ceiling mounted type fitted into a field-insulated boot with spigot for receiving supply air duct as detailed on the drawings.
- Diffusers of extruded aluminium shall be power coated polyester finish to a colour as approved by the Engineer.
- Number of slots and lengths of diffusers and capacity shall be as indicated on the drawings.
- Provide air boot to the diffusers as shown on the drawings. Air boot casing shall be constructed of 0.6 mm thick galvanised steel with interior surfaces insulated to prevent erosion. Insulation and air boot shall be extended to cover the collar of diffuser. Volume control dampers shall be provided in the air boot spigot.
- Subject to the ceiling panel design, the flanges of the diffusers shall be designed to support "drop in" ceiling pane.
- Provide suitable support points independent of suspended ceiling for the air boots and the associated diffusers.
- Air boot spigot location and dimensions shall generally be as indicated on the drawings.
- Provide galvanised steel sheet painted black at the front view to seal off the dummy part of the diffusers.
- Linear air diffuser shall comply with the following performance requirements at design flow as:
  - i. Maximum pressure drop: 30 Pa
  - ii. Throw: 6m
  - iii. Noise criteria: NC 35

- iv. Minimum terminal velocity: 0.5 m/s

| DATA SHEET FOR GRILLS AND DIFFUSER |  |
|------------------------------------|--|
| Function                           | Air Distribution   |
| Standard                           | Air Diffusion Council  |
| Requirement                        | For Supply Air, Return Air and Air Extraction                                    |
| Grills                             | Linear Flow / Double Deflection Registers  |
| Diffuser                           | Four Way Rectangular / Square / Round  |
| Construction material              | Aluminum   |
| Flange                             | As per manufacturer standard Suitable for Continuous Joint With Alignment Strips |
| Design                             | Extruded section   |
| Blade / Louvers                    | Adjustable Front and Rear  |
| <b>Bars</b>                        |  |
| Front                              | Aluminum   |
| Rear                               | Aluminum   |
| <b>Damper</b>                      |  |
| Type                               | Adjustable Lever Operated  |
| Fire Rating                        | Non-Fire Rated   |
| Finish                             | Black Anodized   |
| Paint                              | Material Duly Treated for corrosion And Anti Corrosive Paint                     |
| Noise Generation                   | Should Have Very Low Air Noise Generation  |

## 6.9 Insulation

The scope includes supply, fixing and testing of insulation for piping, ducting and equipment's described in this section.

### A. Materials of Insulation:

The following insulating materials shall be used:

- (i) For Ducting:  
Fire-resistant closed cell cross linked polyethylene (XLPE) foam and factory laminated Al PE foil of density 33 Kg/m<sup>3</sup> with 13mm thick and thermal conductivity not exceeding 0.35 w/mk at an average temperature of 40degC.
- (ii) Acoustic lining:  
Acoustic lining of duct with Rigid fibreglass board with density 48 Kg/m<sup>3</sup> sealed in fibre glass tissue paper and covered with 0.5mm perforated Al sheet. Thickness of fibre glass board shall be 25mm.

### B. Duct insulation installation requirement

- i. Insulation without cement plaster. Clean the duct surface to be insulated. Apply bituminous paint to duct surface. Fix specified thickness of insulation laminated with Aluminium foil backed by craft paper with at least 50 mm wide aluminium tape of Johnson/Birla 3 M make insulation finished with cement plaster. Fix the specified thickness of insulation laminated with craft paper.
- ii. Wrap the insulation with 500-gauge Polythene sheet with overlapping of all joints and seal with at least 50 mm wide PVC tape of Johnson/Birla 3 M make Cover with 0.63 mm x 19 mm GI wire netting butting all the joints and tightening with GI wire of 1.00 mm. Cover with 12 mm sand cement plaster in 2 layers of 6 mm each to welled to smooth finish.
- iii. Apply 2 coats of approved enamel paint to plastered surface.
- iv. In case of duct exposed to weather plastered surface shall be covered with two layers of tar felts with sufficient overlap and two coats of bitumen paints in lieu of enamel paint.

**6.10 Access Door- (As and If applicable)**

- Gasketed airtight access doors shall be provided at the duct for access, inspection and maintenance of fans, equipment, dampers, filters, smoke probes and controls.
- Doors shall be hinged type complete with minimal of two sash locks and shall be made of same metal thickness as ducts. Doors shall have suitable size to access.
- Access doors for insulated ductwork shall be of double skin construction with insulation in between. The insulation for the access doors shall be of the same type and thickness as the adjacent ductwork.
- The door panels shall be made of suitable material and they shall have not less than 12 mm wide neoprene rubber gasket around the entire perimeter to ensure air tightness. It shall have the same fire rating as the adjacent duct construction.
- The access doors shall be hung on approved heavy-duty hinges and provided with suitable quantity with locks. The locks shall be able to operate both from inside and outside. Where it is impracticable to use hinge doors, the access doors may be fixed in position with wedge type locks on opposite sides with suitable quantity per door. The section of the duct where the access door is located shall be reinforced with suitable material.
- Where the duct is of smaller dimensions than the access door specified, the door shall be of the full width of the duct Sealant and gasket used shall be in accordance with the recommendations of HVCA, DW/144 Specification.

**6.11 Flexible Connections**

- A. Flexible connections shall be provided on all duct work connections to fans, rotating plant and equipment isolated from structure and anti-vibration materials or mountings. Pipe work and duct work crossing building movement or construction joints shall be installed with flexible connections.
- B. Flexible connections on duct work to fans etc., shall be a minimum/ maximum free length of 100 mm./200 mm. respectively to minimise noise transmission and noise breakout. They shall be completely free from stress and shall not be required to accept any weight.
- C. Thickness and strength of flexible connection materials shall be suitable to withstand the positive and negative fan pressures to which they will be subjected to and shall not allow perceptible leakage. The materials shall be durable, non-flammable having good acoustical quality.
- D. Flexible connections shall be fitted to all pump suction and discharge connections, and other vibrating equipment and where anti-vibration mounts and inertia basis are fitted.
- E. Flexible connections shall allow freedom of movement of plant in all plans.
- F. Matching flanges to pipe work flexible connections shall be of the smooth faced weld- nick type.
- G. Rubber Bellows shall be fitted as close to the source of vibration as practicable. The pipe at the other end of the bellows shall be a fixed point.
- H. Rubber bellows shall be single convolution of multiply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be able to swivel and be removable. The date of manufacture shall be moulded on the bellows. For traceability membranes shall have an indelible identification showing manufacturer, country of origin, the type and a batch number.
- I. Tie bars with rubber top hat washers shall be used on bellows.
- J. For working temperatures up to 70°C the rubber bellows shall be high tensile synthetic fibre reinforced.
- K. For working temperature between 70°C and 100°C the bellows carcass shall be steel wire mesh reinforced throughout. Steel reinforced bellows shall be manufactured and approved to the Standards.
- L. For temperatures above 100°C bellows shall be multiply stainless steel with Van Stone ends swivel flanges. The overall length shall not exceed 130 mm.
- M. Flexible connections with screwed connections shall be reinforced EPDM rubber hoses and shall have at least one full union to avoid torquing on installation.

**7. FIRE STOPPING / FIRE SEALANT MATERIAL**

- A. Duct, damper, pipe, cable tray, unused slots and other penetrations of VAC services opening in floors, walls, ceiling or other general construction shall be closed and sealed with a fire stopping material.
- B. The contractor shall close the all opening, which is located inside and outside the station box.
- C. Fire stopping materials shall comply with UL / BS standard and it shall withstand 250°C for minimum of 3 hours.
- D. Fire stop board / rock wool insulation shall be provided with minimum of 60mm thickness and 160 kg/m<sup>3</sup> density.

- E. Fire rated filler sealant shall be provided with minimum 10mm thickness.
- F. Fire stop coating of minimum 1.0 mm thickness shall be provided.
- G. Fire stopping board finish shall be applied on both side of wall, floor and ceiling.
- H. The manufacturer shall submit the method statement for installation of fire stopping material.
- I. Mock-up shall be offered at site.
- J. Method statement shall be submitted as recommended by manufacturer to Employer for notice of no objection along with the typical installation drawings.
- K. The manufacturer and contractor shall verify, validate and certify the installation of fire stopping materials and the same shall be submitted for notice of no objection.
- L. Future Slots: Identify unused sleeves and slots if any for future use by permanently anchored brass nameplates identifying size and purpose of the covered slot.
- M. Supply, Installation & Testing of 3 hours Fire rated system for closing the openings between rooms with help of Rock wool, G.I Sheet and Hilti or equivalent Sealants (Quantity measurement will be as per the size of opening).

## **8. ACOUSTIC TREATMENT AND VIBRATION CONTROL**

### **8.1 General Requirements**

- A. This section specifies the requirements for the Vendor submittal, manufacturing, supply, delivery, installation, testing, commissioning and guarantee of acoustic and vibration control equipment to be used in the isolation of the VAC equipment. It also specified the maximum allowable Sound Power Level and/or Sound Pressure Level limits for some of the major mechanical and electrical systems, on which the noise and vibration control measures shall be based.
- B. The intent of this Specification that noise levels due to mechanical and/or electrical equipment and related services shall be controlled to the objectives stated herein, in all occupied areas, public area and to the external. The requirements specified herein are considered to be the minimum precautions necessary to achieve these requirements. In addition, all requirements by relevant local authorities on noise and environmental controls shall also be complied with.
- C. The Contractor shall comply with the Employer's Requirements for balancing and mounting of the equipment, alignment of driving and driven units and operating speeds.
- D. The Contractor shall install all mechanical and electrical plant and services in accordance with the methods of installation and precautions stated herein. Such additional precautions as shall be necessary to ensure that the operation of the plant does not result in noise levels or vibration amplitudes beyond the specified limits and the limits set by all relevant local authorities.
- E. The Contractor shall guarantee that the complete plant and installation, when operated within the design criteria shall comply with the Noise Criteria / sound pressure level ratings specified in this section below.
- F. The Contractor shall be responsible for all costs of any corrective action, which may be necessary either during installation, testing, commissioning or after completion of the works, to achieve the design objectives specified herein and/or as specified elsewhere in the technical specification wherever is stringent.
- G. The Contractor shall carry out his own assessment on the noise levels to the external surrounding environment, particularly for stations with vent shafts planned close to residential developments. The Contractor shall be responsible for all costs to provide the necessary liaison officers to handle public complaints and of any preventive and corrective action, which may be necessary, to achieve the design objectives specified herein and as specified elsewhere in the technical specification and to resolve the complaints from the public.
- H. If the equipment offered fails to meet the specified limit, the Contractor shall supply, at no additional cost, all necessary additional noise control measures to compensate for the excess.
- I. Any gaps between fire dampers, duct, pipe & cable tray and wall / floor / ceiling penetrations shall be packed with appropriate fire-rated materials and sealed off with fire stopping / sealant material, which has to have an approval from ER.
- J. The sound pressure levels, due to the operation of any mechanical and/or electrical equipment supplied and installed under this Contract but excluding all extraneous sources, shall not exceed the noise level ratings set out in the schedule below.
- K. Unless otherwise specified, the specified noise level limits apply to every position within a room at a height of 1.5 metres from the floor and not closer than 1.5 m from any air outlet, or equipment.

- L. The maximum allowable sound pressure level for different areas in Elevated & At Grade station mentioned below:

| S.NO. | LOCATION                           | MAXIMUM ALLOWED SOUND PRESSURE LEVEL |
|-------|------------------------------------|--------------------------------------|
| 1     | Pump Room                          | 85 dBA                               |
| 2     | ASS and Transformer room.          | 75 dBA                               |
| 3     | All Air conditioning rooms/offices | 55 dBA                               |
| 4     | All ventilation rooms              | 55 dBA                               |

Any other noise criteria stipulated by relevant local authorities shall also be complied with. However, where the noise criteria, as stipulated by the relevant authorities, are less stringent than the specified noise criteria, then the more stringent criteria as specified shall be complied with.

## 8.2 **Manufacturer's eligibility criteria, Quality assurance and Performance requirements**

Reference standards and Codes

- A. ASTM C423: Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
- B. ASTM E90: Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
- C. ASTM E413: Rating Sound Insulation
- D. ASTM E477: Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers
- E. BS 2750: Measurement of Sound Insulation in Buildings and of Building Elements
- F. BS 4718: Methods of Test for Silencers for Air Distribution Systems
- G. BS 5588: Part 9: Fire Precautions in the Design and Construction of Buildings Part 9: Code of Practice for Ventilation and Air Conditioning Ductwork.
- H. BS 8313: Code of Practice for Accommodation of Building Services in Ducts
- I. BS EN 20354: Acoustics–Measurement of Sound Absorption in a Reverberation Room
- J. IEC 60651: Sound Level Meters
- K. NFPA 90A: Installation of Air-Conditioning and Ventilating Systems
- L. ASHRAE Handbook

### **Installation Schedule of Vibration Isolation Equipment:**

| Equipment                                 | Vibration Isolation   | Remarks  |
|---|---|--|
| Axial and centrifugal fans 1 kW and below | Double deflection neoprene in hear hangers or support of minimum 10 mm total static deflection.   | There shall be no rigid ties to the structure, all connections shall be looped or flexible. All duct connections shall be truly aligned and executed using flexible material of same temperature and fire rating as fan. |
| Axial and centrifugal VAC fans above 1 kW | Un-housed type steel springs in series with 2 layers of 15 mm thick 40 durometer neoprene waffle pads and 1 mm thick shim of the following total static deflection:<br>Above 1000 RPM – 25mm<br>100 to 1000 RPM – 38mm<br>400 to 600 RPM – 50mm | There shall be no rigid ties to the structure; all connections shall be looped or flexible. All duct connections shall be truly aligned and executed using flexible material of same temperature and fire rating as fan. |

|                  |   |   |
|------------------|---|---|
| VRF indoor units | 2 layers of 8 mm thick 40 durometer neoprene pads in between mounting or suspension brackets. | There shall be no rigid ties to the structure, all connections shall be looped or flexible. |
|------------------|---|---|

## 9. SUBMITTALS, TOOLS, TRAININGS & MAINTENANCE

### 9.1 Submittal for Vender / Material Technical Submittal

Contractor shall submit the following details during vendor / material technical submittal for notice of no objection. Clause wise compliance matrix shall be signed by both manufacturer and contractor support document to take necessary approval from Employer/Engineer.

- A. Company profile & machineries used for entire manufacturing process from raw material to finish products.
- B. Quality Assurance Plan (QAP) from raw material to the finished product.
- C. All certification copies as mentioned in manufacturer's eligibility criteria, quality assurance and performance requirements.
- D. Basis of selection of equipment including all components / materials.
- E. Technical catalogue, certified data sheet and material specification for all components of the equipment for proposed project.
- F. Schedule of equipment or materials.
- G. General arrangement and submit shop drawings including all components or parts. Shop drawing shall show plans, elevations, sections and mounting details.
- H. Manufacturer shall submit certification that the material / equipment supplied is in conformance to the standards set out in this specification.
- I. Type test certificate.
- J. Previous customer's factory acceptance test / performance test reports for the similar product / equipment.
- K. Reference list of projects including End user / customer name, material / equipment details, month & year supplied & installed, quantity, completion certificate / appreciation letter from end user from product.
- L. List of spare & special tools as recommended by the equipment manufacturer for future maintenance. The list shall be certified by the manufacturer.
- M. Method statement for installation (Installation Manual) as recommended by manufacturer.
- N. Operation & maintenance (O & M) Manual.
- O. Contractor shall ensure that selection of equipment to meet the design requirement & as per the actual site condition.

### 9.2 Submission of drawings

The Contractor shall furnish detailed/schematic drawings which shall include but not limited to:

- A. Shop Drawings: Distance between each component shall be shown where applicable.
- B. CRD / Work reference drawings: Contractor shall liaise with interfacing contractor for CSD, SEM and RCP co-ordination. Further, contractor to submit the CRD / work reference drawings to Employer for notice of no objection prior to start the work at site.
- C. As Built drawings shall be submitted.

### 9.3 Factory Visit and Factory Acceptance Test (FAT)

- A. Factory visit shall be arranged by the contractor for all material & equipment based on the request from Employer/Engineer.
- B. FAT shall demonstrate that each subsystem meets its performance specification in accordance with technical submittal.
- C. FAT plan shall be submitted incorporating following details at least 28 days prior to FAT.
  - i. Test plan includes date of testing, manufacturer / test location, testing and inspection items / equipment.
  - ii. Test Purpose
  - iii. Reference test design and testing standard. Soft copy and hard copy of the copies of all standard shall be submitted.



- iv. Test methodology / Procedures. Test procedures shall be presented prior to FAT as requested by Employer.
- v. Performance parameters with tolerances as per test standard.
- vi. QAP (Quality Assurance Plan) from raw material to the finished product.
- vii. The following shall be shown during the FAT.
  - a. Raw material & brought items test certificate, in process & finished product certificates shall be shown during FAT. In addition, the same shall be submitted along with delivery of product.
  - b. Dimensional verification report, Run-test report, Bill of materials along with the specification.
  - c. List of instrument / equipment used for the testing and calibration certificate shall be shown during FAT.
- viii. The Employer will witness the FAT.
- ix. The FAT shall include but not limited to the tests detailed for each category of equipment.
- x. Material / equipment delivery schedule.
- xi. No equipment / material should be delivered to the site until the contractor has demonstrated to the satisfaction of the employer that the equipment conforms to the specification carrying out the FAT.
- xii. The Employer shall be responsible for all costs associated with travel, accommodation, food, visas and permits for the Employer/Engineer attendance only at witnessed inspections or tests scheduled in accordance with the agreed works Programme and subject to a Notice of No Objection from the Employer/Engineer.
- xiii. In case of re-test, the contractor shall be responsible for all costs associated with travel, accommodation, food, visas and permits for the Employer/Engineer.

#### 9.4 Tools

The Contractor shall provide a list of tools and test equipment for the repair of any special apparatus and proposal for conducting system acceptance testing and to support the extended period of trial running.

#### 9.5 Training of operating and maintenance personnel

Prior to final inspection or acceptance, the contractor shall train and instruct designate operating and maintenance personnel in the operation, adjustment, and maintenance of all equipment and systems.

The contractor shall explain to O&M personnel, in full and to their complete understanding, all procedures necessary to operate and maintain all equipment and systems on a continuing basis.

The contractor shall Prepare and review the contents of the s with O&M personnel in full detail to explain all aspects of the Manual and the operation and maintenance of all equipment and systems.

