9.7.9 Digital motor protection relay (DMPR) shall be provided, if specified in job specifications/datasheets. All DMPR relay shall have Multi-Protection features like Motor protection (Overload, Overcurrent, Earth leakage Protection, Ground fault, Stalled Rotor, Loss of load, Phase unbalance, Negative phase sequence, Reverse connection), overcurrent, undercurrent & under voltage protection.

9.7.10 DMPR shall also have display and following features shall be provided in display like type of fault, three phase current, power, voltage and motor load (%), power factor etc.

9.7.11 CT ratio shall be settable in Digital MPR and communicable type DMPR shall be provided if specified in datasheet/ job specification.

9.8 Instrument Transformers (CTs/PTs)

9.8.1 Current transformers shall generally conform to IS:16227 and any special requirement with respect to numerical relay shall be taken care by the vendor.

9.8.2 For general guidance the vendor shall note that the protective current transformers shall have an accuracy class "5 P" and an accuracy limit factor of minimum "20". However, CTs for restricted earth fault shall be of class "PS"/"PX". Vendor shall co-ordinate the knee point voltage, magnetising current for PS class CTs to avoid saturation and mismatching of CTs provided at other end by other vendor.

9.8.3 Current transformers for metering shall have an accuracy class 1.0 and instrument security factor not greater than 5.0.

9.8.4 The current transformers in breaker feeders shall be capable of withstanding the applicable peak momentary short circuit and the symmetrical short circuit current.

9.8.5 For numerical relays having protection and metering functions, dual rated CT shall be provided suitable for protection class and metering class. One leg of the CTs shall be earthed.

9.8.6 The voltage transformers shall be cast resin type transformers and PT shall generally conform to IS:16227. PT shall be provided with HRC fuses on primary side and Miniature circuit breakers with auxiliary contact on the secondary side.

9.9 Measuring Instruments

9.9.1 All measuring instruments shall be of 72 x 72 mm square pattern, flush mounting type for incomer and outgoing feeders in the switchboard. The accuracy class for all instruments shall be 1.0 as per IS: 1248.

9.9.2 All auxiliary equipment such as shunts, transducers, CT, PT, etc. as required shall be included in the supply of the switchboard.

9.9.3 All AC ammeters and voltmeters shall be of moving iron type. Ammeters for motor feeders shall have a non-linear compressed scale at the end to indicate motor starting current and red mark for the full load current.

9.9.3 The KW/KWH meters shall be suitable to measure unbalanced loads on 3 phases 4-wire system. Test terminal block shall be provided for KWH meters.

9.9.4 Multifunction meters/ Digital meters shall be provided, if specified in job specifications/datasheets. All MFM/ digital meters shall be highly reliable, accurate and compact. MFM/ Digital meter data shall be saved in case of power failure. Communicable type MFM/ Digital meter shall be provided if specified in datasheet/ job specification.

9.10 Control/ Selector Switches

9.10.1 All control/ selector switches shall be rotary type, having a cam-operated contact mechanism. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles and shall be lockable type. Knob type handle shall be provided for other control/ selector switches.

9.10.2 Ammeter selector switches shall have make before break feature on its contacts. The selector switch shall generally have 4 positions, three for reading 3 phase currents and the fourth

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position for off. The voltmeter selector switch shall also have 4 positions. Three positions shall be used to measure phase-to-phase voltage and fourth shall be OFF position.

9.11 Push Buttons

Push button colours shall be as follows:

Stop /open/emergency stop	:	Red
Start/close	:	Green
Reset/test	:	Yellow / Black /White

The stop push button shall be stay put type & shall have protective hood to avoid accidental operation.

9.12 Indication

9.12.1 Clustered LED type indicating light with minimum 8 mm diameter size shall be provided for indications.

9.12.2 Breaker positions (Close, Open, spring-charged, test position, service position) electrical indications, with colors as given below, shall also be provided:

Breaker `Closed'/ ON	:	Red lamp
Breaker `Open'/ OFF	:	Green lamp
Breaker auto-trip	:	Amber lamp
Trip circuit healthy	:	White lamp
Spring charging	:	Blue lamp

9.12.3 Outgoing feeder (Close, Open, trip) electrical indications, with colors as given below, shall also be provided:

`Closed'	:	Red lamp
`Open'	:	Green lamp
'Trip'	:	Amber lamp

9.13 Auxiliary Relays/Contactors

Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts. However, in the case of numerical relays, the interlocking logic shall be built in the relay itself.

9.14 Timers

For re-acceleration duty, timers shall be electronic type or static type. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder and re-acceleration feeders shall have minimum setting of 0-5 minutes.

9.15 Miniature Circuit Breaker

MCB shall provide high mechanical and electrical life, reliable protection of circuits against overload and short circuit and shall have minimum breaking capacity of 9 kA unless otherwise specified. Positive ON/OFF indication shall be provided.

10.0 INTELLIGENT MOTOR CONTROL CENTRE (iMCC)

10.1 In case iMCC is required as per job specification/ datasheet, in addition to requirements specified above, iMCC switchboard shall be intelligent type with microprocessor-based device (intelligent motor controller) with integrated control (feature shall be available but usage shall be as per Job specification), monitoring and protection functions and communication facility in each single motor starter draw-out modules.

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10.2 The iMCC and network shall possess all intelligent functionalities but not limited to following: -

i) The intelligent motor controllers shall have Multi-Protection features like Motor protection (Thermal Overload, Overcurrent, Earth leakage Protection, Ground fault, Stalled Rotor, Loss of load, Phase unbalance, Negative phase sequence, Reverse connection), overcurrent, undercurrent & under voltage protection.

ii) Each intelligent motor controller shall also have additional i.e Status, Number of operations, Motor current, Motor running up /starting time, Motor hour run, Local Stop, manual reset of all other alarms and trips, Configurable inputs for external trips (2 as a minimum), status monitoring of LOCAL/REMOTE switch of local control station near motor, Motor reacceleration, Monitoring of consumed active power and the power

iii) The intelligent motor controllers shall have an LCD human-machine interface panel for local programming and operation. All intelligent motor controllers shall have a serial interface in front of device for connection to a laptop computer via RS-232 or USB port configuration.

iv) These modules shall be suitable for communication with a personal computer based Operator work station (OWS) & Engineering Work Station (EWS), Hand held device/Laptops and remote Instrumentation DCS and upper level ECS/SCADA system.

11.0 INSPECTION, TESTING AND ACCEPTANCE

11.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

11.2 For testing requirements refer Inspection & Test Plan No. 6-81-1018. Prior notice of minimum 4 weeks shall be given to EIL/owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

11.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1018.

12.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special precaution notations such as 'Fragile', 'This side up', 'Centre of gravity', 'weight', Owner's particulars, Purchase order number etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be supplied duly enclosed in a waterproof cover along with the shipment.

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SPECIFICATION FOR LV & MV OIL FILLED TRANSFORMERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	09.08.2024	REVISED & REISSUED AS STANDARD SPECIFICATION	MKM	VT	HK	MN
6	05.04.2018	REVISED & REISSUED AS STANDARD SPECIFICATION	MKM/DA	HK	BRB	RN
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4	27.02.2009	REVISED & REISSUED AS STANDARD SPECIFICATION	SA	NS	JMS	VC
3	10.02.2004	REVISED & REISSUED AS STANDARD SPECIFICATION	NPG	RR	VPS	MG

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Abbreviations:

AC	:	Alternating Current
BEE	:	Bureau of Energy Efficiency
BS	:	British Standards
BIS	:	Bureau of Indian Standards
BDV	:	Breakdown Voltage
CBIP	:	Central Board of Irrigation & Power
CEA	:	Central Electricity Authority
CT	:	Current Transformer
DC	:	Direct Current
ECS	:	Electrical Control System
FEC	:	Fire Extinguishing Cubicle
FRLS	:	Flame Retardant Low Smoke
FO	:	Fibre Optic
GI	:	Galvanised Iron
GSM	:	Global System for Mobile Communication
HMI	:	Human Machine Interface
HV	:	High Voltage
IEC	:	International Electro Technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standards
KNAF	:	(Non-Mineral) Oil Natural Air Forced
KNAN	:	(Non-Mineral) Oil Natural Air Natural
KV	:	Kilo Volt
KVA	:	Kilo Volt Ampere
LED	:	Light-emitting diode
LIU	:	Light Interface Unit
LV	:	Low Voltage
MR	:	Material Requisition
MSL	:	Mean Sea Level
MV	:	Medium Voltage
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
NEMA	:	National Electrical Manufacturers Association
NGR	:	Neutral Grounding Resistor
NIFPES	:	Nitrogen Injection Fire Prevention and Extinguishing System
NO	:	Normally Opened
ODV	:	Oil Drain Valve
OEM	:	Original Equipment Manufacturer
OLTC	:	On Load Tap Changer
ONAF	:	Oil Natural Air Forced
ONAN	:	Oil Natural Air Natural
OTI	:	Oil Temperature Indicator
PESO	:	Petroleum and Safety Explosives Organisation
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
PRV	:	Pressure Release Valve
RPRR	:	Rapid Pressure Rise Relay
RTCC	:	Remote Tap Changer Control
SCADA	:	Supervisory Control and data Acquisition
SMS	:	Short Message Service
SS	:	Stainless Steel

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TCIV	:	Transformer Conservator Isolation Valve
TPN	:	Three Phases and Neutral
VDE	:	Verband Der Electrotechnik, Elecktronik und Information Stechnik
WTI	:	Winding Temperature Indicator
XLPE	:	Cross Linked Polyethylene

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1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of MV (>1kV upto 33kV) & LV (upto 1000V) oil filled power/distribution transformers along with nitrogen injection fire protection system (if specified in MR/ Tender specification).

2.0 CODES AND STANDARDS

The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS.

IS:5	:	Colours for Ready Mixed Paints and Enamels
IS:335	:	New Insulating oils - Specification
IS:1180-1	:	Outdoor type oil immersed distribution transformers up to and including 2500 kVA, 33kV – Mineral Oil Immersed
IS:1180-3	:	Outdoor/indoor type liquid immersed distribution transformers up to and including 2500 KVA, 33 kV – Natural/ Synthetic organic ester liquid immersed
IS:1271	:	Electrical insulation - Thermal evaluation and designation
IS:1747	:	Nitrogen Compressed gas and Liquid-Specification
IS:2026 (Various Parts)	:	Power transformers
IS:2312	:	Specification for propeller type AC ventilating fans
IS:2705	:	Current transformers
IS:3024	:	Grain Oriented Electrical Steel Sheet and Strip
IS:3347	:	Dimensions for porcelain Transformer Bushings
IS:3401	:	Silica Gel Specification
IS:3624	:	Specification for pressure and vacuum gauges
IS:3637	:	Specification for gas - Operated relays
IS:3639	:	Specification for fittings and accessories for power transformers
IS:4253 Part-2	:	Cork composition sheets - Specification: Part 2 cork and rubber
IS:4201	:	Application guide for Current Transformer
IS:7098 Part-1	:	Specification for crosslinked polyethylene insulated pvc sheathed cables: Part 1 for working voltages up to and including 1100 volts
IS:8468	:	Tap - Changers Part 1 Performance Requirements and Test Methods
IS:8478	:	Application guide for On-load tap changers
IS:11149	:	Specification for rubber gaskets
IS 13503	:	Classification of insulating liquids
IS:16081	:	Insulating Liquids — Specification for unused synthetic organic esters for electrical purposes
IS:16227	:	Instrument Transformers
IEC 60076 (Various parts)	:	Power transformers
IEC 60214	:	Tap-changers
IEC 60296	:	Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment
IEC 60599	:	Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis

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IEC:61869	:	Instrument Transformers
IEC:62535	:	Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil
IS/IEC:60137	:	Insulated Bushings for Alternating Voltages above 1000 V
IS/IEC 60273	:	Characteristic of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages Greater than 1000 V
IS/IEC:60529	:	Degree of protection provided by enclosures (IP Code)
IS/IEC:60947	:	LV switchgear and control gear.
IS/IEC 61850	:	Communication Networks and Systems for Power Utility Automation
IEEE C37.91	:	IEEE Guide for Protective Relay Applications to Power Transformers
IEEE C57.104	:	IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
CBIP GP-317	:	CBIP Manual on Transformer
GOI Order	:	Latest Gazette of India Notification
NEMA TR-1	:	Transformers, Regulators and Reactors

2.1. In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.2. The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.3. In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

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

3.0 GENERAL REQUIREMENTS

3.1. The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2. Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3. Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1. Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres. The transformer shall be designed to operate under site conditions as specified in data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000m above MSL shall be considered.

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5.0 CONSTRUCTION

5.1. Transformer tank shall be of welded sheet steel construction and provided with gasketed steel cover plates. Base shall be suitably reinforced to prevent any distortion during lifting. Base channels shall be provided with skids and pulling eyes to facilitate handling.

5.2. Transformer shall be double wound, core type with high grade cold rolled non-aging grain oriented low loss, high permeability silicon steel laminations (M-4 or better grade) perfectly insulated and clamped to minimise vibration and noise. Care shall be taken to insulate core-fastening bolts to reduce losses and avoid hot spots. All parts of magnetic circuit shall be bonded to earth system.

5.3. Power/ Distribution Transformers shall have conventional type of windings. However, distribution transformer with Foil type LV windings are also acceptable. Windings shall be of copper and shall be designed to withstand the applicable thermal and dynamic short circuit stresses.

5.4. All covers and seals shall be oil and airtight and shall not be affected by mineral or synthetic oil action. Detachable radiators (tank mounted) equipped with air vent, drain plug and lifting lugs shall be provided with shut-off valves for transformer rated more than or equal to 500kVA to permit removal of any radiator unit without emptying the tank. Radiators shall be securely braced to prevent undue vibration.

5.5. All fasteners and bolts etc. shall be galvanised. All surfaces to be painted shall be thoroughly cleaned, de-scaled, made free from rust and transformer shall be epoxy painted.

5.6. Different non-current carrying parts of transformers shall be connected by copper flexible for earth continuity purpose.

5.7. Transformer shall be supplied with first filling of oil and 10% extra oil in non-returnable drums. Oil shall conform to IS-335 (Mineral Oil)/ 16081 (Synthetic Ester Oil) as specified in MR/tender.

5.8. Distribution transformer rated upto 2500 kVA shall comply with latest IS-1180 (Part-1)/ IS-1180 (Part-3) (including amendments) and latest Gazette of India Notifications. Accordingly, efficiency of transformer at 50% and 100% load shall be considered with total losses at 50% and 100% loading not exceeding maximum losses values specified in Table-6 of IS-1180 (Part-1)/ IS-1180 (Part-3): (including amendments) for Energy Efficiency Level 3/ Table-3 of GOI Notification dt. 08 Dec 2023, BEE Star Rating 3 (including latest GOI Notifications). Higher energy efficiency levels/ star ratings shall be provided, if specified in MR/ Tender.

5.9. The transformer shall bear standard mark of the Bureau of Indian Standards in line with Gazette of India notifications. Copy of the license obtained from Bureau of Indian Standards shall be furnished by vendor in compliance with IS-1180 (Part-1)/ IS-1180 (Part-3). Further, energy efficiency labelling for distribution transformer shall be also provided as per Bureau of Energy Efficiency (BEE).

5.10. Temperature rise limits shall be limited to limits of Temperature rise specified in Gazette of India notifications/ IS-1180 (Part-1)/ IS-1180 (Part-3).

5.11. The guaranteed minimum value of efficiency shall be demonstrated during inspection.

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6.0 TERMINALS AND MARSHALLING BOX

6.1. Windings shall be brought out and terminated on outdoor bushings, cable boxes or bus-duct chamber, which will be located as specified in MR/ Tender.

6.2. When outdoor bushings are specified, these shall be supplied complete with terminal connectors suitable for the specified conductor size.

6.3. Cable box shall be supplied with cable lugs and glands.

6.3.1. For HV XLPE Cables and MV XLPE Power/control cables, double compression nickel plated brass cable glands and crimped type tinned copper cable lugs shall be supplied. Gland plate shall be removable type. For single core cables, gland plate shall be of non-magnetic material. HV cable box shall be suitable for termination of specified size of XLPE insulated cable. The head-room available between cable gland plate and terminals shall not be less than 600mm for cable upto 11 kV, and 900 mm for 22 kV and 33 kV cables. Cable box and disconnecting chamber shall be air insulated.

6.3.2. Cable box shall be weatherproof to minimum IP-55. For fixed portion of cable box, inspection cover with lifting handle shall be provided.

6.3.3. Primary cable box (where applicable) shall be able to withstand specified primary system fault level for 0.20 second.

6.4. Terminal chamber for bus-duct termination shall have a gasketed cover plate bolted to it and shall be weatherproof to IP-55. A separate inspection cover with lifting handle shall be provided to facilitate connection and inspection.

6.5. Marshalling box shall be weatherproof and vermin proof with minimum IP-55 degree of protection. All protective devices and neutral CTs shall be wired by means of XLPE insulated copper conductor armoured cables (As per IS 7098-Part 1), FRLS type upto the marshalling box. Terminals shall be clamp type. Removable gland plate with double compression type glands shall be provided. Lamp with switch & socket shall be provided in the marshalling box. Preferably, marshalling box shall be located on the front side of transformer unless authorised by purchaser. Marshalling box for the distribution transformer shall be mounted on the transformer. Marshalling box for power transformer shall be mounted on transformer/ wall mounted/ pedestal mounted as agreed by purchaser.

6.6. For transformers having provisions for terminating TPN bus duct on the 433V side, neutral of the star connected secondary winding shall be brought out to a secondary terminal chamber. CT(s) shall be mounted (if specified) on the neutral terminal with CT secondary wired up to the marshalling box.

6.7. A separate neutral bushing shall be provided for neutral earthing of transformers. The neutral CT(s) shall be mounted as below: -.

a) CT for 51G shall be located in the earth path after bifurcation of neutral.
b) CT for 64 R can be located before bifurcation of neutral.

Supporting arrangement for GI strip/cable as applicable shall be provided for connection of neutral bushing to earth/NGR.

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6.8. All contacts including 'spare contacts' and 'contacts for Owner's interface' shall be duly wired & terminated at the terminal block.

7.0 COOLING

7.1. Type of cooling shall be in accordance with MR/ Tender.

7.2. Forced air-cooling system shall have a weather proof IP-55 control panel to be installed on the body of the transformer, complete with cooler controls and cable glands necessary for Purchaser's external cable connections. Contacts shall be provided for remote indication/alarm for following operating conditions:

a) Auto/manual selection
b) Winding over temp.
c) Fans ON (for each fan separately) & Fans tripped (for each fan separately).

Cooling fans shall be complete with mounting/supporting structure. These shall be suitably sized to limit the temperature rise of the transformer to specified values with continuous maximum loading of ONAF/KNAF rating and at maximum specified ambient temperatures. One standby fan per 50% cooler bank shall be provided.

In Auto mode, all fans including redundant fans shall be running. In manual mode, provision shall be made for starting each fan independently.

8.0 TAPPINGS & CONTROL

8.1. These shall be provided on high voltage side and connected to off circuit or on-load tap changing gear as specified in MR/ Tender. Under conditions of external short circuit, the tap changing equipment shall be capable of carrying the same current as the windings.

8.2. **Off circuit tap changing gear:**

Off circuit tap changing gear shall have an external operating handle mounted on the transformer side and shall meet the following requirements:

a) Positive snap-action contact changing
b) The mechanism shall be such that it is impossible for the contacts to be set in a position whereby the windings remain open-circuited or partly short-circuited.
c) Mechanical stops at the ends shall be provided to prevent overrun.
d) The driving rod through cover or tank wall shall be properly sealed against oil leakage under all service conditions.

The handle shall be metallic and adequately sized in order to allow operation without the need of tools and shall be located in a directly accessible position.

The handle shall be provided with padlock facilities to lock the tap changer in the desired position.

Tap positions shall be clearly marked in line with the data given on the rating plate.

8.3. **On Load Tap Changer**

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8.3.1. High speed on load tap changing gear with number of steps as specified on MR/ Tender shall be provided and mounted on the transformer. The OLTC gear shall have diverter resistance and the current diverting contacts shall be housed in a separate oil chamber segregated from the main tank of the transformer. The contacts shall be accessible for inspection and their tips shall be replaceable.

OLTC oil chamber shall have oil filling, drain and sampling facility. It shall be provided with oil level indicator, connection orifices, valves and silica gel breather. Pressure relief device with trip contact and oil surge relay with trip contact shall be provided for OLTC.

8.3.2. OLTC shall be provided with local and remote controls.

8.3.2.1. **Local Control**

a) Manual-Mechanical Control

The cranking device for operation of the OLTC gear shall be removable type and located at a height not exceeding 1500mm above ground level for easy operation. The mechanism shall be complete with normal accessories including at least the following: -

i. A mechanical tap position indicator (Rated tap voltages shall be marked on the diagram plate).
ii. A mechanical operation counter.
iii. Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.

b) Electrical Control

Control circuit shall incorporate the following:

i. Local/remote manual electrical operation.
ii. Device to ensure a positive and full completion of tap change once it is initiated even if here is loss of power.
iii. An interlock to cut-off electrical control automatically upon recourse being taken to manual mechanical control in emergency.
iv. Electrical interlock to cut-off a counter impulse for a reverse tap change, being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.
v. All auxiliaries and devices for electrical control of OLTC gear shall be housed in a weather-proof cabinet mounted on the transformer and shall include:
   - Local tap position indicator
   - 5-digit operation counter
   - Cubicle lighting
   - Thermostatically controlled space heater.
   - Miniature circuit breaker with magnetic and thermal overload devices for controlling the incoming supply to the OLTC motor.
   - Padlocking arrangement for the hinged cabinet door.
   - Removable plate with cable glands.
   - Inside tag with control scheme indelibly marked.

8.3.2.2. **Remote Tap Changer Control Panel**

a) Remote Tap Changer control panel shall comprise of the following:

- Individual/parallel control on Master follower sequence selector switch.
- Raise/lower control switch.

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- Potentiometer type tap position indicator.
- Out of step relay.
- Time delay relay.
- Indicating lamp for out of step.
- Out of step buzzer.
- Indicating lamp for tap changer supply available.
- Indicating lamp for tap change in progress.
- Voltage Sensing Relay (If specified)

b) RTCC panel shall be dust & vermin proof, floor mounting, and free-standing type. The enclosure shall be cold rolled sheet of 2.0 mm thickness. All doors and opening shall be provided with neoprene gaskets. RTCC can be offered in conventional or digital configuration unless a specific type of RTCC is mentioned elsewhere in the MR/ Tender.

8.3.3. OLTC, wherever called for, shall be suitable for bi-directional power flow.

9.0 ACCESSORIES

9.1. The following accessories shall be provided as a minimum:

a) Rating Plate
b) Terminal marking Plate
c) Two earthing terminals
d) De-hydrating breather
e) Conservator
f) Air release Device (for transformers with conservator)
g) Oil filling hole with cover
h) Oil Level indicator with alarm contact
i) Thermometer pocket
j) Oil temperature indicator with alarm & trip contacts
k) Winding temperature indicator with alarm & trip contacts (for transformers of rating 500 KVA and above)
l) 4-20mA transducers for OTI & WTI (For Transformers rated above 1000kVA)
m) Pressure relief valve shall be provided (with trip contact)
n) Sampling valve
o) Conservator drain valve
p) Top oil filter valve
q) Drain cum bottom filter valve
r) Double float Buchholz relay
s) Separate neutral bushing outside terminal box with connector assembly
t) Inspection cover
u) Terminal box
v) Marshalling box
w) Lifting lugs
x) Jacking lugs
y) Cross channels with towing lugs
z) HV and LV bushings

9.2. Conservator shall be complete with oil filling plug and cap, oil drain valve, oil level gauge in addition to magnetic oil level gauge. A flexible oil resistance air bag shall be provided for conservator for transformer rated above 2500kVA unless specified otherwise in MR/ Tender. Air bag shall be designed to withstand repeated expansion and contraction due to changes in oil level.

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9.3. Separate buchholz relay shall be provided for main tank and OLTC chamber. This shall be double float type for the main tank with separate normally open trip and alarm contacts. For the OLTC chamber the relay shall be of single float type or oil surge relay with one trip contact. Isolating valve shall be provided on either side of the relay and distance piece shall be supplied.

9.4. Size of valves for drain, filter and sampling shall be as per table below.

Transformer rating (kVA)	Size of drain valve (mm)	Size of filter valve mm	Size of sampling valve Mm
Upto 1600	25	25	15
>1600 to 10000	50	25	15
>10000 to 25000	80	50	15
>25000 to 50000	100	50	15
>50000	100	50	15

9.5. ECS Interface signals as listed below shall be provided if specified in the data sheet / projects specifications.

a) Selector switch status (OLTC/RTCC/Remote Control mode)
b) Master / Follower status
c) Auto/Manual mode status
d) Tap changer out of step status
e) Tap changer stuck status
f) Tap changer status signal (Digital) for each step
g) Control Supply failure for RTCC Panel / OLTC
h) Raise/Lower Control from ECS

10.0 NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM (NIFPES)

Nitrogen Injection Fire Prevention and Extinguishing System (NIFPES) provided by the manufacturer/ vendor shall be complete in all respects. The scope shall cover design, supply, installation, connections, testing & commissioning. The scope also includes provision of heat/ fire detectors (sensors), required pipes, cable connections etc. All other components meant for activation and successful operation of the NIFPES shall be provided by the manufacturer/vendor.

10.1. Nitrogen Injection Fire Prevention and Extinguishing System (NIFPES) shall be designed to prevent the fire from taking place in the transformer and possible explosion of transformer tank due to internal faults/ arcing. In case of fire inside the transformer tank, the NIFPES shall be capable of extinguishing the fire, minimizing the damage to the transformer and thus avoiding the spread of fire.

10.2. NIFPES system shall work on the principle of drain and stir of transformer oil. On activation of NIFPES, it shall isolate conservator tank oil from the oil in the main transformer tank, drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, and inject nitrogen gas from the bottom side of the tank through the inlet valves to create stirring action and reduce the temperature of oil to prevent/ extinguish the fire. On the operation of NIFPES, the quantity

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of oil removed from the tank shall be such that adequate amount of oil shall remain in the transformer to cover the active part of the transformer i.e. the core-coil assembly. The NIFPES shall be designed in such a way that heat/ fire detection period upon commencement of incident will be maximum 10 second and fire extinguishing period on commencement of Nitrogen injection shall be 30 second (maximum).

10.3. The detection properties of the detector/ sensor shall be site configurable.

10.4. Electrical isolation of transformer shall be an essential pre-condition for activation of NIFPES system.

10.5. **Operation controls**

The system operation shall be automatic and will be activated when the pre-set conditions of activation of the system are attained/triggered. Maximum time period for extinction of fire from commencement of nitrogen injection into the transformer shall be 30 seconds. In addition to automatic operation, remote operation from the control room/remote centre/local control in the fire extinguishing cubicle (FEC) shall also be provided. System shall operate in the following situations:

10.5.1. **System Activation in Fire Prevention Mode**

To prevent fire and explosion in the transformer including that from internal fault, signals from the following shall be used to activate the NIFPES:

a) Operation of either of the protective relays i.e. differential or restricted earth fault REF) or over current;

AND

b) Operation of either protective relays [Buchholz Relay or Pressure Relief Valve (PRV)] or the signal from Rapid Pressure Rise Relay (RPRR)

AND

c) Operation / Feedback of tripping of associated circuit breakers

Transformer shall be electrically isolated after which only the NIFPES shall operate. In case of some problem in main protection, the NIFPES shall derive the operation signal from the backup protection.

However, the exact logic for system activation shall be finalized during detailed engineering.

10.5.2. **System Activation in Fire Detection Mode**

In case of fire detection mode, signals from the following shall be used to activate the NIFPES:

a) Fire/heat detectors/sensors

AND

b) Operation of either of the protective relays [Buchholz relay or Pressure Relief Valve (PRV) or Rapid Pressure Rise Relay (RPRR)]

AND

c) Operation / Feedback of tripping of associated circuit breakers

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Transformer shall be electrically isolated after which only the NIFPES shall operate. In case of some problem in main protection the NIFPES shall derive the operation signals from the backup protection system.

However, the exact logic for system activation in fire detection mode shall be finalized during detailed engineering.

10.5.3. If the fire detection is not associated with any other fault, the system activation shall be manual. Manual operation switch with a proper cover to avoid inadvertent operation of the switch, shall be provided in the control room / remote center and in FEC. Interlock shall be provided so that manual operation shall work only when the transformer is completely electrically isolated. NIFPES shall operate once the circuit breakers are isolated and feedback signal for isolation of breakers is received on NIFPES panel. The manual operation of NIFPES shall override the automatic operational mode and the operator shall ensure the complete isolation of the transformer before activation of the NIFPES.

10.5.4. The NIFPES manufacturer should provide the warning information on the Control Box and Fire Extinguishing Cubicle (FEC) that *"Ensure that HV, IV and LV breakers are open before operating in Manual Mode"* both in Hindi and English and the local language as prevalent.

10.5.5. The logic for OLTC and Cable box protection shall be on similar lines as that of transformer main tank in case if separate provisions are being provided by transformer OEM.

10.6. **Operation of System**

On receiving activation signal, the system shall:

a) Open the quick opening drain valve of transformer to drain its top layer oil (pre-determined quantity);
b) Shut off the transformer conservator isolation valve (TCIV) to prevent flow of oil from the conservator tank to the main transformer tank; and
c) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated. There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

The system shall be designed in such a manner that Nitrogen purging shall commence only after ensuring that the oil draining has commenced.

10.7. **Technical Particulars**

10.7.1. The vendor/manufacturer shall be responsible for design of the complete system and shall submit the drawings and design calculations for the number of Heat (Fire) detectors (sensors), sizing of drain pipe, Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc and get approval from the user. The facility shall be provided to test the system by operation of valves [Nitrogen injection valve, TCIV and Oil Drain Valve (ODV)] when the transformer is in service, without actually draining the oil and injecting Nitrogen in real time operation by obtaining the feedback from valve. The Nitrogen injection scheme shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/leakage of valve.

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10.7.2. The oil drain mechanism may or may not be a part of the fire extinguishing cubicle.

10.7.3. Owner shall provide two distinct station auxiliary DC/AC supplies for control power supply purposes. The system shall work on station DC/AC supply with voltage variation as per relevant standards. The control box of fire prevention and extinguishing system shall have facility to receive these DC/AC supplies for auto changeover of supply. It shall be the Vendor's/NIFPES supplier's responsibility to further distribute power to the required locations. In case auxiliary DC/AC power supply requirement is different than station auxiliary DC/AC supply, then all necessary converters shall be provided by the Vendor.

10.7.4. Following minimum indications and alarms shall be provided in the control cubicle in the control room:

a) DC supply 'ON'
b) AC supply 'ON'
c) Total System Healthy
d) DC supply fail
e) AC supply fail
f) System out of Service
g) Differential relay trip
h) PRV trip/RPRR trip
i) Buchholz Relay trip
j) Master Relay trip [(HV, IV and LV (Tertiary Voltage)]
k) Restricted Earth Fault (E/F) Relay Trip
l) Overcurrent Relay Trip
m) Nitrogen cylinder pressure low
n) Fire alarm
o) Heat/Fire detector/Sensor faulty Signal
p) Heat/Fire Detector/Sensor alarm/signal
q) Nitrogen injection Valve open
r) Nitrogen injection Valve close
s) Nitrogen injection Valve leakage
t) Oil drain Valve open
u) Oil drain Valve Close
v) Leakage in Oil drain valve
w) TCIV Open
x) TCIV Closed
y) Cable fault signal for interconnecting cable for transformer trip signals
z) Auto operation failed
aa) NIFPES system in Auto Mode
bb) NIFPES system in Manual Mode
cc) NIFPES system in Test / Maintenance mode

Another indicator which supplier/user consider necessary shall also be provided.

10.7.5. The following push buttons shall be provided as a minimum:

a) Mode Selection Switch, Auto/Manual/ (test/Off)
b) Lamp test push buttons
c) System reset push button

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d) Detector reset push button, if applicable.
e) Manual extinction push-button for manual operation of the system
f) Hooter reset push button

10.7.6. Apart from the above list Nitrogen cylinder pressure indication manometer with sufficient number of adjustable 'Normally Opened (NO)' contacts shall also be provided in FEC. In case of fire in the transformer and fulfilling the conditions of defined logic for NIFPES operation for fire extinguishing mode and fire prevention mode alarm (Audio & Visual) will be generated in control room.

10.8. **Technical Data Sheet:**

The following are the technical requirements of the NIFPES:

Sl. No.	Item	Requirements
1.	Fire detection period on commencement of fire	Maximum 10 seconds
2.	Fire Extinction period on commencement of Nitrogen injection	Maximum 30 seconds
3.	Fire detectors'/ sensors' "heat sensing" temperature	120 ^{0}C temperature of the transformer oil minus 5 ^{0}C with tolerance of +/- 2^{0}C.
4.	Power source for: a) Control Box b) Fire extinguishing cubicle	 110/220 V DC (+10% & -15%) / 230 V AC 110/220 V DC (+10% & -15%) / 230 V AC
5.	Nitrogen Cylinder and Valve (PESO approved)	As per IS:7285 (Part 2) and IS:3224 (latest) BIS Mark
6.	Degree of protection of (a) FEC Heat (fire) detector / sensor and Signal / Junction box (if any)	 (a) IP 65 IP 65
7.	Steel Sheet of FEC, Control Box and Signal Box	Steel sheet shall be as per grade CR2 of IS: 513, Part-1. Thickness of Steel Sheet of FEC and Control Box and Signal Box shall be 3.0 mm minimum
8.	Colour of all panels and Nitrogen Injection pipes	Shade 538 of IS: 5
9.	Heat (fire) detector / sensor	OEM shall furnish technical details
10.	Minimum distance of FEC from the Transformer	FEC should be at a safe distance from Transformer (preferably 5-7 meters). Firewall (minimum 2 hrs fire withstand capacity) will be provided around FEC with the height 600 mm from the top of FEC to protect it from fire of the transformer.
11.	For conservator valve of flow-based mechanism, flow rate for closing of flow-based conservator isolation valve	60 Ltrs. / minute.

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In case the pressure in the nitrogen cylinder somehow exceeds the rated pressure, there should be the provision for extracting the excess nitrogen to attain the safe pressure in the nitrogen cylinder.

10.9. **Details of Supply of System/Equipment and Other Related Activities:**

Nitrogen injection fire protection system shall broadly consist of the following components/ devices. However, all other components that are necessary for fast, reliable, complete, and effective working of the fire protection system shall deemed to be included in the scope of supply.

10.9.1. Fire extinguishing cubicle with base frame and containing at least the following:

a) Nitrogen gas cylinder and cylinder valve having the Petroleum and Explosive Safety Organization (PESO) certificates of sufficient capacity.
b) Pressure regulator with indicators for nitrogen pressure of the cylinder and actual injection pressure through nitrogen cylinder and manometer with sufficient number of adjustable 'Normally Open (NO)' contacts.
c) Oil Drain Assembly including oil drain valve and its equipment for operation, oil drain pipe extension of suitable size for connecting pipes to Oil Storage Tank, along with level switch for detecting leakage in oil drain valve;
d) Mechanical release device for oil drain and nitrogen gas release;
e) Limit switches for monitoring of the systems;
f) Panel lighting;
g) Flanges on top of the panel for connecting oil drain in case of oil drain mechanism is part of fire extinguishing cubicle and nitrogen injection pipes for transformer;
h) Fire Extinguishing Cubicle (FEC) shall have proper illumination.
i) The heater with thermostat shall be provided in the FEC. Heater should be operated as per the setting of thermostat.
j) One set of mandatory spares as applicable.

In case if oil drain mechanism is not a part of FEC – the related items shall be as per the Original Equipment Manufacturer (OEM) design, however functional requirements have to be met with.

10.9.2. The FEC shall be provided with canopy / shed to be protected from 3 sides to avoid water ingress and protect the FEC from direct sunlight and radiant heat. The canopy / shed shall be designed to cover almost more than half of the FEC height from top.

10.9.3. Control box/cubicle to be installed in the control room of the substation for monitoring the NIFPES operation, automatic control, and remote operation, with alarms, indications, switches, push buttons, audio signal etc. Control Box/Cubicle should be microprocessor based /PLC based compatible to be interfaced with Owner's/ Purchaser's Supervisory Control and data Acquisition (SCADA) system in the Substation / Switchyard.

10.9.4. The required number of heat/ fire detectors / sensors to be located at strategic locations and to be finalized during detailed engineering. Diagonal / adjacent distance between two heat/fire detectors / sensors shall not exceed more than 800 mm. heat/fire detector / sensor shall be IP 65 approved. All the control / power cables between the NIFPES panel and the transformer, from the control room to FEC, from the Control and Relay Panel to the Control Box / cubicle, Control Box / cubicle to DC / AC supply Source, Signal / junction box to FEC or any additional junction box placed near FEC shall be Fire Survival Cable type up to the thermal limit (in case of fire and or explosion). Fire survival cables shall be suitable to withstand a temperature of 750 °C. Further, Technical Data sheet and applicable valid type test report as per applicable latest IS shall be submitted to the user during detailed engineering.