#### 9.6 Maintenance

A maintenance plan shall be provided which shall include the following:

- A. Operating and maintenance instructions which shall describe the procedures for operating and maintaining each item, unit/equipment and which shall include all technical data for its operation, routine inspection/survey, routine maintenance, procedures for removal and replacement of components and test running.
- B. Parts catalogue and recommended list of spares for one-year operation and for 10 years operation
- C. Special tools, jigs or fixings required for dismantling and test/diagnostic equipment performance monitoring.
- D. Training requirements
- E. Manpower plan required for maintenance
- F. The documentation included within the various operation and maintenance manuals being supplied shall include sections as appropriate to the specific equipment and systems being provided:
  - i. **Operating/User manuals:** Broken into as many sub-sections as may be necessary and providing sufficient information to enable non-technical staff to exploit fully the facilities of each system.
  - ii. **Workshop manual:** Installation and circuits description, full schematics, circuits, wiring diagrams, mechanical construction drawings and itemized parts list to enable all maintenance rectification and setting-up to be carried out.
  - iii. **Software system manuals:** Each software package and each piece of equipment which incorporates programmable devices and for which bespoke software has been prepared specifically for this application.

- iv. **Equipment room manuals:** All wiring diagrams and circuits, equipment layout, terminal and cable listing and including such external equipment as may be necessary for completeness.
- v. **Maintenance and Services Manuals:** To specify requirements, procedures and servicing intervals for planned preventative maintenance and in addition to convey sufficient information on equipment principles and practice to enable first line fault diagnosis and rectification by technician staff.

The Operating/User Manuals & technical datasheet shall be provided in English language.

#### 9.7

##### **Asset identification**

- A. All items of equipment shall have attached to it a rating plate or be indelibly labelled or otherwise identified to show its type, serial number, version, function, location, rating or limitation as appropriate.
- B. Removable modules shall have the same identification on the fixture to which the module is attached. The identification plate or label on the fixture shall be adjacent to the identification plate of the module such that it will not be obscured when the module is in place.
- C. Prominent labels will be provided on equipment to indicate where any hazardous situation could arise due to fluctuating voltage level, air pressure, maladjustment, mal-operation, etc.
- D. In general, all labels shall be in English language.
- E. All equipment and software, down to the line replaceable units, shall have a unique identification number that is capable of being identified electronically and manually.

##### **Standardization**

- A. Where practical and as part of the general design philosophy to minimize the number of efficient components used on the plant and equipment supplied for the Contract, similar plant and equipment will be replaceable/interchangeable, of modular design and adaptable and extendable.
- B. To this end, the following principles shall apply:
  - i. Operating system shall be uniform for all systems/sub-systems
  - ii. Standards for maintenance planning shall be uniformly categorised
  - iii. Uniform standard shall be designated for procurement, replacement stocking and availability
  - iv. Equipment and accessories shall be provided with uniform standard spare capacity, protection
  - v. Piping and cabling shall carry standard colour coding for identification and categorisation for each kind of use/type. Similarly, a standard procedure shall be followed for identification of each category of equipment while marking and numbering each category of equipment.
- C. Test standards shall be framed such that all the plant and equipment meet the same test criteria. To ensure that this will be the case the following shall apply:
  - i. Type testing, routine testing and endurance tests shall be carried out under similar conditions
  - ii. Test evaluation and performance shall be compared with standardized acceptance criteria.

#### 9.8

##### **Testing and commissioning**

- A. An approved Commissioning Specialist shall undertake the entire commissioning and performance testing of VAC installation. The Contractor shall at all times be responsible for the supervision of the Commissioning Specialist's work and shall ensure satisfactory completion of commissioning and recording results.
- B. The Employer/Engineer will be given the opportunity to witness all tests. A minimum of 6 weeks advance written notice of tests shall be given.
- C. Any defects of Workmanship, materials, performance, maladjustment, non-compliance with this specification or other irregularities, which become apparent during the tests or commissioning, shall be rectified by the Contractor, at its own expense, until the whole Works is free from defects and in full working order to the complete satisfaction of the Employer/Engineer.
- D. The Contractor shall provide all instruments, and sufficient evidence of the accuracy of the test instruments shall be provided. Test methods shall be demonstrated to the Engineer where required.
- E. The Contractor shall submit to the Employer/Engineer a schedule detailing the equipment, which he proposes to use in the testing and commissioning of the services and the test methods to be employed.
- F. Testing and commissioning of major items of proprietary plant or specialist equipment will be carried out by the supplier's personnel and witnessed by the Commissioning Specialist. The Engineer will be advised of such activities.
- G. Test results will be recorded on approved Commissioning certificates
- H. All test and commissioning instruments will be provided by the Contractor or its Commissioning Specialist, and certified evidence of the accuracy of the test instruments will be provided. The

Contractor will submit to the Engineer a schedule detailing the equipment which he or its Commissioning proposes to use in the testing and commissioning of the services and the test methods to be employed.

- I. Instruments for testing will include as a minimum the following:
  - i. Anemometer (range 1.5m/s to 13 m/s)
  - ii. Mercury in glass thermometers
  - iii. Weekly recording thermometers
  - iv. Weekly recording R.H. meters
  - v. Specially mounted anemometers fixed in a conical sheet metal sheet box hood for measuring accurately air flow from diffusers
  - vi. Ammeter, Tachometer
  - vii. Vibration and Noise testing instruments
- J. **Site tests:** Vibration transmission-break equipment will be thoroughly checked for correct installation and alignment and will be statically tested to ensure that suspensions and/or connections operate as intended. Any unacceptable vibration apparent during plant operation will be corrected.
- K. Wiring terminations to control equipment will be checked for compliance with the wiring diagrams and for interlocking with other equipment. Any faults will be rectified unless associated with wiring carried out under separate Contract in which case they will be recorded, and the details passed to the Engineer for action.
- L. Ductwork systems will be cleaned by blowing out using the supply air fan. No fan will be started until cleaning is to commence. Filters made dirty after completion of cleaning will be cleaned or replaced if required.
  - i. Cleaning will be completed before the connection of terminal units and fittings.
- M. **Air flow balancing:** All ventilation systems will be commissioned in accordance with the procedures recommended in ASHRAE/SMACNA.
  - i. Records of commissioning results shall be provided to the Engineer/Employer which will detail the recorded air volume and percentage deviation from design air volume, for each supply and extract terminal. Wet and dry bulb temperature measurements will be taken in all room served by air supply systems, and the results indicated on the schedule of commissioning results, together with external ambient wet and dry bulb temperature recorded at hourly intervals over the measuring period.
  - ii. After all air systems have been regulated, the final settings are to be recorded on the Commissioning Certificates provided.
- N. **Refrigerant circuits:** If not already carried out at works, all refrigerant systems will be vacuumed and charged with gas/oil in accordance with equipment supplier recommendations.
- O. All electrical circuits (power and control) will be checked for correct functioning of control of the refrigerant system. Similar checks will be carried out for the control panel, local panel (dimensional and functional), etc.
- P. **Sound level measurements:** Reading will be taken to ensure that the required noise ratings are not exceed. Representative areas will be selected by agreement with the Engineer.
  - i. The acoustic performance of items of plant where limitations on permitted noise levels are specified and the noise transmission from plant room areas will be measured, recorded and the results assessed.
  - ii. Wherever necessary, when measuring room sound levels, normal continuous background noise from sources other than the installation will be taken into account. Measurements relating to plant and equipment will generally be taken 1.5 m from the item.
- Q. **VAC performance testing:** The Contractor will demonstrate by measurement and recording that an installation, or part of an installation, functions correctly without need of adjustment and is capable of maintaining internal environmental conditions within specified limits under varying plant loading. All tests will be witnessed by the Engineer
  - i. The Contractor will submit his proposal for the performance tests to the Employer/Engineer for approval 6 weeks before start of commissioning. For the duration of performance tests, the Contractor will ensure that all qualified commissioning and other specialist personnel are present and available at all times to make any necessary immediate adjustments and repairs.
  - ii. Specialized installations including technical rooms, switch rooms and safety critical equipment rooms and computer rooms and other close-control applications, will be required to achieve

- satisfactory system performance when subjected to artificial internal and external loads in accordance with the procedure laid down.
- iii. Comfort and process air conditioning installations will be required to achieve satisfactory system performance in accordance with the procedure indicated.
  - iv. The plant will be continuously operated for a minimum period of 24 hours before tests are witnessed. The Contractor will confirm to the Employer, giving a minimum period of 24 hours' notice, that the installation is ready for witness of performance testing.
  - v. The Contractor will be responsible for the supply, fixing, connection and safe operation of sufficient temporary artificial heat load equipment and any instrumentation necessary to demonstrate system performance and for subsequent disconnection and removal from site when the Employer is satisfied that tests are complete.
  - vi. Individual room temperatures shall be measured by mercury-in-glass thermometers located 1.5m above floor level at points unaffected by the influence or draughts or direct radiation from hot or cold surfaces.
  - vii. Measurements and records of performance test results will be entered on the Commissioning formats and handed to the Employer/Engineer within a reasonable time after the tests are completed. Copies of the results will be retained on site by the Contractor and be available to other official representative as required.

#### 10. TEST CERTIFICATES TO BE FURNISHED BY CONTRACTOR

##### Technical Data Sheet for VRF System

*(Technical information to be furnished in following format by Bidder)*

| SR   | SPECIFICATION  | TO BE FILLED IN BY BIDDER |
|------|--|---------------------------|
| 1    | <b>OUTDOOR UNIT :</b>  |                           |
| 1.1  | <b>COMPRESSOR</b>  |                           |
|      | 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  | <b>FAN SECTION:</b>  |                           |
|      | Fan dia. (mm)  |                           |
|      | No. of fans  |                           |

| <i>(Technical information to be furnished in following format by Bidder)</i> |  |                           |
|--|--|---------------------------|
| SR   | SPECIFICATION  | TO BE FILLED IN BY BIDDER |
|  | Fan speed (rpm)  |                           |
|  | Type of drive  |                           |
|  | Design air quantity (cu.m./hr.)                          |                           |
|  | KW at full load  |                           |
|  | Motor HP   |                           |
| <b>1.3</b>   | <b>CONDENSER COIL:</b>                                   |                           |
|  | 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)                      |                           |
| <b>1.4</b>   | <b>ELECTRIC MOTOR FOR CONDENSER FAN:</b>                 |                           |
|  | 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                              |                           |
| <b>2</b>   | <b>INDOOR UNIT:</b>                                      |                           |
| <b>2.1</b>   | <b>COOLING COIL:</b>                                     |                           |
|  | 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)                   |                           |

| <i>(Technical information to be furnished in following format by Bidder)</i> |  |                           |
|--|--|---------------------------|
| SR   | SPECIFICATION                              | TO BE FILLED IN BY BIDDER |
|  | 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)        |                           |
| <b>2.2</b>   | <b>EVAPORATOR FAN SECTION:</b>             |                           |
|  | 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.                                 |                           |
| <b>2.3</b>   | <b>ELECTRIC MOTOR FOR EVAPORATOR FAN:</b>  |                           |
|  | 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               |                           |
| <b>2.4</b>   | <b>EXPANSION VALVE:</b>                    |                           |
|  | Make & type                                |                           |
|  | Model                                      |                           |
|  | Quantity                                   |                           |
|  | Refrigerant                                |                           |
|  | Capacity (TR)                              |                           |
| <b>2.5</b>   | <b>COP</b>                                 |                           |
|  | 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       |                           |
| <b>2.6</b>   | <b>DERATION CAPACITY in BTU / HR</b>       |                           |
|  | Actual detated Capacity of ODU at 40 °C    |                           |
|  | Actual Detated 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 |

## SECTION-B.01 BUILDING MANAGEMENT SYSTEM

### 1.1 General

- A. This Specification describes the minimum standards of the Building Management System (BMS) for Elevated & At Grade stations of CLIENT/Bengaluru SUB URBAN STATION network. The Works to be executed under the Contract include the design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete BMS to fully integrate the control, monitoring, and supervision of Low Voltage Power & Distribution, Emergency Power Supply-DG sets and UPS, Fire Alarm System, Hydraulic System (Bore Well Pumps etc.), and other nominated Building Services Systems. The BMS shall also interface with the requirements for control, monitoring, and supervision as required at the Operational Control Centre (OCC) and also seamless integration with existing BMS system for other sections at OCC.
- B. The BMS is to be designed manufactured, supplied, installed, tested and commissioned by the Contractor and shall meet all performance and functional requirements as defined in the Specification. This specification contains a description of the system concepts and major components, and sections covering definitions, requirements for interfaces with other contracts, general mechanical and electrical installation design/performance requirements, and testing requirements.
- C. The emphasis is to explain the requirements of work, interfaces with other contractors for achieving an efficient & safe working system commensurate to the best international standards and practices. Every effort has been made to cite the design requirements very clearly, however in this contract, the contractor shall follow acceptable standards & design procedures akin to the best adopted practices in BMS system, wherever this is not explicitly mentioned.

### 1.2 Scope

The Services to be performed by the Contractor shall include, but not be limited to the following:

- i. Design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete BMS, including all PLC/RTU Equipment, CPU's, Modules, Sub Modules, Power Supplies, Local Control Panels, PC Work Stations, Printers, Local Area Network (LAN), Ethernet Hubs and Switches, Remote Fireman's Control Panel, electrical containment and wiring systems, and other components, to fully integrate the control, monitoring, and supervision of Low Voltage Power & Distribution including Energy Metering, remote relay setting of ACBs, Diesel Generator System and strategic emergency power supply from DG sets, UPS, Lighting Control System, Fire Alarm System, Lift and Escalators, Hydraulic System (Raw Water pumps, Domestic water pumps and Fire Water pumps etc.) and other nominated Building Services Systems , as required whether or not specified, necessary to deliver the requirements of this Specification. The scope of BMS Programming (HMI & Logic development) has been further given in detail as per I/O list with this document and it may vary according to the need of site requirement (addition or deletion in I/O List and programming (HMI). The BMS shall also interface with the requirements for control, monitoring, and supervision, as required at the Operational Control Centre (OCC). The system should be capable of independent functioning as well as seamless integration with centralized BMS system.
- ii. Earthing of Programmable logic controller and Work Stations to the clean earth. Earthing drawing will be submitted to the Employer/Engineer for approval.
- iii. Integration of BMS with other BMS at OCC.
- iv. Presentations, reviews and audit support as specified in the Specification;
- v. Interface management as specified in the Specification;
- vi. System operations and maintenance support services;
- vii. Training for the Employer's Engineers and Training Instructors, operations staff, maintenance staff and Engineering staff;
- viii. Dismantling, removal and/or disposal of Temporary Works;
- ix. Warranty period after commissioning.
- x. Transfer of Technology
- xi. Warranty and Maintenance Support System-AMC

- xii. Report generation and trend settings as per employers' requirements.
- xiii. DLP liability period should be performed for 02 years.

The List is not intended to be complete and the Contractor shall supplement it adequately for obtaining a satisfactory working of BMS System.

### 1.3 **Standardization**

- A. The Contractor shall, in establishing his design, follow the principles provided below in the design and specification of all plant, equipment and components:
  - i. Similar plant and equipment shall be replaceable/interchangeable, modular in design, adaptable and extendable.
  - ii. The technical specifications and design standards shall be uniform. Uniform standards for clear spaces, working clearances, protection of equipment and physical dimensions of equipment and interfacing with other systems.
  - iii. Test standards and standardized equipment shall be selected or built or framed carefully, bench marked, designated and explicitly marked.
  - iv. A standard procedure shall be followed for identification of each category of equipment explicitly (suffixing or prefixing while marking and numbering for each category of equipment).
  - v. The operating system shall be uniform for all systems/sub systems.
  - vi. Standards for maintenance planning shall be uniformly categorized.
  - vii. Uniform standards shall be designated for procurement, replacement stocking and availability.
  - viii. Equipment and accessories shall be provided with uniform standard spare capacity, protection.
  - ix. Piping, cabling etc. shall be suitably colour coded for identification and categorization for each kind of use/type. The cable terminations should be tagged and numbered as per the standards.
  - x. The software shall be upgradable for 10 years without any extra cost.

### 1.4 **Quality Control of Equipment, Components and Material**

- A. The contractor shall furnish the following information for each item of equipment as applicable:
  - i. Manufacturer.
  - ii. Type and model No. of equipment.
  - iii. Nominal capacity
  - iv. Power supplies i.e. Voltage & Frequency at which the equipment operates.
  - v. Type of Frame and foundation required for the equipment.
  - vi. Space requirements
  - vii. Controls & Protection
  - viii. Indications/alarm/annunciation
  - ix. Standards
  - x. Insulation class
  - xi. EMC Conformance and certification.
  - xii. Any other technical information related to the equipment.

The Contractor shall provide a List of Tools and Test Equipment for the installation, Testing and Repair of any Special Apparatus and proposals for Conducting System Acceptance Testing and to support the extended period of Trial Running.

### 1.5 **Submission of Drawing & Details**

- A. The contractor shall state the number and scales of all the drawings it intends to produce in support of the works under this contract. The detailed/schematic drawings to be furnished by the Contractor may include but not be limited to:
  - i. Schematic drawings
  - ii. Interlock drawings
  - iii. Erection drawings
  - iv. Wiring drawings
  - v. As erected/finished drawings
  - vi. Any other drawings
  - vii. I/O Schedule and Cable Schedule
  - viii. As-Built drawings
  - ix. A complete schedule of drawings to be produced by the contractor shall be submitted to the Employer/Engineer within one month (30 days), of contract award.

## 1.6 Design Considerations

- A. The complete installation shall be in strict accordance with the national and local electrical codes.
- i. All system components are to be designed and built to be fault tolerant.
  - ii. Satisfactory operation without damage at 110% and 85% of rated voltage and at +3 hertz & - 1.5 Hz variation in line frequency.
  - iii. Static, transient, and short circuit protection on all inputs and outputs.
  - iv. Communication lines protected against in-correct wiring, static transients and induced magnetic interference.
  - v. Bus connected devices to be a.c. coupled or equivalent, so that any single device failure will not disrupt or halt bus communication.
    - a. All equipment, cables and wiring shall be designed, manufactured and installed so as to secure a service life as shown below:
 

|                                 |   |                  |
|---------------------------------|---|------------------|
| • Control Panels                | : | 30 Years         |
| • Cables                        | : | 30 Years         |
| • Tray, trunking and supports   | : | 30 Years         |
| • Sub-assemblies and components | : | 30 Years         |
| • All other equipment           | : | 20 Years minimum |
    - b. Switchboards, equipment, and other control components shall be rated for operation in ambient temperatures of 50°C and humidity up to 95% and shall have degree of protection IP- 65.
    - c. In the design of switchboards, local control panels, Cabinets of PLC, an allowance of 30% spare space capacity shall be provided for possible future expansion and all panels shall be user friendly, modular and aesthetic design, termite and vermin proof. Spare capacity of 30% shall be provided for all cable trays, trunking, wire ways, (raceways), and brackets, for future expansion.
    - d. At least 20% spare capacity available at the time of system acceptance shall be provided for future expansion of memory storages, processor power, hard disk storages, communication links/ports and I/O points.
    - e. Incorporating IP 54 protection for Free standing PLC enclosure and SCADA PLC equipment complete with Single ended TBs, SMPS, MCBs, etc. including interconnections, labelling, earthing, associated foundation/masonry work and all cable ducting, control wiring, fixing accessories, LV Power isolation indicator lamps, OFC Converter, LED's, fuses, circuit breakers, terminal rail, terminals, marker ferrules and all accessories.
- B. The workstation pc with recent configuration and operating system shall be supplied and installed in the station control room of each station. This shall be a standalone PC.