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10.9.5. Transformer Conservator Isolation Valve to isolate the conservator oil from the main tank oil is to be provided by the NIFPES supplier. This valve shall be located in the piping between the conservator and the Buchholz relay.

10.10. **SCADA compatibility**

10.10.1. The NIFPES shall be provided with IEC 61850 / RS 485 / TCP IP compatible port or using suitable converters for integration with user's SCADA system. Integration to SCADA system will be done as per contract outlined by owner, however necessary support shall be provided by NIFPES OEM.

10.10.2. For transformers rating of 25 MVA and above – the control panel of NIFPES shall be HMI (Human Machine Interface) based SCADA system having facility to store and take print out of the events and history of all the alarms & faults occurred into the NIFPES system. The data retention capacity shall be of minimum 6 months.

10.10.3. The HMI screen size shall be of minimum 12" or above as per manufacturer standard. The HMI shall display the graphical representation of the system along with dynamic status of all the valves.

10.10.4. The system shall also be designed keeping in view for addition of GSM modem & card for future so as to send SMS alerts to minimum of 5 personnel.

10.10.5. The ethernet switch, patch cord, Light Interface Unit (LIU) and Fibre Optic (FO) cable are not included in the present scope.

10.11. **Drain Oil Storage Tank**

10.11.1. A drain oil storage tank for each transformer shall be provided at suitable location.

10.11.2. The oil storage tank shall have non-corrosive, waterproof, epoxy coated, mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPES.

10.11.3. The total capacity of storage tank shall be more than 12% of transformer tank oil to avoid over flowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. All the pipes and physical connections from transformer to storage tank shall be in the scope of NIFPES OEM / Vendor.

11.0 ONLINE INSULATING OIL DRYING SYSTEM

11.1. If specified in MR/ tender specification, transformer shall be provided with a cartridge type on line insulating oil drying system of adequate rating with proven field performance. It shall be designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition.

11.2. There shall be molecular sponge device for moisture absorption in easily replaceable cartridges. It shall display the moisture content in oil (PPM) and temperature of the inlet and outlet oil from the drying system. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge.

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11.3. The system shall be housed in IP-55 metallic enclosure of grade SS 304. Oil flow to the equipment shall be controlled through pump of suitable capacity with oil flow indicator for visual monitoring of flow. It shall be an integrated system comprising of filters, cartridges, sampling valves, sensors and protection devices, as required for completeness of the system suitable for operating at oil temperature up to 105°C, unless specified otherwise. All components shall be capable of withstanding the applicable thermal and dynamic stress.

11.4. Drying system, if transported without oil, shall be suitable for withstanding vacuum to ensure that no air/ contamination is trapped during commissioning. In case, it is transported with oil, the oil shall conform to specifications for unused transformer oil. Oil sample shall be tested before installation to avoid contamination of main tank oil.

11.5. The equipment shall be capable of transferring data to substation automation system through FO port on IEC 61850 protocol. Potential free contacts for system trip/ off for relaying shall be provided.

12.0 NOISE LEVEL

Audible Noise level shall not exceed the limits specified in NEMA TR-1/ CBIP manual.

13.0 INSPECTION AND TESTING

13.1. Owner's representative shall be given free access in the works from time to time for stage wise inspection and progress reporting. Four weeks advance notice shall be given to witness the final routine test as per relevant IS and other tests as agreed upon. These tests shall be performed on the complete assembly at manufacturer's works. Test certificates duly signed by owner's representative shall be issued as part of final document.

13.2. Routine tests and special tests as listed below shall be carried out on all transformers:

a) GA along with verification of all accessories
b) Dimensional & electrical clearance
c) Rating plate details
d) Terminal/ tapping markings
e) Earthing arrangement
f) Measurement of winding resistance
g) Measurement of voltage ratio and check of voltage vector relationship
h) Measurement of impedance voltage and load loss
i) Measurement of no- load loss and current
j) Induced over voltage withstand test
k) Separate-source voltage withstand test (HV Test)
l) Measurement of insulation resistance before and after HV test
m) Noise level check
n) Magnetic Balance test
o) Dielectric test
p) BDV on transformer oil
q) Tests on OLTC/ control panel (if applicable)
r) Measurement of power taken by fans & oil pumps (on sample basis on one transformer)

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13.3. **Additional Tests:**

For transformers rated upto 2.5 MVA rating, oil leakage test, vacuum test and pressure test values shall be as specified in IS-1180-1/ IS-1180-3. For transformers rated > 2500 kVA following shall be considered:

13.3.1. Oil leakage Test - All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air/oil of a viscosity not greater than that of insulating oil at an ambient temperature and subjected to a pressure equal to the normal pressure plus 35 kN/m2 measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air, during which time no leakage shall occur.

13.3.2. Vacuum Test - One transformer tank of each size shall be subjected to the specified vacuum as in Table-1 below. The tanks designed for vacuum of 760mm of mercury shall be tested at a maximum internal pressure of 3.33 kN/m^2 (25mm of Hg) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in Table-2 below without affecting the performance of the transformer.

Table – 1

Highest System Voltage	MVA Rating	Vacuum Gauge pressure kN/m2	mm of Hg
Upto 36 kV	above 2.5 & upto 20	68.0	500
	Above 20	100.64	760

Table – 2

Horizontal length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5
751 to 1250	6.5
1251 to 1750	8
1751 to 2000	9
2001 to 2250	11
2251 to 2500	12.5
2501 to 3000	16
Above 3000	19

13.3.3. Pressure Test - One transformer tank of each size shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/m2 whichever is lower measured at the base of the tank and will be maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified in Table-2.

13.3.4. One transformer of each rating shall be subjected to heat run test, if specified in MR/ Tender.

13.3.5. Impulse test, if specified in MR/ Tender, shall be carried out on all three limbs of the transformer.

13.3.6. Transformer shall be subjected to short circuit test, if specified in MR/ Tender.

13.3.7. All the instruments, meters, etc. used for testing shall be duly calibrated at NABL laboratory and necessary calibration certificate shall be made available during inspection.

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13.3.8. Type test report of the heat/fire Detector/Sensors shall be submitted to Owner/ EIL along with the design/drawing documents.

14.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers, P.O. number etc.

Transformer tank shall be filled with oil/ pure dry nitrogen/ air depending upon the transport weight limitations or as specified in MR/ tender specifications. Dry air should be preferred due to safety of personnel entering transformer. If nitrogen is used, the information shall be stencilled on tank prominently. External gas cylinders should be provided to make up any gas leakage during transit and storage. Pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

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शुष्क किस्म के लाईटिंग ट्रांसफॉर्मर के लिए विनिर्देश

SPECIFICATION FOR DRY TYPE LIGHTING TRANSFORMER

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.11.2022	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKM	HK	MKS	SM
5	03.04.2017	REVISED AND REISSUED AS STANDARD SPECIFICATION	NT	SA	BRB	RN
4	08.04.2011	REVISED AND ISSUED AS STANDARD SPECIFICATION	MK	SA	UAP	DM
3	25.04.2008	REVISED AND ISSUED AS STANDARD SPECIFICATION	SA	NS	JMS	VC
2	25.03.03	REVISED AND ISSUED AS STANDARD SPECIFICATION	NPG	RR	VPS	SKG

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Abbreviations:

AN	:	Air Natural
BIS	:	Bureau of Indian Standards
BS	:	British Standards
CEA	:	Central Electricity Authority
CRCA	:	Cold Rolled Cold Annealed
IEC	:	International Electro technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
KVA	:	Kilo Volt Amperes
MSL	:	Mean Sea Level
MV	:	Medium Voltage
NEMA	:	National Electrical Manufacturers Association
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
SWG	:	Standard Wire Gauge
VDE	:	Verband Der Electrotechnik, Elecktronik und Information Stechnik

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1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of cast resin / resin impregnated dry type lighting transformers suitable for indoor location.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS.

IS: 5	:	Colours for ready mixed paints and enamels
IS: 1271	:	Electrical Insulation-thermal evaluation and designation.
IS: 2026: Part 11 / IEC: 60076-11	:	Dry Type Transformer
IS: 2705: Part I	:	Current transformers - General requirements
IS: 10028	:	Code of practice for selection, installation and maintenance of transformers.
IS/ IEC: 60529	:	Degree of protection provided by enclosures (IP Code)
ECBC 2017	:	Energy Conservation Building Code

2.2 In case of imported equipments standards of the country of origin shall be applicable provided these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

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

3.0 GENERAL REQUIREMENTS

3.1 All the offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the user of equipment and EIL, before phasing out the product/ spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres found in Refineries, Petrochemical and Fertilizer plants or as specified in the material requisition / tender. The transformer shall be designed to operate under site conditions as specified in data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000m above MSL shall be considered.

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5.0 CONSTRUCTION

5.1 The transformer shall be dry type, AN cooled suitable for indoor installation. Transformer shall be conventionally housed in a freestanding panel type enclosure of welded sheet steel frames with expanded metal screens of suitable size or louvres backed by wire-mesh. Transformer and the enclosure shall be suitably reinforced to prevent distortion during handling.

For panel mounted transformer, if specified in datasheet, the panel shall be floor mounted type suitable for installation in substation and shall not have any wheels / rollers. The panel shall be provided with integral base frame which shall be suitable for tack welding.

The frame of vertical panels of panel mounted transformer shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2mm (14SWG) CRCA except the doors and covers that may be made of 1.6mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

5.2 After preparation of the under surface, the vertical panels of panel mounted transformer shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.
All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

5.3 The transformer shall be double wound core type with non-ageing, cold rolled grain oriented silicon steel insulated laminations with high magnetic permeability and clamped to minimise vibrations and noise. Core lamination shall be free of burrs and shall be stacked without Air gaps. Core fastening bolts shall be insulated to reduce losses and to avoid hot spots. All parts of the magnetic circuit shall be effectively connected to the earth system.

5.4 The winding shall be of copper and shall be designed for full load current and to withstand the thermal and electromagnetic stresses arising due to the through fault current. The current carrying winding joints shall be electrically brazed. Foil type windings are not acceptable.

5.5 Voltage ratio of lighting transformer shall be as mentioned in Datasheet/Material Requisition/Tender.

5.6 Vector group of transformer shall be as mentioned in Datasheet/Material Requisition/Tender. The windings shall be provided with class 'F' insulation for lighting transformers upto 100 KVA and class 'H' insulation for rating more than 100 KVA.

5.7 Conventional Lighting Transformer shall have minimum degree of protection as IP-23. The enclosure of panel mounted transformer shall be dust and Vermin-Proof and shall provide a degree of protection not less than IP-41. In case of conventional transformer, Marshalling box and cable termination box shall have degree of protection not less than IP-55.

5.8 Different non current carrying parts of the transformers shall be connected by copper flexibles for earth continuity purpose.

5.9 All doors and movable parts of panel mounted transformer shall be earthed, using flexible copper connections, to the fixed frame of the panel. The panel mounted transformer shall be provided with two earthing studs with lugs on the external surface of the enclosures suitable for termination of GI strip / earthing cable.

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5.10 All the fasteners and bolts shall be galvanized. All surfaces to be painted shall be thoroughly cleaned, descaled, made free from rust and shall be epoxy painted.

5.11 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on panel mounted transformer. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

5.12 Dry type transformer shall be energy efficient with permissible maximum losses at 50% and 100% loading not exceeding the values as defined in Energy Conservation Building Code (ECBC) - 2017.

6.0 TERMINALS

6.1 Windings shall be brought out and terminated in cable boxes for conventional lighting transformer.

6.2 Cable boxes shall be supplied with cable lugs and glands. For MV XLPE power/control cables single compression cable glands and crimped type tinned copper cable lugs shall be supplied. Gland plate shall be removable type. For single core cables, gland plate shall be of non-magnetic material.

6.3 In case of panel mounted transformer, panel shall be provided with bottom cable entries for connecting both primary and secondary windings of transformer installed inside panel. Thus a separate cable termination box is not required. Primary and secondary cable termination arrangement inside panel shall be oriented accordingly for routing and termination of Owner's cables inside panel.

6.4 A separate neutral terminal on the secondary side shall be provided for neutral earthing of the transformers. The neutral terminal shall be complete with connector block assembly for easy termination of GI earth strip / cable.

7.0 ACCESSORIES

Tappings shall be provided on the Primary side. Tap changer shall be off-circuit rotary type or tap links type. Under conditions of external short circuit, the tap changing equipment shall be capable of carrying the same current as the winding. Tap changer regulation range shall be +5% / -7.5% with each step of 2.5%. Tap changing mechanism shall be easily accessible and it shall be possible to change the taps without opening the main transformer enclosure.

Base channels shall be provided with skids and pulling eyes to facilitate handling. Tag plate shall be provided. In case of panel type transformer, suitable removable type eye bolts /lifting hooks shall be provided on the panel to facilitate lifting and handling of the panel. These eyebolts /lifting hooks when removed shall not leave any opening in the panel.

Temperature monitoring system shall be supplied with temperature sensors fitted in each limb. Temperature monitoring system shall initiate alarm and trip for winding over temperature. Alarm and trip temperatures value shall be site settable. The monitoring system shall also have an indicating device.

240V SPN supply at one point shall be provided by purchaser at transformer panel. All the further distribution from this point shall be done by vendor.

ON/OFF Indication Lamps mounted on the door and LED lamp controlled through a door limit switch shall be provided for illumination inside the panel for panel mounted type transformer.\

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8.0 NOISE LEVEL

Audible noise level for lighting transformers shall not exceed the limits specified as below:

KVA	Average sound level in decibels (At 30 cm from transformer)
0-50	50
51-150	55
151-300	58
301-500	60

9.0 INSPECTION AND TESTING

9.1 During fabrication, the transformer shall be subject inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

9.2 For testing requirements, refer Inspection & Test Plan doc. no. 6-81-1042. Prior notice of minimum 4 weeks shall b given to EIL/Owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. All testing shall be carried out at manufacturer's works under his care and expense.

9.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1042.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers, P.O. number etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

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मध्यम एवं उच्च वोल्टेज केबल एवं असेसरिज के लिए विनिर्देश

SPECIFICATION FOR MEDIUM AND HIGH VOLTAGE CABLES & ACCESSORIES

Rev. No	Date	Purpose	Prepared by	Checked by	StandardsCommitteeConvenor / Approved by	Standards Bureau Chairman
9	30/06/22	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	RSR	MKS	SM
8	20/01/17	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	BRB	RN
7	01/04/16	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	BRB	RN
6	11/04/11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM

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Abbreviations:

ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CEA	:	Central Electricity Authority
DGMS	:	Director General of Mines and Safety
EIL	:	Engineers India Limited
EPR	:	Ethylene Propylene Rubber
FR	:	Flame Retardant
FRLS	:	Flame Retardant Low Smoke
FS	:	Fire Survival
ICEA	:	Insulated Cable Engineers Association
IEC	:	International Electro technical Commission
IEEE	:	The Institute of Electrical & Electronic Engineers
IS	:	Indian Standards
LF	:	Low Frequency
NEMA	:	National Electrical Manufacturers Association
PE	:	Polyethylene
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
UV	:	Ultra Violet
XLPE	:	Cross linked Polyethylene

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1.0 SCOPE

This specification along with data sheets covers requirements for design, manufacture, testing at works and supply of Fire survival Medium voltage cables and Flame Retardant Low Smoke Medium & High Voltage cables and cable jointing / terminating accessories for medium and high voltage systems.

2.0 STANDARDS

2.1 The cables and cables jointing & terminating accessories shall comply with the latest edition of the following standards as applicable:

IS: 209	:	Specification for zinc.
IS: 1554 Part-1	:	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V (including amendment no. 1, 2, 3, 4 & 5)
IS:1554 Part-2	:	Specification for PVC insulated (heavy duty) electric cables for working voltages from 3.3 kV up to and including 11 kV (including amendment no. 1, 2, 3 & 4)
IS: 3961(Pt-6)	:	Recommended current rating for cables: Part- 6 Cross-linked Polylene insulated PVC sheathed cables
IS: 3961(Pt-7)	:	Recommended current ratings for cables part 7 cross-linked insulated thermoplastic sheathed cables
IS: 3975	:	Mild steel wires, strips and tapes for armouring of cables.
IS: 5831	:	PVC insulation and sheath of electric cables.
IS: 6380	:	Specification for elastomeric insulation and sheath of electric cables.
IS: 7098 Part-1	:	Cross linked polyethylene insulated PVC sheathed cables for working voltage upto and including 1100V (including amendment no. 1,2,3,4 & 5)
IS: 7098 Part-2	:	Cross linked polyethylene insulated thermoplastics sheathed cables for working voltages from 3.3 kV up to and including 33 kV (including amendment no. 1 & 2)
IS: 8130	:	Conductors for insulated electric cables and flexible cords.
IS: 10418	:	Drums for electric cables.
IS:10462 (Pt-1)	:	Fictitious calculation method for determination of dimensions of protective coverings of cables: Part - I Elastomeric and thermo-plastic insulated cables.
IS: 10810	:	Methods of test for cables: - Part 41: Mass of zinc coating on steel armour - Part 58: Oxygen index test - Part-61: Flame retardant test - Part-62: Fire resistance test for bunched cables. - Part-63: Measurement of Smoke density of Electric cables under fire conditions
IS: 13573 (Pt-1):		Cable accessories for extruded power cables - part 1 for working voltages for 1.1 kv upto and including 3.3kV (E) - test methods and test requirements
IS: 13573 (Pt-2):		Cable accessories for extruded power cables - part 2 for working voltages for 3.3kV (UE) upto and including 33kV (E) - test requirements
IS: 13573 (Pt-3):		Cable accessories for extruded power cables - part 3 for working voltages for 3.3kV (UE) upto and including 33kV (E) - test methods
IS: 16269	:	Recommended short circuit ratings of electric cables with rated voltage from 1.1kV to 220kV

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IEC: 60331-21	:	Tests for electric cables under fire conditions circuit integrity – Procedures and requirements – Cables of rated voltage up and including 0.6/1.0kV.
IEC: 60332-1	:	Test of the fire behaviour on single core or single cable (flame retardancy)
IEC: 60332-3	:	Tests of the fire behaviour on bunched cables (reduced flame propagation)
IEC-60754-1	:	Test on gases evolved during combustion of materials from cables, Determination of the amount of halogen acid gas content
IEC: 61034	:	Measurement of smoke density of cables burning under defined condition
NEMA-WC53	:	Standard test methods for extruded dielectric power, control, instrumentation and portable cables for test.
IEEE-383	:	Standard for qualifying electrical cables and splices for nuclear facilities
ASTM-G-154	:	Standard practice for operating fluorescent light apparatus for UV exposure of non metallic materials.
ASTM-D-2863	:	Measurement of minimum oxygen concentration to support candle like combustion of plastics
BS: 7846	:	Electric cables- 600/1000V armoured fire resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.

2.2 The cables and accessories shall also conform to the provisions of CEA Regulations and other statutory regulations, as applicable.

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

3.0 GENERAL CONSTRUCTION

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

3.2 Outer sheath of all cables shall be black in colour and the minimum value of oxygen index shall be 29% at 27 ± 2 ° C. In addition suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack. However, for earthing cables; colour of outer sheath shall be green.

3.3 All cables covered in this specification shall be Flame Retardant Low Smoke (FRLS) or Fire Survival (FS). The outer sheath of FRLS cables shall possess flame propagation properties meeting requirements as per IS-10810 (Part-62) category AF. FRLS cable shall be identified by indenting, embossing or printing the appropriate legend i.e. 'FRLS, Category – C2' throughout the cable length. FRLS properties shall be as per IS:10810 Part 61 & 62, IEC-60332 Part 1 & Part 3, IEEE-383, IEC-61034, IEC-60754 Part 1, ASTM-D-2863.

3.4 Sequential marking of the length of the cable in metres shall be provided on the outer sheath at every one metre. The embossing/engraving shall be legible and indelible.

3.5 The overall diameter of the cables shall be strictly as per the values declared by the manufacturer in the technical information subject to a maximum tolerance of ±2 mm up to overall diameter of 60mm and ±3mm for beyond 60mm.

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3.6 PVC/ Rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand metre length. In addition, ends of the cables shall be properly sealed with caps to avoid ingress of water during transportation and storage.

3.7 The joints in armour wire/strips shall be made by brazing or welding and any surface irregularities shall be removed. A joint in any wire/strip shall be at least 300mm. from the nearest joint in any wire/strip in the complete cable.

3.8 The cables meant to be used in mining area under the jurisdiction of DGMS shall satisfy the following

(a) "DGMS CERTIFIED" to be embossed at outer sheath at regular interval.

(b) Cables to be used in Mines shall have copper conductor only.

(c) The resistance of armour shall not exceed that of the conductor as specified in IS-8130 by more than 33%. To satisfy this, substitution of galvanised steel wire/strip in armouring by the required number of tinned copper wires/strips is permissible.

(d) For mining cables, the size and type of armour shall be such that the combined conductance of armour shall be equivalent to 75 percent of the conductance of the largest conductor of the cable.

3.9 Medium Voltage Cables

3.9.1 All power/control cables for use on medium voltage systems shall be heavy-duty type, 650/1100V grade with aluminium/ copper conductor (as mentioned in datasheet / Material requisition), XLPE insulated, inner-sheathed, armoured/ unarmoured and overall PVC sheathed. XLPE insulated cables shall meet the requirement specified in IS-7098 (Part-1).

3.9.2 The conductors shall be stranded for all sizes of MV power cable. Conductors of nominal area less than 16 mm^2 shall be circular only. Conductors of nominal area 16 mm^2 and above may be circular or shaped as per IS 8130. Cables with reduced neutral conductor shall have sizes as per Table- 2 of IS 7098 (Part-1).

3.9.3 The core insulation shall be with XLPE compound applied over the conductor by extrusion. It shall conform to the properties given in Table-1 of IS: 7098 (Part-1).

3.9.4 The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of Type ST-2 PVC compound as per IS: 5831. The minimum thickness of inner sheath shall be as per Table-5 of IS: 7098 (Part-1). Single core cables shall have no inner sheath.

3.9.5 All cables shall be provided with armour except those specifically specified as unarmoured. For single core cables intended for use on AC system, the armouring shall be of non-magnetic material. For multicore cables, the armour shall be by single round galvanised steel wires where the calculated diameter below armouring does not exceed 13 mm and by galvanised steel strips where this dimension is greater than 13 mm. Requirement and methods of tests for armour material and uniformity of galvanisation shall be considered as per IS - 3975 and IS - 10810 (Part 41). The dimensions of armour shall be considered as per method (b) of Table-6 of IS - 7098 (Part -1). For single core cables, the armour shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter for cable having calculated diameter under armour upto 55 mm. In case of calculated diameter under armour is more than 55 mm. Table-6 of IS: 7098 (Part-1) shall be followed for dimension of armour.

3.9.6 The outer sheath for the cables shall be applied by extrusion and shall be formulated for lower smoke and shall be of PVC compound conforming to the requirements of type ST-2

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compound as per IS: 5831. The minimum and average thickness of outer sheath for unarmoured cables and minimum thickness of outer sheath for armoured cables shall be as per Table-8 of IS: 7098 (Part -1).

3.9.7 For XLPE insulated cables, it shall be possible to continuously operate the cable at a maximum conductor temperature of 90°C under full load condition and 250°C under short-circuit condition.

3.9.8 The fire survival cables shall meet the following additional requirements :

i) The insulation shall be of EPR or equivalent material with glass mica tape below or above insulation.

ii) The cables shall meet requirement of circuit integrity test for a minimum period of 3 hours at maximum temperature of 950° C.

3.10 High Voltage Cables

3.10.1 Power cables from 3.3kV and up to and including 33kV systems shall be Aluminium/ Copper conductor, XLPE insulated, sheathed, armoured/ unarmoured and overall PVC sheathed.

3.10.2 The conductors shall be stranded and compacted circular for all cables.

3.10.3 All cables rated 3.8/ 6.6kV and above shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi conducting screen.

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

3.10.5 The insulation screen shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic copper screen. The copper screen for all the three cores together shall be capable of carrying the single line to ground fault current value and the duration specified in the data sheet. For single core cable, copper screen provided shall be capable of carrying the single line to ground fault current value and the duration specified in the data sheet. For screen sizing, final temperature shall be considered as 200°C under adiabatic condition as per IS: 16269.

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

3.10.7 The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST 2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness. The minimum thickness of inner sheath shall be as per Table-5 of IS: 7098 (Part-2). In case of single core cables, there shall be extruded inner sheath between insulation metallic screen and armouring.

3.10.8 All cables shall be provided with armour except those specifically specified as unarmoured. For single core cables intended for use on AC system, the armouring shall be of non-magnetic material. For multicore cables, the armour shall be by galvanised steel strips. Requirement and methods of tests for armour material and uniformity of galvanisation shall be as per IS-3975 and IS -10810 (Part 41). The dimensions of armour shall be as per method (ii) of Table-6 of IS -7098 (Part -2). For single core cables, the armour shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter for cable having calculated diameter under armour

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upto 55 mm. In case of calculated diameter under armour is more than 55 mm. Table-6 of IS: 7098 (Part-2) shall be followed.

3.10.9 The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of Type ST 2 compound of IS: 5831. The minimum and average thickness of outer sheath for unarmoured cables and minimum thickness of outer sheath for armoured cables shall be as per Table-7 of IS: 7098 (Part-2).

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

4.0 CABLE ACCESSORIES

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

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

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

4.4 The contents of the accessories kit including all consumable shall be suitable for storage without deterioration at a temperature of 45° C, with shelf life extending to more than 5 years.

4.5 Terminating Kits

The terminating kits shall be suitable for termination of the cables to an indoor switchgear or to a weatherproof cable box of an outdoor mounted transformer/ motor. For outdoor terminations, weather shields/ sealing ends and any other accessories required shall also form part of the kit. The terminating kits shall be from one of the makes/ types mentioned in the data sheet.

4.6 Jointing Kits

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

5.0 INSPECTION, TESTING AND ACCEPTANCE

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

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5.1 Cables

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

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

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

5.1.4 Test for Resistance to Ultra Violet Radiation: This test shall be carried out as per ASTM-G-53 or ASTM-G-154 on outer sheath. The retention value of tensile strength and ultimate elongation after the test shall be minimum 60 % of tensile strength and ultimate elongation before the test. Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by EIL before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognised test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided outer sheath remains same.

5.1.5 Acceptance tests as per IS-7098 (Part-1 & Part-2) and the following special tests to be performed on the cables as per sampling plan for all cables. However these tests are required to be witnessed by EIL/ Owner for HV cables.

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

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

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

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

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

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

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

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

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b. Temperature index as per ASTM-D-2863 i.e. to determine at what temperature normal oxygen content of 21% in air will support combustion of FRLS sheath which shall remain as 250°C.

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

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

5.1.7 The test for circuit integrity for fire survival cables shall be carried out as per IEC-60331 (Part-21).

5.2 Cable Accessories

Type tests should have been carried out to prove the general qualities and design of a given type of termination/ jointing system as per IS-13573. The type test certificates from independent testing laboratory shall be submitted before despatch.

6.0 PACKING AND DESPATCH

6.1 Cables shall be despatched in non-returnable steel drums of suitable barrel diameter, securely packed, with the take-off end fully protected against mechanical damage. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit or storage.

6.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, voltage grade of cable, length of cable in metres, drum no., cable code, BIS certification mark, gross weight etc. shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

6.3 Cables shall be supplied in drum lengths as follows:

6.3.1 **MV Cables**

-	Multicore Power cables upto 50 mm^2	:	2000 m
-	Multicore Power cables from 70 mm^2 up to 500 mm^2	:	1000 m
-	Single Core Power cables upto 630 mm^2	:	1000 m

6.3.2 **HV Power Cables Upto 11kV Grade**

-	Three Core cables upto 400 mm^2	:	750 m
-	Single Core cables upto 400 mm^2	:	1000 m
-	Single Core cables above 400 mm^2 and upto 1000 mm^2	:	750 m

6.3.3 **HV Power Cables Above 11kV Grade and upto 33kV Grade**

-	Three Core cables upto 300 mm^2 grade	:	500 m
-	Single Core cables upto 400 mm^2	:	1000 m
-	Single Core cables above 400 mm^2 and upto 1000 mm^2	:	500 m

However exact drum lengths shall be finalised during order execution. A tolerance of ± 3 % shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to (-2%) to (+0%).

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संचार, अग्नि चेतावनी और कंट्रोल पेयर्ड केबल के लिये विनिर्देश

SPECIFICATION FOR COMMUNICATION, FIRE ALARM AND CONTROL PAIRED CABLES

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	07/04/21	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	PG	SM
6	01/04/16	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	BRB	RN
5	27/04/11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
4	25/04/08	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
3	21/03/03	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	SKG

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Abbreviations:

ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CEA	:	Central Electricity Authority
DGMS	:	Director General of Mines and Safety
DOT	:	Department of Telecommunications (Government of India)
EIL	:	Engineers India Limited
EPR	:	Ethylene Propylene Rubber
FR	:	Flame Retardant
FRLS	:	Flame Retardant Low Smoke
FS	:	Fire Survival
IEC	:	International Electro technical Commission
IEEE	:	The Institute of Electrical & Electronics Engineers
IS	:	Indian Standards
LF	:	Low Frequency
PE	:	Polyethylene
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
UV	:	Ultra Violet
XLPE	:	Cross Linked Poly Ethylene

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1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture and supply of Flame Retardant Low Smoke type and Fire Survival type paired PVC sheathed control cables and cables for use in plant communication & fire alarm systems and jelly filled telecommunication cables.

2.0 CODES AND STANDARDS

The equipment shall comply with the requirements of the latest revision of the following standards:

2.1 BIS and other Standards

ASTM-D-883	:	Standard terminology relating to plastics.
ASTM-D-2863	:	Measurement of minimum oxygen concentration to support candle like combustion of plastics.
ASTM-G-154	:	Standard practice for operating fluorescent light apparatus for UV exposure of non-metallic materials.
ASTM-D-924	:	Standard test method for dissipation factor (or power factor) and relative permittivity (dielectric constant) of electric insulating liquids.
BS-6234	:	Specification for polyethylene insulation and sheath of electric cables.
IS-694	:	Polyvinyl Chloride Insulated Unsheathed and Sheathed Cables/cords With Rigid and--Flexible Conductor for Rated Voltages--Up to and Including 450/750V.
IS-1554 (Part-1)	:	PVC insulated (heavy duty) electric cables: Part 1 for working voltages up to and including 1100V.
IS-3975	:	Mild steel wires, formed wires and tapes for armouring of cables.
IS-5831	:	PVC insulation and sheath of electric cable.
IS-6380	:	Elastomeric insulation and sheath of electric cables.
IS-7098 (Part-1)	:	Cross Linked polyethylene insulated PVC sheathed cables: For working voltage up to and including 1100 V.
IS-8130	:	Conductors for insulated cables and flexible cords.
IS-9938	:	Recommended colours for PVC insulation for LF wires and cables.
IS-9968	:	Elastomer insulated cables: Part 1 For working voltages upto and including 1100 V.
IS-10418	:	Drums for electric cables.
IS-10462 (Part 1)	:	Fictitious calculation method for determination of dimensions of protective coverings of cables (Part-1: Elastomeric and thermoplastic insulated cables).
IS-10810	:	Methods of Test for Cables: - Part 41: Mass of zinc coating on steel armour. - Part 58: Oxygen index test. - Part-61: Flame retardant test. - Part-62: Fire resistance test for bunched cables. - Part-63: Measurement of Smoke density of Electric cables under fire conditions.
IS-12444	:	Continuously cast and rolled electrolytic copper wire rods for electrical conductors.
IEC: 60331-21	:	Tests for electric cables under fire conditions circuit integrity – Procedures and requirements – Cables of rated voltage up and including 0.6/1.0kV.
IEC: 60332-1	:	Test of the fire behavior on single core or single cable (flame retardancy).

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IEC-60332-3	:	Tests of the fire behavior on bunched cables (reduced flame propagation).
IEC-61034	:	Measurement of smoke density of cables burning under defined condition.

2.2 **DOT Standards**

GR/WIR-06/03	:	Specification for cable - switchboard (Screened and Unscreened) - Generic requirements.
GR/CUG-01/03	:	Specification for solid polythene insulated fully filled, polythene sheathed underground telecom cables.

2.3 In case of imported cables, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.4 The cables shall also conform to the provisions of the CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.5 In case Indian standards are not available for any material, standards issued by IEC or equivalent agency shall be applicable.

2.6 In case of any contradictions between various referred standard/specification/data sheet and statutory regulations, the most stringent one shall govern and decision of owner/EIL in this regard will be final and binding.

3.0 GENERAL CONSTRUCTION

3.1 Cables shall be suitable for installation in following conditions:

i. Above ground in open-air locations (trays/ ducts) in tropical, humid and corrosive atmosphere prevalent in refineries/ petrochemical plants with severe weathering and exposure to solar radiation.

ii. Directly buried in underground trenches, conduits with uncontrolled back-fill and possibility of flooding by water and chemicals.

iii. Design ambient air temperature of 40°C/ ground temperature of 30°C.

3.2 The joints in armour wire/strips shall be made by brazing or welding and any surface irregularities shall be removed. A joint in any wire/strip shall be at least 300mm from the nearest joint in any wire/strip in the complete cable.

3.3 The cable meant to be used in mining area under jurisdiction of DGMS shall satisfy the following:

a. "DGMS CERTIFIED" to be embossed at outer sheath at regular interval.
b. The resistance of armour shall not exceed that of the conductor as specified in IS: 8130 by more than 33%. To satisfy this, substitution of galvanized steel wire/strip in armouring by the required number of tinned copper wires/strips is permissible.
c. For mining cables, the size and type of armour shall be such that the combined conductance of armour shall be equivalent to 75% of the conductance of the largest conductor of the cable.

4.0 TECHNICAL REQUIREMENTS FOR NON JELLY FILLED CABLES

4.1 The control cable shall be heavy duty type, 650/1100V grade with copper conductor, XLPE insulated, twisted pair, individual pair screened/shielded, overall screened/shielded, inner sheathed, armoured and PVC overall outer sheathed.

4.2 Non jelly filled communication and fire alarm cables shall in general conform to the requirements of DOT specification GR/WIR-06/03.

4.3 **Conductors**

4.3.1 The size of conductor shall be as per job requirements/data sheets.

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4.3.2 The conductors shall consist of annealed, high conductivity copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/WIR-06/03.

4.3.3 The conductor shall be stranded for the control cables and shall be solid for fire alarm and communication cables.

4.4 **Insulation**

4.4.1 For fire alarm and communication cable, the core insulation shall be with PVC compound applied over the conductor by extrusion.

4.4.2 For control cable, the core insulation shall be with Cross Linked Poly Ethylene (XLPE) compound cured, applied over the conductor by extrusion. It shall be free from voids and shall conform to the properties given in Table-1 of IS: 7098 (Part-1).

4.4.3 PVC Insulation shall meet the following requirements:

Conductor Diameter (Area)	Type of Insulation	Thickness of Insulation (Minimum)
Up to 0.5mm ($0.2mm^2$)	Type-A as per IS-5831	0.18 mm
Above 0.5mm ($0.2mm^2$) & up to 0.71mm (0.4mm2)		0.26 mm
Above 0.71mm ($0.4mm^2$) & up to 0.9mm (0.63mm2)		0.31 mm
Above 0.9mm ($0.63mm^2$) & up to 1.12mm ($1mm^2$)		0.39 mm
Above 1.12mm ($1mm^2$) & up to 1.38mm ($1.5mm^2$)		0.58 mm
1.78mm ($2.5mm^2$)		0.71 mm

4.4.4 The nominal thickness of XLPE insulation for $1.5mm^2$ and $2.5mm^2$ conductor size control cables shall be 0.7mm in line with Table-3 of IS: 7098 (Part-1).

4.4.5 The colour used for insulation shall conform as nearly as practicable to the standard colours as per IS-9938. The wire insulation shall have colours in accordance with Table-2 of DOT specification GR/WIR-06/03. The applied colour shall neither have deleterious effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.

4.4.6 For single pair cables, the colour shall be incorporated in the insulation.

4.4.7 For multi pair cables, cores shall have uniform pattern of continuous spiral (Pitch not exceeding 25mm) to facilitate easy identification. This may be done by the application of one or more coloured strips on a base colour or by direct extrusion.

4.4.8 Alternately, colouring may consist of concentric coloured rings or dots or dashes on the base colour. The coloured rings, dots or dashes shall have a width of not less than 1.0mm and shall be repeated along the length of the insulation at an interval not less than 15mm and not more than 25mm.

4.4.9 The dots or dashes shall be applied on diametrically opposite sides of the insulation, so that all colours are visible when the insulation is viewed from any side.

4.4.10 In addition to colouring, control cables shall also be identified with prominent and indelible Alpha Numeric numerals on the outer surface of the insulation/ screen. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50mm between two consecutive numbers.

4.5 **Twisting**

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 80mm.

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4.6 **Core Formation**

The core formation shall conform to Cl. 6.0 of DOT specification no. GR/WIR-06/03.

4.7 **Screen/ Shield**

4.7.1 The control cables shall be provided with individual pair screen/shield and also overall screen/shield. Fire alarm and communication cables shall be provided with overall screen/shield. The screen/shield shall be of aluminium tape with minimum thickness of 0.04mm. The overlap shall be minimum 3mm for cables up to 50 pair & minimum 6mm for cables above 50 Pair. The screen/shield shall be backed by an outer protective layer of 0.13mm PVC tape or other non-hygroscopic material lapped applied longitudinally or helically with overlap.

4.7.2 The cables shall be provided with a drain wire. Drain wire shall have a minimum cross-section of 0.5mm^2, shall be composed of multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the overall screen/shield. The drain wire resistance including screen shall not exceed 30 ohm/km.

4.8 **Ripcord**

A non-metallic ripcord of suitable quality shall be laid longitudinally under the inner sheath & overall screen/shield. The ripcord when pulled shall cut through the sheath and strip the core.

4.9 **Inner Sheath**

4.9.1 An extruded inner sheath of type ST1 PVC, as per IS-5831, with minimum thickness as per Table-4 of IS-1554 (Part-1) shall be provided for PVC insulated cable. For XLPE insulated cable, an extruded inner sheath of type ST2 PVC, as per IS-5831, with minimum thickness as per Table-5 of IS-7098 (Part-1) shall be provided. It shall be applied over the laid up core, by extrusion to fit closely on it.

4.9.2 The inner sheath shall be as circular as possible. It shall be possible to remove the inner sheath without damage to the insulation.

4.9.3 When one or more layers of non-hygroscopic tape is helically applied over the laid up cores, as a binder, the thickness of such tape(s) shall not be construed as a part of the inner sheath.

4.10 **Armour**

4.10.1 The cables shall be provided with armouring, made of hot dip galvanized steel wire /strip over the inner sheath.

4.10.2 The armour shall be by means of 1.4mm thick round wires for cables with under armour diameter up to 13mm. For cables with an under armour diameter above 13mm, the armour shall be of flat steel strip with thickness as per IS-1554 (Part-1) or IS-7098 (Part-1), as applicable.

4.11 **Outer Sheath**

4.11.1 The cables shall be provided with an extruded PVC sheath for external protection. The PVC shall be type ST1 PVC, as per IS-5831 for PVC insulated cable and type ST2 PVC, for XLPE insulated cable.

4.11.2 All cables covered in this specification shall be flame retardant low smoke (FRLS). The outer sheath shall be with oxygen index minimum 29% at 27$\pm$2^{0}C and shall possess flame propagation properties meeting requirements as per IS: 10810 (Part-62) category AF. FRLS cables shall be identified by indenting, embossing or printing an appropriate legend i.e. 'FRLS, Category – C2' throughout the cable length. FRLS properties shall be as per IS: 10810 Part 61 & 62, IEC-60332 Part 1 & Part-3, IEEE-383, IEC-61034, IEC-60754 Part-1, ASTM-D-2863.

4.11.3 In addition, suitable chemicals shall be added to the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

4.11.4 The thickness of outer sheath shall be as per IS-7098 (Part 1) for XLPE insulated cable and as per IS-1554 (Part-1) for PVC insulated cable.

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4.11.5 The outer sheath shall fit tightly on the armour and shall be applied in such a manner that no undue residual strain is left in the material.

4.11.6 The outer sheath shall be red in colour for cables to be used for fire alarm system, grey in colour for cables to be used for telephone & communication system and black in colour for control cables.

4.11.7 Sequential marking of the length of the cable, in meters, shall be provided on the outer sheath at every one meter. The marking shall be legible and indelible by suitable method.

4.11.8 The overall diameter of the cables shall be strictly as per the values declared in the data sheet, subject to a maximum tolerance of $\pm$2mm.

4.11.9 The fire survival cables (if specified in specification/ data sheet) shall meet the following additional requirements:

i) The insulation shall be of EPR or Silicone rubber or equivalent material with glass mica tape below or above insulation.

ii) The cables shall meet requirement of circuit integrity test for a minimum period of 3 hours at maximum temperature of 950^0 C.

iii) Vendor shall have the test certificate for circuit integrity test as per IEC: 60331-21.

4.12 **Cable Capacitance**

4.12.1 The core to core capacitance of the cables shall not exceed 100nF/km at 1kHz.

4.12.2 The core to screen capacitance for the screened cables shall not exceed 250nF/km at 1kHz.

5.0 TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES

5.1 Jelly filled telecom cables shall in general conform to the requirements of DOT specification GR/CUG-01/03.

5.2 **Conductors**

5.2.1 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/CUG-01/03.

5.3 **Insulation**

5.3.1 Each conductor shall be insulated with insulating grade PE conforming to Cl. 4.0 of DOT specification GR/CUG-01/03.

5.4 **Twisting**

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 150mm.

5.5 **Core Formation**

The core formation shall conform to Cl. 6.0 of DOT specification GR/CUG-01/03.

5.6 **Filling Compound**

5.6.1 The cable core shall be filled with a suitable stable water resistant compound, which shall be compatible with the insulation, binders and tapes used in the cable.

5.6.2 It shall be homogeneous and uniformly mixed material containing an anti-oxidant.

5.6.3 The compound shall not obscure the identification of the colour of the insulation of the conductors.

5.6.4 It shall not contain dirt, metallic particles or other foreign matter.

5.6.5 The compound shall be readily removable from the insulated conductors by wiping.

5.6.6 It shall be free from any unpleasant odour and shall have no toxic or dermatic hazards.

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5.6.7 The flash point of the compound shall not be less than 200°C.

5.6.8 The volume resistivity measured at 100°C shall not be less than 10^{10} ohm-cm.

5.6.9 The permittivity at 1 MHz tested as per ASTM D-924 shall not be greater than 2.3 at 20°C.

5.7 **Core Wrapping**

At least one closed helical or longitudinal application of a non-hygroscopic and non-wicking polyester tape or tape of any other suitable material shall be provided over the cable core.

5.8 **Screen/ Shield**

5.8.1 The cables used for telephone system shall be provided with overall screen/shield. The screen/ shield shall be of aluminium tape with minimum thickness of 0.2mm. The overlap shall be minimum 3mm for cables having maximum diameter over inner sheath < 30mm & minimum 6mm for cables having maximum diameter over inner sheath ≥ 30mm. The screen/shield shall be coated with 0.05 mm nominal thickness polythene/copolymer on both sides. The thickness of the composite tape shall be 0.3mm ± 15%.

5.8.2 The aluminium tape shall be electrically continuous throughout the length of the cable.

5.9 **Inner Sheath**

5.9.1 The inner sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.9.2 The inner sheath shall be of polythene conforming to type 03C or H03C of BS 6234 and shall contain a suitable antioxidant system. The material shall be virgin as per ASTM D-883 and meet the requirements of Cl. 10.1 of DOT specification no. GR/CUG-01/03.

5.9.3 The thickness of inner sheath shall conform to Table-6 of DOT specification no. GR/CUG-01/03.

5.9.4 The maximum diameter over inner sheath shall conform to Table-7 of DOT specification no. GR/CUG-01/03.

5.10 **Armour**

5.10.1 The cables shall be provided with bedding and armour over the inner sheath.

5.10.2 The bedding shall consist of two close helical lappings of polythene or polypropylene tape. Each tape shall be applied with a minimum of 5% overlap.

5.10.3 The armour shall be made of hot dip galvanized steel tape of thickness as per Table-8 of DOT specification GR/CUG-01/03.

5.11 **Outer Sheath**

5.11.1 The external protection shall consist of a polythene sheath conforming to the material specification defined in Clause 5.9 above.

5.11.2 The thickness of outer sheath shall conform to Table-9 of DOT specification GR/CUG-01/03.

5.11.3 The outer sheath shall be as circular as possible and free from pinholes and other defects.

5.11.4 Colour of outer sheath shall be grey.

5.11.5 The maximum diameter over outer sheath shall conform to Table-7 of DOT specification GR/CUG-01/03.

5.12 **Cable Capacitance**

The average mutual capacitance of the pairs measured at 800 to 1000Hz shall be 52 ± 3 nF/km. However, the mutual capacitance of individual pairs shall be within the limits of 52 ± 4.5 nF/km.

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6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected to examination, testing and approval by EIL/ Owner. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality.

6.2 The following acceptance tests shall be conducted on the completed jelly filled cables as per the test procedures given in DOT specification GR/CUG-01/03 and this specification:

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.
ii. Measurement of thickness of insulation, inner sheath, screen, armour & outer sheath.
iii. Measurement of resistance of conductor.
iv. Measurement of resistance unbalance.
v. Continuity check & measurement of resistance of Poly-al tape.
vi. Colour coding.
vii. Conductor continuity test.
viii. Mutual capacitance test.
ix. Capacitance unbalance test.
x. Cross talk test.
xi. Attenuation test.
xii. Insulation resistance test.
xiii. Dielectric strength test.
xiv. Drip test.
xv. Armour galvanization test.
xvi. Conductor annealing test.
xvii. Measurement of drum length.

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

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

b. Temperature index as per ASTM-D-2863 i.e. To determine at what temperature normal oxygen content of 21% in air will support combustion of FRLS sheath which shall remain as 250°C.

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

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

6.4 The test for circuit integrity for fire survival cables shall be carried out as per IEC-60331 (Part-21).

6.5 The following tests shall be conducted on the completed non jelly filled cables as per the test procedures given in DOT specification GR/WIR-06/03 and this specification:

6.5.1 **Acceptance tests**

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.
ii. Measurement of thickness of insulation, inner sheath, screen, armour & outer sheath.
iii. Measurement of resistance of conductor.
iv. Colour coding.
v. Conductor continuity test.

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vi. Mutual capacitance test.
vii. Capacitance unbalance test.
viii. Insulation resistance test.
ix. High voltage test.
x. Armour galvanization test.
xi. Conductor annealing test.
xii. Measurement of drum length.

6.5.2 **Special Tests**

The non-jelly filled cables shall also be subjected to following special tests:

i. Oxygen index test as per IS-10810 (Part 58).
ii. Flammability test on finished cable as per IS-10810 (Part 61 & 62).
iii. Test for rodent and termite repulsion property shall be done by analyzing the property by chemical method.

The special test shall be conducted on one sample from each lot. The sample will be selected by the inspector.

7.0 PACKING AND DESPATCH

7.1 Cables shall be dispatched in non-returnable steel drums of suitable barrel diameter, securely packed, with the take-off end fully protected against mechanical damage.

7.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, 'Owner's particulars', 'P.O. numbers' etc., shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

7.3 The drum lengths for cables shall be as below:

a.	Upto 6 pairs	: 2000 meter
b.	Above 6 pairs & upto 10-pair, upto 0.9 mm dia	: 2000 meter
c.	Above 6-pairs & upto 10 pairs, above 0.9 mm dia	: 1000 meter
d.	Above 10 pairs & upto 50 pairs	: 1000 meter
e.	Above 50 pairs & upto 100 pairs	: 500 meters
f.	Above 100 pairs	: As per job requirement (subject to max. length of 500 meters)

7.4 A tolerance of ± 3% shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to -2% to +0% only.

7.5 For non-jelly filled cable, PVC/ rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables shall be properly sealed, with caps, to avoid ingress of moisture/ water during transit and storage.

7.6 For jelly filled telephone cables, the ends of the cable shall be sealed by thermo shrinkable end caps of adequate wall thickness. Alternately ends may be sealed by enclosing them in rubber or PVC caps of wall thickness not less than 1.8mm. The caps shall be secured to the outer sheath with hose clips or ties or black adhesive tape or heat shrinkable sleeves.

7.7 The cables may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains and high ambient temperature.

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मध्यम एवं उच्चवोल्टेज बस डक्ट के लिए विनिर्देश

SPECIFICATION FOR MV AND HV BUS DUCT

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Abbreviations:

AC	:	Alternating Current
BS	:	British Standard
BIS	:	Bureau of Indian Standard
CEA	:	Central Electricity Authority
CPRI	:	Central Power Research Institute
EIL	:	Engineers India Limited
GI	:	Galvanized Iron
HV	:	High Voltage
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronic Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
FRP	:	Fiber Reinforced Plastic
MV	:	Medium Voltage
kA	:	kilo Ampere
kV	:	kilo Volts
MCB	:	Miniature Circuit Breaker
NEMA	:	National Electrical Manufacturer Association
NABL	:	National Accreditation Board for Testing & Calibration Laboratories
PVC	:	Polyvinyl Chloride
RoHS	:	Restriction of Hazardous Substances
V	:	Volts
VDE	:	Verband Deuthscher Electrotechniker

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1.0 SCOPE

This specification covers the requirements for design, manufacture, testing at manufacturer's works, packing and supply of Medium Voltage (non segregated phase air insulated or sandwich type) & High Voltage (segregated phase/isolated phase) air insulated bus duct.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS (Bureau of Indian standards) unless otherwise specified.

IS: 5	:	Colours for ready mixed paints and enamels.
IS: 737	:	Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes.
IS: 4171	:	Copper Rods and Bars for general engineering purpose.
IS: 5082	:	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes.
IS: 8084	:	Interconnecting bus bars for AC voltage above 1 kV upto and including 36 kV.
IS: 12729	:	Common High voltage switchgear and control gear standards.
IS/ IEC 60529	:	Degree of protection provided by enclosures (IP Code).
IS/ IEC 60947	:	Low Voltage switchgear and control gear.
IEC 61439 Part-1:		Low-voltage switchgear and control gear assemblies - Part 1: General rules
IEC 61439 Part-6:		Low-voltage switchgear and control gear assemblies Busbar trunking systems (busways)

2.2 In case of imported equipment, standard of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendmentsand other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between various referred standards/specifications/data sheets and statutory regulations, the most stringent requirement shall govern and decision of owner/EIL in this regard shall be final & binding.

3.0 SITE CONDITIONS

Bus duct shall be suitable for installation and satisfactory operation in a tropical, humid and corrosive atmosphere found in refineries, petrochemicals and fertilizer plants or as specified in the material requisition. The equipment shall be suitable for continuous operation under the site conditions as specified in the material requisition/data sheet. If not specifically mentioned therein the bus duct shall at least be designed for an ambient temperature of 40°C, relative humidity of 90% and altitude not exceeding 1000 m. If design ambient is more that 40°C, suitable de-rating factor shall be considered. Unless otherwise specified elsewhere, the busduct assembly and components shall be suitable for use in highly polluted (Class-3) environment as per IS/IEC.

4.0 GENERAL REQUIREMENTS

The offered equipment shall be brand new and having proven field track record. No prototype equipment shall be offered. Bus duct should be designed for maintenance free service life not

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less than 10 years from the date of commissioning for all types of installation & under described environmental conditions. Same shall also have corroding proof & moisture proof enclosure.

5.0 TECHNICAL REQUIREMENTS FOR BUSDUCT (COMMON FOR BOTH AIR INSULATED AND SANDWICH TYPE BUSDUCT)

5.1 Busbars of busduct shall be made of high conductivity electrolytic aluminium or copper flats/ channels.

5.2 The enclosure of busduct shall be designed to withstand the maximum applicable mechanical and electro-dynamic forces. The enclosure of air insulated bus duct shall be of box frame construction having 3 mm thick cold rolled sheet steel, galvanised steel or aluminium alloy suitably braced. The enclosure of the sandwich busduct system shall be of galvanised steel or aluminium alloy painted to provide high protection and mechanical resistance for the phase conductors along the entire length. The aluminium alloy sheet shall be grade 31000 H2 or better as per IS: 737.

5.3 The hotspot temperature of insulated bus bar surface including joints at design ambient temperature shall not exceed 95°C for normal operating conditions. However, for silver plated joints, the allowable maximum temperature shall be 115° C.

5.4 The continuous current rating of the neutral bus bars shall be at least half that of the phase bus bars.

5.5 The busbars, busduct construction and supports shall be adequately sized and braced such that entire length shall be able to withstand dynamic and thermal stresses expected due to the specified short time rating

5.6 The busbar installation shall be suitably designed to accommodate expansion and contraction during all modes of operation.

5.7 Bus duct shall be manufactured in standard lengths. However maximum length of single straight section generally shall not exceed 3000mm considering transportation and handling.

5.8 The construction of bus duct shall be such that all nuts/bolts shall be easily accessible at site during installation and maintenance.

5.9 Necessary flanged opening shall be provided at the terminating ends of bus duct. These flanges shall match with corresponding flanges in the equipment to which they are connected.

5.10 GI earth bus of minimum size 75 x 10 mm2 (50kA for 1sec.) or 100 x 12 mm2 (65kA for 1 sec.) shall run throughout the length of bus duct and all metallic non-current carrying parts shall be connected to it. Sandwich busducts with aluminium enclosure acting as earth conductor (integral earth) with provision of fitment of external earth strip is also acceptable, however the aluminium enclosure shall be suitable to withstand rated short circuit current for specified time and type test certificates for same shall be available with vendor. The earth bus shall have provision to connect it either to the system earth bus or to the earth bus of the equipment on which the bus duct is terminating, as the case may be. The earth bus shall run outside the bus duct enclosure. Suitable provision shall be made to cross bus duct flanges/joints etc.

5.11 Proper alignment and co-ordination regarding phase sequence etc. between bus duct, transformer installed outside the switchgear room, switchgear termination etc. shall be ensured by the bus duct supplier.

5.12 Phase crossover chamber, if required, shall be provided.

5.13 Separate adapter chambers shall be provided at the transformer and switchgear ends, matching with the transformer flange and switchgear flange respectively.

5.14 The termination of bus bars at the equipment end (e.g. transformer switchgear and generator end) shall be done through copper flexible.

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5.15 Copper flexible shall be thermally fused together at ends and the fused portion of the flexible shall be tinned. Alternatively, tinned copper strips, riveted at ends, can also be used.

5.16 The bus duct shall be supplied with all the necessary hardware required for the site assembly of shipping sections & their installation, including that for bus bar joints/coupling/termination etc. Stainless steel bolts, nuts and washers shall be used for all bus bar joints and supports. Nuts & bolts used for bus bar connections shall be protected to prevent corrosion. All bus bar joints shall be of high pressure bolted type.

5.17 Bus duct shall be suitably supported inside the switchgear room and for outdoor installation. Suitable supporting arrangement shall be designed and supplied by the manufacturer with busduct.

5.18 Each bus duct shipping section shall have details such as switchboard number, bus duct tag number, section number, painted arrows on the shipping section for connection and easy matching of adjacent bus duct sections, etc.

5.19 Bus duct drawings shall indicate shipping section markings and the same shall be marked on crates and the bus duct to ease assembly.

5.20 Suitable wall frame assembly shall be provided at all the wall crossings.

5.21 Busbar design, material, dimensions; Enclosure design, material, dimensions; Support insulator design, material, creepage/thickness; Phase-Phase/Phase-Neutral clearance shall be as per type tested design.

5.22 The joint design shall have inbuilt provision of absorbing expansion & contraction of maximum of 4 mm. per joint during operation. Also, the joint construction must allow ± 3 mm. adjustments at the time of installation for ease of adjusting to site measurement variations.

5.23 For MV busduct, insulation voltage & rated impulse withstand voltage shall be considered as 1kV & 8kV respectively. In case of HV bus duct, offered configuration shall be designed to withstand impulse & power frequency withstands voltage as per Table-1 of IS: 8084.

6.0 SPECIFIC TECHNICAL REQUIREMENTS FOR AIR INSULATED BUSDUCT

6.1 High Voltage bus duct shall be phase-segregated type with metallic/ insulating material.

6.2 The busbars of air insulated busduct shall be insulated by using heat shrinkable PVC sleeves for flats and insulation coating in case of channels. The sleeves/ insulation coating shall be rated to withstand the system line-to-line voltage for 1 minute.

6.3 All bus bar phases shall be identified with red, yellow, blue, black colour sleeves. Alternatively colour bands may be used for bus bars identification at all cover openings and at regular intervals not exceeding 600mm.

6.4 The bus duct shall meet the requirement of water tightness test and air tightness test as per IS/IEC: 60529. Minimum degree of protection for indoor & outdoor section of busduct shall be IP-55 & IP-65 respectively. For outdoor section, canopy shall be supplied by bus duct vendor which is mandatory. Material of canopy shall be GI sheet & thickness shall be min. 1.6mm.

6.5 All bus bar joints shall be provided with removable FRP shrouds.

6.6 Bus bars shall be supported at regular intervals on insulators made of high dielectric strength, non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in standards.

6.7 All joints and covers shall be provided with Neoprene/HDPE/EPDM or equivalent gaskets.

6.8 The covers shall be in suitable lengths for ease of removal and shall be arranged to give complete accessibility to the bus bars, joints, bends, supports etc.

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6.9 Suitable drain holes with drain pipes and plugs shall be provided for natural draining of any water collecting within enclosure due to moisture condensation. Necessary slope shall be provided for water drainage so that water does not fall on the switchgear /transformer.

6.10 One flexible, as a minimum, shall be provided for each 3000 mm long straight length of bus duct. Copper flexible shall be used for expansion joints.

6.11 Bus bar chamber shall be provided with adequate number of space heaters rated at 240V and shall be complete with MCB and thermostat having variable setting. Suitable connectivity between different sections of the bus duct shall be provided for the space heaters power supply

6.12 Space heater junction box for termination of incoming cable for bus bar space heaters shall be provided near switchgear end termination. All wiring/cabling beyond this junction box shall be in the scope of bus duct supplier. The minimum degree of enclosure protection for junction box shall be IP-31. Indication lamp shall be provided in space heater terminal box for visual identification from outside.

6.13 Bus duct shall be provided with easily accessible inspection covers at suitable intervals not exceeding 3 meters. Inspection covers shall be provided at bends and bus bars joints. Inspection covers having weight more than 5 kg shall have lifting hooks. Warning and caution boards shall be fixed to these covers. Inspection cover shall be suitable for opening from the bottom or top or sides as per the final bus duct layout.

6.14 At wall/floor crossings, seal off bushings shall be provided in HV or MV bus duct to prevent propagation of fire. FRP barrier/plate shall not be acceptable. The seal off bushings shall be type tested for the specified short time rating. Additional arrangement shall also be made so that in case of fire at transformer bay, smoke shall not enter to switchgear hall through bus duct.

7.0 SPECIFIC TECHNICAL REQUIREMENTS FOR MV SANDWICH TYPE BUSDUCT

7.1 The sandwich busduct shall have arrangement such that the busbars are sandwiched together to provide compactness & low impedance.

7.2 The each busbar of sandwich type busduct shall be insulated with non-hygroscopic and high thermal conductivity providing minimum Class-F insulation. The rated insulation voltage shall be minimum 1000V.

7.3 All bus bar phases shall be identified with red, yellow, blue, black colour.

7.4 The bus duct shall meet the requirement of water tightness test and air tightness test as per IS/IEC: 60529. Minimum degree of protection for indoor & outdoor section of busduct shall be IP-55 & IP-65 respectively. For outdoor section, canopy shall be supplied by bus duct vendor which is mandatory. Material of canopy shall be GI sheet & thickness shall be min. 1.6mm.

7.5 The joint covers shall be in suitable lengths for ease of removal and shall be arranged to give complete accessibility to the bus bars joints etc.

7.6 The sandwich busduct shall be Resistant to flame propagation in accordance with the applicable IS/IEC standards.

7.7 Thermoset material (resin or equivalent) shall be utilized as insulation medium to ensure longer life, higher temperature withstand capability & better insulating property.

7.8 Insulation material must be Halogen free with no toxic fume when burnt, self extinguishing type & RoHS compliant

8.0 PAINTING

After preparation of the under surface, the busduct shall be spray painted with two coats of epoxy based final paint or shall be powder coated (external & internal surface). The colour shade of the final paint shall be 631 of IS-5 / RAL-7032 and 632 of IS-5 / RAL-7031 for

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indoor and outdoor part of the bus duct respectively, unless specified otherwise. busduct finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion.

9.0 INSPECTION, TESTING AND ACCEPTANCE

9.1 During fabrication, the BUSDUCT shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

9.2 For testing requirements refer Inspection & Test Plan No. 6-81-1054. Prior notice of minimum 4 weeks shall be given to EIL/owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

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न्यूमेरिकल रिलेय व सबस्टेशन स्वचालन प्रणाली के लिए विनिर्देश

SPECIFICATION FOR NUMERICAL RELAYS & SUBSTATION AUTOMATION SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	30-09-19	REVISED AND ISSUED AS STANDARD SPECIFICATION	AKG	SV	SA	RKT
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Abbreviations:

AC	:	Alternating Current
BS	:	British Standard
BTD	:	Bearing Temperature Detector
CBCT	:	Core Balance Current Transformer
CPU	:	Central Processing Unit
CT	:	Current Transformer
DC	:	Direct Current
DCS	:	Distributed Control System
ECS	:	Electrical Control Station
EMI	:	Electromagnetic Interference
FIFO	:	First in first out
FO	:	Fibre Optic
GPS	:	Global Positioning System
HV	:	High Voltage
I/O	:	Input/output
ICT	:	Intermediate Current Transformer
IDMTL	:	Inverse Definite Minimum Time Lag
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IRIG- B	:	Inter-Range Instrumentation Group Subcarrier Channel-B
KEMA	:	Keuring Electrotechnisch Materieel Arnhem
LAN	:	Local Area Network
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
HMI	:	Human Machine Interface
TCP-IP	:	Transmission Control Protocol-Internet Protocol
MOG	:	Magnetic Oil Gauge
NEMA	:	National Electrical Manufacturers Association
NO	:	Normally Open
OTI	:	Oil Temperature Indicator
PC	:	Personal Computer
PCB	:	Printed Circuit Boards
PLC	:	Programmable Logic Controller
PRP	:	Parallel Redundancy Protocol
PT	:	Potential Transformer
PVC	:	Poly Vinyl Chloride
REF	:	Restricted Earth Fault
RSTP	:	Rapid Spanning Tree Protocol
RTD	:	Resistance Temperature Detector
RTU	:	Remote Terminal Unit
SNTP	:	Simple Network Time Protocol
SOE	:	Sequence of event
VDE	:	Verband Deutscher Elecktrotechniker
WTI	:	Winding Temperature Indicator

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1.0 SCOPE

The intent of this specification is to define the minimum requirement of design, manufacture, testing, packing and dispatch of numerical relays. The specification also defines the requirement of communication and integration for Substation Automation System.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following IEC standards / equivalent Indian Standards, unless otherwise specified:

IEC 60068 : Environmental Testing

IEC 60073 : Basic safety principles for man machine interface, marking & identification – Coding principles for indicators and actuators

IS/IEC 60529 : Degree of protection provided by enclosure (IP Code)

IEC 60255 : Electrical relays

IEC 61000 : Electromagnetic compatibility (EMC)

IEC 61850 : Communication networks & systems in substations

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or more stringent than the applicable IEC / Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC / BS / VDE / IEEE / NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standard/ specification/ data sheet and statutory regulation, most stringent requirements shall prevail. However, Owner's decision in this regard will be final and binding.

3.0 SITE CONDITIONS

3.1 The relay shall be tropicalised, for satisfactory operation when installed in a panel located in a pressurised substation with restricted natural air ventilation, in tropical humid and corrosive atmosphere. Relay shall be designed to perform all its functions and operate under site conditions specified in numerical relay data sheet. If not specifically mentioned there in, a design ambient temperature of 40°C and an altitude not exceeding 1000M above the mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

4.1 The equipment offered shall be brand new with state of the art technology with proven field track record of similar type and model or model in same series with additional features. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.4 In case of relays manufactured outside India, the relay manufacturer through his Indian establishment or associate in India shall provide application, testing, commissioning, after sales service and other necessary support for minimum of 10 years to customer. Their Indian establishment or associate company in India shall also maintain adequate inventory of each type of relay or spares to meet the requirement arising during project execution and plant operation. Relay manufacturer shall possess a signed Memorandum of Understanding with their Indian associate for providing customer support

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5.0 TECHNICAL REQUIREMENTS

5.1 Auxiliary Power Supply

Unless otherwise specified, numerical relays, data concentrator, Ethernet switches, gateway & HMI shall be suitable to accept both AC/DC supplies with range 110V to 240V with tolerance of ± 15%. The auxiliary power supply shall preferably be site-selectable requiring no additional hardware.

5.2 Basic Requirement and Construction Details

5.2.1 Relay shall be suitable for flush mounting. The relay enclosure front shall be dust tight having degree of protection minimum as IP5X.

5.2.2 Relay terminals shall be suitable for termination of 1.5/2.5/4 sq mm wires, for all hardwired connections.

5.2.3 Relay should have drawout feature with CT shorting arrangement. Alternatively, relay shall be modular with plug in type PCB for easy replacement. The relay terminals shall be easily accessible for testing and commissioning.

5.2.4 Current operated relay shall have provision for minimum 3 number phase CT inputs and 1 number CBCT input. Voltage operated relay shall have provision of minimum 3 numbers PT inputs. The exact number of CT and PT inputs shall be based on the schematic requirements, relays shall be selected accordingly.

5.2.5 CT shorting link shall be provided at terminal block as required.

5.2.6 All numerical relays shall have key pad/ keys to allow relay setting from relay front. All hand-reset relays shall also have reset button on relay front. Self reset or hand reset feature of the relay shall be software selectable and password protected.

5.2.7 Relay shall be suitable for 1 A or 5A CT secondary. CT secondary 1A or 5A shall either be software selectable or by providing suitable link. Selection between 1A or 5A should be possible at site.

5.2.8 Relays shall have self-diagnostic feature with indication of relay failure on relay front. Relay faults (Self- diagnostic) shall be communicated and annunciated to substation automation system.

5.2.9 Relays shall, as a minimum, have protection functions as per feeder equipment data sheets. Other functions such as metering and control shall be provided, if specified in data sheets/job specifications.

5.2.10 The PCB used in relay should have harsh environment G3 conformal coating as per standard IEC 60068.

5.3 Software Security

The relay should comply with international standard of NERC CIP of BREW for cyber security to provide protection against unauthorized disclosure, transfer, modification or destruction of information and/or information systems, whether accidental or intentional.

The security should be available for change in relay settings locally from relay HMI as well as when relay is accessed remotely through manufacturer software/ remote HMI.

5.4 Display and Indication

5.4.1 All relays shall have LCD display along with LED indications for display of settings, status, faults and events. Relays for generator protection, switchyard and GIS shall be provided with medium size LCD display having facility for graphical display of mimic with upto 15 objects on each page.

5.4.2 LCD display shall be backlit and temperature compensated up to 55°C for contrast and legibility.

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5.4.3 Relays shall have 3 fixed LEDs for Relay ON/Control supply ON, fault trip & relay unhealthy apart from freely configured LEDs.

5.5 Protection Functions

5.5.1 Over Current/Earth Fault Protection

i) This section describes over current & earth fault protection function, which mainly include different setting stages such as low set, high set and high set instantaneous (51, 50, 51N, 50N). Over current protection function provided should have IDMTL characteristic for low set and high set stages and definite time delay for high set instantaneous stage.

ii) Over current relay shall be three phase type with 4 elements; 3 elements for inverse and definite time delay over current and one element for inverse and definite time delay earth fault current. Selection of inverse or definite time feature shall be user selectable.

iii) The IDMTL characteristic (for 51 and 51N) shall be as per IEC. The inverse characteristics shall include normal inverse, very inverse, extremely inverse, long inverse and shall be soft ware selectable. Inverse element shall have two or more stages (low and high set) for selection of required inverse characteristic to achieve close protection as required.

Definite time characteristic shall have minimum 2 stages with adjustable current and time setting.

iv) Relay shall also have separate current input from CBCT for measured earth fault current element. It shall be possible to connect earth fault element either through CBCT or to be connected residually. Minimum setting current for sensitive earth fault element shall be 1%.

v) Directional overcurrent & earth fault element shall be provided, wherever required.

vi) Voltage biased overcurrent / earth fault element shall be provided wherever required.

5.5.2 Motor Protection

i) Motor protection relay shall have all protection function such as over current, thermal (over load), locked rotor current, zero sequence, negative sequence, maximum number of start, motor overload pre-alarm, motor re-acceleration, lock out, sensitive earth fault protection, inhibit of over current protection during motor starting through contactor feeders, hour run count, inhibit start after elapse of maximum number of starts etc. Relay shall be provided with resistors/ metrosil to avoid spurious tripping due to earth fault. Cold load pick-up settings shall be available to prevent spurious tripping during motor start-up.

ii) The relay shall be provided with 6 Nos. RTD and 2 Nos. BTD analog inputs, if specified in the data sheet / job specification. The numerical relay with RTD / BTD inputs shall be suitable for shielded triad cable of conductor size upto 2.5sqmm copper, unless otherwise specified. Numerical relays with RTD/BTD shall provide data for viewing of RTD/BTD parameters at DCS end.

iii) Separate motor differential protection shall be provided, wherever specified.

5.5.3 Transformer Protection

i) In addition to overcurrent & earth fault function, wherever required, the main numerical relay shall also include standby earth fault protection function (51G) for the transformer. The standby earth fault shall operate from a separate neutral CT input and shall have definite time / IDMTL characteristics as per IEC. Cold load pick-up settings shall be available to prevent spurious tripping during transformer in-rush.

ii) Wherever the transformer requires restricted earth fault protection (64R), separate numerical relay shall be provided. 64R function can be included as a part of main differential protection relay (87T), unless otherwise specified. For details of transformer differential protection relay refer Cl. 5.5.6. Resistor/ Metrosil to be provided to avoid spurious tripping due to earth fault.

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iii) Transformer auxiliary protection (OTI/WTI/Buchholz/MOG etc) shall be included as a part of numerical relay.

iv) Transformer differential protection shall be provided, wherever specified.

5.5.4 **Generator Protection**

i) Medium Voltage Generators (415V) shall have all protection functions such as voltage restrained overcurrent (51V), standby earth fault (51G), negative sequence (46), Reverse power (32), under voltage (27), overvoltage (59), thermal overload (49), PT fuse failure monitoring function (60), generator differential (87G) as a minimum.

ii) In addition to the above, HV generators (turbine / diesel engine driven) shall have additional protection functions such as rotor back up earth fault (64R)-1st and 2nd stage, low forward power flow (37), loss of excitation (40), under frequency (81U), rate of change of frequency (df/dt) unless otherwise specified.

iii) If specified in the datasheet, additional protection functions such as field overcurrent, over frequency (81O), back up impedance (21), over fluxing (99), out of step shall be provided as a part of generator protection numerical relay.

iv) The generator protection functions can be included as a part of one numerical relay or a separate numerical relays can be provided.

5.5.5 **Voltage Operated Protection Functions**

i) These functions include under voltage (27), over voltage (59), ON delay and OFF delay timers, phase sequence voltage, neutral displacement and Synchro-check functions etc.

ii) The under voltage and overvoltage protective function shall have different stages with definite time characteristics.

iii) If specified in datasheet, the relay shall have under and over frequency function along with frequency supervised Rate of change or average rate of change of frequency function.

5.5.6 **Differential Protection**

Suitable differential protection shall be provided as required as per data sheet / job specification for the specific application such as for generator, transformer, overall generator & transformer, motor, feeder, bus section etc. The following requirements, as applicable, shall be complied:

i) Differential protection shall be either high impedance or low impedance type. In case of high impedance type, suitable non linear resistor shall be provided to limit the peak overvoltage.

ii) Transformer differential protection shall have suitable harmonic restraint feature to avoid maltripping during switching.

iii) For transformer differential protection, necessary correction for ratio error and for transformer primary and secondary vector grouping shall be taken care in the relay itself without additional ICTs. The required relay setting for this shall be programmable.

iv) Bus differential relay shall have feature for CT supervision and check differential.

v) In case separate hard-wired relay is used for check differential, the status/ event of same shall be communicated through the numerical relay provided for main differential application.

vi) Unless otherwise specified, the differential relays such as generator differential, transformer differential, overall generator transformer differential, motor differential, feeder differential etc. shall be suitable for cable connection between CTs and relay using 2.5 sq.mm., Cu conductor, PVC insulated, armoured cable. However for differential protections provided for feeders having long lengths, armoured FO cable may be considered. In cases where FO cable is not suitable, shielded twisted pair cable of conductor size upto 2.5 sqmm copper

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shall be specifically mentioned by the bidder in the offer for EIL/Owner's acceptance on case to case basis.

5.6 Metering Functions

The metering function shall be provided as required and same shall be built inside the numerical relays.

5.7 Control Functions

5.7.1 The control function shall be built inside the numerical relays. For this purpose relays shall have all graphical PLC/Boolean logic functions such that complete control logic of the feeder along with all necessary interlocks as required can be developed inside the relay.

5.7.2 Relays for motor feeder shall be equipped with all control functions and interlocks related to motor feeder. If reacceleration is a part of motor feeder, the control function shall also cover reacceleration logic.

5.7.3 Relays shall have sufficient integral I/Os to take care of complete feeder logic. External I/O module for implementation of logics is not acceptable.

5.7.4 Numerical relays shall have provision of online supervision of logic function configured in the relay.

5.8 Lock Out (86), Trip Circuit Supervision (95), Auxiliary Relays and Timer Functions

5.8.1 Unless otherwise specified the numerical relays shall have built in lock out function. For motor feeders additional built-in lockout element shall be provided to receive process trip signals. Lock out elements shall be self reset or hand reset and shall be software selectable.

5.8.2 The numerical relays shall have built in trip circuit supervision function, unless otherwise specified.

5.8.3 Auxiliary relays/ Timers function etc as required for control schematics shall be programmable as a part of numerical relay. The number of such elements as required for schematic shall be considered.