## 1.7 Redundant Programmable Logic Controller

- A. Necessary Redundant PLCs shall be installed to provide the most economic configuration based upon cost balances between PLC modularity and cabling costs, consistent with the performance requirements of this specification.
- B. Location of Redundant PLCs shall be chosen such that minimum length of cable will be required between PLC and power DB.
- C. Redundant PLC can be opened freely, so sufficient distance from the wall or obstruction will be maintained.
- D. Cables shall be kept at a distance of 300 mm from the power cable trays/conduits at all places as entry/exit to DB, PLC etc.
- E. Hubs / switches — these will be installed in separate enclosures near the, PLCs/ workstation.
- F. Repeaters-these will be installed in separate enclosure at a distance of 90 meter from hub/repeater of the communication cable to boost the signal.
- G. Field sensors- sensors will be located on, or adjacent to, that equipment which is being monitored. For example, it could include sensing the electrical load, water level etc. that changes within building.
- H. Considered Redundant PLC system Primary at ASS Room, secondary at Pump Room building. CPUs are considered at ASS Room and Pump Room will be operate as redundant controllers using FO communication network. Redundant PLC is connected to two distribution switches. A system

consists of Two different enclosures/panels located in ASS room & Pump Room building. Following are the core components that will be used in panels

- i. Controllers (ASS Room and Pump Room)
- ii. Power supply
- iii. I/O modules and interface cards
- iv. SMPS (if required, in case 24VDC supply not available)
- v. Network switch along with LIU

#### 1.8 Facility

- A. The BMS system shall be centralized and comprise of a powerful central computer. This shall run highly sophisticated programs, which operate in 'real-time'. Workstation shall have continuous communication between the central or main operator station's central processing unit (CPU) and the remote field processing units (PLCs). The CPU is continuously updated with the conditions being monitored by, and control actions being taken by, the PLCs. It will therefore be able to implement global actions with the minimum time delay, across the whole system. However, configuration of PC and hardware components given in subsequent paras of this specification.
- B. A central database management and communications system, to communicate with the PLCs and local workstations over the communications link shall be provided and to maintain a database regarding health and operation of all system points. The system should be able to log the defective sub-systems, communication failures/ breaks and also update the data on restoration of the fault.
- C. Bulk data server facilities for software back up and historical data, including equipment history of maintenance & frequent defects shall be provided at station & O.C.C. Maintain equipment history of maintenance and frequent defects. The backup historical data shall be available minimum for a month at a time and backup rate shall be fortnightly.
- D. The BMS should activate designated alert for the attention of operations and maintenance staff rapidly to equipment malfunctions, especially those likely to cause uneasiness to the SUB URBAN STATION passengers (for example lighting system, escalators). SMS to Mobile phones of DGM (O&M) and other designated officials of CLIENT regarding high priority alarms, energy audit reports and specific fuel consumption of DG sets.
- E. Provide clear, comprehensive displays and printed logs of equipment status to each operator workstation.
- F. Provide comprehensive displays and printed logs based upon historical data, with the option of overlaying data from earlier periods.
- G. Time-tag all events detected by the BMS system, to 1 millisecond Resolution for selected high-speed inputs, and to present this information in logs as a true system-wide sequence of events.
- H. Generate routine maintenance schedules automatically, based upon elapsed time and equipment operation times. Also record the maintenance activities carried out including the maintenance block taken, persons attending or having access to the plant rooms.
- I. Operating systems based on a Graphical User (GUI) format incorporating the widely used WIMPs procedures (windows, icons, menus, and pointing device), where one display can overlay another shall be provided. WYSIWYG (what-you-see-is-what-you-get) display printing and print previewing features shall be provided.
- J. The following primary facilities shall be available at each workstation:
  - i. Visual and Audible Alarms and event logging and printing.
  - ii. Operator acknowledgement of alarms.
  - iii. Selective display and printing of alarms and of events lists.
  - iv. User friendly group display on a single screen of various E&M systems.
  - v. Execution of operator commands with access code security.
  - vi. Provision of user-friendly operator sequences.
  - vii. Operator entered text messages.
  - viii. Access to historical data files of plant status.
  - ix. Generation of tabular displays based upon spreadsheets.
  - x. Generation of graphical displays based upon mimic diagrams.
  - xi. Generation of printed reports and printed copies of display pages.
  - xii. Utilities consumption monitoring and check metering.

- xiii. Operator entered data, including tagging, manually entering values and the forcing of status points.
- xiv. Automatic logging of selected displays at specified times.
- xv. System timekeeping.

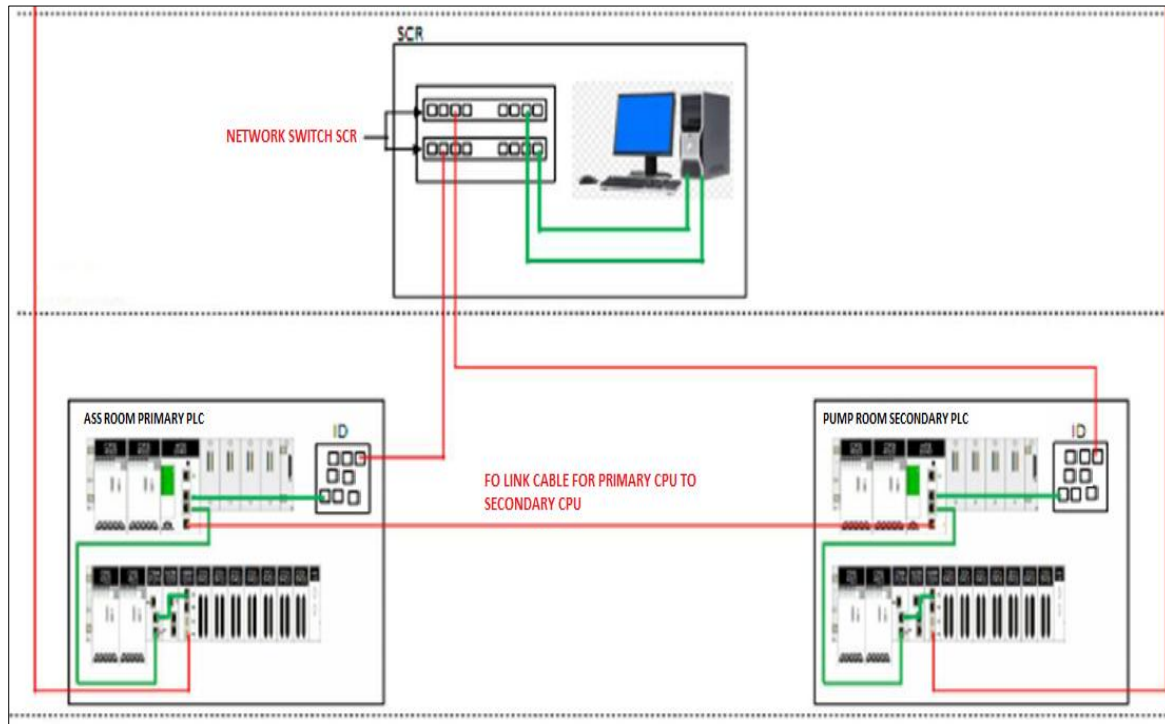
#### 1.9 **Specification/Requirements for Hardware Components**

Off the shelf supplied items should be supported with AMC to cover the warranty period. The terms should ensure prompt attention & not later than 12 hours. In case the standard warranty terms do not provide such service then the contractor should build in suitable mechanism for prompt attention.

#### 1.10 **Specifications of Redundant Programmable Logic Controller (PLC)**

- A. Redundant PLC consists of main CPU with secondary, I/O modules, DC/DC converter and terminal blocks. It collects data from the process, pre-processes and transmits the same, using suitable protocol (MODBUS RTU or similar), to the SCR Workstation which in turn communicates to the Central Server at the OCC via an optimized and event-based TCP/IP protocol.
- B. Redundant PLC shall be an intelligent modular, compact system that allows suitable expansion, minimum from 14 up to 1000 I/Os using the same set of basic components. The Redundant PLC shall be programmed for local control by implementing specific logic in the PLC. Input and Output modules are connected serially to make it a complete compact and modular data acquisition system. The PLC shall communicate with SCR workstation through MODBUS Protocol, using the RS232/485 port. PLC shall have a local 'intelligence' so that in the event of a breakdown in communications with the CPU, the points connected to that unit continue to be controlled according to the time schedules initially provided by the CPU.
- C. The Contractor shall ensure that the Redundant PLCs are compatible with the input/output signals from the Workstation and other Subsystems. Power supplies for interrogation of volt-free contact shall be provided as part of the PLC.
- D. Redundant PLC terminals shall be of the clamp type preferably of cage -clamp and shall be provided with isolating links
- E. Redundant PLCs shall be supplied complete with 30% spare capacity for handling additional input and output signals. Expansion by at least 50% shall be possible simply by adding more I/O modules and reconfiguring the software. A further 100% expansion shall be possible by adding additional interfacing equipment in additional cabinets, etc. and reconfiguration of the software.
- F. A manual switch inside the Redundant PLC cabinet shall be provided as a hardwired facility to disable the operation of control outputs. Change of switch status shall be registered as a system event.
- G. The Contractor shall establish the I/O requirements and provide the most economic configuration of PLCs based upon cost balances between unit modularity and cabling costs for individual stations.
- H. The Redundant PLCs shall be suitable for either wall or floor mounting and shall be suitably robust for operation in Electrical switchgear room/ Pump room areas, to IEC529 IP54 enclosure standard. Wall mounting is preferred. Redundant PLC shall be of the same make and type at all sites and individual components shall be interchangeable between PLCs at different sites.
- I. The Redundant PLCs shall be suitable for operating in the environment described in the General Specification clause.
- J. The Redundant PLCs shall be able to be interrogated fully and be fully reconfigured from operator workstations. The Employer's personnel shall be able to re-configure fully the PLC hardware and software after completion of the training courses provided under this Contract. However, a nominated person with authorized password should have access for making such change with using proper authorization from DGM/ SUB URBAN STATION or OCC.
- K. It shall be possible to disable an individual PLC locally or from an operator workstation for servicing or reconfiguring without affecting other PLCs. When disabled or enabled, a change of status condition shall be announced on the Control Centre monitor and the changed log as an event.





- L. Ring topology has been considered as shown in the architecture diagrams Below.
- M. Redundant PLC panel and associated accessories that is intended for industrial use must be able to withstand extremes of temperature, humidity, voltage spikes and drops; survive in an atmosphere that often contains corrosive vapours, oil, and dirt; and withstand shock and vibration.
- The following standards are applicable, in addition to the reference documents and other standards given in this document
- i. **Vibration:** IEC 61131-2 compliant
  - ii. **Shock:** IEC 60068-2-27 compliant
  - iii. **Vibration / shock Immunity International standards:** IEC61131-2, IEC 68-2- 6 (TEST Fc)/IEC61131-2 & IEC 68-2-27 (TEST Ea.).
- N. Redundant PLCs shall be fully autonomous in operation and continue to function normally in the event of failure of any equipment in the Control room, failure of any other PLC on the network or failure of the communication system will not impact the autonomous functionality of PLC.
- O. The individual internal PLC memory shall be sized to hold, in addition to all the necessary programs, the logged input data and controls output for a period of normal operation covering a minimum of 24 hours in the event of communication failure. Operation of PLCs or any other aspect of the SMS SCADA system shall not be adversely affected as memory utilization increases to the maximum, the design value of which shall be stated in the Design Specification (DS), prepared by the Contractor and approved by the Employer/Engineer.
- P. Redundant PLC memory shall be non-volatile and shall be supported for a minimum period of 72 hours in the event of power failure.
- Q. Standards and certifications
- The Redundant PLC must conform to the main national and international standards covering electronic equipment for industrial control systems:
- i. CE marking according EN 61131-2
  - ii. CSA 22-2 N° 142 (Canadian Standards Association)
  - iii. UL 508 (Underwriters Laboratories)
  - iv. C-Tick ACA (Australian Communication Authority/Australia)
  - v. CSA 22-2 N° 213 Hazardous Location (CSA)
  - vi. FCC Part 15 – Class A
  - vii. GOST CEI

The PLC must conform to the main certifications relating to marine classification:

- i. BV (Bureau Veritas/France)
- ii. DNV (Det Norske Veritas/Norway)
- iii. GL (Germanischer Lloyd/Germany)
- iv. LR (Lloyd's Register/United Kingdom)
- v. RINA (Registro Italiano Navale/Italy)
- vi. ABS (American Bureau of Shipping / USA)
- vii. RMRoS (Russian Maritime Register of Shipping / Russia)

The PLC must conform to Ethernet robustness certification:

- i. Achilles Level 2
  - ii. Be compliant with IEC – 62443 standards
- R. Internal architecture of PLC
- i. Microprocessor base CPU
  - ii. Input and output interface modules suitable for a mixture of digital, analog and pulse inputs and outputs.
  - iii. Terminal for external cable termination
  - iv. Thermostat for temperature control
  - v. Fan
  - vi. Power indication lamps
  - vii. Document holder
  - viii. MCBs for modules, Power supply unit, Fan, Tube lights
  - ix. Tube lights
  - x. Door switches
  - xi. Fuses for digital output, input and analog input terminals
  - xii. Power supply unit

The PLC processor will have minimum Salient features as following:

- i. 34 KB user program memory RAMS and Flash.
- ii. 0.4 ms/kobo bit processing
- iii. Integrated ports: 2xMODBUS or 1xMODBUS.
- iv. 2 interrupt inputs and 2 cyclic tasks.
- v. Direct access to I/O for fast response.
- vi. Real-time clock.
- vii. It shall have real time clock & time resolution of the clock should be 1msec.
- viii. PLC shall have separate battery for the above clock. PLC shall be capable of time stamping the event before communication to BMS.
- ix. The event scanning resolution of PLC should be of 1msec.

The PLC processor will have the capability to support the following language structures:

- i. Structured Text
- ii. Sequential Function Charts
- iii. Ladder Logic
- iv. Function Block

The processor shall support the Advanced Instruction Set that includes basic and advanced ASCII string instructions, and advanced math functions.

The processor shall support a system protection environment with passwords and privileges and support a form of backup communications module.

### **Redundant PLC Interface Modules**

The following hardware described will interface to the field mounted sensors and equipment for control and monitoring.

### **Digital Inputs:**

- 12 VDC, 24 VDC, 50 VDC, 110 VDC, 110 VAC, 240 VAC (1.5 kV isolation)

**Digital Outputs (relay):**

- i. Volt-free contact, 24 VDC, 30 VA
- ii. Volt-free contact, 240 VAC, 125VA

**Analog Inputs:**

- i. 0-10 VDC, 0-10 mA, 4 -20 mA with electrical isolation from ground
- ii. DC 16-bit resolution minimum
- iii. >60dB interference rejection at 50Hz

**Analog Outputs:**

- i. 0-10 VDC, 4-20mA

**Pulse Inputs:**

- i. 12 VDC, 24 VDC up to 10 pulses/sec (2kV isolation)

**Serial Link:**

- i. RS 485, RS 232 / V24, RS422

**S. Redundant PLC Hardware Requirements**

PLC Operating Voltages: The PLC must be able to operate at 100% from the following power sources:

- i. 100 VAC — 250 VAC
- ii. 24 VDC — 100 VDC

Note: The PLC must operate at the nominal supply frequency of 50 Hz with a 15% variation.

**T. Redundant PLC Programming**

- i. The PLC shall be programmed with manufacturer proprietary software, IEC 1131.3-compliant, mixable and reversible List language and Ladder language. The software shall feature Windows-based editing functions and integrated online help.
- ii. An original copy of the latest manufacturer's proprietary software shall be provided to CLIENT upon completion and handover together with all generated site-specific data.
- iii. Redundant PLC should be remote programmable from SCR workstation.

**U. Redundant PLC Communications**

Although the PLC processor specified above will have the capability of communicating directly with a BMS system via Modbus over TCP/IP protocol. In addition to the above, the PLC shall have the capability to be monitored directly using the HTTP protocol.

**V. Redundant PLC Cabinet and Panel Internal Wiring**

- Redundant PLC is compact and modular in design. All the components inside the panel are din-rail mounted. PLC cabinets will be freestanding type and will have colour matching with Electrical Panel.
- Control panel, switchboards and distribution boards wiring shall be clearly identified in accordance with the Definitive Design Drawings using cable core markers. Cable core markers shall read left to right or top to bottom.
- Wiring shall be enclosed in metal ducts or neatly loomed with nylon ties or spiral binding as required. Wiring ducts shall be filled to a maximum space factor of 50%.
- Where wiring is required to connect to devices mounted on doors it shall be arranged such that opening and closing of the door is not impeded whilst minimizing flexing of the wiring loom. The loom shall be effectively fixed at both ends of the door opening with insulated saddles or clamps.
- Wire colours shall comply with the following requirements:
 

|             |                         |
|-------------|-------------------------|
| Phases      | Red, Yellow, Blue       |
| Neutral     | Black                   |
| AC Control  | Grey                    |
| DC Positive | Orange                  |
| DC Negative | Lilac                   |
| Earth       | Green with Yellow trace |
- Terminals shall be clearly numbered, and shall be rail mounted, adequately sized to suite wiring size and provided with 20% spare rail space. The bridging of terminals shall be provided by the use of terminal bridging links as supplied by the terminal manufacturer.
- Control wiring shall be terminated using pre-insulated pin or spade type crimp lugs. Conductors

terminating to study type terminals shall be fitted with spade type crimp lugs.

- A separate earth bar shall be provided for the termination of all earth wires. Only one wire shall be connected into each termination point.
- Minimum conductor size shall be 1.5mm<sup>2</sup>.
- Cable glanding plates shall be earthed directly to the control panel earth bar.
- Panels shall be fitted with a suitable pocket to contain circuit diagrams and other relevant Definitive Design Drawings. An "as installed" set shall be provided with the panel.

#### 1.11 **Electro-Magnetic Compatibility**

This Paragraph defines the minimum Electro-magnetic compatibility (EMC) requirements for all electronic and electrical equipment supplied under this Contract. All PLC Panel should be EMC/EMI compatible.

The Contractor shall co-ordinate with Project Contractors and ensure that the frequencies and bandwidths employed in the PLC Systems will not fall into the frequencies known to be major sources of interference. The Contractor shall ensure that the fundamental frequencies, harmonics and cross products produced by the PLC Systems will not interfere with those of other systems in the Project.