5.8.4 Timer function shall be programmable for both ON/OFF delays.

5.9 Disturbance/ Event Recording and Data Storage

5.9.1 Breaker trip/ close status, relay faults, trip values, event data and disturbance record data shall be stored in the relay in non-erasable memory or memory backed up by lithium battery. Under no circumstances such as withdrawal of power to the relays shall the status, data and events in the memory get erased. Unless otherwise specified, it should be possible to store total 50 seconds of disturbance recording and 1000 sequence of event records. Subsequent events shall be overwritten following principle of FIFO.

5.9.2 All disturbances/ events shall be time stamped within the relay.

5.10 Input/ Output Interface, Filters and Galvanic Isolation

5.10.1 Voltage (through PT) input to relay, shall be 110V +/- 10%, unless otherwise specified.

5.10.2 Out put relays shall have 4 numbers spare NO contacts; each shall separately be programmable for either hand reset or self- reset.

5.10.3 Contacts of pushbuttons from field, interlocks from DCS/ other switchboards shall be wired to the relay as binary input using 1.5/2.5sqmm, multi core, shielded copper conductor cables. The distance between push buttons/ interlock to switchboard may be considered as 1000m, unless otherwise specified. The pick-up voltage for BIs/BOs shall be site selectable. The additional components as required to overcome the cable capacitance effect shall be considered as a part of supply of relay. The binary input to relay from field contacts and interlocks shall be momentary type. Logic to latch the momentary contact, as required shall be built as a part of protection relay.

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5.10.4 All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.

5.11 Relay Communication

5.11.1 All numerical relay shall have RS232/RJ45/USB port on the front for hooking laptop.

5.11.2 At the rear numerical relays shall have suitable redundant communication port for communication with data concentrator/ HMI/ Station bus. The type of port shall be selected based on method of communication (Serial or Ethernet) and type of physical transmission medium (twisted pair copper or fiber optic). For serial communication, the relay port shall be RS485 or FO (fiber optic) and for Ethernet (IEC 61850 based) communication same shall be RJ45or FO.

5.11.3 The communication protocol shall be selected to transfer all information including time stamp data from relay to data concentrator/ substation HMI. The relays shall communicate on industry open protocol such as IEC 60870-5-103/IEC 61850/ Modbus-RTU / Modbus TCP-IP or any other open protocol.

5.11.4 For IEC 61850 based communication, each relay shall be suitable for communicating with minimum four numbers client devices.

5.11.5 The relay must support IEC 61850 Edition 1 & Edition 2. They must support IEC 61850 Goose Messaging & meet the performance requirements for tripping applications (<10 ms) so that anytime critical interlocking can be built over communication. The relay should support sharing analog values such as temperature, resistance and tap position using IEC 61850 Goose messaging. Time synchronization of all relays should be possible over IEC 61850 network over SNTP.

5.11.6 Relay should have support for redundant communication over PRP to have seamless changeover.

6.0 SUBSTATION AUTOMATION SYSTEM

Substation automation system broadly comprises of numerical relays, data concentrator panels (as required), HMI, laptop, printers and their associated software for monitoring of the electrical system.

6.1 Communication

Communication is the backbone of any substation automation system. It is through this medium, the monitoring of various parameters takes place effectively.

6.1.1 **Serial Communication**

i) Data concentrator shall have two serial ports (1 no. in each CPU module) for simultaneous remote communication on relay LAN. The relays shall be multi-dropped on RS485 through single drop from LAN to each relay. In the event of either failure of any relay or break in LAN cable or failure of port at data concentrator, the redundant hardware shall ensure healthy communication between relay and data concentrator (refer Figure-1).

ii) Alternatively, relays shall communicate in star topology using star coupler. Communication from relays to star coupler shall be through single communication port. Communication from star coupler to data concentrator shall be through redundant communication link (each link part of separate star coupler unit). RS485 to FO converters wherever required shall be part of offered relay/ other hardware. Star coupler shall be provided with dual power supply module

iii) The maximum number of relays in one loop shall be decided so as to achieve maximum scan time as 500 ms for status input and maximum 6 sec for analog and historical data considering total number of serial loop and star coupler as a total integration. The above scan time does not include screen refresh rate at HMI.

iv) For sequence of event recording, time discrimination between two events shall be maintained to 1 m sec or better.

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6.1.2 **IEC-61850 based Communication**

i) Ethernet switches shall provide error free communication in harsh substation environment and shall be immune to EMI. The Ethernet switches shall comply to IEC 61850-3 and shall be KEMA approved or equivalent.

ii) For real time deterministic performance, managed Ethernet switch shall be considered in the Ethernet network. The switch shall support following features:

- Full duplex operation
- Priority Queuing
- Virtual LAN (VLAN)
- Rapid Spanning tree
- Multicast filtering

iii) Dedicated Ethernet switches shall be provided for each switchboard. 20% spare ports shall be provided in each Ethernet switch.

iv) Ethernet switch shall have dual DC power supply facility.

v) Communication between relay and HMI shall be provided as follows:

Redundant Ethernet communication architecture shall have RSTP topology. Numerical relays shall be hooked up to Ethernet switch in star topology and the switches (within the switchboard) shall be further connected in ring (refer Figure 2).

Alternatively, from each switch (within the switchboard) redundant communication link shall be extended to two number backbone switches to be located within the switchboard (refer Figure 3)

For PRP type of connectivity each switchboard shall be provided with redundant ring with dedicated Ethernet switches connected to the Master Ethernet switches (refer Figure 4)

For hooking up to HMI/gateway for upper level connectivity, redundant communication link either from any two switches within the ring or from back bone switches shall be further extended and hooked up to two numbers master Ethernet switches dedicated for hooking HMI/gateway/printers/GPS etc. From HMI redundant communication link shall be extended to the master Ethernet switches.

6.2 Data Concentrator

6.2.1 Data concentrator shall be supplied to facilitate communication with relays on open protocol.

6.2.2 As a minimum data concentrator shall have separate power supply module, CPU module and I/O module. To achieve redundant architecture, either separate data concentrator shall be considered or data concentrator shall have redundant power supply module and redundant CPU module. The CPU module shall have sufficient communication ports depending on relay LAN requirement.

6.2.3 Data concentrator shall provide gateway to upper level control system on Ethernet/ IEC61850 protocol/Modbus-RTU protocol or protocol as specified in the data sheet. The communication to upper level control system shall be redundant as per data sheet/ system architecture.

6.2.4 Data concentrator shall have binary and analog (4 to 20mA) I/O cards suitable for interface requirement specified in data sheet. Unless otherwise specified, 20% I/Os shall be considered as spare. Alternatively, a separate Data Acquisition Unit may be supplied for binary and analog interface.

6.2.5 Data concentrator shall have required number of ports for relay LAN/ star couplers. Number of relay LAN/ star couplers shall be as per project requirement. 20% or minimum 2 Nos. spare ports whichever is maximum shall be provided for future extensions.

6.2.6 Data concentrator shall have required number of RS232/ RS422/RJ45 ports for connection to Laptop PC and substation HMI having operator's work station and engineering station PC.

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6.2.7 Data concentrator shall have redundant RS485/ FO/ Ethernet port for communication to substation HMI and upper level ECS-RTU. Hook up to upper level system shall be carried out by extending serial connectivity from each communication ports in two CPU modules.

6.3 Gateway

6.3.1 Gateway for upper level connectivity if separately provided shall have redundancy in power supply module, CPU module. Alternatively, redundant gateways can be provided.

6.3.2 In case of IEC-61850 based communication, if gateway is envisaged, gateway shall have binary and analog (4 to 20mA) I/O cards suitable for interface requirement specified in datasheet. Unless otherwise specified, 20% I/Os shall be considered as spare. Alternatively, a separate Data Acquisition Unit may be supplied for binary and analog interface with communicates to ethernet switch on IEC-61850 protocol.

6.4 Human Machine Interface (HMI)

6.4.1 Relays connected in LAN shall also be provided with web based HMI interface which shall have following functions :

- Programmable LEDs and event lists
- System Supervision
- Parameter Settings
- Measurement Display
- Disturbance Records
- Phasor diagram
- Single Line Diagram
- Importing and Exporting of parameters
- Historical Data & Trending

6.4.2 Human machine interface shall include engineering and operator function. Engineering and operator workstations shall be separate.

6.4.3 HMI shall be of industrial grade suitable for continuous operation at design ambient temperature with restricted natural ventilation.

6.4.4 HMI shall be of latest version of industrial grade PC and the same shall be provided with 21" color monitor (TFT flat screen) with non glare glass filters to minimize glare from external lighting.

6.4.5 Operator workstation shall have user friendly software for interactive display of substation data in multiwindow feature. Software shall have capability to display substation single line diagrams, display of electrical system parameters, reports, alarm annunciation, daily and monthly data logging, continuous polling, relay monitoring, relay supervision, fault disturbance record of each relay, graphic representation and trending of data etc. The offered system shall comply with requirements of IEC for basic and safety requirements for Human-machine interface.

6.4.6 Engineering workstation shall have software for engineering, detailed self diagnostic for maintenance, trouble shooting and changing parameters. Further, it shall also have facility to program and configure numerical relays, data concentrator and other intelligent devices. In addition engineering work station shall have all the facilities as provided for operator workstation.

6.4.7 The HMI system shall be provided with color laser jet A3 printer for generating hardcopy of alarm, event and logging report. The printing shall be on demand, unless otherwise agreed.

6.4.8 If specified, separate laptop shall be provided. The laptop shall include all functionalities as specified for HMI system and the same shall be provided with required licensed software,

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hardware, accessories and material. System configuration shall be latest proven model and upgradable.

6.4.9 HMI system shall be provided with all associated furniture for PC, printer etc.

6.5 Time Synchronization

6.5.1 All internal clocks of numerical relay, data concentrator, SOE modules, HMI etc. shall always work in synchronism such that there is one and only one system-wide time. GPS shall be considered to synchronize with an external satellite clock. The time synchronization accuracy shall be ± 1.0 msec or better.

6.5.2 The GPS system shall consist of GPS antenna, lightning arrestor, GPS receiver/server and associated cables.

6.5.3 The time synchronization shall be carried out either through communication over substation relay LAN or by considering dedicated time synchronization channel. In case of synchronization through relay LAN, the communication protocol shall support to carry time synchronization message to the relays/data concentrator/HMI and maintain the desired accuracy. In case of time synchronization through dedicated time synchronization channel, relays, data concentrator and HMI shall be provided with IRIG- B port and the same shall be directly hooked up to GPS receiver.

6.5.4 In Ethernet based communication network, GPS receiver shall be directly hooked up to Ethernet LAN and all internal clocks of HMI and numerical relays shall be updated using SNTP protocol.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During assembly, EIL / Owner or his authorized representative shall be permitted to assess the progress of work as well as to ascertain that quality raw material is used for the same. All assistance as required during inspection shall be given to inspector.

7.2 For testing requirements refer Inspection & Test Plan No. 6-81-1055.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for transportation by ship/rail or trailer. All equipments shall be wrapped in polyethylene sheets before being placed in wooden crates/ cases with fillers to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'centre of gravity', 'weight', 'Owner's particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order.

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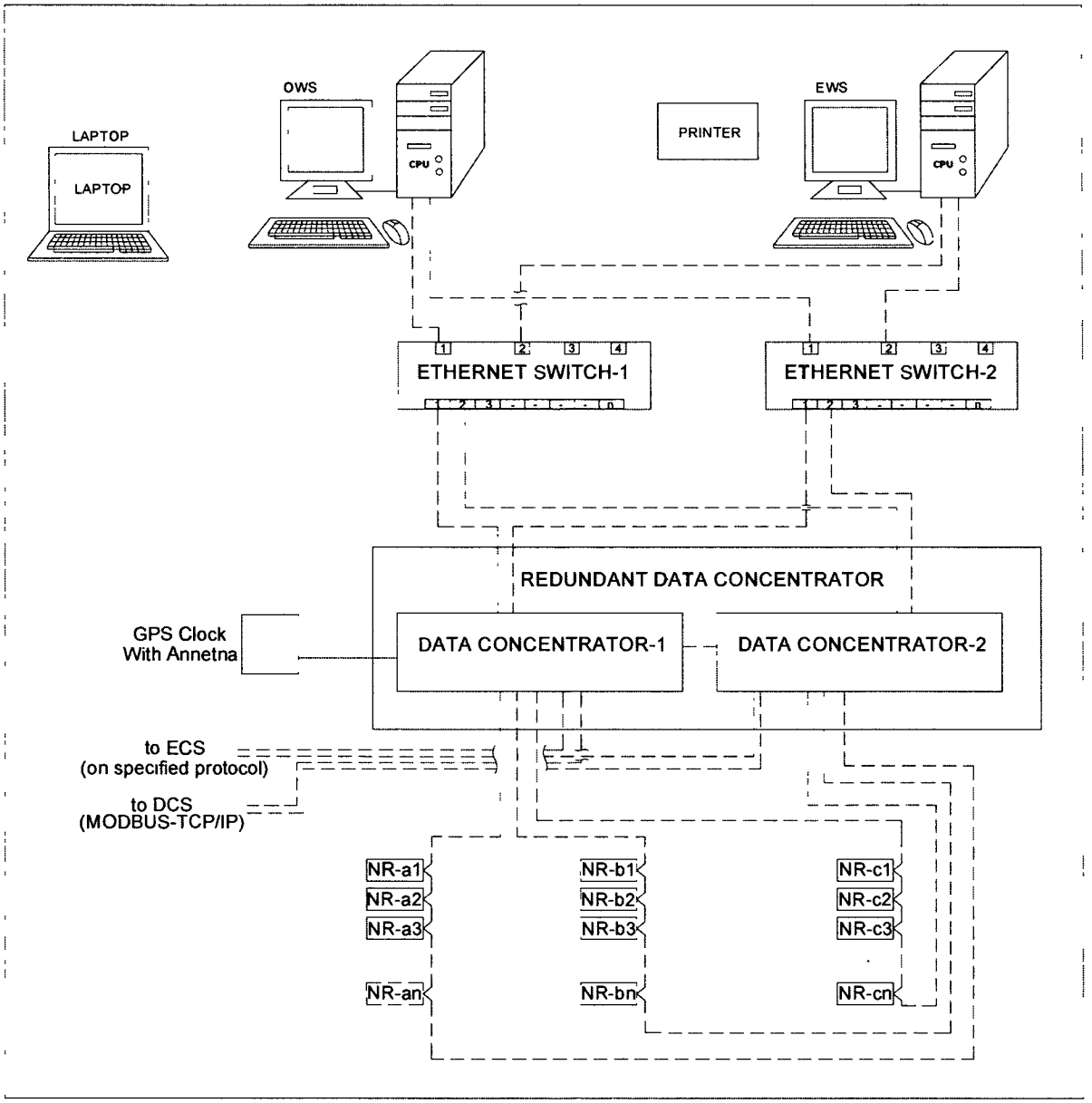

FIGURE 1: TYPICAL ARCHITECTURE FOR SERIAL COMMUNICATION

Note : Relays have been indicated connected in a ring topology, alternatively relays can be connected in star topology also.

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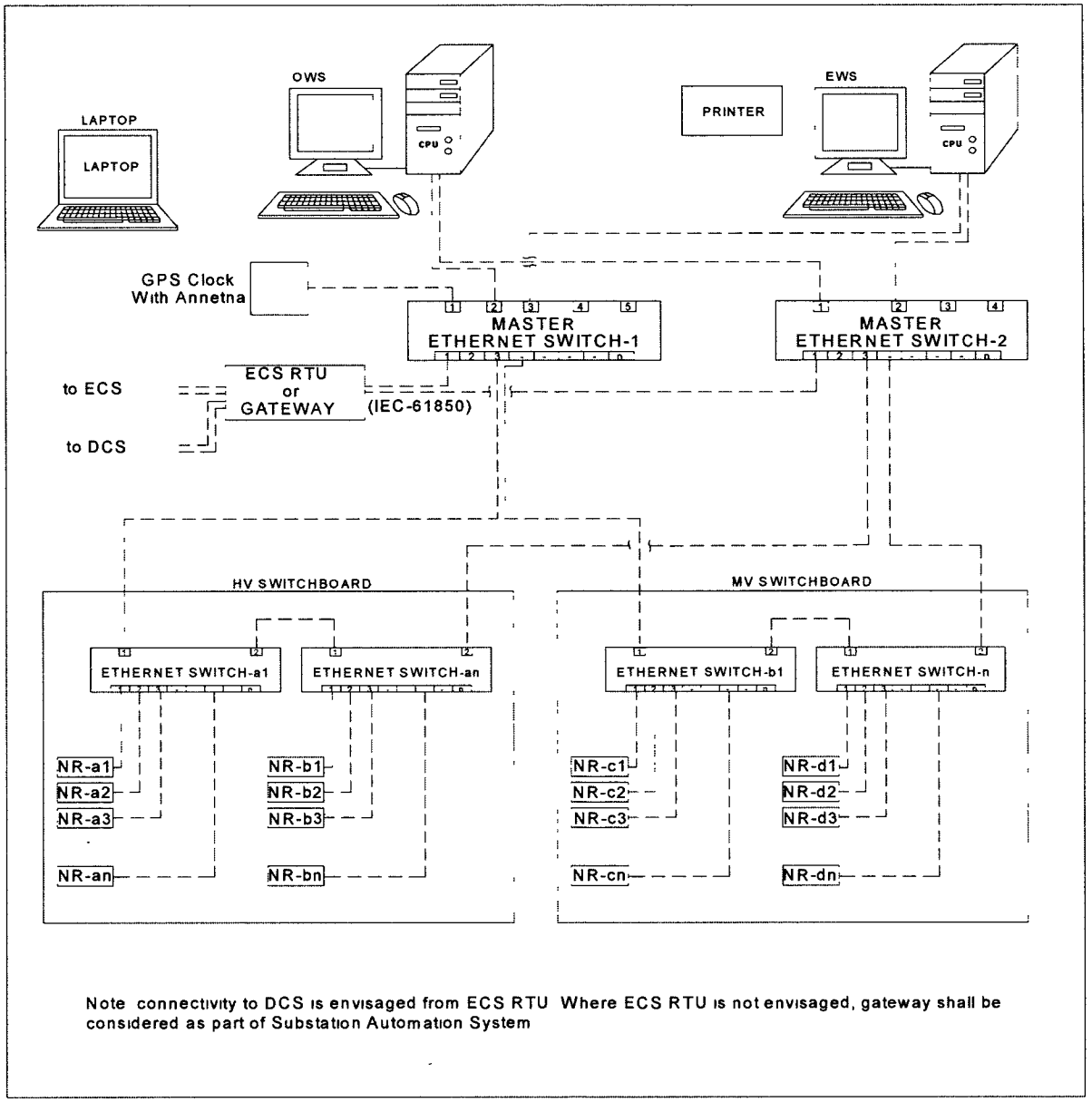

FIGURE 2: TYPICAL ARCHITECTURE FOR IEC-61850 COMMUNICATION

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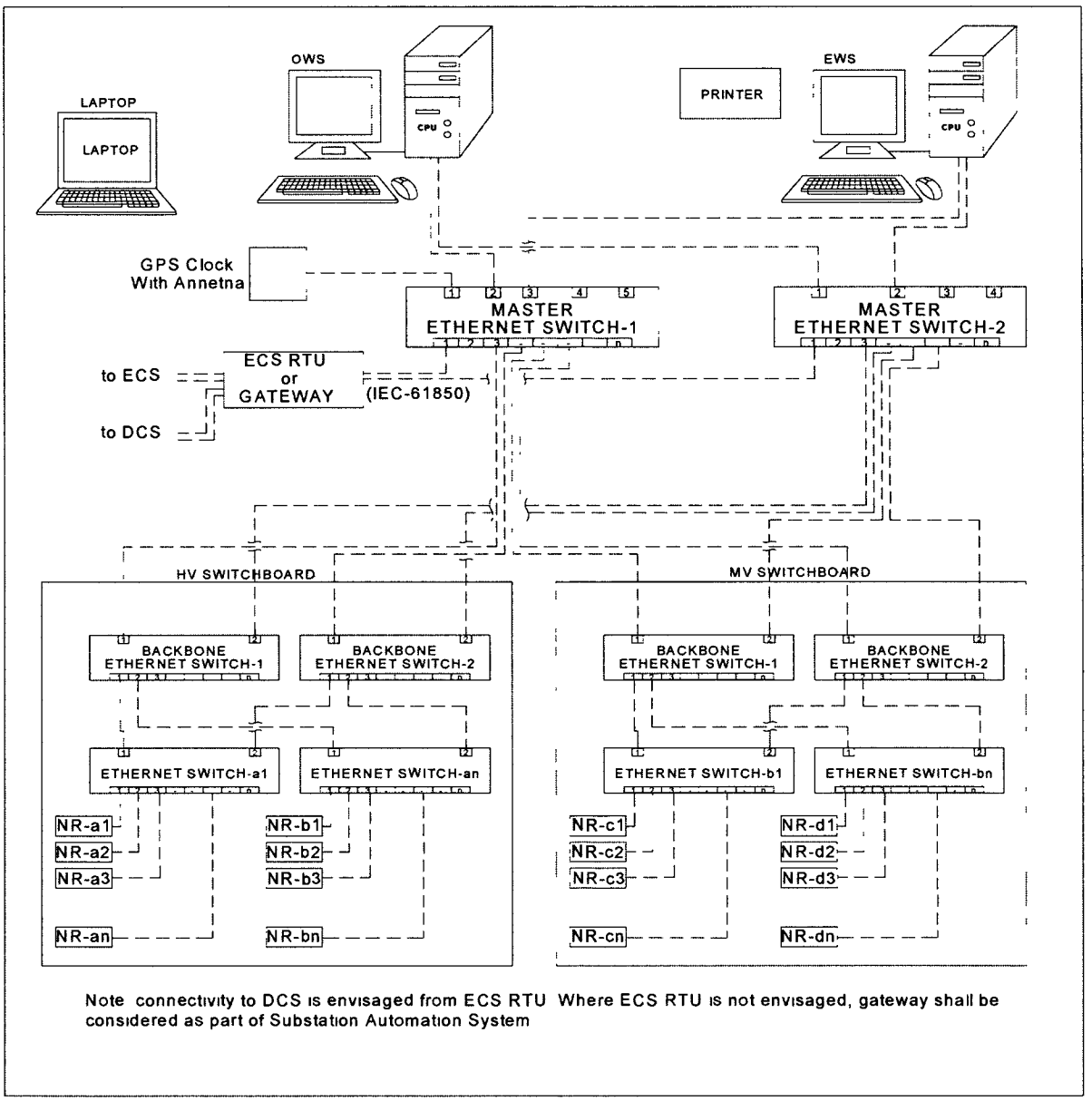

Note connectivity to DCS is envisaged from ECS RTU Where ECS RTU is not envisaged, gateway shall be considered as part of Substation Automation System

FIGURE 3: TYPICAL ARCHITECTURE FOR IEC-61850 COMMUNICATION

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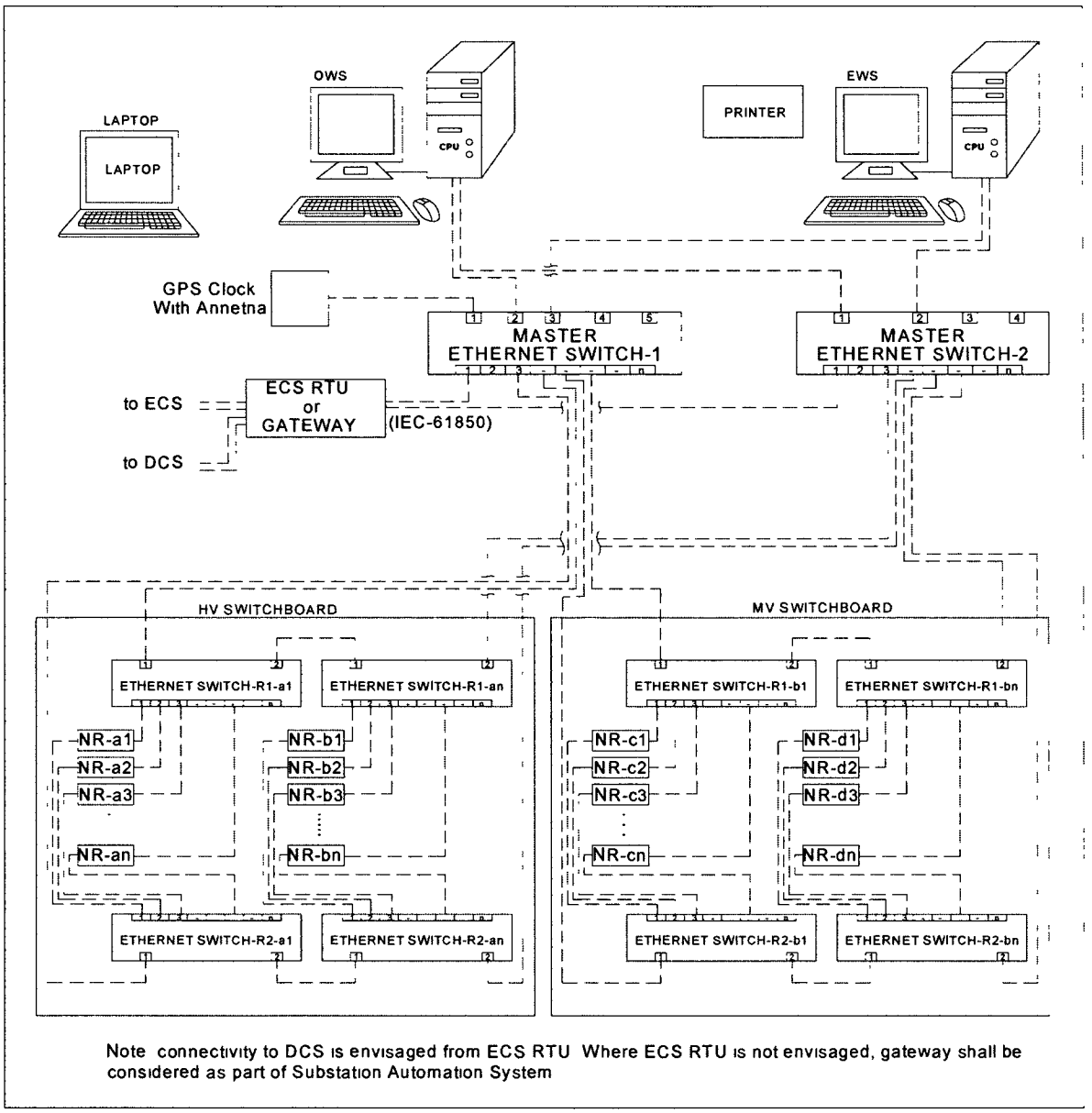

Note connectivity to DCS is envisaged from ECS RTU Where ECS RTU is not envisaged, gateway shall be considered as part of Substation Automation System

FIGURE 4: TYPICAL ARCHITECTURE FOR IEC-61850 COMMUNICATION

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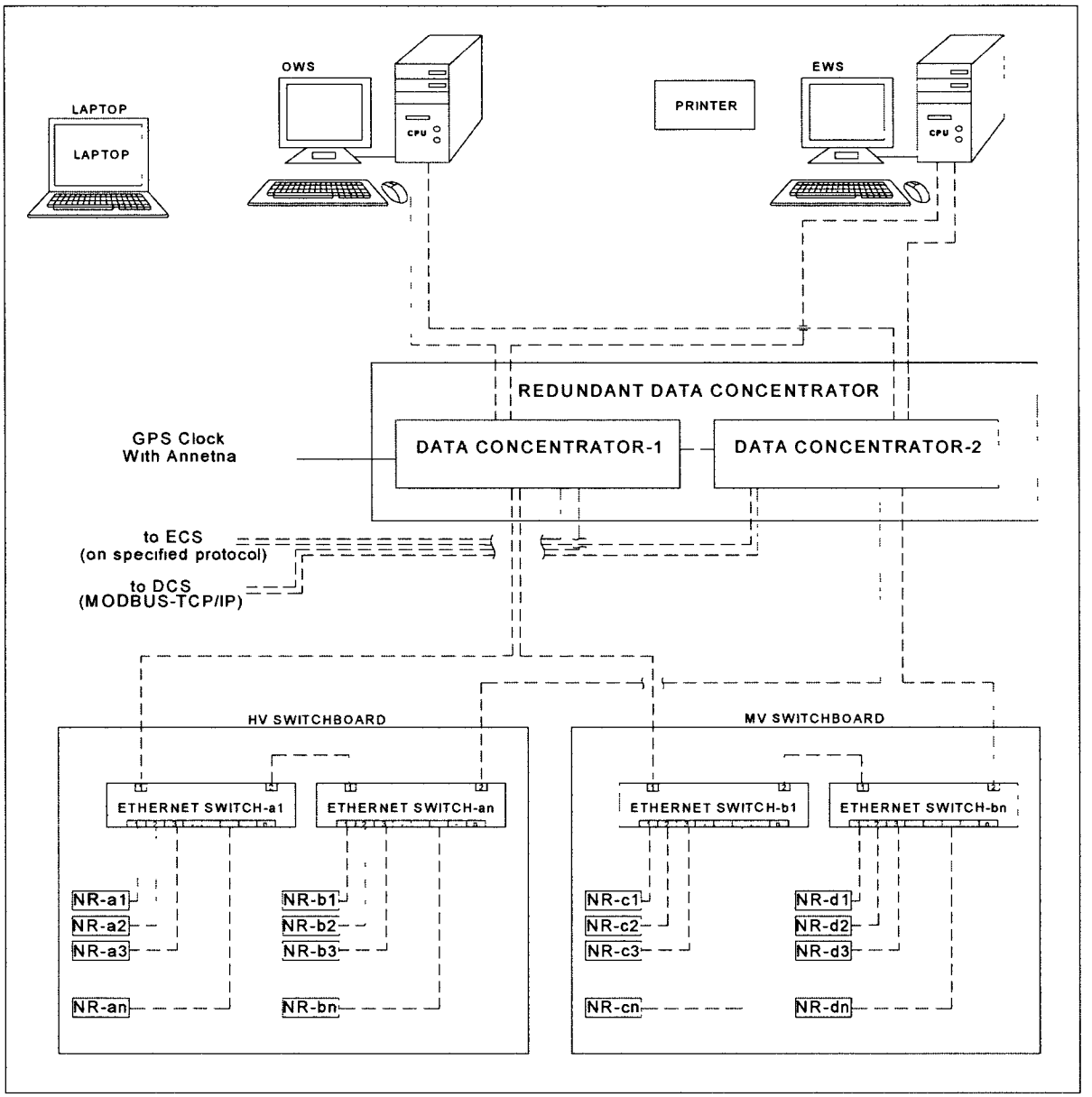

FIGURE 5: TYPICAL ARCHITECTURE FOR IEC-61850 COMMUNICATION

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संकटमय क्षेत्रों में लाइटिंग फिक्सचरों एवं जंक्शन बक्सों के लिए विनिर्देश

SPECIFICATION FOR HAZARDOUS AREA LIGHT FIXTURES AND JUNCTION BOXES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.12.20	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/RKS	ANPS	PG	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	27.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

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Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CRI	Colour Rendering Index
DC	Direct Current
DGCA	Director General Civil Aviation
EIL	Engineers India Limited
FRLS	Flame Retardant Low Smoke
IEC	International Electrotechnical Commission
IES	Illuminating Engineering Society
IP	Ingress Protection
IS	Indian Standard
LED	Light Emitting Diode
MR	Material Requisition
NABL	National Accreditation Board for Testing and Calibration Laboratories
PESO	Petroleum and Explosives Safety Organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
SPD	Surge Protection Device
SPN	Single Phase Neutral
SS	Stainless Steel
XLPE	Cross Linked Poly Ethylene

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1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of LED lighting fixtures, complete with LED lamp and driver, junction boxes and accessories suitable for installation in locations handling flammable liquids and gases/ vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels
IS-10322	:	Luminaires
IS-13383	:	Photometry of luminaires - Method of measurement
IS 15885 (Part 2/ Sec 13)	:	Safety of lamp control gear-Part-2 Particular requirements-Section 13 d.c. or a.c. supplied electronic control gear for LED modules
IS-16101	:	General lighting – LEDs and LED modules – Terms and Definitions
IS-16102	:	Self-ballasted LED lamps for general lighting services
IS-16107	:	Luminaires performance
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General requirements)
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d")
IS / IEC 60079-7	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Increased Safety "e")
IS / IEC 60079-15	:	Electrical apparatus for explosive gas atmospheres Construction, test & marking of type of protection "n"
IS / IEC 60529	:	Degrees of protection provided by enclosures (IP Code).

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries,

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petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 POWER SUPPLY

All AC lighting fixtures/ junction boxes shall be suitable for 240V ± 10%, SPN, 50Hz ± 3% power supply and all DC lighting fixtures/ junction boxes shall be suitable for 110/ 220V ± 10% power supply.

6.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals, as applicable, for the specified location, and marking as per IS/IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The enclosures of the lighting fixtures and junction boxes shall be of cast light metal alloy.

7.1.2 All equipment shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection.

7.1.3 The enclosures shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flameproof Exd (Gas group IIA/IIB) and AC supply: Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flameproof Exd (Gas group IIC) and AC Supply : Light yellow shade 355 of IS-5/ RAL 1012
- Non-sparking ExnR/ Increased safety Exec and AC Supply : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- DC lighting fixtures : Bright red shade 538 of IS-5/ RAL 3003

All unpainted parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving elements then these shall be greased with non-solidifying grease.

7.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

7.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

7.1.7 All equipments on single phase supply shall be provided with an independent earth terminal with lug inside the enclosure for terminating the third (earth) core of the cable and shall have facility for looping.

7.1.8 A nameplate shall be provided to indicate the details of testing agency, name of manufacturer, test certificate number, statutory approval agency (PESO), serial number, BIS license number, applicable gas group etc. and any additional marking required by statutory authority like approval no. etc. The nameplates shall be Al anodized or SS-304 engraved type or laser-

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marked and permanently fixed/ fixed with rivets on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

7.2 Lighting Fixtures

7.2.1 Glass used for all types of lighting fixtures shall be clear and suitable for use under conditions involving exceptional risk of mechanical damage. Glass shall be toughened type.

7.2.2 All well/ bowl glass fixtures shall be provided with Stainless Steel SS-304 protective wire cage using minimum 5mm welded steel construction and having mesh dimension not exceeding 50mm x 50 mm. The mounting bolts of SS-304 required for physically connecting the hazardous area well/ bowl glass lighting fixtures (bracket/ ceiling mounted type) to the respective mounting bracket shall be supplied by Vendor along with the fixtures.

7.2.3 The fixing parts of the enclosure, which are to be opened for replacement of lamp, shall be so fastened that they can be unfastened only with special tools.

7.2.4 The lighting fixtures in Zone-2 area shall be Ex nR type, unless otherwise specified in the MR/ Tender.

7.2.5 For LED fixture, integral junction box shall be provided with 3 nos. cable entries for loop-in, loop-out and associated wiring to fixture. Alternatively, lighting fixtures shall be provided with 2 nos. threaded entries and 2 nos. hazardous area double compression nickel plated brass cable glands, and internal wiring shall be provided for driver and lamp. The glands shall be suitable for the specified cable size. 20% of the fixtures shall be supplied with 1 no. nickel plated brass plug for sealing the unused entry.

7.2.6 The top of all well/ bowl glass lighting fixtures shall be identically drilled/ threaded to facilitate installation on pole/ column or ceiling.

7.2.7 The flood lighting fixtures shall be supplied with adjustable mounting arrangement both in horizontal and vertical plane.

7.2.8 The aviation warning lighting fixtures shall have cluster LED lamps of Type C, medium intensity (as per DGCA civil aviation statutory regulations) and of red colour, fixed (not flashing), 2000cd, unless otherwise specified.

7.2.9 All lighting fixtures shall be provided with suitable mirror-polished aluminum internal reflector of suitable thickness to ensure adequate mechanical strength.

7.2.10 Lighting fixtures shall be tested for resistance to impact in line with IS/ IEC 60079-0. Impact test certificates shall be furnished by vendor.

7.2.11 All LED fixtures shall be supplied complete with lamp and driver. LED driver shall be suitable for surge protection of minimum 4 kV surge. However, for flood lights, aviation warning lights, and lighting fixtures with wattage higher than 90W, LED driver shall be suitable for surge protection of minimum 10 kV surge. An additional fail safe SPD may be provided, as required, to achieve 10 kV surge protection. LED driver shall comply with the requirement of IS 15885-2-13. Fixture lifetime (L70) shall be greater than 50000 hours at ambient temperature of 40°C.

7.2.12 LED type lighting fixtures shall fulfill the following requirements:

a. Minimum power factor shall be 0.95.

b. LED lighting fixture luminous efficacy shall be minimum 100 lumen per watt.

c. LED lighting fixture beam angle shall be 120°/ 90° depending upon fixture location and mounting height.

d. The CRI for LED lighting fixtures shall be greater than 80 for indoor fixture and greater than 70 for outdoor fixture.