The Contractor shall comply with the requirements of the international standards EN 50121-1/-5 Railway Applications – Electromagnetic Compatibility, 2003 and related standards and the IEC 61000 series for Electromagnetic Compatibility, or equivalent standards. EMC considerations shall be incorporated in the Concessionaire's procedures for functional safety and engineering verification.

The following standards and documents are applicable, in addition to the reference documents and other standards given in this document

- I. EU Directive on EMC (89/336/EEC);
- II. Européen Generic Emission Standard - Part 2: Industrial Environment EN50081-2.
- III. EN 50121-1, Railway Applications – Electromagnetic Compatibility - Part 1: General
- IV. EN 50121-2 Part 2: Emission of the whole railway system to the outside world
- V. EN 50121-5 Part 5: Emission and immunity of fixed power supply installations and apparatus
- VI. IEC 61000-4-2: Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.
- VII. IEC 61000-4-3: Electromagnetic compatibility (EMC) –Part 4-3: Testing and measurement techniques – Radiated, radiofrequency, electromagnetic field immunity test
- VIII. IEC 61000-4-4: Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test
- IX. IEC 61000-4-5: Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test
- X. IEC 61000-4-6: Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields
- XI. IEC 61000-4-8: Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test
- XII. IEC 61000-4-9: Electromagnetic compatibility (EMC) – Part 4-9: Testing and measurement techniques – Pulse magnetic field immunity test
- XIII. IEC 61000-4-12: Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Oscillatory waves immunity test
- XIV. IEC 61000-6-1: Electromagnetic Compatibility (EMC) – Part 6-1: Generic Standards – Immunity Standard for Domestic and Light Industries
- XV. IEC 61000-6-4: Electromagnetic Compatibility (EMC) – Part 6-4: Generic Standards – Emission Standard for Industrial Environments

**1.12 Work Station**

The central processing equipment shall comprise one high performance real time, digital personal computer, rated with such application, complete with keyboard and mouse, one colour graphic VDU, system Laser printer(s) to log all transaction and alarm printer(s). All the equipment shall be suitable for the power supply voltage of 230VAC +6% 50Hz +2%. The central equipment shall be located where shown on the plans and shall meet the following minimum criteria.

**1.13 Personal Computer**

The Standalone commercial grade Work Station shall be a personal computer (PC) based central, with a minimum feature of full 64 bit processor, features latest Intel I7 , 5th Gen processor with 3.0 GHz or higher, 8 GB RAM, 1TB Hard Disk drive, ATI/NVIDIA graphics card , DVD R/RW, Dual LAN card, 2GB Dual Video Accelerator, Dual Monitor support, 2 Nos. spare USB ports, SATA/SCASI disk drive crashworthiness, and all other miscellaneous components including communication interface RS-232/485 card (MOXA Card with minimum 8 ports) to meet the requirements and specifications. Notwithstanding the foregoing guidelines, the Work Station shall be to the latest state-of-the-art performance for similar systems and shall be operated by the use of a USB mouse (Optical) connected to the station without the need of keyboard entry. To ensure hardware quality, computer clones shall not be acceptable. The PC shall be supplied with 24" VDU, One Laser Printer and with latest operating system software.

The PC shall be configured such that external media of any kind may not be loadable at Operator level, which could pose the threat of external virus infection or compromise the operating system.

The Work Station shall be complete with detached 101-keys keyboard, which includes full upper/lower case ASCII keyset, a numeric keypad, dedicated cursor control keypad, and a minimum of 30 programmable function keys.

**1.14 Colour Monitor**

The Work Station color monitor shall be Colour monitor shall be minimum 24-inch diagonal antiglare, antistatic flat LED screen, high resolution of 1280x1024 and 16 Million colour support, on screen control support, Vertical & Horizontal viewing angle 160 deg., Tilt Swivel Support as per specifications etc. as required Work stations shall include all accessories needed to comply with UL requirements for listing under the appropriate standards as specified in UL864 and UL916. Further, all accessories shall be included to satisfy the local authorities having jurisdiction over the system. UL listed cards (originals preferred or photocopies) shall be provided to support the documentation that such listing is in effect.

**1.15 Notebook PC**

The sub-contractor shall provide two number color notebooks of reputed make with built-in modem for remote dialing-in for use as a portable programming tool. The color notebook shall be Ultraportable, Ultrabook have minimum feature of a high resolution colour 13-inch LCD, 8 GB RAM, Intel core i7 or higher, 3.0 GHz, Touch Screen. Intel HD graphic card weighing 1.5kg or less, 1 TB hard disk capacity with high-speed disk access. The note book shall come with a USB mouse (Optical) for user interfacing. The overall weight for the notebook shall not be more than 1.5 kg. To ensure hardware quality, computer clones shall not be acceptable.

**1.16 Printers**

The sub-contractor shall provide printers as specified for recording alarms, operator transactions and system reports. To ensure hardware quality, printers shall be internationally branded, warranted, and technical support, spare parts and consumables should be freely available from the manufacturers authorized distributors.

**1.17 Laser Printer**

A hard-copy multi-color graphics laser printer shall be provided for recording graphic displays and associated dynamic data. Printer shall meet minimum requirements as follows:

- i. Print speed — Black: up to 20 ppm; color: up to 4 ppm
- ii. First page out — 18 seconds black, 29 seconds' color
- iii. Resolution- 600 by 600 dpi
- iv. Memory — 64 MB built-in SDRAM; expandable to 192 MB with one open memory SDRAM DIMM slot
- v. Duty cycle — 30,000 pages per month



- vi. Media — Media handling 125-sheet multipurpose tray 125-sheet multipurpose tray, 250-sheet input tray 2 — Letter, legal, statement, executive, No. 10 envelopes, Monarch envelopes
- vii. Output — 125 sheet face down bin
- viii. Types Paper (plain, letterhead, prepunched, bond, color, rough, preprinted, recycled)
- ix. Glossy Media, Cover Paper, Color Laser Jet Transparencies, labels, envelopes, and card stock
- x. Compatibility— Interfaces Hi-Speed USB 2.0 port, IEEE 1284-B compliant parallel port
- xi. Hi-Speed USB 2.0, IEEE 1284-B compliant parallel port
- xii. Languages PCL 6 and Postscript level 3 emulation with automatic language switching
- xiii. Font capabilities — 80 TrueType TM internal scalable PCL 6 fonts; 80 TrueType internal scalable HP postscript fonts
- xiv. Client operating systems — Microsoft Windows 98, 2000, Me, XP, 10 or latest NT 4.0 Mac OS 9.1, X v.10.1 and later; UNIX®, Linux, and OS/2 (limited functionality) vista.
- xv. Network operating systems — Microsoft Windows 98, 2000, NT 4.0 Me, XP, 10 or latest; Mac OS 9.x, OS X Vista
- xvi. Network protocols supported — TCP/IP

#### 1.18 **Network Switches, Modems, Hubs, Gateways**

All modems, hubs, switches, gateways and other serial equipment to be used in the application of system networks must be of industrial grade quality to meet the following criteria:

- i. Can tolerate up to -40°C to 85°C
- ii. Can tolerate 5-95% humidity
- iii. Provides vibration resistance (1E68-2)
- iv. Withstands power surges (IEEE-472)
- v. Provide easy DIN-rail mounting
- vi. Are powered directly from 230V AC/110V DC
- vii. Not less than 8-port 10/100 Dual-Speed ports-up to 200Mbps

#### 1.19 **Communication**

The suitable communication open confirming IEC 60870-5-104 protocol shall be adopted for various communication links. The communication Protocol can be classified as per following requirements:

- i. The communication between E&M equipment to Redundant PLC: MODBUS Protocol
- ii. The communication between Redundant PLC to the SCR Workstation: MODBUS Protocol over TCP/IP.
- iii. The communication between Multifunction Meters and Energy meters and their communication to Redundant PLC/Workstation: MODBUS Protocol on RS 232/485 port.
- iv. The communication between Dimming Light Control Panel, Fire Alarm Control Panel, and MDB & Electrical panels, Escalator Panels/MCCBs, AMF Panel etc. to the PLC/SCR Workstation: MODBUS Protocol on RS232/485 Port.
- v. Communication between SCR Workstation to OCC: TCP/IP protocol on optic fiber link through TER.
  - A. Supply of the hardware essential to integrate all systems for communication link as above.
  - B. The communication link between SCR workstations and the OCC shall be done using TCP/IP based protocol. All the SCR workstations and OCC shall be connected in LAN TCP/IP that is being provided at TER by the main communication contractor.
  - C. Communication software in each PLC or workstation node on the network shall enable peer-to-peer operation, such that failure of any node shall not affect other nodes on the network.
  - D. The system should provide instant alarm to the operator about the communication failure.
  - E. The healthy operation of all PLCs shall be verified at intervals not exceeding 30 seconds. PLC failure shall be displayed on the appropriate workstations as a system alarm.
  - F. In the event of a failure of the main communications system, local operation from control panel at each station shall be maintained. Updating of the central database at the OCC shall take place immediately on restoration of the communications link.
  - G. Operational changes and expansion will be made without shutdown the system.

#### 1.20 **Cables**

All types of cables used in this project shall be Armoured.

- A. Cables installed between PLC and DB/Sensors shall be Fire resistant low smoke Zero Halogen (FRLSZH)



- B. Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq mm copper.
- C. Ethernet cables for networking of Redundant PLCs and Workstation shall be provided.
- D. 2#3C shielded cables (communication bus) shall be provided over RS232/485.
- 1.21 **Moxa Card/ Router**
- A. For communication with RS 485 port of different panels Moxa card of minimum 8 ports/Router shall be installed with the BMS workstation.
- B. Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq. mm copper.
- 1.22 **Sensor And Operating Equipment**
- The Contractor shall supply the sensors, (to be specified) transmitters and relays necessary for the SCADA system, where necessary. All sensors shall be calibrated after testing and commissioning of system. Monitoring and controlling points shall include but not limited to the following:
- Air proving switches** shall utilize a differential pressure activated, diaphragm actuated, snap acting Single Pole Double throw (SPDT) switch.
  - Pressure transmitters** shall have a linear output of 0-10V. Pressure transmitters shall be a span of not greater than twice the static pressure at maximum flow or differential pressure at shutoff as applicable.
  - Temperature sensing elements** to be provided shall be of liquid, vapour or bimetallic type with supply adjustable set point and differential set point, snap action type rated at 220 volts, 10 amps or 24 volts DC and the Sensors shall be able to operate and reset automatically.  
Temperature switches sensing elements shall be of the following types.
    - Room type shall be suitable for wall mounting on standard electrical box with or without protective guard.
    - General purpose duct type shall be suitable for insertion into air ducts, insertion steel.
    - Strap-on type shall be completed with helical screw stainless steel clamps.
  - Start/stop relay modules** shall, if possible, provide either momentary or maintained switch actions as appropriate for the unit being started and depending on the fact whether the units are subjected to a power fail restart program or not. All relays shall be mounted in interface panels and/or starter panels.
  - Water Level Switch with Three Level Indication - max 5 mts**
    - Diameter of Electrode:  $\Phi 6/ 8/ 10/ 15/ 20\text{mm}$
    - Quantity of Electrode (n): 3
    - Separator: Standard, 1 each by every 2000mm
    - Flange: over 100A, JIS10K
    - Electrode Material: 304SS, 316SS, 316LSS, Titanium Hastelloy C & B
- 1.23 **Flange Material: PVC, 400SS, 304SS, others**
- Housing Material: PVC, SGP, 304SS, others
  - Painted color: Housing /Munsell 5Y 7/1 (SGP only) Flange / Munsell 5Y 7/1 (400SS only)
  - Mat. of sheathed Electrode: PVC tube, Teflon tube
  - Mat. of stilling well: PVC, SGP, 304SS
- vi. **Voltage Transducer**

|  |
|--|
| • <b>Type</b> -DIN Series  |
| • <b>Standards</b> -IEC 688 / EN 60688, EN 61010-1, EN 61326-1, IS12784 (Part-1)1989 |
| • <b>AC Input</b> - 0–63.5, 0-110V, 0-230V, 0-300V, 0-440V, 0-500V                   |
| • <b>DC Output</b> - Current (mA): 0-1, 0-5, 0-10,2-10, 0-20, 4-20mA                 |
| Voltage (V): 0-1V, 0-5V, 1-5V, 0-10V, 2-10V  |
| • Accuracy - Standard: $\pm 0.5\%$ of Span   |
| • <b>Auxiliary</b> SMPS - HV: 85-265V AC / DC  |
| SMPS - LV: 19-90V AC / DC  |
| Self-powered Available. Refer PDF  |

|   |
|---|
| • <b>Isolation</b> - Complete (Input / Output / Auxiliary / Case) |
| • <b>Dielectric Strength</b> 2.5kV at 50 Hz for 1 min. (Standard) |
| 4kV (Optional), across  |
| Casing - Input/Output/Auxiliary                                   |
| Input - Output  |
| Input - Auxiliary   |
| Output - Auxiliary  |

vii. **Current Transducer**

|   |
|---|
| • <b>Type</b> -DIN Series   |
| • <b>Standards</b> - IEC 688 / EN 60688, EN 61010-1, EN 61326-1, IS12784 (Part-1)1989 |
| • <b>AC Input</b> - 0-5A (Direct), 0 - 1A (Direct), CTR/5A, CTR/1A                    |
| • <b>DC Output</b> - Current (mA): 0-1, 0-5, 0-10, 2-10, 0-20, 4-20mA                 |
| Voltage (V): 0-1V, 0-5V, 1-5V, 0-10V, 2-10V   |
| • <b>Accuracy</b> - Standard: $\pm 0.5\%$ of Span                                     |
| • <b>Auxiliary</b> - SMPS - HV: 85-265V AC / DC                                       |
| SMPS - LV: 19-90V AC / DC   |
| Self-powered Available. Refer PDF   |
| • <b>Isolation</b> - Complete (Input / Output / Auxiliary / Case)                     |
| • <b>Dielectric Strength</b> - 2.5kV at 50 Hz for 1 min. (Standard)                   |
| 4kV (Optional), across  |
| Casing - Input/Output/Auxiliary   |
| Input - Output  |
| Input - Auxiliary   |
| Output - Auxiliary  |

Note: -In case any other sensors are required for proper monitoring and control of equipment, Contractor needs to consider the same in their design.

1.24 **Specification/Requirement for System Software****A. Software Features**

- (i) It is necessary to provide a time and date for alarms, which occur, and other significant events, including operator commands.
- (ii) Software will allow the database (points) and operating parameters (time, temperatures, limits etc.) to be modified on-line, by the operator.
- (iii) When a binary contact goes from open to closed, or vice versa, the 'change of state' is reported by the system.
- (iv) Some alarms may, however, be critical and should never be locked out. It should be possible to define these alarms when they are entered into the system in such a way that it is impossible to lock them out.
- (v) On start-up of certain plant, it takes a finite time before stable conditions are reached and the BMS should allow for automatic lockout of alarms for a pre-set period following start-up.
- (vi) If, either as a result of time programming, or an operator command, several large electrical items are called to start at the same instant, this may cause overloading. BMS shall have capability to overcome this by defining these items as 'heavy' electrical items, and introduce a delay time to prevent starting of the next load until delay time has elapsed.
- (vii) Logging of important status information will be provided. The list of such important items shall be provided by contractor for approval of ER.
- (viii) This should contain, in plain language, identification of the point, status and other data, plus time, date etc.

- (ix) It should be possible to call up logs for various 'levels'.
- (x) It should be possible to cancel logs under certain conditions.
- (xi) Facility of summary logs, i.e. the ability to call for a print out, for example, of all points in alarm, all points off normal, all motors which are running, all points which are locked out, etc.
- (xii) It should be possible to log system advisory messages, e.g. malfunctions within the management system itself, such as hardware failures, power loss, failure of a point to respond to a command, communication errors etc.
- (xiii) Operator will be allowed to define the engineering units, e.g. voltage, kWh, degrees centigrade, etc., and the ranges over which they are to be measured.
- (xiv) An alarm should be reported in case of breaking the pre-set limit of analogue points such as voltage, current etc.
- (xv) To avoid nuisance alarm, the software should have flexibility to allow varying the differentials or introducing time lag. For example, if a space temperature alarms at 25°C high and has a 0.1°C differential, it will be constantly going in and out of alarm between 25°C and 24.9°C. It would probably just as acceptable to have a 2°C differential which would reduce the number of alarms reported considerably and furthermore, when they did occur, would be more meaningful to the operator.
- (xvi) It should be possible to lock out analogue alarms, both by the operator and automatically, during start-up maintenance operations if nuisance alarms are to be avoided.
- (xvii) It should allow start/stop commands to be set up at precise times, with daily variations as well as allowing holiday programming.
- (xviii) The system will keep a record of how many hours a plant has been running or how long a point has been running or how long a point has been in a normal or off-normal condition.
- (xix) Limits to be set which can be used to alert the operator to the fact that maintenance is necessary or perhaps can automatically switch from one pump to another after a present period.
- (xx) A record of consumption of things such as litters of fuel used, kWh etc. will be kept.
- (xxi) English language for both input and output will be accepted.
- (xxii) The output information should be grouped in accordance with the make-up of the 'services' systems in the station building rather than the location of the field hardware.
- (xxiii) 'Prompting' feature will be provided, which takes the operator through the operation step by step, prompting and teaching him as he does it.
- (xxiv) Dynamic colour graphics will be used to show the schematic diagram of the system.
- (xxv) Different colours will be used to bring particular conditions to the attention of the operator. The contractor should submit scheme in this regard for approval of Employer/Engineer.
- (xxvi) The operator will have the facility to generate or draw his own graphics on the VDU and have a library of standard symbols available to him held in the memory of the system.
- (xxvii) Password will restrict access to certain important areas, so it is necessary to control who has access to a BMS, at what level and through which operator devices.
- (xxviii) Number of characters of password will not be less than eight.
- (xxix) Password time-out will be not more than 15 minutes ideally.
- (xxx) 'Database save' feature to copy the system database onto a separate storage medium, usually a disk, will be provided.
- (xxxi) Equipment's will run on its requirement; in the rest time it will be possible to be switched off to save the energy.
- (xxxii) HMI software- On the front screen icons for all systems shall be shown. Healthy and unhealthy status of these systems shall be shown by dynamic colour change of these icons.

## **B. General**

- (i) The Redundant PLC shall be application-software controlled, with the software assembled from proven software modules, and shall be capable of the following function and facilities:
  - a. Local time tagging of events.
  - b. Alarm handling from discrete inputs derived parameters.
  - c. Combining of digital inputs Boolean functions to give conditional outputs.

- d. The equipment shall be self-monitoring for fault conditions, and shall generate an alarm on the appropriate operator workstations in the event of a fault arising.
- (ii) Redundant PLC- software shall be capable of being reconfigured, under password control, either locally from the portable-programming device to be supplied under the Contract, or remotely over the communications links from operator workstations.
- (iii) Event processing shall have the following order of precedence, but shall be re-configurable:
  - a. Receipt of manual commands from operator workstations, each of which shall have an assignable level of command priority.
  - b. Pre-defined control sequences.
  - c. High-speed alarms.
  - d. Normal alarms.
  - e. Digital events.
  - f. Clock synchronization (With the master clock at OCC).
  - g. Analogue events.

#### C. Practical Considerations

##### (a) Design

- (i) Design and performance requirements
- (ii) Equipment or systems comprising several components shall be controlled through the BMS with suitable control regimes to achieve desired operation normally automatically but with provision for manual intervention. The automatic operation shall conform to the operational, functional and overall system needs as specified in this specification.
  - a. The contractor shall prepare in clear and logical form documents describing the functions transmitted and the operations carried out at the stations control room workstation and that at OCC. The control and transmission scheme shall be submitted for the consent of the Employer/Engineer.
  - b. The equipment shall also have arrangements to log and record various parameters on a regular basis and store the results for at least six months.
  - c. The BMS supplier/ contractor may propose the use of a serial data link instead of voltage free contacts. In this case the physical characteristics and data transmission protocol proposed shall conform to an internationally recognized publicly available standard. If there should be a match between the BMS supplier's proposal and the capabilities of the electrical/mechanical equipment in the field for serial data link to be adopted with the consent of the Employer. The contractor shall interface with other electrical and mechanical equipment supplier, as per the interface matrix.

##### (iii) Design Coordination Requirements

The Contractor shall submit a list of all design review documents for the review of the Employer/Engineer.

#### D. Applicable Design Standards

The list of references and standards already given in chapter (0). However, the following specifications in particular may be partially or wholly applicable, in respect of BMS design:

| SN | Standard/Code No. | Title   |
|----|-------------------|---|
| 1  | IEC 445           | Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system    |
| 2  | IEC 571-1         | General Requirements and tests for electronic equipment's   |
| 3  | IEC 571-3         | Components, programmable electronic equipments and electronic system reliability.   |
| 4  | IEC 617-12        | Binary logic elements-Graphical symbols to represent dependency notation, combinative and sequential element as well as complex function elements |
| 5  | IEC 801-3         | Radiated electromagnetic field requirements.  |

| SN | Standard/Code No.              | Title  |
|----|--------------------------------|--|
| 6  | IEC 870-1-1                    | Tele control equipment and systems-General Considerations  |
| 7  | IEC 870-2-1                    | Operating conditions   |
| 8  | IEC 870-4                      | Performance requirements   |
| 9  | IEC 870-5-4                    | Definition and coding of application information elements-Transmission protocols   |
| 10 | IEC 1082-1                     | Preparation of document (Signals, Diagrams)  |
| 11 | ISO/IEC 4873                   | Information Technology ISO 8-bit code for information interchange structure and rules for implementation                           |
| 12 | IEC 60848                      | Preparation of function charts for control systems   |
| 13 | IEC 61175                      | Designations for signals and connections   |
| 14 | IEC 61436<br>(All parts)       | Industrial system installation, equipment's and Industrial products-Structuring principles and reference designations              |
| 15 | IEC 61850-<br>Part-2           | Glossary   |
| 16 | IEC 61850-<br>Part-3           | General Requirements   |
| 17 | IEC 61850-<br>Part-4           | Communication networks and systems in substations system and project management  |
| 18 | IEC 61850-<br>Part-6           | Substation automation system configuration description language  |
| 19 | IEC 61850-7-1                  | Basic communication structure for substation and feeder equipment-Principles and models  |
| 20 | IEC 61850-10                   | Conformance testing  |
| 21 | BS 4737: Part 2                | Specification for installed system configuration description language  |
| 22 | BS 4737:<br>Section 4.1        | Code of practice for planning and installation   |
| 23 | BS 4737:<br>Section 4.2        | Code of practice for maintenance and records   |
| 24 | BS EN 14908-<br>1:2005         | Open data communication in building automation controls and building management, building network protocol, protocol stack         |
| 25 | BS EN 50090-<br>2-1            | Home and building electronic system-system overview, Architecture  |
| 26 | BS EN 50090-<br>2-2            | Home and building electronic system-system overview, General Technical Requirements  |
| 27 | BS ISO/IEC<br>6592             | Information technology: Guidelines for the documentation of computer-based applications system                                     |
| 28 | BS 5839-<br>1:2002 68<br>Pages | Code of practice for system design, installation, commissioning and maintenance for fire detection and alarm systems for buildings |
| 29 | BS EN 54-2 30<br>Pages         | Specifications for control and indicating equipment  |
| 30 | BS 6266 38<br>pages            | Code of practice for fire protection for electronic data processing installations  |
| 31 | BS EN ISO<br>9000-3            | Development, Supply, Installation and Maintenance of computer software   |
| 32 | IS: 1765                       | Direct Current potentiometers  |
| 33 | IS: 3043                       | Code of practice for earthing  |
| 34 | IS: 3700                       | Essential Rating and Characteristics of semiconductor device   |
| 35 | IS: 4007 Part1                 | Terminals for electronic equipment- General Requirements   |
| 36 | IS: 5051 Part1                 | Relays for electronic and telecommunication equipment- General Requirements  |

| SN | Standard/Code No.      | Title  |
|----|------------------------|--|
| 37 | IEEE 802 Series        | Local Area Network   |
| 38 | ISO 3511               | Process measurement control functions and instrument symbolic representation-part 1 basic requirements |
| 39 | IEC-60947-7-1          | Low voltage switch gear and control gear   |
| 40 | IEC-61643, 62305,60364 | Lightning and surge protection.  |
| 41 | EN: 60715-35           | Din rail made thick layer passivated (ROHS) complaint cold rolled carbon steel                         |

**E. Application of Specification**

The above specifications shall be applied in a manner altered, amended or supplemented by this specification and the latest Indian Electricity rules wherever applicable.

**F. Lightning**

- (i) The contractor shall ensure that all equipment are fully protected against the effects of mains surges and direct and indirect lightning strikes. Protection such as high voltage cut outs or high current cut outs shall be applied to incoming mains power supplies and to input and output signal lines to externally located sensors, transducers, actuating equipment, etc. or to any other equipment likely to be affected.
- (ii) Lightning protection systems shall be in accordance with BS 6651 —"Lightning Protection" or an equivalent Indian/international standard.
- (iii) All surge suppression equipment shall be self-contained and self-resetting.

**G. Alarm**

- (i) All alarms generated by the installation including processor alarms, power supply alarms, and control equipment alarms, shall be sustained until cleared. Alarm handling shall be implemented through the BMS system.
- (ii) Alarms will flash on the present screen and be audible to the station controller; it will be messaged to the mobile phone of the station controller and other concerned CLIENT authorities, as decided by the Employer.
- (iii) The Alarm shall be in a form of a hooter positioned at SCR, near to the BMS system

**H. Selection of Equipment**

- (i) The contractor should select the equipment's, subsystems of the BMS keeping in view the requirements given in this specification.
- (ii) In their technical bid, the bidders should provide details of systems, its subsystem, components etc.

**I. Installation**

- (i) It should be ensured that the noise within the communication links between the PLC and the SCR Workstation is avoided.
- (ii) Proper installation techniques should be employed to ensure adequate quality of signals from analogue sensors (transducers) to PLCs.
- (iii) Adequate measures shall be taken by the contractor to mitigate potential problems confronted due to the various forms of interference.
- (iv) A semi-rigid, shielded cabling, which is, to a certain extent, self-supporting, can be used for signal and communication wiring.
- (v) The Contractor shall supply and install all materials including but not limited to cable tray, brackets, and supports and execute all other works needed for supporting and routing all cabling and wiring relating to BMS. The contractor shall interface with Building/ Civil Contractors will make provisions in structures to accommodate the fastenings.



- (vi) The PLCs should preferably be wall mounted. All floor mounted PLCs will be grouted in the floor, so that vibrations due to SUB URBAN STATION train movement can be born. If the problem persists then rubber AVMs can be used.
- (vii) Separate tray, trunking and conduits will be used by the contractor for BMS cabling.
- (viii) All cables will be laid in tray, trunkings, and conduits as appropriate etc. Saddling of cables on the wall shall not be permitted.
- (ix) Dressing of cables will be done in such a manner that all cables will be laid parallel without laying/ crossing on each other. All the cables shall be properly tagged and marked on both ends and along the cable.
- (x) Bunching of cables near PLC entry, Power feeder entry and anywhere not permitted.
- (xi) All trays, trunkings and conduits will be marked with a definite colour and tray will be marked clearly as 'BMS Control'.
- (xii) A separate team of experienced BMS installation engineer, Software engineer, Electrician, Unskilled persons etc. will be kept for BMS work, for work completion as per schedule in the contract. A list of such team will be submitted to the Employer/Engineer one month before of the start of work.
- (xiii) Scaffold, welding machine, soldering iron and other tools/special tools & plants required for execution of works under this project shall be arranged by the contractor.
- (xiv) Installation, testing schedule will be provided one month before start of work and weekly progress will be submitted to the Employer/Engineer.
- (xv) Without complete installation, tray marking, cable tagging and dressing etc., no test will be allowed.
- (xvi) Where cables cross the track, wall or are in any part external to cable trough routes, then they shall be suitably protected through PVC conduits encased in concrete. Advantage shall be taken, in consultation with the Civil Contractors, to incorporate such additional protection into the basic construction of the concrete structures.
- (xvii) All cables except main power supply cables, entering or leaving equipment rooms and wayside apparatus boxes shall be terminated in order of their core number on combined terminal/disconnection or terminal/fuse links. Each wire shall be capable of being disconnected and isolated without removing the wire itself. These links shall be easily accessible for inspection and test. Each link or terminal shall be identified with the designation of the circuit it carries.
- (xviii) All electronic equipment shall comply, as a minimum, with IEC 571 or equivalent international specification. All components used shall be purchased from suppliers complying with internationally recognized quality management and reliability certification procedures. The Contractor shall declare in his offer the specifications to which he proposes to comply.
- (xix) Printed circuit boards shall be used to mount electronic components. The boards shall be of sufficient thickness to ensure mechanical rigidity. They shall not be the sole support for connectors, fascia panels, handles etc.
- (xx) All components shall be identified either by carrying a manufacturer's designation or part reference number or unique value in a standard format.
- (xxi) All metal enclosures shall be provided with an earthing terminal. The Contractor shall ensure that all the equipment's are properly and adequately earthed in accordance with safety standards and its rules.

#### **J. Testing and Commissioning**

##### **A. Testing General Requirements**

- i. There will be five type of tests-
  - a. Factory Acceptance test for PLC, Workstation and Printer- During the test all logics shall be demonstrated with simulator and sample PLC, Workstation and printer.
  - b. Installation test- After delivery of the PLC at the site, this test shall be arranged to check the physical healthiness of the hardware.

- c. Functional test- This test shall be arranged -to test the functioning of PLC, workstation and printer and communication network.
- d. System acceptance test- This test shall be arranged to test all automation and I/O list, with integration of communication network.
- e. Integrated test- This test shall be arranged to test the integration of the BMS server at SCR with OCC and all workstations of different stations.  
However, indicative S.A.T document shown in this specification, but it is contractor's responsibility to submit the separate test document for each type of test to the approval of Employer/Engineer. All tests shall be in sequence and on completion of previous test, next test shall be arranged. Before installation test, all QA/QC document shall be submitted to the Employer/Engineer for the approval.
- B. Basic monitoring and control functions will be demonstrated on a point-by-point basis. Checking out the software features is much more difficult and many of the programs will only be proved correct or otherwise by closely monitoring the BMS operation over an extended time period. The contractor shall provide necessary support till the time the system is reasonably established.
- C. A re-commission or check out of the operation of the BMS at the end of twelve months shall be carried out.
- D. The following requirements are intended to supplement and explain the General Specification requirements without in any way limiting their application.
  - a. The testing philosophy for the BMS SYSTEM shall ensure that the equipment functionality is thoroughly verified and validated at the Contractor's premises before delivery and commissioning. The test methodology shall be in line with the design methodology and the two shall be developed in parallel.
  - b. The principle of testing shall be that, at stages throughout the work, formal tests shall be performed and recorded against written test specifications, to provide a high level of confidence to the Contractor and the Employer/Engineer that subsequent stages can proceed.
  - c. The responsibility for specifying, conducting and recording tests shall be with the Contractor, but all aspects must be to the satisfaction of the Employer/Engineer. The Employer/Engineer will at his discretion witness any tests. The degree to which the Employer/Engineer intervenes in the process will depend upon the level of confidence built up during the project.
  - d. This document does not constitute a Test Specification or Test Procedure for any part of the system; rather it sets out the stages at which tests are required and the subjects, location and purpose of each stage. Inspection of incoming goods and components, and subassembly testing, shall be undertaken by the Contractor in accordance with the procedures set out in the Contractor's own Quality Management Plan and are not described here.
- K. **Responsibilities for Testing & Commissioning**  
(All test documentation associated with a subsystem or system test shall be submitted for review by the Employer/Engineer at least 30 days prior to the scheduled commencement of the associated test.
  - (i) The Contractor shall revise and re-submit any documents to which the Employer/Engineer has raised an objection such that all test documentation associated with any testing has achieved letter of no objection from the Employer/Engineer prior to the commencement of the corresponding testing.
  - (ii) The Contractor shall successfully carry out all pre-tests according to the finalized test procedures and correct any errors prior to any (associated) witnessed acceptance tests.
  - (iii) The Contractor shall produce permanent records of all test progress and results in a formal systematic manner and submit to the Employer/Engineer for his review.
  - (iv) The Contractor shall carry out all remedial work and re-testing found to be necessary in order that equipment shall pass the tests.

- (v) Control logics of all the BMS associated equipment are to be developed and consequently should be ratified by employer before commissioning of PLCs.
- (vi) Each of the above responsibilities shall be discharged to the satisfaction of the Employer/ Engineer, but no objection by the same shall not imply any diminution of the Contractor's responsibilities.

**L. Production Testing**

- (i) Inspection - Inspection of incoming goods and component, and subassembly tests, shall be performed in accordance with the Contractor's Quality Management Plan and shall include software production and integration testing.
- (ii) Product Inspection - Contractor's System Integration Testing - This is the contractors own internal and un-witnessed testing on the complete BMS SYSTEM, including all simulation programs necessary to prove the totality of functionality, prior to offering them up to the customers witnessed test(s).

**M. Acceptance**

- (i) The Contractor shall complete all relevant Production testing before offering any Item, Subsystem or the System as a whole for any witnessed acceptance test. All documentation covering the results of Production tests shall be referenced in the notice of witness testing submitted by the Contractor. The acceptance test stages follow the requirements of the GS clauses of the contract.
- (ii) All parts subject to wear, such as electromechanical peripherals, may be omitted from the tests if agreed by the Employer/Engineer. The printing and recording equipment needed for conducting the test shall be run throughout the test. All refills should be supplied during the period up to final handing over.
- (iii) Tests shall be conducted to prove the individual and integrated functioning of the system hardware and demonstrate performance in the face of various contingencies.
- (iv) Integrated system tests shall be conducted to prove the functionality of all applications software in the context of the complete integrated system, equipment and software configuration. The contractor shall develop system test, procedure for all sub systems.

**1.25 Input / Output List (Indicative)**

- A. The BMS system shall provide monitoring and control of the following sub systems, as specified in the respective clauses of this specification. It is the responsibility of the contractor to interpret the entire requirements of the specification and to provide input/output interfaces as per Employer & operational requirement during execution.
- B. Automation
  - (i) When water level becomes lower than a predefined mark, pump will start to fill it.
  - (ii) When water level reaches to up-to-mark, pump will stop.
  - (iii) Fire water level will not be less than 90%, at such situation Tube well pump will start and alarm will be generated.
  - (iv) If main water supply pump fails, then standby pump shall be started automatically.
  - (v) Based on the detailed design, the Contractor shall develop a detailed BMS input/output point list for all equipment's to be monitored and/or controlled subject to the approval of the Employer/Engineer.
  - (vi) Control and monitoring shall be provided primarily at the SCR. It shall be possible, however, to enable secondary control and monitoring of equipment's from OCC
  - (vii) Description of basic functions is given in Table below:

| Category                | Functions                  |   |
|-------------------------|----------------------------|---|
|                         | Specified Categories       | Description   |
| Monitor and Supervision | CRT- based supervision     | Window functions are available, enabling display of plural supervisory screen at the same time. |
|                         | 1) Status display of units | Displaying position symbol of units with the shape, color, flickering                           |
|                         | 2) Fault Display           | Displaying position symbol of units with the shape, color, flickering                           |

| Category             | Functions  |   |
|----------------------|--|---|
|                      | Specified Categories   | Description   |
|                      | 3) Telemetry value display   | Display major telemetry values of voltage, current etc.   |
|                      | 4) Ready for command   | Graphics colour will be yellow  |
|                      | 5) Running status  | Graphics colour for green   |
|                      | 6) High/Low limit check  | Supervision and display of deviation of voltage, current and such telemetry data from High/Low setting values.                                |
|                      | 7) Trip  | Trip status of the breaker will be shown by specific color (Red)  |
| Control              | Local  | No control from BMS workstation, graphics colour will become Red  |
|                      | Remote/Auto  | Workstation control available, Graphics colour becomes yellow. In auto state controlled by predefined logic.                                  |
| Record and Reporting | 1) Reporting management  | Automatic collection of various achievement data for editing and listing of operational achievement documents.                                |
|                      | a) Daily Report  | Reporting and printing out a daily report of data arising from hourly telemeter and incidence occurrence                                      |
|                      | b) Monthly Report  | Reporting and printing out a monthly report of data arising from daily report   |
|                      | c) Annual Report   | Reporting and printing out an annual report of data arising from Monthly report   |
| Record and Reporting | 2) Message summary record  | Reporting and printing out a message list, supported by sorting and editing functions based on specific factors, such as time and facilities. |
|                      | a) Message list Record   | Reporting the contents of equipment operation status change and alarming  |
|                      | b) Memo recording screen   | Reporting the contents of equipment operation status change and alarming  |
| Other Functions      | 1) Change over remote control to manual control and vice versa   | Security protection by log-on password checks (operators, system managers, programmers)   |
|                      | 2) Right of operation supervision and setting.<br>a) Security Protection<br>b) Operation Privilege setting | Setting up the scope of right-of –operation with a user name to cover supervisory control objectives.   |