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e. The colour temperature of white colour LED shall be from 5700K to 6500K, unless otherwise specified.

f. Polar curves/ photometric drawings shall be submitted by vendor for the offered lighting fixtures.

g. LED lamps and drivers shall be provided with minimum 5 years warranty period, unless specified otherwise in the MR/ Tender. Driver shall have valid BIS certification and the same shall be furnished during drawing review stage.

h. The LED light fixtures, should be tested for luminous lux level as per IES-LM-79. Wherever wire guard is provided, testing shall be done with wire guard. Type test certificates for LM-79 for all fixtures shall be from an NABL-accredited/ IECEx-certified/ equivalent lab.

i. The LEDs used in the lighting fixtures should be tested for the service life as per IES-LM-80. Type test certificates shall be furnished in compliance to same.

7.3 Junction Boxes

The junction boxes shall be of flameproof or non-sparking type construction as mentioned in the MR/ Datasheet. All junction boxes for looping of single phase lighting circuits using cables up to 6mm^2 shall be minimum 125mm diameter in size. Each junction box shall be complete with requisite number of cable entries and double compression flameproof nickel plated brass cable glands to suit the specified cable size.

7.4 Terminals & Wiring

7.4.1 The fixtures and junction boxes shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. The terminals for external cable termination shall be suitable for 2.5mm^2 solid Copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

7.4.2 All internal wiring shall employ 1.5mm^2, 660/ 1100 V grade, FRLS type, XLPE/ PVC insulated Copper conductor wires, colour coded for phase, neutral and earth. All termination shall be with suitable lugs.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1061.

8.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test Plan no. 6-81-1061.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before

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being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight',' Owner's particulars', 'PO nos.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

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ऊर्जा दक्ष निम्न वोल्टेज प्रेरण मोटरों के लिए विनिर्देश

SPECIFICATION FOR ENERGY EFFICIENT LOW VOLTAGE INDUCTION MOTORS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	15.09.25	REVISED & ISSUED AS STANDARD SPECIFICATION	SS/RKR	ST	HK	MN
2	11.10.19	REVISED & ISSUED AS STANDARD SPECIFICATION	RKR	VKJ	SA	RKT
1	12.08.14	REVISED & ISSUED AS STANDARD SPECIFICATION	SS/SHIRALI	VKJ	BRB	SC
0	20.04.09	ISSUED AS STANDARD SPECIFICATION	SD	BRB	JMS	ND

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Abbreviations:

AL	:	Aluminium
BIS	:	Bureau of Indian Standards
BS	:	British Standards
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mines and Fuel Research
CPRI	:	Central power research institute
CT	:	Current Transformer
CU	:	Copper
DGMS	:	Directorate General of Mines Safety
DOL	:	Direct On Line
EIL	:	Engineers India Limited
ERTL	:	Electronics Regional test laboratory
EU	:	European Union
FM	:	Factory Mutual
FRP	:	Fiber Reinforced Plastic
IEC	:	International Electro-technical Commission
IEEE	:	Institute of Electrical & Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
JEC	:	Japanese Electro-technical Committee
KLPL	:	Karandikar laboratories Pvt. Ltd.
LCIE	:	Laboratoire Central des Industries Electriques
NEMA	:	National Electrical Manufacturers Association
PESO	:	Petroleum and Explosive Safety Organisation
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
RPM	:	Revolutions per Minute
UL	:	Underwriter's Laboratories
VFD	:	Variable Frequency Drive
VDE	:	Verband Deutscher Elektrotechniker

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1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of energy efficient-High efficiency (IE2/IE3/IE4 as specified in data sheet) three phase medium voltage squirrel cage induction motors.

2.0 CODES AND STANDARDS

2.1 The squirrel cage induction motors and their components shall comply with the latest editions of following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

IS - 5	:	Colours for ready mixed paints and enamels.
IS - 1076	:	Preferred numbers.
IS - 1231	:	Dimensions and output series of foot mounted induction motors-frame numbers 56 to 315 L.
IS - 1271	:	Electrical insulation- Thermal evaluation and designation.
IS - 2223	:	Dimensions of flange mounted AC Induction motors.
IS - 2253	:	Designation for types of construction and mounting arrangement of rotating electrical machines.
IS - 2254	:	Dimensions of vertical shaft motors for pumps.
IS - 4029	:	Guide for testing three phase induction motors.
IS - 6362	:	Designation of methods of cooling of rotating electrical machines.
IS - 8223	:	Dimensions and output series for rotating electrical machines.
IS - 8789	:	Values of Performance Characteristics for Three-Phase Squirrel Cage Induction Motors with Degree of Protection IP-2X.
IS - 9283	:	Motors for submersible pump sets.
IS - 12065	:	Permissible limits of noise level for rotating electrical machines.
IS - 12075	:	Mechanical vibration of rotating Electrical Machines with shaft heights 56 mm and higher - measurement, evaluation and limits of vibration severity.
IS – 12615	:	Line Operated Three Phase a.c. Motors (IE CODE) "Efficiency Classes and Performance Specification"
IS - 13529	:	Guide on effects of unbalanced voltages on the performance of three phase cage induction motors.
IS - 13555	:	Guide for selection and application of three phase induction motors for different types of driven equipment.
IS - 14568	:	Dimensions and output series for rotating electrical machines, frame numbers 355 to 1000 and flange numbers 1180 to 2360.
IS / IEC60079-0:		Electrical apparatus for explosive gas atmospheres (General requirements)
IS/IEC-60079-1:		Explosive Atmospheres-Equipment protection by flame proof enclosures "d".
IS/IEC60079-2	:	Explosive protection by pressurized enclosure "p".
IS/IEC60079-7	:	Explosive Atmospheres-Equipment protection by increased safety – "e".
IS/ IEC: 60529	:	Degree of protection provided by enclosures (IP Code)
IS/IEC-60034/ IS 15999	:	Rotating Electrical machines
IS/IEC 61241:		Electrical apparatus for use in the presence of combustible dust
IS/IEC 60072-1:		Dimensions and output services for operating electrical machines Part-1 : Frame number 56-400 and flange number 55 to 1080

2.2 In case of imported motors, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian Standards.

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2.3 The motors shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian Standards are not available, standards issued by IEC/ BS/ VDE/ IEEE/ JEC/NEMA or equivalent agency shall be applicable.

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

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to ensure the end user for placement of order for spares and services.

4.0 OPERATING CONDITIONS

4.1 Ambient Conditions

Motors shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in refineries, petrochemical, fertilizer and metallurgical plants. Service conditions shall be as specified in the motor data sheet. If not specifically mentioned therein, a design ambient temperature of 40 ° C and an altitude not exceeding 1000 meters above mean sea level shall be taken into consideration.

4.2 Frequency and Voltage Variations

Unless otherwise agreed, motors shall be designed for continuous operation at rated output under the following conditions:

a) The terminal voltage differing from its rated value by not more than ± 10 % or
b) The frequency differing from its rated value by not more the ± 5 % or
c) Combined variation — The sum of absolute percent variations of (a) and (b) not exceeding 10 percent.

4.3 Starting

a) Motors shall be designed for direct-on-line starting or other method of starting as specified in datasheet.
b) Motors shall be designed for re-acceleration under full load after a momentary loss of voltage with the residual voltage being 100% and is in phase opposition to the applied voltage.
c) Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. In addition, Locked Rotor withstand time under hot conditions at 75% & 100% voltages, shall be minimum 1.4 times the starting time at the corresponding voltage.

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d) Unless otherwise specified, all motors shall be suitable for starting under specified load conditions with 75 % of the rated voltage at the motor terminals.

e) Motors shall be designed to allow the minimum number of consecutive starts indicated in Table below:

Starts	Min. no. of consecutive starts
No. of consecutive start-ups with initial temp. of the motor at ambient level (cold)	3
No. of consecutive start-ups with initial temp. of the motor at full load operating level (hot).	2

4.4 Direction of Rotation

Motors shall be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. Directional arrow should be manufactured from corrosion resistant material. When a motor is provided with bi-directional fans, a double-headed arrow should be provided.

Normally, clockwise rotation is desired as observed from the driving (coupling) end, when the terminals UVW are connected to a power supply giving a terminal phase sequence in the order UVW. Counter-clockwise rotation of the motor shall be obtained by connecting the power supply to terminals so that the phase sequence corresponds to the reversed alphabetical sequence of the terminal letters. Ample space shall be provided at the terminal box for interchanging any two external leads for obtaining the reverse phase sequence.

5.0 PERFORMANCE

5.1 Motors shall be rated for continuous duty (S_1), unless otherwise specified.

5.2 Unless specified, the starting current (as % rated current) shall be as per IS 12615, subject to IS tolerance

5.3 In particular cases, when the starting current is to be limited, care shall be taken such that the design values of torque meets the load requirement while at the same time complying to clause 4.3 above of this specification. Unless otherwise specified the minimum pull-up torque of motors, at rated voltage & frequency shall be minimum 50% of the rated full load torque.

5.4 In particular cases, when the starting with reduced voltage is specified, care shall be taken such that the design values of torque meets the load requirement while at the same time complying to clause 4.3 above of this specification.

5.5 Starting torque and minimum torque of the motor shall be compatible with the speed torque curve of the driven equipment under specified starting and operating conditions.

In case where characteristics of driven equipment are not available while selecting the motor, minimum starting torque shall be 110% of rated value for motors up to 75 kW and shall be 90% of rated value for motors above 75 kW.

5.6 The breakdown torque at the rated voltage shall be not less than 175% of the rated load torque with no negative tolerance. Unless otherwise agreed, the breakdown torque shall not exceed 350% of the rated load torque.

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In case of motors driving equipment with pulsating loads (e.g. reciprocating compressors, crushers, ball mills) the minimum value of pull out torque at 75% of the rated voltage shall be more than the peak value of pulsating torque and the current pulsation shall be limited to 40%.

5.7 Motors fed by variable frequency drive shall additionally meet the following requirements

a) The motor shall be converter grade motor suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control and shall comply to IS 16724, IEC-60034-25 and relevant part of IS/IEC-60079.

b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c) The motor shall be designed to operate continuously at any speed over the range (1-100%) of rated speed or as specified in data sheet.

d) Motor shall be provided with thermistor type temperature detector.

e) The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.

f) Motor shall be designed suitable to deliver the torque required for complete speed torque characteristics of the load considering the voltage available at the motor terminals after taking into account supply voltage tolerances, voltage drop within VFD panel and voltage drop within cable as specified in VFD specification.

g) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in line voltage, frequency and starting current limitations as specified in data sheet.

h) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid state power supply.

i) The motor insulation shall be designed to accept the applied voltage wave form, within the Vpeak and dv/dt limits as per IEC-61800-2 and 60034-25.

j) The motor vendor shall also coordinate with driven equipment vendor & VFD vendor and obtain requisite details for motor design.

k) Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning. Insulated bearing (Non-Drive End) shall be provided irrespective of motor frame size.

l) Motor for hazardous area application shall have valid type test certificate issued by recognized independent test house certifying that motor is suitable for converter duty application. Corresponding statutory approval (e.g. PESO/DGMS etc.) as applicable for the specified location shall also be furnished for the hazardous area motor.

m) The motors shall be suitable for the current wave forms produced by the power supply including harmonics generated by the drive. The necessary coordination by motor manufacturers with drive manufacturers regarding harmonics generated by VFD shall be taken care and incorporated in motor design suitably.

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n) The motors shall be designed to operate continuously at any speed over the range as per process requirement with minimum range as 10–100% of rated speed or as specified in data sheet. The characteristics shall be based on the application – in terms of constant torque / variable torque as per the driven equipment. Additional cooling fan shall be provided if required to limit the temperature rise to specified limits, alternatively option of applying suitable de-rating may be considered.

o) The motors shall withstand torque pulsation resulting from harmonics generated by the solid state power supply.

p) The motors required to be transferred to DOL bypass mode shall be rated for specified variations in line voltage and frequency.

5.8 The minimum values for performance characteristics of these motors shall be as given in the tables 1, 2 & 3 of IS 12615 for IE2/IE3/IE4 motors, subjected to tolerance as per IS/IEC. Motors operated by frequency converters may have higher losses as compared to line (sinusoidal) power supply due to the harmonic voltage content. These motors must be tested on sinusoidal supply and efficiency must meet the declared efficiency class (which should not be lower than IE 2 class).

6.0 CONSTRUCTIONAL DETAILS

6.1 Windings

6.1.1 Unless otherwise specified, motors shall be provided with class `B' insulation as a minimum. In case of motors with class 'F' insulation, the permissible temperature rise above the specified ambient temperature shall be limited to those specified in the applicable Indian standards for class `B' insulation.

6.1.2 The winding shall be tropicalised. The windings shall preferably be vacuum impregnated. Alternately the windings shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmospheres.

6.1.3 Windings shall be adequately braced to prevent any relative movement during operation. In this respect, particular care shall be taken for the stator windings for direct-on-line starting squirrel cage motors. Insulation shall be provided between coils of different phases that lie together. Core laminations must be capable of withstanding burnout for rewind at 350 ºC without damage or loosening.

6.1.4 In case of motors driving equipment with pulsating loads, special care shall be taken for the joints of rotor bars and end rings to avoid premature failures due to induced fatigue stresses.

6.1.5 The windings shall be connected in delta. However, for motors rated 2.2 kW and below, star connection may be accepted. In case of motors with star-delta starting, the motor windings shall be fully insulated for delta connection.

6.1.6 The ends of the windings shall be brought out into a terminal box. These shall be terminated by means of terminals mounted on an insulating base made of non-hygroscopic and non-flammable material.

6.1.7 All motors shall be provided with six terminals and suitable links to connect them in star or in delta except for motors rated up to and including 2.2 kW which may be accepted with three terminals.

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6.2 Terminal Box and Cable Entries

6.2.1 Unless otherwise agreed, the terminal box shall be located on the right hand side as viewed from the driving (coupling) end. The terminal box shall have side cable entry from non-driving end. However, as a special case, terminal box located on top may also be accepted, particularly for hazardous area motors, in case manufacturer has only top mounted terminal box design which is duly tested/certified & approved by corresponding agency as mentioned in clause 11.0 below for installation in hazardous area. The terminal box design shall allow rotation in steps of 90°C to facilitate cable entry from any direction at site.

6.2.2 Terminal box cover shall be provided with handles to facilitate easy removal. However, for terminal box covers weighing less than 5 kg., terminal box covers without handles can be accepted.

6.2.3 The terminal box shall be provided entries for suitable cable glands corresponding to the size of the specified cable. Crimp type tinned Copper lugs and nickel-plated brass (or aluminum if specifically required), double compression type cable glands shall be supplied along with the motors for the specified cable sizes for power and space heater cables.

6.2.4 For flameproof motors, terminal box can be also provided in increased safety 'Exe' execution.

6.2.5 The terminals, cable lugs, terminal box, cable entries and cable glands shall be suitable for the minimum cables sizes as specified below for 2 pole, 4 pole or 6 pole motors:

Motor rating up to and including	Size of phase conductor (mm^2)
2.2 kW and below	2.5 cu
3.7 kW	6 cu
5.5 kW	10 cu
7.5 kW	16 cu
9.3 kW	16 cu
11.0 kW	16 cu
15.0 kW	50 Al.
18.5 kW	70 Al
22.0 kW	70 Al
30.0 kW	95 Al
37.0 kW	120 Al
45.0 kW	150 Al
55.0 kW	240 Al
75.0 kW	2x95 Al
90.0 kW	2x120 Al
110.0 kW	2x240 Al
125.0 kW/132 kW	2x240 Al
160.0 kW	2x240 Al

NOTE: - Exact cable size for the motor shall be informed during vendor drawing review. Vendor to provide required size of the terminal box.

6.2.6 Cable sizes for motors having synchronous speeds 750 RPM and below shall be as agreed between the purchaser and manufacturer.

6.3 Motor Casing and Type of Enclosure

6.3.1 The minimum degree of motor enclosures including terminal boxes and bearing housing shall be IP-55 as per IS/IEC.

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6.3.2 Motors for outdoor use shall be suitable for installation and satisfactory operation without any protective shelter or canopy. Motor casing shall be provided with a suitable drain for removal of condensed moisture except in case of flameproof motors (Type Ex d/Ex de).

6.3.3 All internal and external metallic parts, which may come into contact with cooling air, shall be of corrosion resistant material or appropriately treated to resist the corrosive agents, which may be present in the atmosphere. Screws and bolts shall be of rust proof material or protected against corrosion.

6.3.4 Unless otherwise agreed, motors shall have standard frame sizes (min.) for various output ratings as stipulated in IS/IEC.

6.4 Bearing and Lubrication

6.4.1 Motors shall have grease lubricated ball or roller bearings. In all cases, the bearings shall be chosen to provide a minimum L-10 rating life of 5 years, (40, 000 hours) at rated operating conditions
(The L-10 rating life is the number of hours at constant speed that 90% of a group of identical bearings will complete or exceed before the first evidence of failure).

6.4.2 The bearings shall be adequate to absorb axial thrust produced by the motor itself or due to shaft expansion. Motors designed to handle external thrust from the driven equipment shall be supplied with a thrust bearing at the non-driving end.

6.4.3 In cases such as pumps for hot liquids where the driven equipment operates at high temperatures, bearings shall be cooled by a shaft-mounted fan. This shall ensure efficient ventilation of the bearing and disperse the heat transmitted from the driven equipment by conduction or convection.

6.4.4 Bearings shall be capable of grease injection from outside without removal of covers with motors in the running conditions. The bearing boxes shall be provided with necessary features to prevent loss of grease or entry of dust / moisture e.g. labyrinth seal/ oil seal/ V seal. Where grease nipples are provided, these shall be associated, where necessary, with appropriately located relief devices, which ensure passage of grease through the bearings.

6.4.5 Pre-lubricated sealed bearings may be considered provided a full guarantee is given for 4 to 5 years of trouble-free service without the necessity of re-lubrication.

6.5 Cooling System

All motors shall be self ventilated, fan cooled. Fans shall be corrosion resistant or appropriately protected. They shall be suitable for motor rotation in either direction without affecting the performance of the motor. If this is not possible for large outputs, it shall be possible to reverse the fan without affecting the balancing of the motor.

For motors operating in hazardous area, the fans shall be of an anti-static non-sparking material.

6.6 Rotor

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and long service life for the bearings. Die cast aluminum rotors for motors in hazardous areas may be accepted provided the same are type tested and approved by competent authorities.

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6.7 Shaft Extension

Motors shall be provided with a single shaft extension with key-way and full key. Motor shaft shall be sized to withstand 10 times the rated design torque.

6.8 Lifting Hooks

All motors weighing more than 30 kg. shall be provided with lifting hooks of adequate capacity.

6.9 Earth Terminals

Two earth terminals located preferably on diametrically opposite sides shall be provided for each motor. Necessary nuts and spring washers shall be provided for earth connection.

7.0 MISCELLANEOUS ACCESSORIES

7.1 Anti-Condensation Heaters

All motors rated 30 kW and above shall be provided with 240 V anti-condensation heaters, sized and located so as to prevent condensation of moisture during shutdown periods.

For motors with heaters installed in hazardous atmospheres (Zone - 1 or Zone - 2), such heaters shall conform to the provisions of applicable Indian Standards and temperature classification specified in the motor data sheet.

The heater leads shall be brought out, preferably, to a separate terminal box which shall be of the same specification and grade of protection as the main terminal box.

A warning label with indelible red inscription shall be provided on the motor to indicate that the heater supply shall be isolated before carrying out any work on the motor.

7.2 Name Plates

In addition to the motor rating plate, a separate number plate for motor tag number shall be fixed in a readily visible position. This number shall be as per the motor data sheets. Nameplates and tag plates shall be of stainless steel material. Name plate shall include details as specified in IS 15999 Part 1 / IEC 60034 Part 1.

8.0 CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 120 % of the synchronous speed. For flexible rotors this shall be between 60 % and 80 % of the synchronous speed; the second actual critical speed shall be above 120 % of the synchronous speed.

9.0 PAINTING

All metal surfaces shall undergo manufacturer's standard cleaning /painting cycle. After preparation of the under surface, the equipment shall be painted with two coats of epoxy based final paint. Color shade of final paint shall be 632 of IS: 5/ RAL-7031. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then these shall be greased.

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10.0 INSPECTION AND TESTING

10.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner, if specified / agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine / acceptance tests shall be carried out at manufacturer's works under his care and expense.

10.2 Type test certificates from CIMFR or equivalent test house, applicable PESO/ DGMS approval certificates, BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The certificates and BIS license must be valid at the time of dispatch.

10.3 Test certificates of bought out components shall be shown to the inspection agency on demand during inspection.

10.4 Combined testing of LV motors along with their associated VFDs shall be carried out as a unit. During this testing, temperature rise and harmonics levels shall be measured to ensure they are within the permissible limits as per applicable standards. This test may not be required in case same make / type / rating of motor & VFD as a unit has been already tested and copy of test certificate is available which will be furnished for EIL/Owner's reference.

10.5 All equipments shall be subjected to various routine / acceptance tests as per Inspection & Test plan no. 6-81-1064.

11.0 CERTIFICATION

A copy of valid BIS license shall be furnished for energy efficient motors as per IS 12615.

All hazardous area equipment shall have hazardous area test certificates and approvals as per following:

For Indigenous manufactured hazardous area equipment:
For all electrical items manufactured in India, the testing shall be carried out & test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished as per IS/IEC 60079-1.

Alternatively, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

For Imported hazardous area equipment:
For all electrical items manufactured outside India, test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished as per IS/IEC 60079-1.

As an alternative option-1 to this, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

As an alternative option-2 to this, EU Type Examination Certificate, which is applicable for manufacturers having manufacturing locations in countries covered under the European Union, valid copy of Production Quality Assessment / Assurance Notification shall be furnished.

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All equipment i.e. Indigenous & imported, shall also have valid statutory approvals, as applicable for the specified location and marking as per IS/IEC 60079 and as required by statutory authorities.
For installations in India, PESO approval letter shall be provided.

12.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to the finish. Crates/cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO Nos.' etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

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अग्नि का पता लगाने और चेतावनी प्रणाली के लिए स्थापना विनिर्देश

SPECIFICATION FOR FIRE DETECTION AND ALARM SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	13 03 2020	REVISED & ISSUED AS SPECIFICATION	VB/SK	ANPS	SA	RKT
5	24 09 2014	REVISED & ISSUED AS SPECIFICATION	SK	SA	BRB	SC
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3	24 12 2003	REVISED & ISSUED AS SPECIFICATION	AKS/RCS	AAN	VPS	SKG
2	24 04 1997	REVISED & ISSUED AS STANDARD SPECIFICATION	NS	VPS	SG	ASONI

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Abbreviations

BIS	Bureau of Indian Standards
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmosphere
BGU	Break glass unit
CEA	Central Electric Authority
CFAP	Central Fire Alarm Panel
CIMFR	Central Institute of Mines and Fuel Research (formerly known as CMRI)
CPU	Central Processing Unit
CRCA	Cold Rolled Cold Annealed
DGFAP	Data Gathering cum Fire Alarm Panel
EEPROM	Electrically Erasable Programmable Read Only Memory
ERTL	Electronic Regional Test Laboratory
FAT	Factory Acceptance Tests
FDD	Floppy Disk Drive
FM	Factory Mutual
FRP	Fibre Reinforced Plastic
FO	Fibre Optic
GUI	Graphic User Interface
HDD	Hard Disk Drive
HMI	Human Machine Interface
HVAC	Heating Ventilation Air Conditioning
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Service Digital Network
IS	Indian Standard
ITU-T	International Telecommunication Union- (Telecom)
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LPC	Loss Prevention Council
LIFO	Last In First Out
MCP	Manual call point
MR	Material Requisition
Ni-Cd	Nickel Cadmium (battery)
NFPA	National Fire Protection Association
NEMA	National Electrical Manufacturers Association
PCB	Printed Circuit Board
PESO	Petroleum and Explosive safety organization
PO	Purchase Order
RF	Radio Frequency
SAT	Site Acceptance Tests
SOE	Sequence Of Event
SMF	Sealed Maintenance Free
SPN	Single phase and neutral
TPN	Three phase and neutral
TAC	Tariff Advisory Committee
UL	Underwriters Laboratory
UPS	Uninterrupted Power Supply
VRLA	Valve Regulated Lead Acid (battery)
VdS	Verband der Sachversicherere.V.
WP	Weather Proof
ZFAP	Zonal Fire Alarm Panel

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1.0 SCOPE

1.1 The intent of this specification is to define the functional and design requirements for an Integrated Fire Alarm System for industrial plants and buildings. This specification covers the requirements for selection, design and engineering, manufacture, testing at vendor's works, supply and installation, testing at site and commissioning unless otherwise stated.

1.2 The Integrated Fire Alarm System shall be conventional or micro processor based analogue addressable system comprising BGUs, detectors; conventional or microprocessor based Fire Alarm panels and associated equipment detailed hereunder and in Project data sheets/ drawings.

2.0 CODES AND STANDARDS

2.1 The fire alarm system and the components used shall conform to the latest edition of the following Codes/Standards, other relevant Indian Standards and International Standards as applicable.

IS-5	Colours for ready mixed paint and enamels.
IS-513	Specification for cold rolled low carbon steel sheets and strips
IS-1646	Code of practice for fire safety of buildings (general): Electrical installations
IS-2175	Specification for heat sensitive fire detectors for use in automatic fire alarm system
IS-2189	Code of practice for selection, installation and maintenance of automatic fire detection and alarm system
IS-3034	Code of practice for fire safety of industrial buildings: Electrical generating and distributing stations
IS-5469	Code of practice for the use of semi-conductor junction devices (Applicable parts)
IS-12459	Code of practice for fire safety in cable runs
IS/IEC 60079-0	General requirements for electrical apparatus for explosive gas atmosphere
IS/IEC 60079-11	Specification for intrinsically safe electrical apparatus and circuits
IS16724/IEC 60079-14	Electrical installations: Design, selection and erection
NFPA 72	National Fire Alarm Code
LPC	Loss Prevention Council recommendations
BS-5839	Specifications for manual call points Part-2
BS-EN 50081-1/2	EMC (Electro Magnetic Compatibility test)
BS-EN 50082-1/2	EMC (Electro Magnetic Compatibility test)
IS-15908	Code of practice for selection, installation and maintenance of control and indicating equipments for fire detection and alarm system

2.2 Standards of country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian Standards in case of imported equipment.

2.3 Equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA/UL/FM/EN54 or equivalent agency shall be applicable.

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2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner in this regard shall be final.

3.0 GENERAL REQUIREMENTS

3.1 Offered equipment shall be brand new with established state of the art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply. The spares shall be available ex-stock with the vendor.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user to place order for spares and services.

3.4 Vendor shall be responsible for design & engineering and manufacturing of the complete system and equipment to fully meet the intent and requirements of this specification and attached data sheets.

3.5 All equipment and accessories required for completeness of the system, whether specifically mentioned or not but considered essential for satisfactory performance, shall be included by the vendor as part of the offered system.

3.6 The system integrator shall coordinate with the manufacturers of various bought-out items associated with the system as required, and shall freely and readily supply all technical information as and when asked for.

3.7 All equipment required to be located in hazardous areas shall have test certificates issued by recognized independent test house such as CIMFR, ERTL, BASEEFA, UL, FM or equivalent. Indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. Equipment (indigenous & imported) shall also have valid statutory approvals e.g. PESO, DGMS, as applicable for the specified location. Indigenous flameproof equipment shall also have valid BIS license and marking as required by statutory authority.

4.0 DEFINITIONS

4.1 CFAP

It is the main or central fire alarm panel located in fire station or in disaster management control room, which receives inputs from automatic and manual Fire alarm devices and supplies power to detection and notification devices along with sub-systems where applicable. CFAP provides interface with telephone exchange, plant's public address system etc. and has features, such as provision to activate plant-wide sirens. CFAP is supported by mimic/ graphical display for geographical depiction of alarms either on panel or HMI.

4.2 DGFAP

It is a Microprocessor based fire alarm panel, designed for use with addressable fire alarm system. It has alpha- numeric LCD displays along with LED displays for fire/ fault conditions. It also includes loop cards (for field devices), I/O (input/ output) cards for interface with other equipment e.g. exit signs and hooters. It functions as fire alarm panel located centrally to population of fire detectors distributed over an area for optimizing and limiting the loop lengths.

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4.3 ZFAP

It is a fire alarm panel for conventional fire alarm system. This is functionality similar to what is provided for DGFAP. This has LEDs for fire/ fault annunciations.

4.4 Repeater Panel

It is similar to distributed fire alarm panels (DGFAP/ ZFAP) but will not have Zone card/ Loop card for field devices. These are provided at manned locations and are configured to acquire information about the fire/ fault of selected zones from DGFAP/ ZFAP and annunciate.

4.5 Integrated Fire Alarm System

It signifies a comprehensive fire alarm system comprising all the distributed fire alarm panels (DGFAP, ZFAP, repeater panels etc) having integration with CFAP for fire/ fault monitoring of total plant/ buildings. It provides audio/ visual alarm building/plant-wide having provisions for connectivity with telephone exchange and public address system. It shall provide interfaces with fire protection system and other systems like pressurization systems, air conditioning, clean agent system, water spray system, Fire & Gas detection system etc. via potential free contacts.

4.6 System Architecture

System architecture is line diagram defining the connectivity of DGFAPs, repeater and CFAP. This also specifies various system requirements such as redundancy, communication protocol, communication hardware, cable requirement, work station and programming tools.

4.7 Data High Way

This term is meant to define the communication path between DGFAPs, CFAP and other network components in microprocessor based fire alarm system. Physical media for Data highway can be FO cable or twisted pair copper conductor, screened cable.

4.8 Field Devices

Devices such as detectors, BGUs, exit signs, hooters, siren etc. are termed as field devices.

4.9 Hazardous Area

An area in which an explosive gas/ dust atmosphere is present, or likely to be present in quantities such as to require special protection for the construction, installation and use of electrical apparatus.

4.10 Signal Loop (Signaling Circuit)/Signaling Line Circuit

A circuit or path between any combination of circuit interfaces, control units, or transmitters over which multiple system input signals or output signals, or both are carried.

4.11 Notification Appliance Circuit

A circuit or path directly connected to notification appliances (eg. Bell, horn, speaker, strobe, printer etc.)

4.12 Zone

A defined area within protected premises. A zone may define an area from which a signal can be received, an area to which a signal can be sent or an area in which a form of control can be executed.

5.0 SYSTEM AND SITE CONDITIONS

All equipment shall be designed to operate with power supply and site conditions as specified below:

5.1 Site Conditions

The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.

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Unless specified otherwise, fire alarm panels along with associated hardware shall be suitable for installation and operation in a closed building/ room with restricted ventilation. Unless otherwise defined, a design ambient temperature of 40°C and an altitude not exceeding 1000M above mean sea level shall be considered for all equipment. For battery sizing, minimum ambient temperature shall be considered as 10°C.

5.2 Input Power Supply

5.2.1 Primary power supply will be provided by Owner at 240V, 50Hz, SPN at one point to each Fire Alarm Panel. Suitable power distribution to various signaling and notification devices shall be included in the vendor's scope. For microprocessor based system, 240V, 50Hz, SPN power supply to remotely located Repeater panel and sub-system, if any, shall be provided by the Owner on the basis of actual system configuration and requirements. For conventional Fire Alarm system, power supply to ZFAP, repeater panel and remotely located strobe etc. shall be planned and provided by the vendor.

5.2.2 For siren, power supply shall be made available by Owner preferably at 110V/240V/415V AC supply.

5.2.3 Unless otherwise specified, secondary power supply for fire alarm panels shall be through battery provided by the vendor. This shall have sufficient capacity to operate the fire alarm system under quiescent load (system operating in a non-alarm condition), i.e., to operate a local central station or proprietary Fire alarm system for a minimum of 24 hours. At the end of that period, this shall be capable of operating all alarm notification devices used for evacuation and to direct aid to the location of emergency for 5 minutes.

The secondary power supply for in-building fire emergency voice/ alarm communication service shall be capable of operating the system under quiescent load for a minimum of 24 hours and then be capable of operating the system during a fire and other emergency conditions for 15 minutes at maximum connected load.

The secondary power supply capacity required shall include all power supply loads that are not automatically disconnected upon the transfer to secondary power supply.

Battery sizing shall consider maximum quantity of detector/ equipment that can be connected in the loops, as well as 3 hooters and 3 exit signs per loop in DGFAP. Battery sizing calculations shall be reviewed during detailed engineering and there shall be no cost/ time implication for providing adequately sized batteries and chargers of approved rating during the order execution. Separate non-redundant battery charger shall be provided in case battery charger part of the DGFAP cannot cater to the boost charging requirement of battery. In case the battery cannot be accommodated in the main DGFAP enclosure, a separate enclosure of same height shall be provided which shall be placed adjacent to the DGFAP.

An overall ageing factor of 0.8 and a temperature correction factor corresponding to minimum temperature of 10°C shall be considered for battery sizing. The battery calculations shall include a 10 percent safety margin to the calculated amp-hour rating.

Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.

The switch-over from primary source to secondary source, in the event of mains failure, shall be automatic. Battery shall be Ni-Cd/ VRLA/ SMF type as specified in the data sheet. Suitable adequately rated battery charger shall be supplied as a part of secondary power

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source. Quick charging of the battery from fully discharged state shall be attainable in 10-14 hours except VRLA batteries, which shall follow the charging cycle according to supplier's recommendations.

6.0 FIRE ALARM SYSTEM DESCRIPTION

6.1 General

Fire alarm system, under this specification, is envisaged to provide fire monitoring in industrial plants and buildings. The system shall be designed to detect incipient fires, smoky fires and flaming fires and generate audio/ visual alarm on detection of smoke or fire.

The system shall consist of automatic fire detectors and break glass units. Automatic fire detectors shall work on the principle of sensing of smoke, heat or infrared/ ultraviolet rays. Depending on type of smoke, optical or ionization type detectors shall be used. Detectors shall generally be provided in plant/ buildings. BGUs shall be provided at exit doors of the buildings, exit routes of industrial plants and along service roads surrounding protected areas. Number of detectors and break glass units shall be decided as per guidelines given in applicable codes and standards.

For conventional FA system, plant/ building shall be divided into fire monitoring zones. In defining zones, care shall be taken to ensure that location of fire can be easily identified. No two buildings shall be combined to form one zone. Detectors and BGUs at these buildings and plants shall be connected to CFAP, ZFAP. These panels shall continuously monitor the state of these devices. On sensing fire condition, an audio/ visual alarm shall be initiated identifying the zone where fire is detected. Panels shall continuously monitor the health of the cabling and in case of short circuit or open circuit fault alarm shall be activated. Fire alarm panels shall also have powered outputs for switching on exit signs and hooters as specified in data sheet/ drawings. Further, panels shall provide required output for interfacing with the Owner's systems such as air conditioning system or pressurization system or fire protection systems.

Alarms, if specified, shall be relayed to repeater panel provided in buildings like control rooms/ administrative buildings to provide zone wise annunciation. In addition facility shall be provided to actuate siren/ hooter.

For integrated fire alarm system where plant-wide large numbers of fire alarm panels are envisaged, these panels shall be integrated to CFAP, which shall be located in fire station, disaster management control room or in administrative control room of the building as per the job requirements. The connectivity shall be achieved using data highway or dedicated cable connection from each fire alarm panel to CFAP. In conventional system Mimic at CFAP shall be provided for fire/ fault annunciation depicting geographical location in addition to the text/ LED on the CFAP. This will be in the form of graphics available at HMI in microprocessor based system. If defined, CFAP shall have provision for automatic and manual actuation of plant-wide siren as per operator's choice. Interface with other systems such as telephone exchange/ plant's public address system shall be provided for communication required for disaster management.

6.2 Conventional/ Addressable fire alarm systems

6.2.1 Fire alarm system shall be conventional fire alarm system or addressable microprocessor based fire alarm system as specified in data sheet. Conventional fire alarm system shall have conventional field devices/ equipment and microprocessor based system shall have addressable type field devices.

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Conventional fire alarm system shall generally comprise but not be limited to the following equipment used in conjunction with conventional automatic fire alarm detectors and BGUs as a minimum.

- CFAP with/ without mimic (as per data sheet)
- ZFAPs
- Repeater Fire Alarm Panel
- Sirens and starters/Siren control panels
- Hooters & exit sign in buildings
- Interface with Owner's systems
- Any other hardware as required to render system complete.

6.2.2 Microprocessor based fire alarm system shall generally comprise but not be limited to the following equipment used in conjunction with addressable automatic detectors and addressable BGUs as a minimum.

- CFAP consisting of computer based graphic work station and engineering station
- Multi loop DGFAPs
- Sirens and starters/ siren control panels
- Hooters & exit sign
- Interface with Owner's systems
- Data highway

  [Copper/ FO cable data highway complete with redundant architecture (applicable for star topology only) for communication, hardware including communication port, switches, processor and power supply]
- Any other hardware/ software required for rendering the system complete.

6.2.3 As specified in data sheet, the system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically as selected by operator from CFAP/ DGFAP located at fire station/ other buildings.

7.0 CONVENTIONAL FIRE ALARM SYSTEM

7.1 Design Features

7.1.1 System shall be modular and facilitate future extension/ modification. Panel design and component selections shall be done for future extension up to 10% of specified zones or one zone whichever is maximum in each panel. 10% spare zone cards subject to minimum of 1 shall be provided. The design of common facility and hardware shall be provided for required future extension of zones.

7.1.2 PCBs shall have watchdog feature for self-diagnostic. Each PCB shall have LED for annunciating card failure. Following self-diagnostic features may be considered as a minimum:

- Open circuit detection
- Short circuit detection
- Earth fault detection
- Power supply failure, e.g. low battery voltage, main incoming supply fail
- System faults (PCB failure)

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7.1.3 Logic of operation shall be built on "Fail safe" feature, i.e. NC contact of field devices shall be considered as healthy condition and NO as fire condition. 1 NO+ 1 NC contact of output relays shall be wired to terminal block for interface with Owner's other equipment.

7.1.4 It shall be possible to test lamps, hooters, flasher circuit, and carry out functional tests etc through common "Test" push button.

7.1.5 The circuit shall be so designed that silencing of the current alarm by ACCEPT push button shall not prevent annunciation of subsequent fire alarm received from any other location.

7.1.6 Signal-to noise ratio shall be high to avoid spurious actuation due to noise induced in the field wiring because of proximity with power cables. Cables for field devices shall be multicore copper conductor, unscreened, armoured, copper conductor FRLS cable. If required noise filters shall be provided at fire alarm panel.

7.1.7 Detectors and BGUs shall be wired through 1.5 mm^2 multi-core, Copper conductor, PVC/ XLPE insulated, armoured FRLS cable. Limiting distance from fire alarm panel to last detector/ BGU shall not be less than 1 km or as specified in data sheet whichever is maximum. For road side BGUs, 2.5 mm^2 multi-core, Copper conductor, PVC/ XLPE insulated, armoured FRLS cable shall be used.

7.1.8 LEDs shall be provided for fire/ fault visual annunciation on the panel front. LED shall also be provided for Power supply healthy, Battery backup ON, Battery/ Charger status.

7.1.9 If zone is protected with clean agent/ CO_2 system, the detectors and BGUs of the zone shall be wired in cross-zones by providing minimum two signaling circuits in a zone. The last device in each circuit shall be provided with end of line resistor of suitable value as per circuit design to facilitate cable open circuit and short circuit detection.

7.1.10 Scheme for FIRE/ FAULT annunciation for CFAP/DGFAP, Zonal Fire Alarm Panel, Repeat Alarm Panel shall be as per the following.

System condition	AUDIO	VISUAL
NORMAL	OFF	OFF
FIRE	ON (tone 1)	Flasher ON, Fire LED Steady ON
Accept	OFF	Flasher steady, Fire LED steady ON
Reset	OFF	Flasher OFF, Fault LED OFF
FAULT	ON (tone 2)	Flasher OFF, Fault LED Steady ON
Accept	OFF	Flasher OFF, Fault LED Steady ON
Reset	OFF	Flasher OFF, Fault LED OFF

7.1.11 Fire alarm panels including repeater panels and CFAP shall be certified/ approved by applicable approving agency of country of origin as required.

7.2 Zonal Fire Alarm Panel

7.2.1 ZFAP shall consist of number of zones as specified in data sheet. Detectors/ BGUs/ heat sensing cables etc shall be connected zone wise in signaling circuits. It shall monitor fire/ fault condition of the zone. ZFAP shall be located indoor in safe area.

7.2.2 ZFAP shall be free-standing, floor mounting vertical panel consisting of audio/visual annunciation with Alarm Accept, Test and Reset Push Buttons, Auto/ Manual control of hooters provided in buildings. Provision to actuate siren shall be provided if specified in data sheet. Circuit shall be designed to provide annunciation if any detector in a zone senses fire.

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7.2.3 Audio/ Visual indication and annunciation shall be as per clause 7.1.8.

7.2.4 ZFAP shall have required interface hardware where integration with CFAP/ repeater panel is envisaged as per data sheet.

7.2.5 Output contacts (1NO+1NC) shall be provided for interface with Owner's systems as per clause 9.0 of this specification.

7.2.6 Input power supply and battery backup for ZFAP shall be as per data sheet and as per clause 5.2 of this specification.

7.3 Repeat Alarm Panel-Conventional

7.3.1 Repeat fire alarm panel shall be provided for repetition of fire/ fault annunciation of CFAP/ ZFAP. Depending on the size Repeat Fire Alarm panel may be floor mounting type or wall mounting type. The display shall be similar to CFAP/ ZFAP.

7.3.2 Where required, input power supply from Owner shall either be 240V or 110V, 1phase, 50Hz. It shall be possible to select supply either 240V or 110V at site without modifying or adding additional equipment in the panel.

7.4 Central Fire Alarm Panel

7.4.1 CFAP shall receive inputs from automatic and manual fire alarm devices and supply power to detection, notification and communication devices. Fire and fault annunciation for each Zone or group of zones at ZFAP shall be repeated at CFAP.

7.4.2 CFAP shall be in vertical panel construction or desk type construction as per datasheet having controls such as Accept, Test and Reset Push Buttons, Auto/Manual control of siren etc.

7.4.3 Unless otherwise specified in the data sheet, CFAP shall have mimic to display geographical location of fire. Mimic shall form an integral part of the CFAP and shall be located at the top of the panel. When separate mimic panel is specified, it shall either be wall mounting or free standing floor mounted type. Two LEDs shall be provided for each zone on mimic panel for display of fire alarm. Mimic panel shall be powered by CFAP. Mimic made out of plastic stickers shall not be acceptable.

7.4.4 Input supply and battery backup for CFAP and MIMIC shall be as per data sheet and as per clause 5.2 of this specification.

7.4.5 Battery charger provided in the CFAP/ ZFAP shall be modular mounted on a draw out chassis. Charger module shall be located on the front allowing withdrawal with the help of handle bars for maintenance.

8.0 ANALOGUE ADDRESSABLE FIRE ALARM SYSTEM

8.1 Design Feature

8.1.1 Unless otherwise specified Microprocessor based FA system shall be analog addressable type. The system shall be integrated as per 'system architecture' indicated in data sheets/ drawings.

8.1.2 Fire alarm system shall be designed consistent with state of the art technology. All fire alarm panels including repeater panel shall be networked through data high way. The system supplied shall not pose any limitation for future expansion by way of networking of fire alarm panels, data transfer, parameterization of addressable field devices, graphic displays etc.

8.1.3 The system shall be modular and shall facilitate future extension/ modification. Panel design and component selections shall be done for future extension up to 10% of specified number of loops or one loop whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension.

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8.1.4 PCBs shall have watchdog feature for self-diagnostic. Each PCB shall have LED for annunciating card failure. Following self-diagnostic features shall be considered as a minimum for the system:

i) Open loop detection
ii) Short circuit detection
iii) Earth fault detection
iv) Power supply failure, e.g. low battery voltage, main incoming supply fail
v) System faults (PCB failure)

8.1.5 Unless specified otherwise in data sheet, system architecture shall have minimum redundancy indicated below at DGFAP & CFAP, however not limited to the same:

i) Redundant at processor level (communication processor and I/O card processor)
ii) Redundant communication port
iii) Redundant data highway cable (applicable for star topology only).
(For data highway ring topology will be preferred)
iv) Redundant microprocessor
v) Redundant work station/ HMI (engineering station + operator's station)
vi) Redundant power supply card at all fire alarm panels (but with non-redundant battery backup)

8.1.6 Data highway shall be using Fibre optic or twisted pair shielded copper cable as specified in data sheets. Whether specified or not, data highway shall include all necessary hardware such as modem, repeaters, network switches/ hubs etc., including power supply system as required to suit the length of data highway. All hardware shall be as recommended by OEM and shall be duly certified and tested.

8.1.7 The communication shall be peer to peer between various DGFAPs, repeater Panels, CFAP and other system components connected on fire alarm system data highway.

8.1.8 Any fault in Analogue detector addressable loop (signaling loop/ circuit), notification appliance circuit and data highway shall not impair communication, i.e. Communication/ flow of analogue signal shall be possible from either end.

8.1.9 The loop cabling for wiring detectors and BGUs shall be class A, fault tolerant type as per NFPA 72. In addition, DGFAP shall have the facility for class-A power supply loops for hooters & exit signs.

8.1.10 Fire alarm logic shall be programmable type. The logic for zone protected with clean agent system/ CO_2, shall be programmed to provide output for actuation after ensuring that there is no false alarm using alarm verification feature. Similarly logic to switch ON sounders. beacon and hooters shall be programmable type. Exit sign shall remain ON all the time.

8.1.11 The logic shall be so programmed that it will ensure silencing of the current alarm by ACCEPT push button & shall not prevent annunciation of subsequent fire alarm received from any other location.

8.1.12 Signal-to noise ratio shall be high to avoid spurious actuation due to noise induced in the field wiring because of proximity with power cables. Unless other wise specified, fire alarm cables laid in buildings shall be twisted pair, screened and unarmoured and shall be laid in conduits while cable laid outdoor in plant shall be twisted pair, screened and armoured. If required noise filters shall be provided at fire alarm panel.

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8.1.13 Unless specified otherwise in data sheet, the maximum number of detectors/ BGUs/ addressable devices in a signal loop shall be 120.

8.1.14 Unless specified otherwise in data sheet, conductor size of loop cable shall be 1.5sqmm Copper. The allowable signal loop length shall not be less than 2 km.

8.1.15 DGFAP and repeater panel shall have backlit alphanumeric LCD display to provide addresses and status of each field device. In addition LEDs shall be provided for fire/ fault visual annunciation. LED shall also be provided for Power supply healthy, Battery backup ON, Battery/ Charger status.

8.1.16 Fire station shall be provided with redundant PC(s) with monitors for operator's work station and for engineering station. Any of the two should be possible to configure as engineering station for programming off line. After Programming, the engineering station will be connected to network as online operator's workstation. Programming shall also allow activating Siren from the keyboard in manual mode as per operator's choice.

8.1.17 All field devices such as detectors and BGUs shall be addressable type. If available in vendor's design, hooters and exit signs may also be connected in addressable loop. Fault isolators shall be provided to minimize outage of number of detectors/ BGUs in case of loop cable fault. For hazardous area flame proof equipment shall be used. As far as possible, the use of intrinsically safe field devices in hazardous area should be avoided. If unavoidable, due care shall be taken care in design to avoid signal distortion and thus the mal-operation due to cable capacitance and inductance.

8.1.18 System shall provide adequate EEPROM size (min. 2GB) to store minimum of 2000 events fire/ fault. The event shall be stored in LIFO structure. All events shall be time stamped. DGFAP shall have real time clock for event time stamping.

8.1.19 Software access for either Zone programming or access to plant/ building graphic on monitor shall be password protected. For viewing status of various field devices e.g. fire and fault status password protection shall not be given.

8.1.20 All Fire alarm panels including repeater panels and CFAP shall be certified/ approved by an international approving agency/ approving agency of country of origin as applicable.

8.2 Data Gathering Cum Fire Alarm Panel (DGFAP)

8.2.1 DGFAP shall have basic design features as per clause 8.1 above. Number of signal loops in each DGFAP shall be as defined in the data sheet/ drawings/ MR. Number of loops shall be basic part of main PCB and should not be extended by providing external electronic devices. LCD display and annunciation scheme shall be as per clause 7.1.10.

8.2.2 It shall be possible to change the reference value of detector sensitivity either manually or automatically as required during the operation to avoid false alarms prior to detector maintenance.

8.2.3 DGFAP shall have serial port for communication to data highway. It should be possible to communicate all the information to CFAP/ FA system work station located with fire marshal. The protocol of communication shall preferably be open protocol.

8.2.4 In the event of non-availability of data highway, DGFAP shall work as stand alone intelligent panel monitoring fire in the zones connected to it.

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8.2.5 It shall be possible to configure DGFAP to access data of any other DGFAP and display as per the operation requirement to be finalized during engineering/ commissioning.

8.2.6 Where specified in MR/ data sheet, it shall be possible to interface with existing fire alarm system consisting of conventional zone detectors and BGUs with end of line resistor as a part of retrofitting.

8.2.7 DGFAPs shall have output relays to provide interface with Owner's system defined in clause 9.0 as minimum.

8.2.8 DGFAP shall have serial port for communication with DCS. Communication shall be on open protocol and type of connectivity shall be serial or RS-485 MODBUS RTU or MODBUS TCP/IP as specified in job specification/ data sheet.

8.3 Repeat Alarm Panel

Repeat fire alarm panel shall be provided for repetition of fire/fault annunciation of CFAP/DGFAP. Depending on the size repeat Fire Alarm panel may be floor mounting type or wall mounting type. The display shall be similar to CFAP/ZFAP.

These panels shall be without loop cards and shall be connected to data highway through serial communication. Panels shall have programming facility to inhibit the display of information that is not required in a particular repeater panel.

8.4 CFAP with PC Based Monitoring Station or Work station

8.4.1 Vendor shall supply CFAP similar to DGFAP along with PC based work stations. Application software shall be installed in PC as Graphic User Interface. The graphic shall include geographical display of locations of various plant areas including locations of addressable detectors and BGUs. The navigation between various graphic pages shall be user friendly. Screen shall have defined area to display the latest fire or fault alarm and shall also have facility to pop up the graphic displaying the location of fire event.

Where specifically indicated CFAP shall include network PC based monitoring station based on vendor's system design directly connected to data highway with other peripherals such as network switches/ controller (HUB).

8.4.2 Unless stated otherwise, CFAP shall have all the features and facilities of the DGFAPs. It shall monitor the status of each addressable field device indirectly from the DGFAPs connected on data highway.

8.4.3 Engineering workstation shall be used for programming off-line. After programming, the changed parameters shall be down loaded to other PC to work in synchronism as normal operation. This station shall also have one laser printer connected to PCs working as engineering printer.

8.4.4 The monitoring station/work station shall be equipped to display the overall plot plan showing all MCPs along the unit roads. The display shall have three levels of penetration, which permits zooming on to any process unit/area or any building. Further one may zoom into specific rooms of the building and view the detectors below the false floor, above the false ceiling or in the room cavity. The CFAP shall also display the location of fire/ fault when such an event occurs.

8.4.5 If specified, adequately rated single phase non-redundant UPS with bypass shall be provided for the workstations and printers of CFAP. Battery backup shall be sized as per criteria given

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under 5.2. Only normal supply shall be made available at one point by Owner at the location of central fire alarm panel. Where both CFAP and PC based work stations are provided the battery back up time for the UPS shall be 30 min. Battery back-up to CFAP shall be as per clause 5.2.

8.4.6 It shall be possible to actuate plant-wide siren in auto/ manual mode. Unless other wise specified, manual actuation shall be done from keyboard of workstation. Auto actuation shall be through software logic, which shall be finalized with end user during implementation. Auto/Manual selection shall be provided at operator's work station. The actuation signal under manual mode selection shall be communicated serially to DGFAP to which siren starter is connected. Siren starters shall be hardwired to DGFAP.

8.4.7 The minimum requirements for the PC and other peripherals shall be as stated below:

* Industrial type Latest generation PC
* DVD-RW
* Mouse and keyboard
* 29 Inch coloured LED monitor
* Engineering laser jet coloured printer with 8 PPM.

*Application software supporting graphics with no limitation on number of graphics, events, alarms, number of field devices as required for any large plant like refinery, petrochemical complex or large multistory building.

8.4.8 It shall be possible to provide multilevel access of fire alarm system. Read only access shall not require password protection. Access for programming and access for controls from keyboard shall be password protected. The levels of password protection shall be agreed with plant operators at the time of commissioning of system.

8.4.9 **Printer**

Printer options shall include graphic laser printer. Printer used in the system shall provide real time records of the system events and provide system reports on demand, and shall be microprocessor controlled, high speed, read only (RO).

9.0 INTEGRATION WITH VARIOUS PLANT SYSTEMS

9.1 Fire Alarm System shall have required hardware to have interface with following plant systems as specified in data sheet via potential free contacts.

i) Public Alarm Announcement system
ii) Paging and plant communication systems
iii) Plant data network
iv) ISDN telephone exchange
v) Fire suppression system
vi) Clean agent system
vii) Fire & Gas detection system.

9.2 Where ZFAP is required to carry out fire suppression functions, it shall be provided with the following interfaces with fire suppression system unless specified otherwise.

i) Automatic signal for release of clean agent/ CO_2 release for protected area and RELEASE audio/ visual alarm for evacuation.
ii) Selector switches for primary or secondary clean agent/ CO_2 supply for each protected area.

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iii) Manual push button for discharge of clean agent/ CO_2 in each protected area. The actual release of clean agent/ CO_2 shall however be delayed by 30sec after the alarm.

iv) Clean agent/CO_2 Discharge inhibit push button for each protected area.

v) Deluge valve activation push buttons, deluge valve test push buttons and deluge valve activated status lamps.

vi) Firewater pumps start push buttons.

vii) Firewater pumps running indications.

viii) Shutdown signals to various air-handling units/ Pressurization system relative to the zone of fire.

10.0 PANEL CONSTRUCTION (CFAP, DGFAP, ZFAP, REPEATER)

10.1 All fire alarm Panels shall be free standing, floor mounting type unless specified otherwise and shall be fabricated out of minimum 2mm thick CRCA sheets and doors shall be fabricated out of minimum 1.6mm CRCA sheets. The panel shall be naturally ventilated in IP-41 enclosure protection as minimum.

The colour shade of final paint shall be 536 as per IS: 5, unless otherwise specified.

10.2 Equipment Mounting

10.2.1 All apparatus, display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. The external cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturer's standard. Routine calibration, adjustments, programming and operation shall be accessible from the front of the panel without opening the door.
External cabling shall preferably be done from the rear.

10.2.2 Power supply system including VRLA battery bank shall be mounted inside the panel.

10.2.3 Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipment.

10.2.4 Cable entry shall be from bottom unless otherwise specified in the data sheet. Terminal strip shall be provided for incoming/ outgoing cables.

10.3 Wiring and Terminals

10.3.1 Wiring within the panel shall be harnessed in slotted plastic raceways enclosed with cover. Control connections shall be done with 660V grade PVC/ XLPE insulated wires having stranded Copper conductors. 1.5mm^2 size of wire shall normally be used for circuits with control fuse rating of 10A or less. Control wiring for electronic circuits shall be through ribbon cable or through copper wire minimum of 0.5mm dia. Panels shall be supplied completely pre-wired, such that only field termination shall be required at site before it is energized.

10.3.2 PCBs for identical functions shall be interchangeable. PCBs shall be plug in type having pin/ edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.

10.3.3 Cables shall be terminated on terminal blocks. Clamp type terminals shall be of spring-loaded, stacking type, mounted on rails. Terminals shall be sized to accept, as a minimum 2.5mm^2 cross section conductors. Not more than one conductor shall be terminated on the

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outgoing side of each terminal. At least 20% spare terminals shall be provided in each panel for termination of spare cores of cables.

10.4 Earthing

A common earth bar of minimum 25 mm x 3 mm. Copper or equivalent Aluminum shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel-mounted equipment shall be earthed. Flexible jumpers shall connect all doors and movable parts to the earth bus. Two numbers earth lugs shall be provided outside the panel.

10.5 Name Plates / Warning plates

10.5.1 All nameplates for panel shall be engraved out of 3 ply (black-white- black) lamicoid sheets or anodized aluminum. Back-engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

10.5.2 Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel. Wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

10.5.3 Special warning plates shall be provided on all removable covers or doors giving access to energized metallic parts above 24 volts.

10.6 Painting

10.6.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

10.6.2 After preparation of the undersurface, the panel shall be powder coated. The colour shade of final paint shall be as approved by the Owner. The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, run-off paint etc.

10.6.3 All unpainted steel parts shall be zinc passivated or suitably treated to prevent rust-corrosion. Moving elements shall be greased.

11.0 CABLE AND CABLE ACCESSORIES

11.1 Supply and laying of FA cables shall be as per the requirement specified in the MR/data sheet. Vendor shall provide JBs for detectors, BGUs, exit signs, hooters etc.

11.2 Where supply and installation of field cabling is excluded from vendor's scope, terminations of all cables (supplied by both vendor/ Owner) at both ends shall be in vendor's scope.

11.3 Bidder, as a part of integration and selection of fire alarm equipment, shall furnish detailed specifications for loop/zone cables, data highway cables, cables for hooter/exit signs etc giving details such as type of cables, number of pairs, size of cable, inductance and capacitance data, number of fibres/ connectors etc.

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11.4 Data Highway Cables

11.4.1 Unless specified otherwise, vendor shall supply Copper cable/ FO type data highway cable to suit system design and equipment specification. Copper cables, if supplied, shall be of adequate size, twisted pair, PVC/ XLPE insulated, overall screened, PVC inner sheathed, armoured, FRLS type PVC outer sheathed as a minimum. Fiber Optic cables, if supplied, shall be armoured, overall FRLS PVC outer sheathed and shall be as per ITU-T recommendation as a minimum.

a) The fiber-optic cable shall be with minimum of 4 spare fibers. Procedure of data transmission error control shall be as per acceptable standards.
b) Cable shall be suitable for water submergence duty and high temperature withstand as per routing requirements in the plant. All lengths shall be joint free single continuous length.
c) Protective Materials/ Coatings — Optical fibres shall be coated with UV cured double acrylate resin. It should not have any reaction with cladding or core material.
d) The coatings shall be in various colours in order to facilitate fibre identification. Fibre colours shall correspond to IEC publication 60793-2 and 60304 and their latest updates. The colours shall correspond reasonably with standard colours and shall be readily identifiable and shall be durable. The colours should have good colour fast properties also in the presence of other materials during the lifetime of cable. The coating and the colour shall not react with the surrounding jelly.
e) The fibre optic cable shall be protected against damages from termite, rodent, chemicals (such as oil & natural gas, LPG and other petroleum products), moisture and water over the life time of the cable.
f) The optical fibre cable construction shall be of loose tube type with multitube / unitube construction. The cable shall have central strength member, inner and outer sheaths and moisture barrier layers.
g) The main cable core containing fibres and core wrappings shall be provided with moisture barrier protection by means of flooding compound (jelly) having properties of non hygroscopic dielectric material and / or by water swellable tape. The core wrapping shall not adhere to the secondary fibre coating.
h) The cable shall have sufficient strength to withstand a load of value T = 9.81 x W newtons, where W = mass of 1 km in kg. The load shall not produce total strain exceeding 0.25% in the fibre. Solid FRP non-metallic strength member / members in the cable core / sheath shall be provided. Aramid yarn can further be used in the periphery over the core of the cable to achieve required tensile strength.
i) The termination enclosures of the optical fibre cable should be dust tight (No dust ingress) and protected against immersion in water (suitable for continuous immersion in water) and should be complete with all accessories including splice cassettes splice protection and all other accessories including accessories for electrical continuity of metallic layers of optical fibre cable and OFC preparation kit alongwith instruction sheet.
j) All fibres (including spare fibres) of a cable shall be terminated in the termination enclosure by pigtails. Subsequent connection shall be by patch chords. Supply and erection of termination enclosure, pigtail, patch chord etc. shall be by vendor.
k) The armouring of the optical fiber cable shall be of corrugated steel (electrolytically chrome plated low carbon steel) tape both side coated with ethylene acrylic copolymer, applied longitudinally with minimum overlap of 6mm. the thickness of the steel tape shall be of 0.15mm minimum. The thickness of each polymer layer shall be 0.04mm minimum.

The fiber-optic cable for data highway shall be laid in HDPE duct by compressed air blowing technology. The HDPE duct, to be supplied for fiber optic cable routing, shall be permanently solid lubricated / with internal spiral groove, UV-protected, fire-retardant (class V2 as per UL-94 and with limited oxygen index of 21 or higher as per ASTM D2863), of 40 mm outer diameter (+5.0/-0.0 mm), minimum thickness 3.7mm, suitable to withstand load of 6 kg/cm^2. HDPE duct shall be supplied in drum lengths of 500m. HDPE ducts of two different colours

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shall be supplied to distinguish between the two redundant data highway cables (applicable for star topology). For routing information highway cables, if any, HDPE ducts of third (and fourth) different colours shall be supplied.

All HDPE ducts shall be supplied along with accessories such as push fit coupler, bend and elbow, end plug, simple plug, sonic head etc. required for blowing cable into HDPE duct by compressed air technology.

11.4.2 Vendor shall supply and install all hardware and cabling accessories as per data high way design including modems, repeaters etc as part of the Fire Alarm system. Modems/ repeaters shall be powered by the supply provided for DGFAPs / CFAP.

11.5 Cable Glands / Accessories

11.5.1 All cable glands/ lugs/ connectors as required for the equipment shall be included in vendor's scope and shall be supplied along with the system, irrespective of whether installation is to be performed by vendor or not.

11.5.2 All the cable glands for outdoor application shall be weatherproof, nickel-plated brass and double compression type, whereas those for indoor application shall be single compression type.

11.5.3 Cable glands for hazardous area equipments shall be flameproof, weatherproof and nickel-plated brass double compression type.

12.0 AUTOMATIC FIRE DETECTORS AND ACCESSORIES

12.1 General Specifications

12.1.1 Detectors for conventional fire alarm system shall be conventional type. End of line resistor shall be provided at the last detector in the zone. Detectors for microprocessor based Analogue addressable FA system shall be addressable type. Detectors shall be plug-in type and shall have twist lock action fitting. Multi-colour LEDs provided on the detectors shall indicate Normal and Alarm state. Essential features of detectors are indicated as below.

12.1.2 Detectors shall be supplied with mounting bases. Mounting base shall be identical for all type of detectors except special application detectors such as linear beam detectors etc. for installation as well as cable connection. Detector housing (body and cover) shall be made up of damage resistant, fire resistant polycarbonate and shall be suitable for either surface or recess mounting. Detector base shall be mounted on Junction boxes having terminals for cable termination. Where installation is included in vendor’s scope, all necessary installation materials shall also be included in vendor’s scope.

12.1.3 Detectors shall be suitable for storage at ambient condition specified in data sheet.

12.1.4 All detectors shall be on the approved list of LPC, UL/ FM/ VdS or equivalent international approving agency as applicable.

12.1.5 All detectors shall be suitable for operation at DC power supply extended from fire alarm panel.

12.1.6 The addressable detectors shall be continuously monitored to measure changes in their sensitivity due to the environment (dirt, dust, temperature, humidity etc.). These detectors shall give an advance indication to the panel regarding the need for maintenance. The analogueue reading sent by the detectors shall be sensed and if there is a rapid increase, an

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alarm shall be generated. However, if there is a gradual increase in the analogueue reading, a maintenance alert shall be generated by the fire alarm panel. It shall be possible to generate maintenance reports from the fire alarm panel. For the addressable detectors two-wire operation shall be possible.

12.1.7 All addressable detectors shall have selectable settings for pre-alarm and alarm and preferably have the facility to set the sensitivity and address from the fire alarm panel.

12.1.8 Break glass units for microprocessor based fire alarm system shall be addressable type. Each device shall have its own address module.

12.1.9 All addressable detectors shall be suitable for installation using fault tolerant wiring (class-A, style - 6 wiring as per NFPA72). T- Tapping shall not be permitted in the case of such wiring.

12.1.10 All detectors must have insect screen to prevent insect entry and cause false alarm.

12.1.11 All field devices shall be from the latest generation in the manufacturer's range of products. Commonly used field devices are listed below. The specification given shall be considered as minimum requirements.

12.1.12 Detector electronics shall be EMR/ RFI shielded in order to avoid nuisance alarms.

12.1.13 The detector shall have automatic addressing capability from DGFAP only.

12.2 Heat Detectors

12.2.1 Heat detectors shall use negative temperature coefficient thermisters for sensing and for reference. The detector shall be designed to give a response that depends on both absolute temperature and rate of rise in temperature.

12.2.2 The rate of rise element shall be carefully calibrated to ignore any normal fluctuation in temperature, but to respond quickly when the temperature rise is 9°C or more per minute.

12.2.3 The fixed temperature feature should be entirely independent of the rate of rise element. The operating temperature of fixed temperature element should be configurable at site with temperature range between 0° C to 70° C with Rate of rise (ROR) feature.

12.2.4 The detector shall be self-restoring type ensuring repeated use and easy maintenance.

12.3 Multi Sensor (Detector)

12.3.1 Multi sensor shall have combined & individual features of smoke detector and thermal sensor (heat detector). Smoke activity shall be monitored by photoelectric sensing technology in a single detector / base assembly. Heat detection shall be fixed with selectable rate of rise settings. Multi sensor detectors shall be able to generate multiple alarm signals from any of the sensors (smoke or heat) employed in design independently or in combination. Detectors shall be analogueue addressable.

12.3.2 The detector shall be able to sense incipient fire by detecting the presence of visible and invisible products of combustion like wood, paper, ammonia processing paper, cloth, PVC, bakelite, nylon, foam, acrylic, thermocol, Photo film, nylon, polyester, painted sheets, Teflon, leather etc.

12.3.3 The sensitivity of the detector shall not vary with change in ambient temperature, humidity, pressure or permissible voltage variation. Its performance shall not be affected by an air

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current of 5 m/sec. It shall have an inbuilt arrangement such that puffs of smoke or hot air pockets do not inadvertently trigger the alarm. The detector shall be protected against dust accumulation/ ingress. It shall have insect resistant screen to prevent nuisance alarms.

12.3.4 In recess above ceiling designed to handle return air for HVAC, it shall be ensured that detectors are compatible to air velocity. Where air velocity is expected to be too high for the detectors to function normally, smoke guard/ baffle shall be used as per requirement.

12.4 UV Flame Detector

12.4.1 UV flame detectors shall work on the principle of a vacuum photodiode tube to detect the UV radiation that is produced by a flame.

12.4.2 UV flame detectors shall respond to ultraviolet rays of a flame. The detector shall not be actuated by artificial lights, sunlight incident through a windowpane or welding arc. False alarm check circuit shall be incorporated to prevent false alarm due to intermittent flash or lightning.

12.5 IR Detectors

12.5.1 IR detectors shall work on the principle of a single wavelength infrared flame detector using one of several different photocell types to detect the infrared emissions in a single wave length band that are produced by a flame.

12.5.2 IR detectors shall react to the infrared rays of a flame. It should be sensitive enough to detect smoky fires in which flame is hardly recognizable. The detector should not react to extremely glaring artificial light or direct sunlight. The detector shall be completely solid-state type.

12.5.3 Where specified combination UV-IR detector shall be used.

12.6 Linear Beam Detector

12.6.1 Linear beam detector shall work on the principle of obscuration of infrared light beam by particles of smoke. The sensitivity shall be such as to enable operation at 30% to 50% obscuration.

12.6.2 Linear beam detector shall consist of transmitter and receiver. Linear beam detector shall be suitable for application in high roofed locations (10 m & above) such as warehouses, pressurization room, transformer room (if required) etc. The detector shall, preferably, be powered from the loop signal itself. However, if external power supply is required the same shall be explicitly stated by the vendor, which shall be covered under common power supply for the fire alarm panel and devices connected with it.

12.7 Heat Sensing Cables

Heat sensing cable shall be analogue type. It shall consist of four copper conductors, each covered with a colour coded, negative temperature co-efficient material. The cores shall be twisted together and protected by an outer sheath of high temperature, flame retardant PVC/ XLPE insulation. External mechanical protection shall be provided over the sensor cables. Vendor shall provide control unit as per OEM design recommendation.

12.8 Break Glass Unit (BGU)

12.8.1 Manual break glass unit shall be fabricated out of 14-gauge cold rolled sheet steel. Alternately the break glass unit may be made of die cast aluminum alloy such as LM6. It shall

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have IP-66 enclosure and weather proof construction for outdoor installation. The break glass unit shall have a minimum dimension of 100x100x80mm.

12.8.2 The box shall be fabricated in such a way it can be mounted flush to the wall or on the surface without any modification. Two nos. 19 mm knockouts shall be provided at the bottom of the box to facilitate cable/ conduit entry. The glass shall cover at least 30cm² area and shall have a thickness not exceeding 2mm.

12.8.3 The box shall have a push button element kept in pressed condition by a glass sheet fitted in the front of the box.

12.8.4 The enclosure shall be painted with fire red colour (shade 536 of IS-5) epoxy painting and an inscription " Break Glass in case of Fire", shall be painted in white letters or riveted on the enclosure by a steel nameplate. A suitable nickel-plated brass hammer, duly chained to the box with stainless steel chain shall be provided with each box for breaking the glass. Each box shall have a distinct identification number boldly painted on it.

12.8.5 One No. blanking plug shall be provided for 5% of the total quantity of MCPs. MCPs for outdoor installation shall be complete with FRP canopy.

12.8.6 Hazardous area Break Glass Units shall meet the requirement of clause 13.0 of this specification.

12.9 Response Indicator

12.9.1 If specified in the data sheet, response indicators shall be provided suitable for wall/ ceiling mounting. Response indicator shall be provided where the detector is located either above false ceiling or below false floor or where detectors are not directly visible. The response indicators shall be connected to the detectors directly and shall be complete with terminal blocks suitable to accept cables with up to 1.5mm² Copper conductor. In the normal state of detector, the LED shall flicker, but in the event the detector goes into alarm condition, the LED shall glow steadily. LEDs shall be red in colour with 5mm dia. as a minimum.

12.9.2 Use of Response indicators in addressable system is not envisaged unless otherwise specified in data sheet.

12.10 Exit Signs

12.10.1 Exit signs shall be fabricated out of 1.6mm thick cold rolled sheet steel. This shall be suitable for wall mounting or suspension from ceiling. Exit signs suspended from the ceiling shall have text/ direction printed on both the side of exit sign.

12.10.2 Fire exit shall be displayed by means of 5mm dia LEDs or backlit text. It shall be powered from the fire alarm panel. Exit sign shall operate on DC power supply.

12.10.3 The exit sign shall be either in red letters on white background or white letters on green background.

12.10.4 Where specified in data sheet, self-luminous exit sign shall be provided.

12.11 Hooters

12.11.1 The unit shall consist of solid-state circuitry on a printed circuit board, a loudspeaker and a flashing lamp housed in a weatherproof dust tight, wall mounting type enclosure. The hooter shall, at least, have 102 db (A) output measured at 1-meter distance. The unit shall be

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powered from the fire alarm panel and operate on DC power. In the event of fire, the hooter shall raise pulsating audio alarm and the lamp shall start flashing.

12.11.2 The hooter shall be selected and triggered independently from DGFAP/ CFAP for performance check and maintenance.

12.12 Flashing Lights (Beacon)

12.12.1 The unit shall consist of solid-state circuitry on a printed circuit board and a red-capped incandescent lamp and audio unit housed in a dust tight, wall/ ceiling mounting type enclosure. It shall derive power from the DGFAP/ ZFAP and shall operate on DC supply.

12.12.2 Flashing lights shall be installed in the enclosed areas where clean agent/ CO_2 is to be released. In the event a signal for clean agent/CO_2 release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area. The audio unit (hooter) shall have 102 db (A) output measured at 1-meter distance.

12.13 Clean Agent / CO_2 Release and Inhibit Switches

12.13.1 This unit is required to be provided at the exit of the protected buildings/ rooms. If specified, this unit is integrated with DGFAP/ ZFAP. This shall consist of pull type release and inhibit switches clean agent / CO_2. The unit shall be fabricated out of 2mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit clean agent / CO_2.

Release switches shall have inscription:
"PULL TO RELEASE CLEAN AGENT / CO_2"
And inhibit switches shall have inscription:
"PULL TO INHIBIT CLEAN AGENT / CO_2".

12.14 Zener Barrier

12.14.1 Preferably flameproof (Ex 'd') equipment that does not require the use of Zener barrier shall be used. When necessary, intrinsically safe (Ex 'i') detectors and BGUs, Zener barriers shall be provided. These shall be located in unclassified/ non-hazardous areas.

12.14.2 Normally not more than 10 detectors shall be connected to one zener barrier. However vendor shall indicate maximum number of detectors/ BGUs that can be connected to one Zener barrier without compromising on working of loop/ zone. Vendor shall also indicate the maximum loop length from zener barrier considering 1.5 mm^2 copper conductor screened cable.

12.14.3 In case loop length permits, zener barrier shall be located at DGFAP itself, else it shall be located in safe area nearest to the detector/ BGU.

12.14.4 Wherever zener barriers are provided in safe area outside the Zonal panel or DGFAP, these shall be housed in their own enclosure with IP-55 degree of protection as a minimum.

12.15 Fault Isolator

12.15.1 Fault isolator shall be installed, if specified in the data sheet.

12.15.2 Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

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12.15.3 On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

12.15.4 The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

12.15.5 Fault isolator modules shall be housed in a enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

12.16 Sirens

12.16.1 Sirens shall be industrial type with minimum 2.5 km unidirectional range (i.e. 5 km diametrical range) against the wind direction.

12.16.2 The decibel level of the siren shall, at least be 132db(A) at 1 meter, to meet the audibility requirement for the above range. Unless otherwise specified, Sirens shall operate preferably at 415V/240V/110V AC supply. Sirens shall be housed in weatherproof enclosure. Starter shall be DOL and shall be housed in a separate IP55 enclosure suitable for installation indoor/ outdoor.