(viii) Description of basic IO Point's is given in Table below:

| S. NO. | DESCRIPTION                                      | Equipment Qty. |    |    |    |            | INTERFACE TYPE |             |
|--------|--|----------------|----|----|----|------------|----------------|-------------|
|        |  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION |
| A      | <b>MDB Circuit Breaker Incomer IC - 01 (ACB)</b> |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                               |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                      |                |    | 1  |    |            | VFC            | TB          |
| 3      | Feeder Line Voltage                              |                |    |    |    | 1          | MFM/DFM/IDM    | Modbus      |
| 4      | Feeder Line Current                              |                |    |    |    | 1          |                |             |
| 5      | Feeder Volt Ampere (VA)                          |                |    |    |    | 1          |                |             |
| 6      | Feeder Frequency (Hz)                            |                |    |    |    | 1          |                |             |
| 7      | Feeder Power Factor (PF)                         |                |    |    |    | 1          |                |             |
| 8      | Feeder Kilo Watt Hour (KWHR)                     |                |    |    |    | 1          |                |             |

| S. NO. | DESCRIPTION  | Equipment Qty. |    |    |    |            | INTERFACE TYPE |             |
|--------|--|----------------|----|----|----|------------|----------------|-------------|
|        |  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION |
| 9      | Feeder Volt Ampere Reactive (VAR)                    |                |    |    |    | 1          |                |             |
|        |  |                |    |    |    |            |                |             |
| B      | <b>MDB Circuit Breaker Incomer - IC - 02 (ACB)</b>   |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                                   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                          |                |    | 1  |    |            | VFC            | TB          |
| 3      | Feeder Line Voltage                                  |                |    |    |    | 1          | MFM/DFM/IDM    | Modbus      |
| 4      | Feeder Line Current                                  |                |    |    |    | 1          |                |             |
| 5      | Feeder Volt Ampere (VA)                              |                |    |    |    | 1          |                |             |
| 6      | Feeder Frequency (Hz)                                |                |    |    |    | 1          |                |             |
| 7      | Feeder Power Factor (PF)                             |                |    |    |    | 1          |                |             |
| 8      | Feeder Kilo Watt Hour (KWHR)                         |                |    |    |    | 1          |                |             |
| 9      | Feeder Volt Ampere Reactive (VAR)                    |                |    |    |    | 1          |                |             |
|        |  |                |    |    |    |            |                |             |
| C      | <b>MDB Circuit Breaker Bus Coupler</b>               |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                                   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                          |                |    | 1  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| D      | <b>Outgoing Breaker for MDB-IC-1 (1 to 7 -MCCB )</b> |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                                   |                |    | 7  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                          |                |    | 7  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| E      | <b>Outgoing Breaker for MDB-IC-2(8 to 13 -MCCB)</b>  |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                                   |                |    | 6  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                          |                |    | 6  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| F      | <b>ESPP PANEL (1 IC working + 1 IC Spare - MCCB)</b> |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                                   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                          |                |    | 1  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| G      | <b>Outgoing Breaker for ESPP-IC (1 to 7 -MCCB)</b>   |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm                                   |                |    | 7  |    |            | VFC            | TB          |
| 2      | Breaker Close Status                                 |                |    | 7  |    |            | VFC            | TB          |
| 3      | Breaker Open Status                                  |                |    | 7  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| H      | <b>MAIN LIGHTING PANEL (MLP -IC-1-MCCB)</b>          |                |    |    |    |            |                |             |

| S. NO. | DESCRIPTION  | Equipment Qty. |    |    |    |            | INTERFACE TYPE |             |
|--------|--|----------------|----|----|----|------------|----------------|-------------|
|        |  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION |
| 1      | Breaker Trip Alarm   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 1  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| I      | <b>MAIN LIGHTING LIGHTING PANEL (MLP -IC-2-MCCB)</b>       |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 1  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| J      | <b>EMERGENCY LIGHTING PANEL (EMLP )</b>                    |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 1  |    |            | VFC            | TB          |
| 3      | Feeder Line Voltage  | 1              |    |    |    |            | 4-20 mA        | Transducer  |
| 4      | Feeder Line Current  | 1              |    |    |    |            | 4-20 mA        | Transducer  |
|        |  |                |    |    |    |            |                |             |
| K      | <b>ACPP PANEL (1 IC working + 1 IC Spare - MCCB)</b>       |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 2  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 2  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| L      | <b>WATER PUMP PANEL (1 IC working + 1 IC Spare - MCCB)</b> |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 2  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 2  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| M      | <b>FIRE PUMP PANEL (1 IC MDB + 1 IC DG - MCCB)</b>         |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 2  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 2  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| N      | <b>EMDB (1 IC MDB1 + 1 IC MDB2 - MCCB)</b>                 |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 2  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 2  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| O      | <b>COMMERCIAL POWER PANEL (CPP)</b>                        |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 1  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |
| P      | <b>UPP PANEL (MDB2-IC-- MCCB)</b>                          |                |    |    |    |            |                |             |
| 1      | Breaker Trip Alarm   |                |    | 1  |    |            | VFC            | TB          |
| 2      | Breaker Open / Close Status                                |                |    | 1  |    |            | VFC            | TB          |
|        |  |                |    |    |    |            |                |             |



| S. NO. | DESCRIPTION                      | Equipment Qty. |    |    |    |            | INTERFACE TYPE |                 |
|--------|----------------------------------|----------------|----|----|----|------------|----------------|-----------------|
|        |                                  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION     |
| Q      | <b>S&amp;T UPS Panel Breaker</b> |                |    |    |    |            |                |                 |
| 1      | Breaker Trip Alarm               |                |    | 1  |    |            | VFC            | TB              |
| 2      | Breaker Open / Close Status      |                |    | 1  |    |            | VFC            | TB              |
|        |                                  |                |    |    |    |            |                |                 |
| R      | <b>E&amp;M UPS Panel Breaker</b> |                |    |    |    |            |                |                 |
| 1      | Breaker Trip Alarm               |                |    | 1  |    |            | VFC            | TB              |
| 2      | Breaker Open / Close Status      |                |    | 1  |    |            | VFC            | TB              |
|        |                                  |                |    |    |    |            |                |                 |
| S      | <b>S&amp;T UPS</b>               |                |    |    |    |            |                |                 |
| 1      | UPS Input Voltage                |                |    |    |    | 1          | RS485          | Micro Processor |
| 2      | UPS Input Frequency              |                |    |    |    | 1          |                |                 |
| 3      | UPS Input Power Factor           |                |    |    |    | 1          |                |                 |
| 4      | UPS Output Voltage               |                |    |    |    | 1          |                |                 |
| 5      | UPS Output Frequency             |                |    |    |    | 1          |                |                 |
| 6      | UPS Output Power Factor          |                |    |    |    | 1          |                |                 |
| 7      | UPS Rectifier Off                |                |    |    |    | 1          |                |                 |
| 8      | UPS Rectifier Over Temperature   |                |    |    |    | 1          |                |                 |
| 9      | UPS Rectifier Fail               |                |    |    |    | 1          |                |                 |
| 10     | UPS Inverter Off                 |                |    |    |    | 1          |                |                 |
| 11     | UPS Inverter Over Temp           |                |    |    |    | 1          |                |                 |
| 12     | UPS Inverter Fail                |                |    |    |    | 1          |                |                 |
| 13     | UPS Load on Bypass               |                |    |    |    | 1          |                |                 |
| 14     | UPS Overload                     |                |    |    |    | 1          |                |                 |
|        |                                  |                |    |    |    |            |                |                 |
| T      | <b>E&amp;M UPS</b>               |                |    |    |    |            |                |                 |
| 1      | UPS Input Voltage                |                |    |    |    | 1          | RS485          | Micro Processor |
| 2      | UPS Input Frequency              |                |    |    |    | 1          |                |                 |
| 3      | UPS Input Power Factor           |                |    |    |    | 1          |                |                 |
| 4      | UPS Output Voltage               |                |    |    |    | 1          |                |                 |
| 5      | UPS Output Frequency             |                |    |    |    | 1          |                |                 |
| 6      | UPS Output Power Factor          |                |    |    |    | 1          |                |                 |
| 7      | UPS Rectifier Off                |                |    |    |    | 1          |                |                 |
| 8      | UPS Rectifier Over Temperature   |                |    |    |    | 1          |                |                 |
| 9      | UPS Rectifier Fail               |                |    |    |    | 1          |                |                 |
| 10     | UPS Inverter Off                 |                |    |    |    | 1          |                |                 |
| 11     | UPS Inverter Over Temp           |                |    |    |    | 1          |                |                 |
| 12     | UPS Inverter Fail                |                |    |    |    | 1          |                |                 |
| 13     | UPS Load on Bypass               |                |    |    |    | 1          |                |                 |

| S. NO. | DESCRIPTION  | Equipment Qty. |    |    |    |            | INTERFACE TYPE |   |
|--------|--|----------------|----|----|----|------------|----------------|---|
|        |  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION                             |
| 14     | UPS Overload   |                |    |    |    | 1          |                |   |
|        |  |                |    |    |    |            |                |   |
| U      | <b>Battery</b>   |                |    |    |    |            |                |   |
| 1      | Battery 01 Voltage   | 1              |    |    |    |            | RS 485         | Micro Processor                         |
| 2      | Battery 01 Current   |                |    |    |    |            |                |   |
| 3      | Battery 01 On Load   |                |    |    |    |            |                |   |
| 4      | Battery 01 Over Temp   |                |    |    |    |            |                |   |
|        |  |                |    |    |    |            |                |   |
| V      | <b>TYPE -1 LDB STATUS ( 1 TO 4)</b>  |                |    |    |    |            |                |   |
| 1      | Trip Alarm   |                |    | 4  |    |            | VFC            | TB                                      |
| 2      | Breaker Open / Close Status  |                |    | 4  |    |            | VFC            | TB                                      |
|        |  |                |    |    |    |            |                |   |
| W      | <b>TYPE -2 LDB STATUS ( 1 TO 2)</b>  |                |    |    |    |            |                |   |
| 1      | Trip Alarm   |                |    | 2  |    |            | VFC            | TB                                      |
| 2      | Breaker Open / Close Status  |                |    | 2  |    |            | VFC            | TB                                      |
|        |  |                |    |    |    |            |                |   |
| X      | <b>TYPE -3 LDB STATUS</b>  |                |    |    |    |            |                |   |
| 1      | Trip Alarm   |                |    | 1  |    |            | VFC            | TB                                      |
| 2      | Breaker Open / Close Status  |                |    | 1  |    |            | VFC            | TB                                      |
|        |  |                |    |    |    |            |                |   |
| Y      | <b>ESCALATOR STATUS ( 1 TO 04)</b>   |                |    |    |    |            |                |   |
| 1      | Trip Alarm   |                |    | 4  |    |            | VFC            | TB                                      |
| 2      | Emergency stop status  |                |    | 4  |    |            | VFC            | TB                                      |
| 3      | Forward / Reverse Status   |                |    | 4  |    |            | VFC            | TB                                      |
|        |  |                |    |    |    |            |                |   |
| Z      | <b>LIFT STATUS ( 1 TO 04)</b>  |                |    |    |    |            |                |   |
| 1      | Trip Alarm   |                |    | 4  |    |            | VFC            | TB                                      |
| 2      | Emergency stop status  |                |    | 4  |    |            | VFC            | TB                                      |
| 3      | UP /Down Status  |                |    | 4  |    |            | VFC            | TB                                      |
|        |  |                |    |    |    |            |                |   |
| AA     | <b>Indoor Unit (IDU//C/01 TO IDU/C/15) (3 No SCR , 3NO SPER, 3 No S&amp;T UPS , 3 No TER , 3 No UPS ELEC )</b> |                |    |    |    |            |                |   |
| 1      | On/Off Command   |                |    |    |    | 15         | RS 485         | Central Processor Unit /Micro Processor |
| 2      | Air Flow direction status  |                |    |    |    | 15         |                |   |
| 3      | IDU Running Feedback   |                |    |    |    | 15         |                |   |
| 4      | Local/Remote Status  |                |    |    |    | 15         |                |   |
| 5      | Emergency Stop Button Position   |                |    |    |    | 15         |                |   |

| S. NO. | DESCRIPTION  | Equipment Qty. |    |    |    |            | INTERFACE TYPE |  |
|--------|--|----------------|----|----|----|------------|----------------|--|
|        |  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION                                      |
| 6      | IDU Trip   |                |    |    |    | 15         |                |  |
| 7      | IDU Current  |                |    |    |    | 15         |                |  |
| 8      | IDU Thermostat                                       |                |    |    |    | 15         |                |  |
| 9      | IDU filter alarm                                     |                |    |    |    | 15         |                |  |
| 10     | IDU set temperature                                  |                |    |    |    | 15         |                |  |
| 11     | Fault/ Normal  |                |    |    |    | 15         |                |  |
| 12     | Lock command   |                |    |    |    | 15         |                |  |
| 13     | Lock status  |                |    |    |    | 15         |                |  |
| 14     | Filter status  |                |    |    |    | 15         |                |  |
| 15     | Mode command   |                |    |    |    | 15         |                |  |
| 16     | Mode status  |                |    |    |    | 15         |                |  |
| 17     | Swing command  |                |    |    |    | 15         |                |  |
| 18     | Swing Status   |                |    |    |    | 15         |                |  |
| 19     | Fan Speed Command                                    |                |    |    |    | 15         |                |  |
| 20     | Fan Speed Status                                     |                |    |    |    | 15         |                |  |
| 21     | Room temp status                                     |                |    |    |    | 15         |                |  |
| 22     | Power status   |                |    |    |    | 15         |                |  |
|        |  |                |    |    |    |            |                |  |
| AB     | <b>Indoor Unit (IDU/01 TO IDU/2)<br/>(2 No TOM )</b> |                |    |    |    |            |                |  |
| 1      | On/Off Command                                       |                |    |    |    | 2          | RS 485         | Central<br>Processor Unit<br>/Micro<br>Processor |
| 2      | Air Flow direction status                            |                |    |    |    | 2          |                |  |
| 3      | IDU Running Feedback                                 |                |    |    |    | 2          |                |  |
| 4      | Local/Remote Status                                  |                |    |    |    | 2          |                |  |
| 5      | Emergency Stop Button Position                       |                |    |    |    | 2          |                |  |
| 6      | IDU Trip   |                |    |    |    | 2          |                |  |
| 7      | IDU Current  |                |    |    |    | 2          |                |  |
| 8      | IDU Thermostat                                       |                |    |    |    | 2          |                |  |
| 9      | IDU filter alarm                                     |                |    |    |    | 2          |                |  |
| 10     | IDU set temperature                                  |                |    |    |    | 2          |                |  |
| 11     | Fault/ Normal  |                |    |    |    | 2          |                |  |
| 12     | Lock command   |                |    |    |    | 2          |                |  |
| 13     | Lock status  |                |    |    |    | 2          |                |  |
| 14     | Filter status  |                |    |    |    | 2          |                |  |
| 15     | Mode command   |                |    |    |    | 2          |                |  |
| 16     | Mode status  |                |    |    |    | 2          |                |  |
| 17     | Swing command  |                |    |    |    | 2          |                |  |
| 18     | Swing Status   |                |    |    |    | 2          |                |  |
| 19     | Fan Speed Command                                    |                |    |    |    | 2          |                |  |
| 20     | Fan Speed Status                                     |                |    |    |    | 2          |                |  |

| S. NO. | DESCRIPTION   | Equipment Qty. |    |    |    |            | INTERFACE TYPE |   |
|--------|---|----------------|----|----|----|------------|----------------|---|
|        |   | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION                             |
| 21     | Room temp status  |                |    |    |    | 2          |                |   |
| 22     | Power status  |                |    |    |    | 2          |                |   |
|        |   |                |    |    |    |            |                |   |
| AC     | <b>Outdoor unit (ODU/01 TO ODU/3 , 2 working &amp; 1 standby )</b>      |                |    |    |    |            |                |   |
| 1      | On/Off Command  |                |    |    |    | 3          | RS 485         | Central Processor Unit /Micro Processor |
| 2      | ODU Running Feedback  |                |    |    |    | 3          |                |   |
| 3      | Local/Remote Switch Status  |                |    |    |    | 3          |                |   |
| 4      | Emergency Stop Button Position  |                |    |    |    | 3          |                |   |
| 5      | ODU Trip  |                |    |    |    | 3          |                |   |
| 6      | ODU Current   |                |    |    |    | 3          |                |   |
| 7      | Local/Remote Status   |                |    |    |    | 3          |                |   |
| 8      | Comp Oper Status  |                |    |    |    | 3          |                |   |
| 9      | Refrigent Type status   |                |    |    |    | 3          |                |   |
| 10     | Inverter Fan Freq   |                |    |    |    | 3          |                |   |
| 11     | High Pressure   |                |    |    |    | 3          |                |   |
| 12     | Low Pressure  |                |    |    |    | 3          |                |   |
| 13     | Suction Temp  |                |    |    |    | 3          |                |   |
| 14     | Liquid Pipe Temp  |                |    |    |    | 3          |                |   |
| 15     | Hex Temp  |                |    |    |    | 3          |                |   |
| 16     | Outdoor EEV   |                |    |    |    | 3          |                |   |
| 17     | Sub-Cool EEV  |                |    |    |    | 3          |                |   |
| 18     | Hot gas Value   |                |    |    |    | 3          |                |   |
| 19     | Inverter Discharge Temp   |                |    |    |    | 3          |                |   |
| 20     | Outdoor Temp  |                |    |    |    | 3          |                |   |
| 21     | Operation Mode  |                |    |    |    | 3          |                |   |
|        |   |                |    |    |    |            |                |   |
| AD     | <b>TOM -Outdoor unit (ODU/01 TO ODU/3 , 2 working &amp; 1 standby )</b> |                |    |    |    |            |                |   |
| 1      | On/Off Command  |                |    |    |    | 3          | RS 485         | Central Processor Unit /Micro Processor |
| 2      | ODU Running Feedback  |                |    |    |    | 3          |                |   |
| 3      | Local/Remote Switch Status  |                |    |    |    | 3          |                |   |
| 4      | Emergency Stop Button Position  |                |    |    |    | 3          |                |   |
| 5      | ODU Trip  |                |    |    |    | 3          |                |   |
| 6      | ODU Current   |                |    |    |    | 3          |                |   |
| 7      | Local/Remote Switch Status  |                |    |    |    | 3          |                |   |
| 8      | Emergency Stop Button Position  |                |    |    |    | 3          |                |   |
| 9      | Refrigent Type status   |                |    |    |    | 3          |                |   |