12.16.3 The siren shall provided with five tones suitable for various conditions as follows

i) SMALL FIRE: No siren

ii) MAJOR FIRE: A wailing siren for two minutes.

iii) DISASTER: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of one minutes i.e.(wailing siren 2min + gap 1 min + wailing siren 2min + gap 1min + wailing siren 2min) total duration of Disaster siren to be eight minutes.

iv) ALL CLEAR (For fire): Straight run siren for two minutes.

v) TEST: Straight run siren for two minutes at frequency atleast once a week.

12.16.4 The siren controller shall be as below

i) The operation of siren shall be in Manual mode with single button operation through Push Buttons – 5 Nos. mounted on the control desk for tone selection.

ii) The siren shall be initiated with a single pulse from the Push Button. The logic shall be such that first Push Button pressed shall be accepted till the completion of cycle of that particular siren tone.

iii) One no Push Button shall be provided for EMG STOP in case the siren tone is required to be stopped mid way.

12.16.5 The operation of the siren shall also be possible in Auto mode. The programming for the same shall be possible from the DGFAP/CFAP.

12.17 **Control relay module**

Intelligent addressable potential-free control module to trigger 3rd party utilities like AHU shut-off, pressurization etc.

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12.18 **Control relay monitor module**
Intelligent addressable, supervised monitor module monitoring potential-free, normally-open dry contact input.

13.0 FIELD DEVICES FOR HAZARDOUS AREA

13.1 Hazardous area is classified as Zone 1/ Zone 2, gas group IIA/ IIB or IIC, temperature class T3 (200 ^{0}C) as specified in data sheet. The field devices shall be suitable for installation in hazardous area as per specified area classification.

13.2 Field devices such as detectors, BGUs, fault isolators, Beacons, hooters etc for use in hazardous area, if specified in the data sheet, shall have flame proof enclosure conforming to IS/IEC 60079. All equipment for hazardous area installation shall be complete with flame proof weather proof cable glands as specified in clause 11.5.

13.3 Equipment, which cannot have flameproof construction, shall be intrinsically safe in design and shall be used with Zener barriers located in safe area.

13.4 Equipment that are tested / certified by a recognized test laboratory of country of origin shall only be offered. The vendor shall possess valid test certificate issued by a recognized independent test house such as CIMFR/ BASEEFA/ UL/ FM or Equivalent for the offered equipment.

13.5 All equipment (indigenous or imported) shall have valid statutory approval as applicable for the specified hazardous location from PESO or any other applicable statutory authority. All indigenous flameproof equipment shall also have valid BIS license and corresponding marking as required by statutory authority.

13.6 A separate name plate shall also be provided on each equipment to indicate details of testing agency, test certificate number with date, statutory approval number with date, approval agency, BIS license number with date, applicable gas group, temperature class etc. The name-plate shall be riveted/ fixed with screws and not pasted. In case above information are embossed on the enclosure, the same need not be repeated.

14.0 ENGINEERING REQUIREMENTS

Unless specified otherwise, vendor shall design entire fire alarm system including design of system architecture with details of integration, cabling requirement and protocol selection etc. Vendor's scope shall also include basic design and preparation of layouts for fire alarm system for plant/ buildings if specified in the data sheet/ purchase documents.

14.1 Conventional Fire Alarm System

i) For conventional fire alarm system, Owner shall provide typical block diagram. On this basis, vendor shall prepare detailed drawing giving various system component details. The design and engineering shall include sizing and selection of various equipment such as fire alarm panels, batteries, battery chargers, field equipments, siren/ siren starter etc. including preparation of General Arrangement drawings of various equipment.

ii) The layout engineering for buildings shall include the drawings showing location of BGU/ Detector and other field devices, cable schedules, interconnection diagram, equipment installation drawings etc as minimum.

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14.2 Addressable Fire Alarm System

i) Vendor shall develop a system architecture based on Owner's requirement showing details of various network elements such as DGFAP, CFAP, Work station, networking hardware, redundancy, protocols, data highway etc. including the maximum permissible loop length and length of data highway.

ii) The design and engineering shall include sizing and selection of various equipment such as fire alarm panels, batteries, battery chargers, field equipment, siren/ siren starter etc. including preparation of General Arrangement drawings of various equipment.

iii) The layout engineering for buildings shall include the drawings showing location of BGU/ Detector and other field devices, cable schedules, interconnection diagram, equipment installation drawings etc. as minimum.

iv) The "Cause & effect" diagram of the system shall be developed by vendor during detail engineering, in consultation with client.

v) The parameterization facilities of various field devices along with the geographic mimic, annunciation, text messages etc shall be available on the fire alarm panel.

15.0 INSPECTION, TESTING AND ACCEPTANCE

15.1 All the equipment shall be tested to the defined specifications as per mutually agreed test plan/ FAT procedure, which shall be submitted and got approved from Owner at least one month before inspection. EIL/ Owner's inspectors shall witness all the tests.

15.2 During manufacture, the equipment shall be subject to inspection by EIL/owner or by an agency authorized by the owner, to assess the progress of work and to ascertain that the quality controls are being maintained. Vendor shall provide all necessary assistance and information concerning the supply to EIL/Owner's inspectors.

15.3 Tests shall be carried out at the vendor's works under his care and expense and Owner shall be informed at least 4 weeks in advance regarding this.

15.4 FAT shall include simulation of operational field conditions and test for functional adequacy besides all routine and acceptance tests specified by applicable codes and standards.

15.5 For bought out items, the routine and acceptance tests shall be conducted at the respective equipment manufacturer's works.

15.6 At the time of inspection, vendor shall produce original of all the type test certificates, test and approval certificates for hazardous area equipment from testing and approving authority and any other certificates as required from statutory authority for the review of inspectors.

15.7 Vendor shall submit a SAT procedure for EIL/ Owner's approval. All equipment and systems shall be tested at site as per the approved SAT procedure

15.8 SAT shall be conducted by vendor after the entire fire alarm system is installed and inter connected by cables. These tests shall establish the operational correctness of the system. Vendor shall rectify deficiencies noticed during SAT with no commercial implication to Owner including replacement of system components and supply of new component for making system successfully operational.

15.9 All equipments shall be subjected to various routine/ acceptance tests as per Inspection & Test Plan no. 6-81-1076.

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16.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to the finish. Crates/cases shall have skid bottom for handling. Special notations such as ''Fragile", ''This side up", ''Center of gravity", ''Weight", ''Owners particulars", ''PO Nos." etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment..

17.0 INSTALLATION AND COMMISSIONING

Where installation of the system is included in the scope of the vendor, vendor shall arrange all necessary manpower and equipment required for the same. Commissioning of the complete system is to be carried out by vendor in all cases irrespective of whether the installation was performed by vendor or not. All tools, test equipment etc. for the successful commissioning of the system shall be arranged by the vendor at his own cost. Only the cabling specifically excluded from vendor's scope shall be installed by others. However, termination at panels for Owner's cables shall be done by the vendor.

18.0 TRAINING

Vendor shall provide comprehensive training on various operation and maintenance aspects of the Fire Alarm system as agreed during ordering at manufacturer's works. Vendor shall also provide training on various operation and maintenance aspects to Owner's engineers at site.

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SPECIFICATION FOR ELECTRICAL EQUIPMENT INSTALLATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	13 08 19	REVISED & ISSUED AS SPECIFICATION	RM	RS	SA	RKT
4	21 05 14	REAFFIRMED & ISSUED AS SPECIFICATION	FA	SA	BRB	SC
3	25 04 08	REVISED & ISSUED AS SPECIFICATION	RKS	SSM	JMS	VC
2	28 02 03	REVISED & ISSUED AS SPECIFICATION	HKM	RSG	VPS	SKG
1	26 08 97	REVISED & ISSUED AS STANDARD SPECIFICATION	RR	VPS	SG	AS

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Abbreviations:

AC	:	Alternating Current
ACDB	:	AC Distribution Board
AL	:	Aluminium
BIS	:	Bureau of Indian Standards
CCoE	:	Chief Controller of Explosives
CD	:	Compact Disc
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mining and Fuel Research
CT	:	Current Transformer
CTC	:	Carbon Tetrachloride
CU	:	Copper
DC	:	Direct Current
DCDB	:	DC Distribution Board
DGMS	:	Directorate General of Mines and Safety
Ex(d)	:	Flameproof
FRP	:	Fibre Reinforced Plastic
HV	:	High Voltage
IR	:	Insulation Resistance
IS	:	India Standard
LV	:	Low Voltage
HMI	:	Human Machine Interface
MV	:	Medium Voltage
OISD	:	Oil Industry Safety Directorate
OSR	:	Oil Surge Relay
OTI	:	Oil Temperature Indicator
PF	:	Power Factor
PI	:	Polarisation index
PRV	:	Pressure relief Valve
PT	:	Potential Transformer
SLD	:	Single Line Diagram
UPS	:	Uninterrupted Power Supply
VRLA	:	Valve Regulated Lead Acid
WTI	:	Winding Temperature Indicator
PESO	:	Petroleum and Explosives Safety Organization

Electrical Standards Committee

Convenor: Ms. Sumita Anand

Members: Mr. Parag Gupta
Mr. M.K. Sahu
Ms. ANP Singh
Mr. Harish Kumar
Ms. Shalini Verma
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1.0 SCOPE

This specification defines the requirements for the installation, field inspection, testing and commissioning of electrical equipment, forming part of electrical power distribution and utilisation system, including Communication and Fire alarm system.

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workmanlike manner in conformity with this specification, EIL Installation Standards, layout drawings and to the following specifications/ codes of practice of Bureau of Indian Standards and OISD standards.

SP-30 (BIS)	National Electrical Code.
IS:7816	Guide for testing Insulation resistance of rotating machines.
IS:10028 (Part-2)	Code of practice for selection, Installation and maintenance of transformers; Part 2 : Installation.
OISD 137	Inspection of Electrical Equipment.
OISD 147	Inspection and safe practices during electrical installations

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations.
b. Regulations laid down by CEA/Electrical Inspectorate.
c. Regulations laid down by PESO/DGMS (as applicable).
d. The petroleum rules (Ministry of Industry Government of India).
e. Any other regulations laid down by central/state/local authorities and Insurance agencies.

3.0 INSTALLATION OF EQUIPMENT

Prior to start of installation of the electrical equipment, Contractor shall verify that equipment and complete materials have been received. Handling, shifting to required site location, installation, testing and commissioning of all electrical equipment shall be done by contractor with utmost care. Manufacturer's instructions and the requirements given in their technical manuals shall be strictly adhered. The substation/switchgear room wherein the equipment shall be installed shall be kept clean, dry and free from all debris. Panel floor cutouts not in immediate use shall be suitably covered to avoid any mishap. When handling the switchboard panels, care shall be taken to observe the correct lifting arrangements and to make sure that slings are attached to the manufacturer's designated lifting points,where applicable. No parts shall be subjected to undue strains or sudden stresses which could cause damage to the equipment.

The lifting position mark indicated on packing casing shall be adhered to strictly, for keeping it in required vertical position.

Contractor shall check and report to the Engineer-in-charge about any damaged item and / or missing component for getting the same replaced as per specifications. During installation, all accessories and loose items shall also be inspected by the contractor before their assembly/mounting.

Manufacturer checklist, manual for erection and installation and any specific requirement for equipment handling, installation and commissioning shall be strictly adhered to.

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3.1 Switchboards and Bus Ducts

3.1.1 The term switchboard here includes all HV / MV/ LV switchboard panels, motor control centers, power and lighting distribution boards, UPS panels, ACDB, Battery charger panels, DCDB etc.

The switchboard panels shall be handled with care, avoiding any impact to the equipment. Dragging of the panels directly on floor shall be avoided. Roller bars may be used for shifting of panels. Use of a crane and trailer shall be made for handling of equipment. The switchboard panels shall be properly supported on the truck or trailer by means of ropes to avoid any chance of tilting. The switchboards shall be lifted after ensuring that panel supports, nuts and bolts are all intact and tightened. While lifting the panels in packed conditions, utmost care shall be taken to avoid any damage to insulators, bushings, metering and protective equipment and if specified in the tender document tyre mounted hydraulic trolley shall be used.

The panels shall be preferably kept inside the packing cases till foundations are ready. Proper rain/sun/dust protection shall be ensured till switchboards are installed.

3.1.2 The switchboard panels shall be installed on prepared foundations or floor cutouts. Steel base channels shall be welded to inserts provided in floor slab. Cross members shall be provided at the junctions of each shipping section and other places as required.. It shall be ensured that the base plate level of HV switchboard shall match with the finished floor level.

The foundation pockets and the grouted bolts shall be cured for a minimum period of 48 hours. Proper level of base frames shall be maintained throughout and shall be checked with water level/spirit level. Steel Shims shall be provided below base frame wherever required.

3.1.3 The switchboard panels shall be taken out from the packed cases and shifted one by one to their proper place. All the panels shall be assembled, aligned and leveled. Alignment of panels shall be checked in both longitudinal and lateral directions. It shall be ensured that panel to panel coupling bolts, bus bar links etc. fit properly without any strain on any part. No new holes for jointing of the panels other than those recommended by the vendor shall be drilled. No gaps shall be left between the panels. Gap if any found between panels shall be suitably sealed using sealing compound or T-profile. The lifting, racking in and out operation of the breaker and all other motions shall be free from any obstruction.

The panels shall be checked for correct vertical position using Plumb line and spirit levels. The switchboard panels shall be tack welded at suitable intervals to base channel.

After erection of switchboard panels, all uncovered portions of floor cutouts shall be covered with 6 mm thick removable chequered plates finished with floor level. The design of the chequered plates shall be such that the maximum allowable deflection is L/200 (where L is the span of the chequered plates in meters) for a live load of 500 kg./sq. meters.

Additional stiffer shall be provided at the bottom if required. Suitable lifting arrangements shall be provided for chequered plates. The chequered plates shall be painted with a coat of red oxide zinc chromate primer after proper surface preparation as per specifications. Where specified, panels' cutouts provided for future use shall be filled with lean concrete.

3.1.4 After completion of Installation of switchboards, all the cubicles, switchboard components such as switches, starters, CT and PT chambers, bus bar chamber shall be cleaned and checked for tightness of all the components.

Vacuum circuit breakers shall be checked for integrity of bottle seals. All loosely supplied items shall be fitted up. Bus bar sections or links shall be inserted and where specified, of high

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voltage equipment shall be insulated. Interconnection wiring between shipping sections shall be done by contractor.

All the wiring connections shall also be checked. Contact resistance of all bus bar joints and contactors shall be checked. Insulator shall be checked for any damage. All the starters, switches, contacts shall be cleaned with CTC where required.

All the moving parts shall be checked for easy and free movement. Hinges of panel doors shall be lubricated to give free and noise less movement. All openings shall be kept completely closed to avoid ingress of any foreign particles inside the panel.

Functional scheme verification of individual feeder shall be carried out and minor wiring modifications in the panel wiring, if required shall be done as per the directions of Engineer-in-charge. Special attention shall be paid to CT circuits' polarity, wiring continuity and correctness in the protection as well as measurement circuits. Auto transfer scheme shall be simulated and verified. During the course of scheme verification tests, defective components if any shall be taken out, after bringing to the notice of Engineer-in-charge. The same shall be replaced by component supplied by owner.

3.1.5 Where switchboard is damp or having a low IR value due to damaged insulators/ bushings/any other insulated parts, or any other reason, the entire switchboard shall be dried-up according to the instruction of the Engineer-in-charge for the IR value to improve to a safe level for commissioning. Care shall be taken to protect the surrounding insulation from direct local heating during the drying up process.

3.1.6 All the metering instruments, protective relays and other relays and contactors shall be tested as per manufacturer's recommendations and according to the instructions of the Engineer-in-charge. Protection relays shall be inserted and connected and settings adjusted as required by the Engineer- in- charge

3.1.7 All moving parts, of closing/tripping mechanism, racking in and racking out mechanism, spouts and shutter closing mechanism shall be checked for proper operation. All the auxiliary contacts of breaker shall be checked-up, cleaned and contact pressure measured.

3.1.8 All the control wiring, PTs, bushings, bus bars, other live parts of switchgear, incoming and outgoing cables shall be meggered.

3.1.9 Electrical simulation tests shall be carried out for all the protective, alarm and annunciation relays and external interfaces to ascertain proper functioning.

3.1.10 Safety insulation mats of approved make and of required voltage grade shall be provided in the sub-station.

3.1.11 **Pre-Commissioning Check List**

Before commissioning any switchboard, following points shall be checked and ensured for safe energising of the switchboard:

i. That the installation of equipment to be commissioned is complete in all respects with its auxiliaries and all other mounting including earthing. Openings in floor within and outside panels have been sealed off. All cover and door gaskets are intact to make the enclosure vermin proof.

ii. That all the metering instruments have been checked and found in working order. Indicating lamps are healthy and are in correct position. All power and control fuses are of proper rating.

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iii. That the polarity test and ratio test of all the PTs and CTs is complete and phase sequence of CTs conforms to the correct vector group connections. Wiring continuity and correctness are ensured in the protection and measurement circuits. Polarity of D.C. supply for all the circuits is correct.

iv. That the high voltage tests of incoming and outgoing cables have been conducted and results are satisfactory.

v. That all the protective relays including both conventional and microprocessor based numerical relays and thermal overload relays/electronic motor protection relays have been tested for secondary injection tests. (Primary injection tests shall be carried out for differential protection, Restricted Earth fault protection at full / reduced current to ensure correctness of complete wiring). Relay settings, status indications, fault annunciations, data logging and display of switchboard SLDs shall be verified from HMI in case the same is provided.

vi. That IR Value has been recorded for bus bars, circuit breaker, incoming and outgoing cables, control wiring and potential transformers. Where required joint resistance of bus bars have been recorded and found to be satisfactory. All the surroundings and panels have been cleaned and temporary earth leads have been removed.

vii. Following tests shall be ensured for all CTs

- Insulation resistance test
- Ratio test through primary injection
- Polarity test
- Knee point voltage for class PS CTs

viii. Following tests shall be ensured for all PTs

- Insulation resistance test
- Ratio test through primary injection
- Polarity test

ix. Following tests shall be ensured for all breakers

- Insulation resistance test
- Breaker closing, opening sequence using 3 pole timers
- High voltage test both in open and close condition for HV breaker
- Contact resistance of all three poles using 100A DC Kit

x. Following tests shall be ensured for all meters

- Calibration of meters
- Functional verification and settings

xi. Following tests shall be ensured for all relays

- Secondary injection test
- Relay settings
- Timing check with timers
- Any other test recommend by the supplier

xii. Following tests shall be ensured for all bus bars

- Tightness of all nuts/bolts using Torque wrench
- IR value
- Contact resistance using 100A DC Kit
- Cleaning of bus bar chamber using vacuum cleaner
- Conducting jelly shall be applied on AL/CU joints as per manufacturer's recommendations
- HV test in case of HV switchboard

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xiii Following tests/Checks shall also be performed on the switchboards

- Functional verification of individual feeders including all spare feeders
- Simulation test for under voltage tripping of related feeders such as motor feeder, capacitor feeders etc
- Verification of control supply schemes
- Stability test for all differential protections
- Simulation test for bus auto/manual change over scheme, fast bus transfer scheme
- Checks for all panel illuminations, indicating lamps, sockets
- All upstream and down stream interlocks

3.1.12 Bus Ducts

The bus ducts as per issued drawings will be supplied in parts and all the parts shall be assembled and the bus bar connections shall be made at site. The insulators in bus ducts shall be inspected for any possible damage during transit and the defective ones shall be replaced. The insulators shall be cleaned. Contact surface of bus bars, bus bar bolts and nuts shall be thoroughly cleaned. Petroleum jelly shall then be applied and bolted connection made. The bus duct enclosure shall be checked for earth continuity and then earthed at two places. The bus duct shall be properly supported between switchgear and transformer. The opening in the wall where the bus duct enters the switchgear room shall be completely sealed to avoid rain water entry. Expansion joints, flexible connections etc. supplied by the manufacturer of the bus duct shall be properly connected. The bus duct levelling shall be checked with spirit level and pendulum weight.

The sandwiched busducts shall be stacked vertically for installation such that each phase and neutral busbar of each sandwich busduct are vertically aligned in a line. This arrangement would allow for shorting of busbars across sandwich busducts before connecting to switchboard.

Pre-commissioning check list

Before commissioning any bus duct, following points shall be checked and ensured for safe energising of the bus ducts

- All joints are tightened using torque trench
- Cleaning of bus duct chamber with vacuums cleaner
- Silica gel breather shall be connected if supplied. If required, silica gel shall be reactivated as per the instruction of engineer in charge.
- Space heater circuit shall be checked and tripping through thermostat shall be ensured
- Contact resistance shall be measured for all phases/neutral using 100A DC kit
- High voltage test in case of HV bus ducts

3.2 Transformers

Transformers on receipt at site shall be unloaded by means of crane or lifting devices of adequate capacity. All lifting lugs shall be used to avoid unbalanced lifting and undue stresses on lugs. Lifting lugs if any provided for partial lifting (e.g. for active part, conservator) etc. shall not be used for lifting complete transformer. Parts other than those identified for lifting of the transformer shall not be used for lifting. While slinging, care shall be taken to avoid slings touching other parts.

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3.2.1 Before lifting transformer, it shall be ensured that all cover bolts are tightened fully. In case when it is necessary to use jacks for lifting, projections provided for the purposes of jacking shall be used. Lifting jacks shall not be used under the valves or radiator tubes. For transporting transformers from stores to site, the transformers shall be loaded on a suitable capacity truck or trailer. The transformers shall be properly supported by steel ropes and stoppers on the trailer to avoid tilting of the transformers in transit due to jerks and vibrations. At no instance, the transformer shall be kept on bare ground. Where it is not possible to unload the transformer directly on a foundation, it shall be unloaded on a properly built wooden sleeper platform. A transformer shall never be left without putting stoppers to the wheels.

3.2.2 Transformers shall be examined, for any sign of damage in transit. Particular attention shall be given to the following in this regard.

i. Dents on tank wall or cooling tubes, radiators
ii. Damage to protruding parts like valves, sight glass etc.
iii. Loosening of bolts due to vibration in transit.
iv. Cracked or broken bushings.
v. Oil leakage particularly along welds.

If anything adverse is noted, the same shall be brought to the notice of Engineer- in- charge.

3.2.3 Contractor shall examine the transformer base, oil pit, fire walls and foundations made by the civil contractor. It shall be ensured that oil spills can not propagate along cable trenches. Any discrepancy noted will be brought to the notice of Engineer- in- charge. Transformers shall be placed on channels or rails over concrete foundations. The transformers shall be levelled, aligned and checked for free movement on the channels or rails. Stoppers shall be provided to the transformers immediately to prevent any movement. Normally transformers upto 1000 kVA rating shall be received duly fitted with radiator tubes, conservator tanks, valves, wheels and other accessories. While the transformers of above 1000 kVA rating may be supplied with loose accessories. All the accessories like radiators, cooling fans, valves, conservator tanks, explosion vent pipe, bushings and other devices which are supplied in different packages shall be checked for any transit damage and cleaned thoroughly before fixing on the transformer. All loosely supplied parts shall be assembled as per manufacturer's instruction manuals/ drawings and documents. All the connections for CTs bushings and other wiring shall be checked for tightness and correctness before replacing the lid or tightening all the bolts. Gravels shall be filled in the transformer bay, soak pit as per requirement.

3.2.4 **Topping of transformer with oil**

Before topping up with oil, transformer shall be fitted with all accessories such as valves, gauges, thermometers etc. Oil samples shall be taken from each drum and tested for determination of dielectric strength. Any sign of leakage of the barrel or of its having been opened shall be recorded and reported. It is necessary to filter the oil before the transformers are filled. It shall be ensured in oil filling operation that no air pockets are left in the tank and that no dust or moisture enters the oil. All air vents shall be opened. Oil shall be filled through a streamline oil filter using metal hose. To prevent aeration of the oil, the transformer tank shall be filled through the bottom drain valve. In a transformer with conservator tank, the rate of oil flow shall be reduced when the level is almost upto the bottom of the main cover to prevent internal pressure from rupturing the pressure relief-pipe diaphragm. Sufficient time shall be allowed for the oil to permeate the transformers and also for the locked -up air bubbles to escape. Any air accumulation in the buchholz relay shall be released.

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3.2.5 **Transformer Oil**

i. Sample of oil from transformer shall be taken from both top and bottom of the tank. In case of oil filled cable box with a separate conservator, separate oil samples shall be taken from cable box.

ii. **Testing of Oil**
For dielectric test, the oil shall be tested as described in IS: 335. The oil shall also be tested for acidity in accordance with the methods prescribed.

iii. Dissolved Gas analysis (DGA) of transformer oil sample may be carried out at site as per IS-9434.

3.2.6 Drying out of the transformers, if required, shall be carried out and record maintained in accordance with IS: 10028. Normally a streamline filter shall be used for drying-up. IR value versus time of both windings along with OTI/WTI and filtrations machine temperature curve for IR value Vs time shall also be plotted and recorded during the drying-up process.

Precautions when drying

i. The maximum sustained temperature to which transformer oil may be subjected shall be limited to 80^0 C.

ii. The transformer shall be carefully monitored throughout the drying out process and all observations shall be carefully recorded.

iii. Drying out shall be continued so that the insulation resistance as prescribed in the standard code of practice is attained and the value remains constant for more than 12 hours. However, a minimum number of cycles shall be done for each transformer as found necessary by the Engineer-in-charge. Generally a Megger reading of 2 megohms / kV at 60^0 C temperature with a 5 kV Megger may be a rough indication for stopping the dehydration.

3.2.7 The following work on transformers shall be performed by the contractor if specifically called for:

i. Before finally commissioning the transformer it may sometimes be desired to run it for a few hours on short-circuit, applying a low voltage, approximately equal to the impedance voltage of the transformer. During this process, regular readings of the insulation resistance of the winding to earth and winding to winding and temperature against time shall be recorded.

ii. Testing of radiator tubes for any leakage and rectifying these by welding / brazing.

3.2.8 **Pre-commissioning Check List**

Before commissioning of any transformer, the following points shall be checked for safe energisation of the transformer:

i. All the accessories have been fixed properly and transformer body and neutral are properly earthed. The transformer dehydration is over and results are satisfactory and approved by the Engineer-in-charge. In case transformers are idle for more than one month after dehydration, transformer oil has been given at least two circulations.

ii. Oil level, in the transformer conservator tank and all the bushings is upto the marked point and the oil has been tested for dielectric strength and acidity.

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iii. Silicagel is in reactivated condition. The breather pipe is clear from any blocking and contains oil upto the proper level.

iv. The explosion vent diaphragm does not have any dents. Accumulation of any oil and air had been released.

v. Operation of off-load and on-load tap changers on all the tap positions is satisfactory. The mechanical parts of the on-load tap changer are lubricated. Motor IR value has been taken and found satisfactory. Tap position mechanical indicator on the transformer and tap position indication meter on the control panel are reading the same tap positions. Tap changer limit switches are operating satisfactorily on the maximum and minimum tap positions. On-load tap changer contact pressure and resistance is as per manufacturers recommendations. Oil level of tap changer tank is upto the required level and oil has been tested for dielectric strength. The tap setting on which the off load tap switch is locked shall be recorded. Generally the off-load tap switch shall be kept on nominal tap.

vi. Buchholz relay (of main tank as well as that of oil filled cable box, as applicable) has been tested and checked up for any friction in the movement, and floats are free. All the other protective relays, alarm and annunciation relays have been tested.

vii. Metering equipment has been tested and polarity test of PT's and transformer winding is satisfactory. Phase sequence and connections have been checked for proper vector group.

viii. Ratio test and winding resistance on all the tap positions is satisfactory.

ix. Gaps of arcing horns for the bushings where provided are in order and earth connections for the surge diverters have been checked.

x. Winding and oil temperature thermometer pockets contain oil and the winding and oil temperature settings on dial gauges are in order.

xi. Transformers fitted with fans for forced air cooling have been checked up for starting and stopping of the fans both in manual and auto mode and air-displacement has been verified.

xii. Simulation tests for all external interface connection alarm, annunciation and trip circuits have been checked and are in order.

xiii. Insulation resistance of all the control circuits and IR value of the transformer windings and all the incoming and outgoing cables have been checked.

xiv. Valves in the cooling system and valve between the buchholz relay and the conservator tank are in open position.

xv. Setting of all the protective relays is at the desired value and DC Trip supply is healthy.

xvi. Magnetic, current and magnetic balance test have been conducted

xvii Simulation test for WTI,OTI,PRV (of main tank as well as that of oil filled cable box, as applicable), OSR

xviii Settings of WTI/OTI as per the instruction of the manufacturer

xix Earth resistance value for the neutral earthing

xx Before charging, it is ensured that water sprinker system, if provided, is installed and is operational.

xxi In case the fire protection system of transformer is by Nitrogen injection system, testing of this system is ensured.

xxii In case of power transformer rated 50MVA and above, SFRA (sweep frequency response analysis) has been conducted at site.

xxiii tan delta test of transformer has been conducted for 50 MVA and above transformer.

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3.2.9 **Observations after Commissioning**

After switching on the transformer the following points shall be observed and recorded.

i. The inrush magnetizing current and no-load current.
ii. Alarm, if any, or if any relay flag has operated.
iii. Voltage and current on all the three phases.
iv. Transformer hum or abnormal noise.
v. Circulation of oil and leakages.
vi. Record current, voltage, cooling air temperature, winding temperature and oil temperature readings, hourly for 24 hours.
vii. Cable end boxes for any over-heating.

3.3. HV and MV MOTORS

3.3.1 All the motors generally would be erected by the mechanical contractor.

3.3.2 Electrical contractor shall keep the motor space heater energised as per the directions of Engineer-in-charge. Electrical contractor shall measure the insulation resistance of motor windings and PI in case of HV motors. Insulation resistance of the motors shall be measured between the winding of the machine and its frame by means of a 500 / 1000 V Meggar in case of 415 V motors. A minimum value of 1 megohm for 415 V motors shall be considered a safe value. In case of lower I.R. Value, the insulation value shall be improved by any of the following methods as directed by the Engineer-in-charge.

i. Blowing hot air from external source.
ii. Putting the motor in oven.
iii. Placing heaters or lamps around and inside after making suitable guarding and covering arrangements so as to conserve the heat.

In case the insulation is low, the following method of drying has to be adopted, after consultation with Engineer-in-charge. During drying the temperature rise of winding shall not exceed the permissible value for the class of insulation used.

i. By locking the motor so that it can not rotate and then applying such a low voltage to the stator terminals so as to pass full load current in the stator keeping the stator winding temperature below 90^0 C . In this case a close watch shall be kept for any possible overheating and I.R. Values vs. temperature shall be plotted and heating continued till I.R. value becomes steady.

ii. By blasting hot air from external source, Maximum temperature of winding while drying shall be 70^0 C to 80^0 C (thermometer) or 90^0 C to 95^0 C by resistance method. Heating shall be done slowly first till steady temperature of winding is reached after 4 to 5 hours, and for large machines after 10 hours. A record has to be kept for drying process, with half an hour readings and, till steady temperature is reached. In case it is essential, the drying process can be supplemented by blower.

3.3.3 It shall be ensured that the motor leads are correctly connected in the terminal box, as indicated in the 'Name Plate'. The covers of all terminal boxes shall be properly fixed, the gaskets intact. The control circuit shall be tested for proper functioning as per circuit diagram.

3.3.4 In case of synchronous machines, slip rings and brush gear shall be polished and brushes shall be fixed in their holders with clearance and pressure as recommended by the manufacturers.

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3.3.5 Before commissioning, the ventilation and cooling system of the motor must be inspected. In case of motor with forced ventilation the air inlet shall be examined to ensure that it is free from moisture and any foreign material. It shall also be ensured that recommended flow and pressure of air is available to produce the required cooling effect.

3.3.6 The motor control gear shall also be carefully examined, the over-load settings may be reduced or time lags bypassed from protective gear to ensure rapid tripping of switchgear in event of faults. The direction of rotation of a new motor especially of large capacity, and phase sequence of supply shall be kept in view while joining and connecting to the motor terminals

3.3.7 Finally the motor shall be started on no-load after decoupling, and shall be allowed to run for a minimum period of 4 hours, or for a time as instructed by Engineer-in-charge. Attention shall be given to the proper running of the bearings, vibration or unusual noises if any. Voltage, starting current, no load current, stator winding and bearing temperature shall be recorded after every 1 hour during this test. Direction of rotation shall be checked and recorded. Normally the motors run in clockwise direction as viewed from the driving end with reference to the phase sequence R, Y, B.

3.3.8 After switching off the motor, the insulation resistance of the motor shall be recorded under hot and cold conditions.

3.3.9 If the no load test run is found satisfactory, the motor shall be allowed to run for 8 hours and all readings shall be recorded.

3.3.10 The following work on motors, may be performed by the contractor if specifically called for.

i. The proper level of bearing oil has to be checked. The condition of grease in bearings shall be checked and in case it is necessary, complete replacement of bearing with specified grade of grease after proper cleaning of the bearing shall have to be done. Wherever external greasing facility exists, the condition of grease may be checked by pumping some new grease of specified grade at start. If the grease coming out is deteriorated grease shall be replaced.

ii. All the motors, motor exciter set and induction generators directly coupled or coupled through reduction gears shall be checked for abnormal vibration, if any Large rated HV motors with journal type bearings are liable to get damaged from shock, rough handling during transit. Any minor defect in a race or roller may give rise to considerable amount of vibration and noise. Contractor shall check and bring to the attention of Engineer-in-charge any defect noticed in this regard.

iii. Due care shall be taken to avoid any damage to bearing insulation wherever provided.

3.4. Batteries/Battery charger

Battery (Lead acid, Nickel Cadmium or VRLA type as specified) shall be erected on stands and insulators supplied by the manufacturer of the batteries. The installation shall be done as per the layout drawings and manufacturer's instructions. Electrolyte if required / as applicable shall be filled as per manufacturer's instructions. Interrow connections shall be made with the leads supplied by the manufacturer. Functional check shall be done on the battery charger including battery charging and discharging, recharging as per the recommendation of the manufacturer.

3.5. Neutral Earthing Resistor

The neutral earthing resistor shall be inspected for any damage to the resistor grid and other components. The resistor shall be levelled and installed. All covers etc. shall be checked for

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tightness to ensure that the enclosure of the resistor is dust, vermin and weatherproof. Earthing conductors shall be taken from the out end terminal of the resistor, for connection to earth electrodes and to the main grid. Check such as IR, operation of space heater, earth resistance shall be done before the commissioning.

3.6 Welding Receptacles

The welding receptacles shall be erected on steel/concrete structures as per the drawings. In isolated places a separate support shall be fabricated and installed.

3.7 Push Button/Control Stations

The push buttons / control stations shall be installed near to the motors to be controlled. Individual channel supports shall be installed as per EIL standard. If control stations for hazardous areas are to be supplied by contractor, these shall be of Ex (d) type, tested by CIMFR and approved by PESO or other applicable certifying authorities. All outdoor push buttons / control stations shall preferably have integral canopies for additional weather protection. The canopy shall be made of 2 mm thick galvanized sheet steel or FRP where these are not integral with the equipment.

3.8 Gang operated Isolators/outdoor Disconnectors

The isolators shall be transported to site in the dismantled condition. All the insulators may be also supplied loose. The contractor shall inspect, clean, assemble and install the isolator on the base structure previously fabricated, erected and levelled by him. The operating mechanism shall be installed on the structure and connected to the isolator poles. The operating mechanism shall be tested by slowly bringing the isolator to the closed position and carrying out the necessary adjustment as per the manufacturer's instructions. The earthing switches, frames and operating handle etc. shall be earthed.

3.9 Contractor shall provide the following items in substation, as per CEA Regulations.

3.9.1 Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires and fire extinguisher (carbon dioxide, dry chemical extinguisher etc.) suitable for dealing with electric fires shall be conspicuously marked and kept.

3.9.2 First aid boxes containing ointments and medicines for immediate treatment of injuries (As prescribed by Indian Red Cross Society or equivalent).

3.9.3 Instructions of restoration of persons suffering from electric shock in English, Hindi and local language of the district shall be affixed in a conspicuous place.

3.9.4 Danger boards (HV, MV) shall be provided on transformer bay gate, switchboards, entrance to switchgear room and at other places as required by Engineer-in-charge.

3.10 The Communication system and Fire alarm system panels and equipment shall be installed complying to manufacturer's instructions. The location of field station (call back station unit, break glass unit, telephone set etc.) shown on the drawing are indicative. The exact location shall be decided at site by contractor in consultation with Engineer-in-charge. Correct type of equipment with regard to hazardous protection as specified on drawing shall be adhered to by contractor, for installation.

4.0 EQUIPMENT COMMISSIONING

4.1 Field inspection, testing and commissioning of the complete electrical installation shall be carried out as per EIL specification no. 6-51-0087.

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After the equipment is installed properly in accordance with drawings and specifications, contractor shall carry out all pre-commissioning checks and tests as per EIL format in the presence of Engineer-in-charge and test readings shall be recorded and furnished to EIL in triplicate.

4.2 All equipment layout drawings shall be marked by the Contractor for "AS BUILT STATUS" and two sets of hard copies shall be submitted to EIL.

5.0 LIST OF CONSTRUCTION EQUIPMENT

The contractor shall have all necessary construction equipment, tools and tackles and testing instruments to carry out the erection works and to commission the system as specified. These shall include but not be limited to the following, and these shall be brought to site by contractor before the start of work.