| S. NO. | DESCRIPTION                            | Equipment Qty. |    |    |    |            | INTERFACE TYPE |             |
|--------|--|----------------|----|----|----|------------|----------------|-------------|
|        |  | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION |
| 10     | Inverter Fan Freq                      |                |    |    |    | 3          |                |             |
| 11     | High Pressure                          |                |    |    |    | 3          |                |             |
| 12     | Low Pressure                           |                |    |    |    | 3          |                |             |
| 13     | Suction Temp                           |                |    |    |    | 3          |                |             |
| 14     | Liquid Pipe Temp                       |                |    |    |    | 3          |                |             |
| 15     | Hex Temp                               |                |    |    |    | 3          |                |             |
| 16     | Outdoor EEV                            |                |    |    |    | 3          |                |             |
| 17     | Sub-Cool EEV                           |                |    |    |    | 3          |                |             |
| 18     | Hotgas Value                           |                |    |    |    | 3          |                |             |
| 19     | Inverter Discharge Temp                |                |    |    |    | 3          |                |             |
| 20     | Outdoor Temp                           |                |    |    |    | 3          |                |             |
| 21     | Operation Mode                         |                |    |    |    | 3          |                |             |
|        |  |                |    |    |    |            |                |             |
| AE     | <b>FIRE HYDRANT PUMP -01 to 02</b>     |                |    |    |    |            |                |             |
| 1      | Flow status                            |                |    | 2  |    |            | VFC            | TB          |
| 2      | Motor Running Feedback                 |                |    | 2  |    |            | VFC            | TB          |
| 3      | Emergency Stop Button Position         |                |    | 2  |    |            | VFC            | TB          |
| 4      | Trip Status                            |                |    | 2  |    |            | VFC            | TB          |
| 5      | Motor Current                          | 2              |    |    |    |            | 4-20 mA        | Transducer  |
|        |  |                |    |    |    |            |                |             |
| AF     | <b>JOCKEY PUMP -01</b>                 |                |    |    |    |            |                |             |
| 1      | Flow status                            |                |    | 1  |    |            | VFC            | TB          |
| 2      | Motor Running Feedback                 |                |    | 1  |    |            | VFC            | TB          |
| 3      | Emergency Stop Button Position         |                |    | 1  |    |            | VFC            | TB          |
| 4      | Trip Status                            |                |    | 1  |    |            | VFC            | TB          |
| 5      | Motor Current                          | 1              |    |    |    |            | 4-20 mA        | Transducer  |
|        |  |                |    |    |    |            |                |             |
| AG     | <b>DEWATERING SUMP PUMP - 01 to 02</b> |                |    |    |    |            |                |             |
| 1      | On/Off Command                         |                |    |    | 2  |            | 230 VAC        | TB          |
| 2      | Flow status                            |                |    | 2  |    |            | VFC            | TB          |
| 3      | Motor Running Feedback                 |                |    | 2  |    |            | VFC            | TB          |
| 4      | Local/Remote Switch Status             |                |    | 2  |    |            | VFC            | TB          |
| 5      | Emergency Stop Button Position         |                |    | 2  |    |            | VFC            | TB          |
| 6      | Trip Status                            |                |    | 2  |    |            | VFC            | TB          |
| 7      | Motor Current                          | 2              |    |    |    |            | 4-20 mA        | Transducer  |
|        |  |                |    |    |    |            |                |             |
| AH     | <b>BOREWELLWATER PUMP -01 to 02</b>    |                |    |    |    |            |                |             |
| 1      | Flow status                            |                |    | 2  |    |            | VFC            | TB          |

| S. NO. | DESCRIPTION                          | Equipment Qty. |    |    |    |            | INTERFACE TYPE |             |
|--------|--------------------------------------|----------------|----|----|----|------------|----------------|-------------|
|        |                                      | AI             | AO | DI | DO | SOFT POINT | CONTACT        | TERMINATION |
| 2      | Motor Running Feedback               |                |    | 2  |    |            | VFC            | TB          |
| 3      | Emergency Stop Button Position       |                |    | 2  |    |            | VFC            | TB          |
| 4      | Trip Status                          |                |    | 2  |    |            | VFC            | TB          |
| 5      | Motor Current                        | 2              |    |    |    |            | 4-20 mA        | Transducer  |
|        |                                      |                |    |    |    |            |                |             |
| AI     | <b>DOMESTIC WATER PUMP -01 to 02</b> |                |    |    |    |            |                |             |
| 1      | On/Off Command                       |                |    |    | 2  |            | 230 VAC        | TB          |
| 2      | Flow status                          |                |    | 2  |    |            | VFC            | TB          |
| 3      | Motor Running Feedback               |                |    | 2  |    |            | VFC            | TB          |
| 4      | Local/Remote Switch Status           |                |    | 2  |    |            | VFC            | TB          |
| 5      | Emergency Stop Button Position       |                |    | 2  |    |            | VFC            | TB          |
| 6      | Trip Status                          |                |    | 2  |    |            | VFC            | TB          |
| 7      | Motor Current                        | 2              |    |    |    |            | 4-20 mA        | TB          |
|        |                                      |                |    |    |    |            |                |             |
| AJ     | <b>DG</b>                            |                |    |    |    |            |                |             |
| 1      | Main Supply Off Alarm                |                |    |    |    | 1          | AMF            | Modbus      |
| 2      | DG Auto<Manual Status                |                |    |    |    | 1          |                |             |
| 3      | Dual Supply Status                   |                |    |    |    | 1          |                |             |
| 4      | Engine Running Feedback              |                |    |    |    | 1          |                |             |
| 5      | DG Common Fault Alarm                |                |    |    |    | 1          |                |             |
| 6      | DG Battery Voltage Status            |                |    |    |    | 1          |                |             |
| 7      | Room Exhaust Fan On/Off Status       |                |    |    |    | 1          |                |             |
| 8      | Lube Oil Low Pressure Alarm          |                |    |    |    | 1          |                |             |
| 9      | DG Radiator High Temperature Alarm   |                |    |    |    | 1          |                |             |
| 10     | DG Radiator Water Level Low Alarm    |                |    |    |    | 1          |                |             |
| 11     | Fuel Tank 1 Low Level Alarm          |                |    |    |    | 1          |                |             |
| 12     | Fuel Tank 2 Low Level Alarm          |                |    |    |    | 1          |                |             |
| 13     | Switch to DG 1 Status                |                |    |    |    | 1          |                |             |
| 14     | Switch to DG 2 Status                |                |    |    |    | 1          |                |             |
| 15     | DG 1 Running Hours                   |                |    |    |    | 1          |                |             |
| 16     | DG 2 Running Hours                   |                |    |    |    | 1          |                |             |
|        |                                      |                |    |    |    |            |                |             |
| AK     | <b>Tanks level Status</b>            |                |    | 1  |    |            |                |             |
| 1      | Fire Water Tank Low Level Alarm      |                |    | 1  |    |            | VFC            | TB          |
| 2      | Fire Water Tank High Level           |                |    | 1  |    |            | VFC            | TB          |



| S. NO.                | DESCRIPTION                           | Equipment Qty. |           |            |           |             | INTERFACE TYPE |             |
|-----------------------|---------------------------------------|----------------|-----------|------------|-----------|-------------|----------------|-------------|
|                       |                                       | AI             | AO        | DI         | DO        | SOFT POINT  | CONTACT        | TERMINATION |
| 3                     | Fire Water Tank very High Level       |                |           | 1          |           |             | VFC            | TB          |
| 4                     | Fire Water Tank Ultra High Level      |                |           | 1          |           |             | VFC            | TB          |
| 5                     | Over Head Water Tank Low Level Alarm  |                |           | 1          |           |             | VFC            | TB          |
| 6                     | Over Head Water Tank high Level       |                |           | 1          |           |             | VFC            | TB          |
| 7                     | Over Head Water Tank Very high Level  |                |           | 1          |           |             | VFC            | TB          |
| 8                     | Over Head Water Tank Ultra high Level |                |           | 1          |           |             | VFC            | TB          |
| 9                     | Domestic Water Tank Low Level Alarm   |                |           | 1          |           |             | VFC            | TB          |
| 10                    | Domestic Water Tank high Level        |                |           | 1          |           |             | VFC            | TB          |
| 11                    | Domestic Water Tank Very high Level   |                |           | 1          |           |             | VFC            | TB          |
| 12                    | Domestic Water Tank Ultra high Level  |                |           |            |           |             | VFC            | TB          |
| <b>TOTAL IO POINT</b> |                                       | <b>12</b>      | <b>0</b>  | <b>175</b> | <b>4</b>  | <b>560</b>  |                |             |
|                       |                                       | <b>AI</b>      | <b>AO</b> | <b>DI</b>  | <b>DO</b> | <b>SOFT</b> |                |             |

**Note:** All software needed for proper functioning/operation shall be supplied by the contractor with adequate license and if any supplied software goes defunct by any way, the same shall be restored by the contractor during defect liability period free of cost. All software to be supplied shall be latest version at the time of tender.

#### 1.26 Training

##### A. General

Training shall be provided for Employer's engineers and staff such that the PLC Control Systems can be operated and maintained in accordance with the Manufacturer's requirements.

The Contractor shall submit for review by the Employer/Engineer a training plan 180 day prior to the first testing and commissioning activity.

##### B. Scope of Training

The training shall include both normal and abnormal operations. At the discretion of K-RIDE training will be provided in the following categories:

Operations staff will include as a minimum:

- i. Duty chief controller;
- ii. station controllers;
- iii. Engineering coordinator;
- iv. Communications coordinator;
- v. Operations planners and scheduler; and
- vi. Employer's Training Instructors and trainers.
  - a. Engineering staff shall include as a minimum: -

- vii. Maintenance staff;
- viii. Fault report centre staff;
- ix. Design staff; and
- x. Employer's Training Instructors and trainers.
  - a. Management staff shall include as a minimum: -
    - xi. Supervisors;
    - xii. Line managers;
    - xiii. Section managers; and
    - xiv. Department managers.

#### Normal and Abnormal Operation

The Contractor shall train the Employer's engineers and staff in the normal day to day operation of the BMS for stand-alone and integrated operation and maintenance of all control, monitoring, and supervision functionality of the Low Voltage Power & Distribution, Fire Alarm System, Hydraulic System (Seepage, Sewage, Bore Well Pumps etc.) for control, monitoring, and supervision at the Operational Control Centre (OCC).

#### C. **System Design and Configuration**

The Contractor shall provide training to the Employer's engineers and staff in the design and configuration of the System. This training shall include:

- i. Systems overview;
- ii. Systems configuration and data preparation; and
- iii. Principles of operation.

#### D. **Maintenance Training**

Training shall be provided to the Employer's engineers and staff to undertake maintenance of the System provided following substantial completion of the Works. This training shall include:

- i. Principles of operation;
- ii. Preventative and corrective maintenance tasks and procedures;
- iii. Fault repair to the lowest level replaceable unit;
- iv. Use of test equipment, diagnostic and maintenance aids; and
- v. Software maintenance including database structure, generation, modification and system software organization.

The courses will be attended by about 20 Employer's staff.

#### E. **Training Format**

The Contractor shall comply with relevant clause of Employer's Requirements - Manufacturing, Installation and Testing.



## Annexure-2 TESTING AND INSPECTION

### 1. General

- A. As part of the preliminary design submission the Contractor shall submit to the “Engineer” for acceptance a schedule of tests giving full details of all tests to be carried out.
- B. Tests at places of manufacture to be witnessed by the “Engineer” shall be grouped together so far as can be arranged so that as many tests as possible can be witnessed on each visit.
- C. The Contractor shall prepare and forward to the “Engineer” an original and four copies of all Test Reports as soon as practicable after completion of each test whether witnessed by the “Engineer” or not. All test data shall be certified by the Contractor’s Professional Engineer.
- D. The Contractor shall perform all applicable test specified in these specifications as per the relevant standards. Any test required as per the applicable safety standards but not specified in this specification shall be performed without any extra cost to K-RIDE.
- E. The contractor has to take the EIG (Electrical Inspector to Government) approval of the E&M Installation before commissioning of the same. The contractor has to comply with all the requirements for the EIG inspection, make the necessary application & should make all the arrangements, conduct tests and submit the required compliance certificates necessary for the approval. The application should be submitted with approval of the Employer/Engineer.

### 2. General Requirements for Type Tests and Acceptance Tests

- A. The Bidder shall provide details of any type and acceptance tests, which have been carried out on equipment offered, or any additional tests he recommends.
- B. In general, certificates of previous type tests may be accepted at the discretion of the “Engineer”, provided that they are for identical equipment and conditions. Where appropriate, new and/or modified components to meet the requirements of this Specification shall be made available for type testing.
- C. All applicable Type tests as per the relevant standards on equipment shall be carried out strictly as specified in the Specification and procedure of testing shall be submitted to “Engineer” for No Objection.
- D. The “Engineer” shall have right to witness tests and inspections on individual materials, components, or sub-assemblies, and details of these shall be agreed between the Contractor and the “Engineer”.
- E. At the conclusion of all type tests, the Contractor shall compile all the test data together with any observations made during the tests, file them into a type test binder and submit it to the “Engineer” for acceptance and record.

### 3. General Requirements for Tests during Manufacturing

- A. The Contractor shall carry out all applicable tests during manufacturing as specified and propose any additional tests to be carried out as per relevant safety standards. These tests shall be subject to the acceptance of the
- B. “Engineer”. Routine tests shall be integrated with the manufacturing program. The “Engineer” will, at his discretion, witness the routine tests during the period of manufacturing, or accept the records of the Contractor’s in-house quality control scheme, where appropriate, as sufficient evidence for the execution of the routine tests.
- C. Routine tests shall be carried out strictly as specified in the test specification.
- D. On completion of the manufacture of items or sub-assemblies, and following completion of the manufacturer’s own tests and inspection, the “Engineer” shall be invited to witness such tests as he deems appropriate. The Contractor shall schedule the routine tests to meet the manufacturing program, whether or not the “Engineer” will be present at the tests, provided advance notice has been served to the “Engineer” minimum 3 weeks for test to be conducted outside India with Invitation letter for Visa and 1 week for test to be conducted within India.
- E. The “Engineer” will determine and advise the Contractor of those tests where certification by the manufacturer may be acceptable in lieu of witnessed tests.
- F. Before equipment is dispatched, the “Engineer” will signify his acceptance by signing certificates releasing such equipment from the place of manufacture or test.

- G. Methods of packing and shipping detail shall be submitted by the Contractor, the “Engineer” reserves the right to visit the manufacturers or packers’ premises to ensure that accepted methods are employed.

**4. Test Specification**

- A. The Contractor shall submit for acceptance by the “Engineer”, test specifications for type tests, routine tests, tests on site, final acceptance tests and commissioning. The specifications shall detail the methods of conducting the tests, the tools and instruments used. Reference to the accepted documents and drawings shall be included in these specifications. The records/results shall be tabulated in a prescribed format applicable to this Contract.
- B. Nothing in this Specification shall prevent the “Engineer” from calling for extra tests.
- C. This test specification shall include the design values of all quantities to be verified, with allowable tolerance or limits. Summary drawings or diagrams shall be included with the test specifications to show the dimensions and tolerances of all structural assemblies and sub-assemblies. In the case of welded fabrications, key diagrams giving all weld data shall be provided to enable systematic inspection to take place.
- D. Verification of accuracy shall be required for all tools, apparatus, testing jigs, measuring instruments and ‘go’ or ‘no go’ gauges used for the purpose of routine tests.
- E. All test instrument shall be calibrated not more than one year prior to their use. The Contractor shall submit calibration certificate or other documents for proof of Compliance.

**5. Testing of Materials and Details**

- A. Where materials or components used in this Contract are not covered by separate test specifications, samples of such materials, or up to two per cent of such components shall, if desired by the “Engineer” be tested at the Contractor’s expense at an approved laboratory.
- B. The Contractor shall supply the material required for testing free of charge and shall supply and prepare the necessary test pieces, labour and appliances for making all tests, and for carrying out all gauging and weighing on his premises in accordance with the terms of this Specification. If the Contractor is unable to provide approved facilities at his own factory for making the prescribed tests, the Contractor shall bear the cost of carrying out the tests elsewhere, at a place subject to the “Engineer” acceptance.
- C. Such radiographic examination of welds or castings as the “Engineer” deems necessary shall be carried out.

**6. Interface and Integrated Tests**

- A. The Contractor shall co-ordinate and carry out interfacing and integrated testing together with other System-wide Contractors to ensure that the all-integrated systems function as desired. The integral testing & commissioning will be carried out with other system contractors such as Traction Contractors, S&T Contractors, Lift & Escalators Contractors. The contractor has to interface with all the contractors to get the testing done. The system shall be taken over only after the completion of the Integral testing & commission done at all the stations of the section.

**7. Certificate of Taking Over**

- A. The final acceptance tests of each item of equipment shall be undertaken in the presence of the “Employer/Engineer”, in accordance with the test specification. Any defects and/or deviations discovered without prior written approval during the tests shall be rectified at the Contractor’s own expenses. These shall be entered into a defects list agreed between the Contractor and the “Employer/Engineer”. The Certificate of Taking Over will not be issued until these tests have been completed and the defect list substantially reduced to such an extent that the “Employer/Engineer” considers that the equipment is safe for operation.

### Annexure-3

## QUALITY ASSURANCE AND SYSTEM ASSURANCE

#### 1. General

A Quality Assurance program shall be developed and implemented as a means of determining compliance with the Employer's Requirements. This program shall comply with the requirements as set out in ISO 9000. The program shall include but not be limited to the procedures necessary to ensure that all equipment, materials, systems and sub-systems are properly specified, designed, purchased, recorded, inspected, installed and tested at all appropriate stages. The procedure shall also ensure that handling, storage and delivery arrangements are satisfactory.

#### 2. Quality Assurance Program

The Contractor's quality assurance program shall include as a minimum, the following functions:

- A. Inspection System: A system for in process inspection of work operations and manufacturing as well as installation processes, including observations, measurements and tests, to ensure conformance with the requirements of the Contract.
- B. Calibration System: A system for periodic calibration and control of the accuracy of precision instrumentation and gauges.
- C. Record System: Data and records essential to the operation of the quality program shall be maintained by the Contractor and made available to the "Employer/Engineer" upon request. These records shall include work performance, inspection and testing observations and the number and type of deficiencies found. In addition, records shall be maintained for monitoring work performance, inspection and testing which indicate the acceptability of work or products and the remedial action taken in connection with deficiencies.
- D. Supplier Control System: A system for ensuring that all supplies and services procured from suppliers (subcontractors and vendors) conform with the requirements of the Contract.
- E. Manufacturing Control System: A system for providing necessary control over manufacturing operations to ensure that the final product conforms with all requirements of the Contract. This system shall include controls for the following areas:
  - i. **Materials**  
Suppliers' materials and products shall be subject to inspection to demonstrate conformance with the technical requirements.
  - ii. **Production Process and Fabrication**  
The Contractor's quality assurance program shall ensure that all machinery, wiring, batching, shaping and basic production operations (of any type) together with all processing and fabricating are accomplished through documented work instructions. These instructions shall be the criteria for acceptable workmanship.
  - iii. **Completed Item Inspection and Testing**  
The quality program shall ensure that there is a system for final inspection and testing of completed products. Such testing shall provide a measure of the overall quality of the completed product and be performed so that it simulates, to a sufficient degree, product end use and functioning.
  - iv. **Statistical Quality Control and Analysis**  
Statistical methods may be utilized for planning, analysis, tests and quality control whenever such procedures are suitable for maintaining the required control of quality. Sampling plans shall be subject to the acceptance of the "Employer/Engineer" prior to use.
  - v. **Indication of Inspection Status**  
The Contractor shall maintain a positive system for identifying the inspection status of products. Identification may be accomplished by means of stamps, tags, routing cards, move tickets or other control devices acceptable to the "Employer/Engineer".  
Installation Control System: A system providing necessary control, monitoring, inspection of the progress, quality of work and protection of equipment, to ensure that the equipment is installed according to the requirements of the contract.  
The system shall include but not be limited to the following, which shall be subject to the acceptance of the "Employer/Engineer" prior to use:
  - vi. **Shop Drawings**



All layout and shop drawings giving detailed layout of equipment, structural cut-outs, supports, openings, all dimensions, tolerances setting, etc.

**vii. Assembly Procedures and Drawings**

This shall show details of all installation and assembly procedures, including tolerances, tightening torque, alignment, precautions, etc.

**viii. Inspection Checklist**

Checklists giving all items to be checked and inspected with tolerances setting, etc.

The Contractor shall submit checklists to demonstrate compliance with all applicable standards.

**3. Systems Assurance**

The Bidder shall demonstrate a clear understanding of all the requirements of this Clause in his tender submission.

**A. General**

- (i) The Contractor shall develop and implement the requirements for Systems Assurance. These requirements shall be applied also to subcontractors and suppliers and shall be carried out during the design, manufacture, installation, testing and commissioning phases of the Works.
- (ii) The Contractor shall prepare and submit for review and acceptance by the "Employer/Engineer" a Systems Assurance Plan thirty days after Contract Award.
- (iii) The System Assurance Plan shall define the Contractor's approach, procedures and schedules for conduct of Safety Engineering, Reliability Engineering and Maintainability Engineering. Human Factors Engineering is an integral part of Systems Assurance and shall be considered and reflected within the Systems Assurance Plan.
- (iv) The Contractor shall pro-actively engineer the systems to meet the safety, availability, reliability and maintainability performance requirements listed below and demonstrate that the requirements have been met by the system installed.
- (v) In the process the potential hazards to safety, availability, reliability and maintainability performance should be further minimized where design options permit.
- (vi) The deliverables listed below are intended to provide the "Employer/Engineer" with a sound basis for acceptance of the safety, availability, reliability and maintainability performance; progress information; confidence that the design is proceeding with a low risk of failing to meet the performance requirements; information that will aid the planning of work schedules; and part of the foundation of the safety case for operation of the line.

**B. Safety Engineering**

- (i) The Contractor shall as part of the safety engineering activity prepare analyses of identified potential hazards to ensure resolution of hazards. The following analyses shall be prepared and submitted by the Contractor:
  - a. Subsystem Hazard Analysis (SSHA)
  - b. Interface Hazard Analysis (IHA)
  - c. Operating and Support Hazard Analysis (O&SHA)
  - d. Quantitative Fault Tree Analysis (FTA)
  - e. Failure Modes, Effects and Criticality Analysis (FMECA)
- (ii) The Contractor shall prepare a Fire Safety Design Report for review and acceptance by the "Employer/Engineer". At a minimum, this report shall contain documentation of the specific fire hardening and life safety features and attributes the Contractor has incorporated in the design; especially those relating to: -
  - a. Structural fire resistivity
  - b. Choice of electrical wiring and insulation for vital safety critical circuitry.
  - c. Flammability, smoke emission, and toxicity characteristics of selected materials.
- (iii) Further, the information presented by the Contractor shall be supported by the history of tests conducted and by approved test certificates from accredited laboratories which attest to the materials' characteristics and behavior.

## Annexure-4 MAINTENANCE REQUIREMENTS

### Maintenance

- A. In addition to his obligations under the Contract, the Contractor shall provide maintenance services throughout the **2 years of Defect Liability Period (hereafter called as DLP)** for all the Equipment. Maintenance work shall include attendance to all service calls, work described in approved Maintenance Schedule, which shall be submitted by Contractor for review and acceptance by Engineer/Employer.
- B. All defects shall be remedied either when observed on the monthly service call or on an attendance to a service call. Service shall include all work necessary to maintain the entire E&M system in good working order at all times.
- C. During the Maintenance Period, the Contractor shall, at its own cost and expense, replace any part or equipment, which may be defective or worn out, by a substitute thereof (the "Spares") which may be necessary for the efficient operation and maintenance of the E&M Work System. The quality and rating of Spares shall be same as of original parts.
- D. The Contractor shall mobilize competent personnel to rectify stoppages at any time during the day or night when being called on by the Employer/Engineer. Repairs shall be carried out on a 24 hours per day, 7 days per week basis until the faulty unit is put back in service.
- E. The Contractor shall carry out periodic testing and examination of equipment safety devices as may be required. A master schedule of such planned tests shall be submitted to the Employer/Engineer at least two months before commencement of the DLP.
- F. Reports: Contractor shall provide Monthly, quarterly, half-yearly and yearly reports on the condition of the equipment in an agreed format with Employer/Engineer.
- G. A report in duplicate shall be sent to the Employer/Engineer immediately following every call out, indicating the time of call out visit, cause, remedial action taken, the time that the service was restored, item replaced if any and Cause of failure. The monthly summary of failure report along with the analysis given details of nature of fault, remedial action taken etc. in the approved format shall be provided.
- H. Reports on routine visits are not required except where necessary to draw attention to defects, which could not be rectified during the routine visit. Records of each routine visit and call-out visit, together with details of the work done or action taken, shall be entered on a log book which shall be provided by the Contractor and retained in SCR room or Maintenance room or other location as decided by the "Employer/Engineer".
- I. The Contractor shall provide a maintenance plan and a major component replacement program for review and acceptance by the "Employer/Engineer" 90 days before the programmed commencement of the Defects Liability Period.
- J. The Maintenance service shall include all Preventive/Scheduled & Corrective/Unscheduled Maintenance. In this context, the Contractor shall submit a PM Schedule and CM procedure for Approval, 3 months before the commencement of the DLP.
- K. K-RIDE may appoint Third Party Agency for Operation and Maintenance of E&M System; therefore, Contractor shall not have any objection and submit the Undertaking in their Technical, "Bidder/Contractor shall not have objection to on handing-over the necessary Contractor's Operation & Maintenance manuals to K-RIDE Nominated Agency for operation and Maintenance of Equipment". K-RIDE will take undertaking from the Third-Party Agency for not using these Operation Manual / documents for any other purposes than the maintaining & operating the K-RIDE owned Equipment supplied under this Contract. Further, Agency will not sale or pass these documents to any other Agency.
- L. Based on the Maintenance Requirement Analysis, the Contractor shall indicate in the Maintenance Plan, the final preventive maintenance program, the proposed skill and manning level, spares level and special tools require. The proposal shall be fully traceable to the maintenance Requirement Analysis output.
- M. The Maintenance Requirement Analysis shall be submitted as part of the maintenance plan, under the main contract Bid submission. However, bidders will be allowed to defer submission of this Analysis, latest 12 months before the commencement of the Defect Liability Period, by presenting formal written request for such deferral.
- N. **Accommodation for Emergency Service Report Centre**  
A Room of approximately 10 sq.mtr will be provided by the Employer as the emergency service report Centre. The Premise will be located at one of the stations on each section to be determined by the Employer. Contractor Shall submit their proposal of Service center for effective and efficient taking care of Commissioned Equipment

### Employer's Maintenance Strategy

**Maintenance Strategy**

- a. The Contractor shall ensure that the system designed, installed and commissioned is supportable throughout the service life of the System to address, as a minimum, the following:
  - i. Design errors in the System;
  - ii. Operational changes;
  - iii. Environment changes; and
  - iv. Changes in infrastructure.
- b. According to the maintenance strategy, all equipment and infrastructure supplied for the 'Project' must be designed for minimum or no maintenance. Maintenance activities required must be capable of being performed with little or no impact on the train service. In addition, the maintenance work systems shall ensure safety of personnel and equipment.
- c. The Contractor, upon noticing any defects, deficiency in quality and quantity of spares and materials shall without delay, arrange for alternative source of supply and submit his proposal to the "Employer/Engineer" for review.

**Responsibility of Contractor during DLP (Defect Liability Period)**

- A. During the 2 years' DLP period, the contractor shall carry out all type of breakdown maintenance. Breakdown maintenance would be done whenever breakdown occurs. The contractor should post his supervisor and maintenance staff at a key place on the stations as determined by the Employer/ Engineer.
- B. The acceptable response & attention time also needs to be mentioned for minor & major breakdowns.
- C. **Maintenance Management System (MMS) and Maintenance Arrangement**  
During non-operation time, sections of line will be closed for maintenance work. The minimum time for possession periods is 4 hours. Ideally, this time shall be the free time available for maintenance.
- D. **Competency of Personnel**  
During the DLP the Contractor shall depute sufficient trained and competent personnel for maintenance purpose. Such persons shall have their generic competence established and must demonstrate their specific competence and knowledge in the particular systems, environment and procedures.  
The Contractor shall provide evidence of specific competence and knowledge, which shall include:
  - assessment and certified training in particular applications and operations;
 In the event of a failure, the Contractor shall undertake the management and investigation necessary to identify and rectify the cause.
- E. **Testing and Re-commissioning of System and Equipment**  
In the event of a failure requiring modifications to the System, the Contractor shall undertake any testing and re-commissioning required. Any such modification shall be submitted for review by the "Employer/Engineer".
- F. **Temporary Alterations to Restore Service**  
The Contractor shall undertake any temporary modifications necessary to maintain service. Any such modification shall be submitted for review and acceptance by the "Employer/Engineer".
- G. **Discrepancies between Installation and Design Records**  
Should the Contractor discover inconsistencies between the maintenance drawings and documentation and the installed equipment, the Contractor shall correct all such errors within two weeks.
- H. **Communications**  
The Contractor shall ensure that adequate communication facilities are provided to its staff during the DLP. Call Center (Single Point Reporting Center) shall be maintained by Contractor for K-RIDE project during DLP on which Employer/Engineer can report the failure and can keep communication for Service calls and status of Failures.
- I. **Location of Staff**  
The Contractor shall be responsible for locating staff such that the Contractor meets its obligations.
- J. **Storage of Equipment and Materials During the Defect Liability Period**  
The Contractor shall ensure that no equipment is stored along the trackside. The Employer will provide defined storage locations for the support of the different levels of Maintenance.
- K. **Maintenance Regimes**  
The Contractor shall produce a maintenance regime for the equipment that shall comprise two constituent parts, corrective and routine/preventative maintenance. Corrective maintenance shall be available 24 hours

per day, able to respond to all foreseeable circumstances. The maintenance regime shall cover all parts and equipment of the system designed, installed and commissioned by the Contractor. The Contractor shall take into account the requirements of the operations and maintenance when determining and proposing its maintenance regime. The regime and structure of corrective maintenance shall be robust in design.

**L. Scope and Hours of Coverage**

The Contractor shall provide a full 24 hour On-Call coverage and shall be such that initial response and rectification of failure are in accordance with the following:

- assistance for first line corrective maintenance (where adjustment within System is required) within 30 minutes, upon request of first line maintainer;
- 24 hour from notification for second line maintenance where spare parts replacement is involved; and
- within 10 days including transportation time for third line maintenance where replacement or repair of component from factory is involved. Any extension to this time shall be agreed with the “Employer/Engineer” and a replacement provided.

All elements of First Line preventative maintenance shall be carried out and completed during non-traffic hours without interrupting train services.

If the equipment is kept non – functional for more than a week then the DLP may be enhanced proportionately in the multiple of month.

**M. Failure Investigations**

The Contractor shall conduct failure investigations. Disputes between the Contractor and other Contractors will be resolved by the “Employer/Engineer”. Contractor shall make available to the Employer all test and failure data as required.

**Software Support**

**a. General**

The Contractor shall submit to the “Employer/Engineer” for review, the software support plan at least 90 days before commencement of software installation. Employer will have the right, for multiple use of the Software. Employer at his discretion may download the software on multiple PCs as per the requirement. For this purpose, no specific password, Key Number etc. should be required from the Contractor / Software firm.

All changes, bug fixes, updates, modifications, amendments, new versions shall not result in any non-conformance with this Specification. The Contractor shall submit all new versions to the “Employer/Engineer” for review at least 2 weeks prior to their installation. The new versions of software shall not degrade the operation of the System.

**b. Security Obligations**

Within 14 days of the installation of any software into the Permanent Works by the Contractor, the Contractor shall submit to the “Employer/Engineer” for retention by the Employer two backup copies of the software, which shall include any specified development tools required for maintenance of the software, including, but not limited to, editors, compilers and linkers.

Any software item delivered by the Contractor to the “Employer/Engineer” pursuant to the above Paragraph shall not be translated or modified by the Employer without the prior consent of the Contractor unless:

the owner of the software becomes insolvent or has a receiving order made against it or makes an arrangement or assignment or composition with or in favor of its creditors (including the appointment of a committee of inspection) or goes into liquidation or commences to be wound up or has a receiver, liquidator, trustee or similar officer appointed over all or any part of its undertaking or assets or if distress, execution or attachment is levied on, or if an encumbrancer takes possession of, any of its assets or any proceeding or step is taken which has an effect comparable to the foregoing in any relevant jurisdiction; or

the owner of the software ceases to trade; or

the owner of the software assigns copyright in the software and the Contractor fails within 60 days of such assignment to procure in favor of the Employer, a license from the new owner in the same terms as that required by the Contract; or

The Contractor is in breach of any of his obligations under the Contract.

**c. Error Correction**

The Contractor shall inform the “Employer/Engineer” immediately when a fault is discovered within delivered software or documentation. On receipt of a request from the “Employer/Engineer” for identification or further

diagnosis of a failure or fault, the Contractor shall provide appropriate resources. The Contractor shall provide written details as to the nature of the proposed correction to the "Employer/Engineer".

d. **Routine and Corrective Maintenance Procedures**

Routine and corrective maintenance procedures shall be supplied for all equipment. The format shall be as follows:

Uniform format and layout irrespective of equipment supplier;

Colour coding for each activity;

Cross referenced to the Operation and Maintenance Manuals; and

Document control information.

## SPARE POLICY

### 1. General

The Contractor shall supply the following spares: -

### 2. Consumable Spares during DLP

- A. The 'consumable spares' shall include items such as lubricants, oils (Excluding Diesel oil for DG operation), greases, sealants, filter Medias, gaskets, lamps and wearable parts etc. whose declared life is less than one year.
- B. The Bidder shall provide a recommended unpriced list of 'consumable' spares for maintenance and repairs of equipment in technical package as per the format in **Appendix-1** below. Any consumable item if required by the Bidder will be deemed to have been included the overall cost of the Bid and shall be supplied as per the provisions of this contract without any extra financial implication to the Employer. Contractor will be required to supply the requisite quantity of spares, as required irrespective of the quantities indicated by the contractor in the recommended list. Employer's decision in determining any particular item(s) as consumable in line with above guideline will be final and binding. In case any changes are required in the supply of consumables on account of changes at design stage, the contractor shall have to supply the required consumables also.
- C. List of consumable spares furnished in the technical package shall be updated during the execution of Contract and following information as minimum shall be provided.
  - i. Names, addresses, telephone numbers and other particulars of manufacturers and their local representatives;
  - ii. Models and part numbers,
  - iii. Full description of spares including a note whether it is sealed unit or an assembly or sub-assembly which can be broken down into component parts;
  - iv. Quantity installed in the system;
  - v. Expected consumption rates;
  - vi. Overall dimensions and weight including minimum packing (if any) for shelf space purposes;
  - vii. Inter-changeability or otherwise with similar parts;
  - viii. Normal manufacturing and shipment lead times; and
  - ix. Shelf life.
- D. The consumable spares shall be stored at the location agreed to by the Employer/Engineer.
- E. It shall be the responsibility of the contractor to maintain sufficient stock of consumable spares till the end of DLP. These spares will be utilized by the Contractor during the DLP and its consumption to be countersigned with K-RIDE Authorized Agency or Employer/Engineer and the old replaced parts shall be destroyed in the presence of Employer/Engineer. Unused spares, if any, by the end of DLP shall be handed over to K-RIDE and it will become property of employer.
- F. Recommended list shall be furnished by the contractor as part of design submission / vendor approval for respective systems and subsystems.

### 3. Unit Exchange Spares (Mandatory Spares)

- A. The Contractor shall submit the list of Mandatory Spares to the Engineer for review and approval. Mandatory Spares shall be handed over 2 months prior to the taking over of 1<sup>st</sup> Section. The Indicative List as Minimum mandatory spare parts to be handed over. Contract shall review the same and update & submit along with Technical Package.

### 4. DLP Spares

- A. The Contractor shall submit the list of DLP Spares to the Engineer for review and approval. The List of DLP Spares shall be as per format **Appendix-1**.
- B. The Contractor shall keep the DLP Spares on Site, at his own cost, throughout Defect Liability periods, stocks of spare parts, as per the agreed list to enable rapid replacement of any item found to be defective or in any way in non-conformance with the Specification.
- C. Contractor shall not be permitted to remove any working/healthy equipment / components / sub-systems / systems for any reason whatsoever without specific approval in writing from K-RIDE Engineer.
- D. Spares as per the agreed list shall be supplied at least three months before ROD. Stocks of such spares as available in **Contractor stores** will be jointly checked with Engineer every three months. Certificate by Engineer confirming availability of the spares in contractor in stations as per agreed list



will be a pre-requisite for release of interim payments of the Contractor. However, this condition will not be applicable for six months before the expected expiry of the DLP period. **The Balance DLP spares shall be the property of Employer and Contractor shall hand over the Balance unconsumed spares.**

5. **Manufacture, Delivery and Warranty**

- A. The major spare parts ordered under the Contract shall be manufactured, tested and inspected in accordance with the relevant quality system, suitably packed and labelled. All spares shall be subject to inspection by the Employer/Engineer. In the event that any item is known to be going out of production, then the Contractor shall give advance notice to the Employer/Engineer.
- B. The warranty period of 'unit exchange' and 'mandatory spares', delivered shall be:
  - Either 24 months from the date of acceptance or
  - Up to expiry of the defect liability period, whichever is later.

6. **Purchase of Spares from airt**

- A. The Contractor shall furnish an undertaking that he has no objection whatsoever to and shall not in any way deter or obstruct the Employer, its licensee or its representative from dealing directly with the Contractor's Vendors for the purchase of the spares during the Contract period. The spares purchased shall be subject to inspection by the Employer/Engineer.
- B. Contractor shall obtain an undertaking from vendors, OEMs etc. at detailed design submission stage that they will deal directly with Employer for supply of spares, equipment and/or sub-systems.
- C. Contractor shall submit technical specifications of the items used in this project for the purpose of purchasing. Engineer's views, if any, shall be suitably incorporated