5.1 Equipment

i. Portable grinder.
ii. Portable welding machine.
iii Portable gas cutting / welding set.
iv. Pipe threading machine.
v. Pipe bending machine (hydraulic).
vi. Portable drill machine suitable to take up drilling for different sizes as per requirement.
vii Dewatering pump sets (diesel driven).
viii. Power Hacksaw.
ix. Conduit dye set.
x. Hydraulic crimping machine with round/hexagonal dye set.
xi. Hand crimping tool.
xii. Portable electric blowers, vacuum cleaners.
xiii. Miscellaneous items such as slings, pulleys, tarpaulins, wooden sleepers, ladders. etc. as required.
xiv. Safety belts, safety goggles, and gloves.
xv. Separate tool kit for each Electrician.
xvi. Hydraulic/Hand held grease gun

5.2 Test Instruments

i. Insulation tester 1000 V hand driven.
ii. Insulation tester 2500 V motor/hand driven.
iii. Insulation tester 5000 V motor/hand driven
iv. Phase sequence indicator.
v. Earth Resistance tester.
vi. Single phase variac
vii. 3 phase variac of adequate capacity.
viii. Secondary and primary injection testing kit.
ix. Multimeter, both analogue and digital
x. Portable Ammeters, Wattmeters, P.F. meters.

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xi. Portable Voltmeters.
xii. Clip on meters of different ranges.
xiii. Tacho-meter.
xiv. Kelvins double bridge for measurement of very low resistance.
xv. D.C. high -pot test kit.
xvi. A.C. high -pot test kit.
xvii. Oil filtration machine of adequate capacity.
xviii. Lux Meter to measure illumination levels.
xix. Breaker timing 3 pole kit
xx. Timers
xxi. 100A DC milli volt drop (Contact resistance) kit
xxii. Vibration measuring Instrument
xxiii. Thermo meters

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केबल डालने के लिए विनिर्देश

SPECIFICATION
FOR
CABLE INSTALLATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	24.01.24	REVISED AND ISSUED AS STANDARD SPECIFICATION	DKC	RS	MKS	MN
5	26.02.18	REVISED AND ISSUED AS STANDARD SPECIFICATION	DC/RM	RS	BRB	RN
4	21.11.13	REVISED AND ISSUED AS SPECIFICATION	FA	SA	UAP/JMS	SC
3	25.04.08	REVISED AND ISSUED AS SPECIFICATION	RKS	SSM	JMS	VC
2	28.02.03	REVISED and ISSUED AS SPECIFICATION	HKM	RSG	VPS	SKG
1	04.08.97	REVISED and ISSUED AS STANDARD SPECIFICATION	RR	VPS	SG	AS

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Abbreviations:

BIS	:	Bureau of Indian Standards
BS	:	British Standards
CCOE	:	Chief Controller of Explosives
CD	:	Compact Disc
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mining and Fuel Research
DC	:	Direct Current
DGFASLI	:	Directorate General Factory Advice Service & Labour Institutes
DGMS	:	Directorate General of Mines and Safety
EHV	:	Extra high voltage
ET	:	Electrical Thread
FGL	:	Finished Ground Level
FLP	:	Flame Proof
FRP	:	Fibre Reinforced Plastic
GI	:	Galvanized Iron
HV	:	High Voltage
IS	:	Indian Standards
ISMC	:	Indian Standard Medium Channel
MS	:	Mild Steel
OISD	:	Oil Industry Safety Directorate
PVC	:	Poly Vinyl Chloride
RCC	:	Reinforced Concrete Cement
SWG	:	Standard Wire Gauge
FO	:	Fibre Optic

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1.0 SCOPE

This specification defines the requirements for supply of materials, wherever applicable, installation, testing and commissioning of cable installation.

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, EIL installation standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD standards listed below :

SP:30 (BIS)	Special Publication - National Electrical Code.
IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating.
IS:10810(Part 43)	Method of Test for cables ; Part 43 Insulation resistance.
IS:10810(Part45)	Method of Test for cables ; Part 45 High voltage test.
OISD RP- 147	Inspection and safe practice during electrical installation
OISD 173	Fire prevention and protection system for electrical installation

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations

b. Regulations laid down by CEA/Electrical Inspectorate.

c. Regulations laid down by CCOE/DGMS/DGFASLI (as applicable).

d. The petroleum rules (Ministry of Industry, Government of India)(As applicable)

e. Any other regulations laid down by central/state/local authorities and insurance agencies

3.0 MATERIAL SPECIFICATIONS

All materials and hard wares to be supplied by the contractor shall be new, unused and of best quality and shall conform to the latest specifications of Bureau of Indian Standards.

3.1 Cable Trays

These shall be ladder type trays either prefabricated hot dip galvanised sheet steel trays or site fabricated angle iron painted trays or FRP trays as specified in job specification.

3.1.1 Pre-fabricated hot dipped galvanised trays

The cable trays shall comply with the requirements specified in EIL installation standard enclosed with the specification/Tender.

3.1.2 Site fabricated angle iron trays

Angle iron cable trays shall be fabricated from standard rolled angle iron sections of size 75x75x8 for runners for supporting spans limited to 3000 mm. Cross support shall be 25 x 6

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mm MS flat for tray width upto 500 mm and 32 x 6 mm flat for tray of more than 500 mm wide and spacing between two cross supports shall not exceed 250 mm.

3.1.3 Vertical supports for both the prefabricated and site fabricated type trays shall be fabricated out of ISMC 100 and horizontal supports shall be with 65 x 65 x 6 mm angle iron sections.

Outer most tier of all vertical cable trays shall be covered with GI sheet for protection against physical damage to cables. Bottom most cable tray shall also be provided with GI sheet from the bottom side for the protection of the cables from the hydrocarbon pipes located below. GI Covers also shall be provided for the top most cable trays located outdoors.

Cable racks and trays shall be covered by removable top covers on upper most tiers allowing adequate ventilation in following cases where:

- Mechanical damage of cables is likely to occur during maintenance in the plant.
- Oil or spillage of chemicals can be expected.
- Protection from exposure to sun is required.

GI cover sheet shall allow adequate ventilation to the cables and shall be in standard length of 3000 mm, flanged on both sides for fixing on cable tray.

3.1.4 **FRP type cable trays**

The cable trays shall comply with the requirements specified in EIL standard specification and installation standard enclosed with the specification/Tender

3.2 Cable Glands

Cable glands shall be of nickel plated brass unless otherwise specified. The single compression type cable glands shall be used for indoor panels/equipment (e.g. substation, control room etc). The cable glands for outdoor terminations shall be weather protected, double compression type. Cable glands forming a part of relevant FLP enclosure shall be FLP type, tested by CIMFR or any other recognized independent testing laboratory and approved by CCoE/DGMS or any other statutory authority as applicable. Indigenous FLP glands shall have valid BIS license as per the requirements of statutory authorities. All cable glands shall comply with the requirements given in IS/IEC-60079 Part 0.

Entry thread of cable gland shall be compatible to the entry thread provided in the equipment (BS, ET, NPT, PG as applicable). If required, suitable reducers/adopters shall be used.

3.3 Connectors

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

Cable lug material shall be selected based on the applicable as under. For HV cable terminations, heavy duty, long barrel, crimping type lugs shall be supplied. Sector shaped/ circular barrel lugs shall be provided for making connections for cables having sector shaped/ circular geometry of conductors respectively.

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Copper conductor cable & copper bus bar/ terminals	Tinned copper
Copper conductor cable & Aluminium bus bar/ terminals	Bi-metallic (Copper barrel with Aluminium palm)
Aluminium conductor cable & Copper bus bar/terminals	Bi-metallic (Aluminium barrel with tinned Copper palm)
Aluminium conductor cable & Aluminium bus bar/ terminals	Aluminium

3.4 Ferrules

Ferrules shall be of approved type and of size to suit core size mentioned and shall be employed to designate the various cores of control/signal cable by the terminal numbers to which the cores are connected, for ease of identification. Ferrule shall be printed type.

4.0 CABLE LAYING

4.1 General

Cable installation shall include power, control, lighting, fire alarm, telephone and communication cables. These shall be laid in trenches/ cable trays /Duct as detailed in the cable layout drawings. Cable routing given on the cable layout drawings shall be checked in the field so as to avoid interference with structures, heat sources, drains, piping, air-conditioning duct etc. Any change in routing shall be done to suit the field conditions wherever deemed necessary, after obtaining approval of Engineer-in-charge.

4.1.1 EHV, High voltage, medium voltage power and control cables shall be separated from each other by adequate spacing or by running through independent pipes, trenches or cables trays, as shown on layout drawings/installation standards. Details of cable routes and cable spacing not shown in detail on these drawing shall be determined by the contractor and approved by the engineer- In-charge.

The individual cable fixing clamps and spacers for laying of single core cables shall be of non-magnetic material. As a general practice, the metallic sheath, screen and armour of single core cables shall be earthed at one point to keep the same at earth potential unless otherwise stated. The continuity of armour and semiconductor screen shall be broken at each joint. Single core cables, when laid in trefoil formation shall be braced by suitable clamps at a distance, not exceeding 3 meters along the cable routing.

If straight through joints are required to be provided on single core cables, armour shall be broken at joints as per manufacturer's recommendations. For single core cables, armour shall be earthed at one end for the cable run length as per manufacturer's recommendation. The armour & screen of EHV cables shall be earthed at one end/both end and surge voltage limiters shall be installed at the straight through joints as specified in job specification/data sheet.

The Telephone, Communication and Fire alarm cables shall run on instrument trays/ducts/ trenches in the units. Wherever these are not available, cables shall be taken in a separate trench/tray with a minimum spacing of 300 mm from power and control cables

Telephone, fire alarm and plant communication cables shall be directly buried in road berm area, (unless otherwise specified in cable layout drawings). These cables shall cross power cables preferably at right angles. Street lighting cables shall be laid on the other side of road berm area.

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Above ground FO cable shall be laid in HDPE ducts and shall run in cable trays of control cables, underground FO cables shall be laid in HDPE duct above layer of control cables & shall be protected with sand & bricks.

Fire barriers shall be deployed at locations where cable enter/exit the substation above ground or/and cable enter/exit between cable cellar to switchgear room through cutouts. Fire barriers shall be as per job specification.

At every 30 meter distances cable tray shall be painted with tray numbers as per cable layout drawings for identification purpose.

The earth continuity of cable trays shall be maintained by providing bonding jumpers as per earthing schedule while changing the level of cable trays.

4.1.2 The lengths indicated in the cables schedule are only approximate. The contractor shall ascertain the exact length of cable for a particular feeder by measuring at site. All cable routes shall be carefully measured .Before the start of cable laying, the contractor shall prepare cable drum schedule and get that approved by Engineer-in-charge to minimize/avoid straight through joints and then the cables cut to the required lengths, leaving sufficient lengths for the terminations of the cable at both ends. The various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. Extra loop length shall be given for feeder cables where required as per the directions of Engineer-in-charge to meet contingencies

Cables shall be laid in directly buried trench or in RCC trench (underground trench) or in cable tray along pipe sleepers or in over head trays as shown on cable layout drawings. RCC covers of trenches shall be effectively sealed to avoid ingress of chemicals and oils.

Overhead trays shall be installed 2700 mm (minimum) above grade level and 300mm above FGL in case cable trays are installed along with pipe sleepers. At road crossings overhead trays shall be installed at 7000 mm (minimum) above grade level or cables shall be routed through cable tray culvert/ Electrical road crossings as per layout drawings.

Sufficient care shall be taken while laying cables to avoid formation of twist, sharp bend etc. in order to avoid mechanical injuries to cables. Rollers shall be used for pulling of cables.

Cable installation shall provide minimum cable bending radii as recommended by cable manufacturer.

4.1.3 Cables shall be neatly arranged in the trenches / trays in such a manner that criss-crossing is avoided and final take off to the motor / switchgear is facilitated. Arrangement of cables within the trenches / trays shall be in line with cable layout drawings. Cable routing between cable trench and equipment/motors shall be taken through GI pipe sleeves of adequate size or branch cable trench as indicated in cable layout drawing. Pipe sleeves shall be laid at an angle of maximum 45 to the trench wall. Bending radii of pipes shall not be less than 12D. It is to be ensured that both the ends of GI pipe sleeves shall be sealed with approved weather proof sealing plastic compound after cabling. In places where it is not possible, cables shall be laid in smaller branch trenches. Different rows of cable trays in cable cellar below the cutout shall be so fixed such that the trays don't obstruct cable entry to the panels.

4.1.4 All cables shall be identified close to their termination point by cable tag numbers as per cable schedule. Cable tag numbers shall be punched on stainless steel straps (2mm thick, 20 mm wide and of enough length) securely fastened to the cable and wrapped around it.

Each underground cable shall be provided with cable tags of stainless steel straps securely fastened every 30 m of its underground length with at least one tag at each end before the cable

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enters/leaves the ground. In unpaved areas, cable trenches shall be identified by means of cable markers as per installation drawing. These cable markers shall be placed at location of changes in the direction of cables and at intervals of not more than 30 m and also at cable straight through joint locations. Cable route markers shall extend 600mm above ground.

4.1.5 All temporary ends of cables must be protected against dirt and moisture to prevent damage to the insulation. For this purpose, ends of cables shall be covered with an approved PVC end cap or rubber insulating tape.

4.1.6 Each row of cables shall be laid in place and before covering with sand. All wall openings/pipe sleeves shall be effectively sealed after installation of cables to avoid seepage of water inside building/lined trench. Every cable shall be given an insulation test in presence of Engineer-in-charge/Owner before filling the cable trench with sand Any cable which is found defective shall be replaced.

4.1.7 Where cables pass through foundation walls, the necessary openings shall be provided in advance for the same by another agency. However, should it become necessary to cut holes in

existing structures for example floor slab etc., the electrical contractor shall determine their location and obtain approval of the Engineer-in-charge before carrying out the same.

4.1.8 Cables for road crossings shall be taken through ERC (Electrical Road Crossing)/cable duct as shown in the cable layout drawings and sleeves/ducts shall be effectively sealed thereafter.

At road crossing and other places where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not slack and get damaged by pipe ends.

4.1.9 Wherever cable trench crosses storm water, waste water channel/drain, cables shall be taken through PVC/RCC pipes. Where cables are required to cross drains of depth more than 1200 mm, cables shall be taken over the drain on cable trays supported suitably using ISMC 150/200 sections.

4.1.10 Ends of cables leaving trench shall be coiled and capped and provided with protective cover till such time the final termination to the equipment is completed.

4.2 Cables Laid Direct in Ground

Cables shall be laid underground in excavated cable trenches where specified in cable layout drawings. Trenches shall be of sufficient depth and width for accommodation of all cables. Cables shall be properly spaced as per installation standards. Maximum number of cable layers in trench shall be preferably limited to 6 layers.

Minimum depth of directly buried cable trench shall be 750 mm for medium voltage and 900 mm for HV Cables. The depth and the width of the trench shall vary depending upon the number of layers of cables as per EIL installation Standards.

Cables shall be laid in buried trenches at depth as shown in the cable layout drawings. It is to be ensured by the contractor that the bottom of buried trenches shall be cleared of all rocks, stones and sharp objects before cables are placed. The trench bottom shall be filled with a layer of sand or stone dust. This sand /stone dust shall be leveled and cables laid over it. These cables shall be covered with 150 mm of sand on top of the largest diameter cable and sand shall be lightly compacted. A flat protective covering of 75 mm thick second class red bricks or concrete tiles as per specification shall then be laid and the remainder of the trench shall then be back - filled with natural soil, rammed and leveled.

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4.3 Cables Laid in Concrete Trench

Cables shall be laid in 5 or 6 tiers in concrete trench as shown on layout drawings. Concrete cables trenches shall be filled with sand /stone dust in hazardous area, switchyard and in transformer bay to avoid accumulation of hazardous gases and oil. RCC covers of trenches shall be effectively sealed to avoid ingress of chemical and oil in process area. Removal of concrete covers where required for the purpose of cable laying and reinstating them in their proper position after cables are laid shall be done by electrical contractor.

Minimum depth of RCC cable trench shall be 500mm for all voltage grades with 300mm clearance between the bottoms of the trench cover and top of the cable. The depth and the width of the trench shall vary depending upon the number of layers of cables and bending radius required for cables as per EIL installation Standards

All wall openings/pipe sleeves shall be effectively sealed after installation of cables to avoid seepage of water.

4.4 Above Ground Cables

4.4.1 Cables installed above grade shall be run in cable trays, clamped on walls, ceiling or structures and shall be run parallel or at right angles to beams, walls or columns. Cable routing shall be planned to be away from heat sources such as hot piping, gas, water, oil drainage piping, air-conditioning duct etc. Each cable tray shall contain only one layer of cables as far as possible for power cables. However control cables may be laid in multiple layers in the cable trays. For power & control cables at least 20% space shall be kept as spare in cable trays after completion of cable laying for future use.

4.4.2 Individual/group of cables which run along steel/concrete structures shall be taken through 60/100/150 mm slotted channel tray or channel ISMC-75/100. Cables shall be supported so as to prevent sagging. In general, distance between supports shall be approximately 300 mm for cables upto 25 mm diameter and maximum 450 mm for cables larger than 25 mm dia. to prevent the sagging of cables.

4.4.3 Cable laid on supporting angle in cable trenches, structures, columns and vertical run of cable trays shall be suitably clamped by means of GI saddles / clamps, whereas cables in horizontal run of cable trays shall be tied by means of nylon cords. Distance between supporting angles shall not exceed 600 mm.

4.4.4 All cable trays (other than galvanized/FRP trays) and supporting steel structures shall be painted before laying of cables. The under surfaces shall be properly degreased, derusted, descaled and cleaned. The painting shall be done with one coat of redoxide zinc chromate primer. Final painting shall be done with two coats of approved bituminous aluminium paint unless otherwise specified.

4.4.5 Where cables rise from trench to motor, lighting panel, control station, junction box etc., they shall be taken in GI pipe for mechanical protection upto a minimum of 300 mm above grade for outdoor area. Cable ends shall be carefully pulled through conduit to prevent damage to cable.

4.4.6 All GI Pipes shall be laid as per layout drawings and site conditions. Before fabrication of various profiles of pipes by hydraulically operated bending machine (which is to be arranged by the contractor) all the burrs from the pipes shall be removed. GI Pipes having bends shall be buried in soil / concrete in such a way that the bend shall be totally concealed. For G.I. pipes buried in soil, bitumen coating shall be applied on the buried lengths. Installation of G.I. pipes

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shall be undertaken well before paving is completed and necessary co ordination with paving agency shall be the responsibility of Electrical Contractor.

Following guide shall be used for sizing of GI. pipe.

a) 1 cable in a pipe - 53% of pipe cross-sectional area occupied by cables.

b) 2 cables in a pipe - 31% of pipe cross-sectional area occupied by cables.

c) 3 and above cables in a pipe - 40% of pipe cross-sectional area occupied by cables.

4.4.7 After the cables are installed and all testing is complete, conduit ends above grade shall be plugged with a suitable weatherproof plastic compound/bitumen/suitable sealing compound. Alternatively rubber bushes shall be employed for the purpose of sealing.

4.4.8 Fire proofing of end of power cables at least 1 meter at each end as per OISD norms for the refinery and Petroleum industry, shall be carried out as per the recommendation of the paint supplier .Rates for the fire proofing of cables shall be included in the cable installation and no separate payment shall be made for the painting.

5.0 TERMINATIONS

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

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

5.2 Power cables cores wherever colour coding is not available shall be identified with red, yellow and blue PVC tapes. Where copper to aluminium connections are made, necessary bimetallic washers shall be used.

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

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

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

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

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

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

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

- The number of joints shall be restricted to minimum as far as possible.
- The location of joints shall be identified with permanent markers.
- No joints shall be allowed in hazardous areas without the approval of Engineer-in-charge.

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

5.9 No unauthorized repairs, modifications shall be carried out on the hazardous area equipment terminal boxes and junction boxes. Damaged enclosures of hazardous area equipment shall be brought to the notice of Engineer-in-charge by contractor. After termination is complete, all the bolts, nuts, hard wares of terminal box shall be properly placed in its position and tightened.

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

6.0 TESTING AND COMMISSIONING

6.1 Field testing and commissioning of electrical installation shall be carried out as per EIL specification.

6.2 Before energising, the insulation resistance of every circuit shall be measured from phase to phase, phase to neutral and from phase/neutral to earth.

6.3 Where splices or terminations are required in circuits rated above 650 volts, insulation resistance of each length of cable shall be measured before splicing and or / terminating. After completion of splices and /or terminations, measurements shall be repeated.

6.4 The insulation resistance of directly buried cables shall be measured before cable trenches are backfilled. Measurements shall be repeated after back filling.

For cables upto 1.1 KV grade 1000 V Megger and for H.V. Cables 2.5 KV / 5 KV Megger shall be used.

6.5 D.C. High Voltage test shall be conducted on cables given below after installation.

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a) All 1100 volts grade power cables in which straight through joints have been made.
b) All cables above 1100 V grade.
c) The DC High Voltage test shall be performed as detailed below in the presence of the Engineer-in-charge or his authorized representative only.

Cables shall be installed in final position with the entire straight through joints complete. During the high voltage test, all other electrical equipment related to the cable installation, such as switches, instrument transformers, bus bars, etc., must be earthed and adequate clearance shall be maintained from the other equipment and framework to prevent flash over.
In each test, the metallic sheath/screen/armour shall be connected to earth.

6.6 All checks and tests shall be made as per EIL standard test Performa available with site engineer.

All test readings shall be recorded and submitted to EIL in triplicate sets.

6.7 Cable schedule, cable layout drawings, Interconnection drawings shall be revised and marked by contractor for 'AS BUILT STATUS' and two sets of copies along with CD shall be submitted to EIL.

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प्रकाश व्यवस्था के उत्थापन के लिए विनिर्देश

SPECIFICATION FOR LIGHTING INSTALLATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	31 12 2019	REVISED AND ISSUED AS SPECIFICATION	DK/RM	RS	SA	RKT
5	10 03 15	REVISED AND ISSUED AS SPECIFICATION	AKG	SA	BRB	SC
4	15 01 14	REVISED AND ISSUED AS SPECIFICATION	FA	SA	UAP	SC
3	25 04 08	REVISED AND ISSUED AS SPECIFICATION	RKS	SSM	JMS	VC
2	28 02.03	REVISED and ISSUED AS SPECIFICATION	HKM	RSG	VPS	SKG
1	01 09 97	REVISED and ISSUED AS STANDARD SPECIFICATION	RR	VPS	SG	AS
0	31 03 82	ISSUED AS STANDARD SPECIFICATION	RR	VPS	--	--

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Abbreviations:

AC	:	Alternating Current
BIS	:	Bureau of Indian Standards
CCoE	:	Chief Controller of Explosives
CD	:	Compact Disc
CEA	:	Central Electricity Authority
CFL	:	Compact Fluorescent Lamps
CIMFR	:	Central Institute of Mining and Fuel Research
DC	:	Direct Current
DG	:	Diesel Generator
DGMS	:	Director General Mines and Safety
ELCB	:	Earth Leakage Circuit Breaker
FFL	:	Finished Floor Level
FRP	:	Fibre Reinforced Plastic
GI	:	Galvanised Iron
HPMV	:	High Pressure Mercury Vapour
HPSV	:	High Pressure Sodium Vapour
HRC	:	High Rupturing Capacity
IP	:	Ingress Protection
IS	:	Indian Standards
JB	:	Junction Box
LED	:	Light Emitting Diode
MCB	:	Miniature Circuit Breaker
MCCB	:	Moulded Case Circuit Breaker
MDB	:	Main Distribution Board
MS	:	Mild Steel
PE	:	Polyethelene
PVC	:	Polyvinyl Chloride
TPN	:	Three Phase and Neutral
SS	:	Stainless Steel

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1.0 SCOPE

This specification defines the requirements for the supply of equipment, materials, installation, testing and commissioning of the lighting system (lighting fixtures, lighting power distribution, telephone wiring etc.).

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, EIL installation standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD standards listed below :

SP:30 (BIS)	Special Publication - National Electrical Code.
IS:5	Colours for ready mixed paints and enamels.
IS:3854	Switch for domestic & similar purpose
IS/IEC 60947	L.V. Switch gear and control gear
IS: 1293	Plugs & socket outlets of rated voltage upto and including 250V & rated current upto 16A.
IS:9537	Conduits for electrical installations
IS 694	Polyvinyl Chloride insulated unsheathed & sheathed cables/cords upto & including 450/750V
OISD RP- 147	Inspection and safe practice during electrical installation
OISD 173	Fire prevention and protection system for electrical installation

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations
b. Regulations laid down by CEA/Electrical Inspectorate.
c. Regulations laid down by CCoE/DGMS (as applicable).
d. The petroleum rules (Ministry of Industry Government of India).
e. Any other regulations laid down by central/state/local authorities and Insurance agencies.

3.0 EQUIPMENT SPECIFICATIONS

All materials, fittings and appliances to be supplied by the contractor shall be new, unused and of the best quality and shall conform to the specifications given hereunder. These shall be manufactured in accordance with the latest revision of the specifications of Bureau of Indian Standards/International standards. In the absence of any specifications for a particular item, contractor shall bring material samples along with proven track record to site and get the same approved by Engineer-in-Charge/Owner before installation.

3.1 Lighting and Power Panels

3.1.1 Lighting and Power panels (general purpose panels for safe area) shall be made of 1.6mm thick sheet steel or polycarbonate material as specified and shall be dust and vermin proof. All metal surfaces shall be cleaned free of rust, given a coat of red-oxide primer and finished with two coats of epoxy based paint of shade 632 of IS 5. Panels shall be indoor/outdoor type as specified. Indoor type panels shall have IP42 degree of protection and shall be suitable for surface or flush mounting on wall surface as specified. Lighting and power panels located outdoor shall be IP55 weather protected and shall also preferably have integral canopy for

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additional weather protection. The canopy shall be made of 2mm thick galvanized sheet steel, FRP, SS (1mm) where these are separate from the equipment.

3.1.2 Lighting and Power panels shall have TPN incoming feeder and single phase outgoing feeders. Lighting circuit feeders shall be rated for 10 amps and power circuit feeders shall have current rating of 16Amps.In power panels for window Air conditioning units, power circuit feeder shall be rated for 20 amps. Panels shall be equipped with phase and neutral bus bars of required current carrying capacity. The outgoing feeders shall be provided with single pole miniature circuit breakers (MCBs) for safe areas and double pole MCBs for hazardous areas. The incomer shall be with MCB and ELCB unit unless otherwise specified. In case of panel for Green Buildings incomer shall also be provided with Energy Meter as per GRIHA requirements. Accordingly, CTs shall be provided in all the three phases for current measurement and voltage shall be tapped directly from phases through control fuses. Miniature circuit breakers shall be mounted in such a way that the operating levers project outside the front Bakelite cover plates for ease of operation. A hinged door to cover the operating knobs shall be provided. In addition, a circuit diagram indicating incomer details and outgoing details viz. Circuit number, circuit rating, and load connected and details of the load shall be pasted inside the panel. Also a laminated copy of the diagram shall be provided inside the panel in a suitably designed pocket. Two external earthing studs for connection to the plant earthing grid shall be provided on the panel. Further, the panel shall be provided with an earth bus bar with terminal studs for connection to the third core of each outgoing circuit. Each circuit phase and neutral shall be given ferrule numbers. Complete wiring inside the panel, shall be neatly bunched with PVC tape and button. Sufficient terminals shall be provided in the terminal block so as to ensure that not more than one wire (core) is connected to a terminal. The panel shall have knock out holes or removable gland plate for the entry of incoming and outgoing conduits or cables. The panels shall be complete with requisite number of cable glands as specified.

3.1.3 The Main distribution board (MDB) where used, shall be made of 2mm thick sheet steel panel, dust and vermin proof similar in construction to Lighting and Power panels but with TPN MCCB or switch fuse incoming and TPN outgoings (MCB with ELCB units and MCB without ELCB unit as applicable) of required numbers as specified.

3.1.4 All MCBs shall be of M9 category as per IS 8828 and sensitivity of ELCBs shall be 100 mA-300 mA unless otherwise specified.

3.1.5 Wherever the size of incoming cable to lighting, power panels/MDB is more than 35 sq.mm a suitable cable adapter box shall be provided and attached to the panel. The incoming cable leads shall be connected to terminal block (bolted type terminals) of required size. This terminal block shall be connected to TPN incomer unit through separate PVC insulated copper conductor wires/bus bars. Sufficient space shall be provided (minimum 300mm) between gland plate and the bottom of terminal block for easy termination.

3.2 Lighting Fixtures

The types, makes and catalogue numbers of various types of lighting fixtures shall be as given in Fixture schedule, job data sheet. HPMV/HPSV/fluoroscent lighting fixtures shall be complete with ballast, starters and capacitor, as required. Control gears for these fixtures shall be integral or non-integral as specified in lighting layout drawings. LED lighting fixtures shall be complete with its driver. All lighting fixtures should have sufficient number of cable entry for loop in & loop out and also should have sufficient terminals & size for connection of cable/wire. All lighting fixtures to be installed in battery room should be flame proof type, suitable to IIC gas group and should have anticorrosive feature. Unless otherwise specified, all fixtures shall be supplied complete with lamps. Ballast for fixture shall be copper wound or electronic type. The fixtures shall be of high power factor type i.e. at least 0.9 or more.

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3.3 Switches

Switches, manufactured in accordance with IS: 3854 shall be used for non hazardous areas. Switches in areas where concealed wiring has been adopted, shall be flush mounting Modular type unless otherwise specified. For surface conduit wiring, Modular type switches in surface mounted box shall be provided. Industrial Type switches (Weather protected) shall be used for outdoor areas. Industrial Type switches (Flame proof/Weather proof) shall be provided for tall structures, columns, vessels, walkways etc as shown in lighting layout drawings.

3.4 Receptacles

Three pin type 5A/15A receptacles manufactured in accordance with IS: 1293 shall be used for non hazardous areas. The receptacles and the controlling ON/OFF switch shall be mounted in the same enclosure box but these shall be in separate units to facilitate replacement by parts. Flush mounting type receptacles shall be used in areas where concealed wiring has been adopted and surface type shall be used in other areas. For exhaust fans and wall mounted air circulators, socket and switch enclosures shall be separate. In buildings such as sub-station, DG. Shed, Workshop, maintenance shop etc. industrial type metal clad socket outlets and plugs shall be provided. These sockets shall be supplied complete with plugs. Modular type receptacles along with required boxes shall be provided for indoor application in case shown in the layout.

3 phase, 5 pin, 40A, 415V sockets shall be provided for tower air conditioners in control rooms. The receptacles and the controlling ON/OFF switch shall be mounted in the same enclosure box but these shall be in separate units to facilitate replacement by parts.

3.5 Outlet Boxes

The outlet boxes used as point outlets shall be prefabricated GI sheet steel of 18 gauge thickness and of adequate depth. Outlet boxes custom fabricated for sockets, switches, fixtures and fan regulators etc. shall be made of MS sheet having minimum thickness of 1.6mm.Outlet boxes shall be galvanized/ nickel plated after fabrication. These shall be complete with terminal block suitable for connection of wires up to 4 sq. mm Front cover plate shall be of 3mm thick Bakelite / PE sheet. The colour shall suit the shade of the walls or shall be white if the shade of the walls is not finalised. The sheet shall extend at least 2 cm on all sides of outlet box. Cover plate shall be fixed by cadmium plated brass screws and cup washers. Outlet boxes shall be provided with adequate number of knock outs on all the sides for ease of wiring either with conduits or without conduits.

3.6 Conduit and Accessories

Conduits for Electrical installations shall conform to IS: 9537. The type of conduit (steel / GI/ PVC) shall be as specified on drawing. Black enameled steel or GI conduit shall be of 1.6mm thick and the minimum wall thickness of PVC conduit shall be 1.6mm. Generally PVC conduits shall be used in concealed wiring and for surface wiring GI conduit (in plant buildings) and black enameled steel conduit (in non plant buildings) shall be used.

3.7 Lighting Poles

Lighting poles shall be fabricated as per EIL installation standards enclosed with the specification from ERW steel tubular pipes of specified section, with joints, swaged together when hot and beveled on outside edges or hexagonal shape. Poles shall be coated with bituminous preservative solution on the ground portion of the outside surface. Remainder of the outside surface shall be given one coat of redoxide primer and finished with two coats of aluminium paint. The pole shall have a marshalling box near the bottom to contain HRC

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fuses, a neutral link, an earth stud and terminal block. FRP/GRP type lighting poles shall be provided in case shown in the layout.

3.8 Lighting Mast

3.8.1 Lighting masts (Lattice tower) where used, shall be fabricated as per EIL Standard Drawing enclosed with the tender/specification. They shall be complete with 2 nos. MS flats provided at the base plate for connection to the plant earthing grid. A ladder, platform, handrail, a weather protected TPN switch (at 1500mm from ground level) and a weather protected distribution board fabricated out of sheet steel shall be provided at the top of mast. The TPN Switch and the distribution board shall also have a canopy for additional weather protection. The TPN switch shall be suitable for looping one more lighting mast from the same incoming power supply. The distribution board shall have TPN bus bars of 30 Amps. rating and 12 Nos. outgoing circuits each with a 6A single pole MCB. The distribution board shall have cable entries from bottom. Necessary space provision and suitable mounting arrangement shall be made on top of the tower for mounting of ballast (choke) and condensers for all the circuits and the lighting fixtures. The masts shall be given one coat of red oxide primer and two coats of aluminium paint. Distribution board shall be fabricated out of 2mm thick sheet steel and shall be painted with two coats of enamel over a base coat of red oxide.

3.8.2 Unless otherwise specified the flood lighting high masts shall be telescopic type conforming to EIL specification and data sheet.

3.9 Wires

Wires shall be PVC insulated and shall be of 660 Volts grade as per IS694. Conductor shall be of stranded copper and size shall be minimum 1.5 Sq. mm for lighting, 2.5 Sq. mm for 15A power socket circuits and 4 sq. mm for split A/C power socket circuits. Red/Yellow/blue wires for phases, black wire for neutral and green wire for earth shall be used (size of earth wire shall be same as for phase and neutral size). Wire size for air conditioning circuit feeders shall be as indicated in the panel schedule.

3.10 Ceiling fan/Exhaust fan

Ceiling fans shall be of 1200mm sweep with BEE (Bureau of energy efficiency) rating of minimum 3 star, unless otherwise specified with double ball bearing and regulator. The suspension down rod shall be sturdy mild steel rod of adequate diameter and of minimum length of 300mm with shackles suspension arrangement as per IS. For exhaust fans, the sweep dia. and air CFM shall be as specified in job specification. Exhaust fans for battery room shall be flame proof type, suitable to IIC gas group and with anticorrosive blades suitable for use in acidic fumes. Exhaust fans shall be with BEE rating of minimum 3 star.

3.11 Decorative switches and sockets

Decorative lighting switches and sockets where specified, shall be modular in design. All these items shall fit into the same frame with overall standard dimensions. Frames shall be suitable for surface and flush mounting in brick / concrete wall. The frames shall be suitable for conduit entry from all the sides. Switches and sockets shall match colors of the frame and cover plates to obtain a combination which shall match décor of the interiors of Control Room, Administrative buildings, offices rooms etc.

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4.0 LIGHTING INSTALLATION

4.1 General

4.1.1 The lighting fixtures in the plant shall be fed from lighting panel. All outdoor lighting shall be group controlled manually or through synchronous timer or photocell. Lighting wiring between panel and lighting fixtures shall be done with PVC insulated 3-core (phase, neutral and earth) copper conductor armoured cable for hazardous areas. Wiring in the building shall be done by means of 3-core copper, conductor PVC insulated, un-armoured cables, or PVC insulated copper conductor wires in conduit/Metsec channel as specified. All joints of conductors in Switch boards/JBs Fittings shall be made only by means of approved mechanical connectors (nylon/PVC connectors). Bare twisted joints shall not be permitted any where in the wiring system.

4.1.2 The lighting layouts furnished by owner will indicate approximate locations of lighting fixtures. The electrical contractor shall determine, with approval of Engineer-in-Charge, the exact locations of each fixture in order to avoid interference with piping or other mechanical equipment and also with a view to obtain as much uniform illumination as practicable, and to avoid objectionable shadows. Conduits shall be laid out by the contractor to suit field conditions and as per directions of the Engineer-in-Charge.

4.1.3 On walkways, platforms and other outdoor area, lighting fixtures shall be located nearer to landing of stairs or ladders, gauges, flow meters, panel boards and other equipment to provide proper illumination.

4.1.4 The minimum height of any lighting fixture shall be preferably not less than 2.5 meters above the floor level.

4.1.5 All outdoor cable terminations to outdoor junction boxes, panels, socket outlets etc. shall be through bottom or from side. Top entries for cables shall be avoided to avoid water entry. All cable glands for outdoor terminations shall be double compression type and the gland shall be covered with PVC or rubber boot shroud. All unused cable entries shall be plugged with suitable blanking plugs.

4.1.6 Mounting height of equipment shall be as under:-

Top of Switch Box	:	1200 mm from FFL (Finished floor level)
Top of Lighting/Power Panel	:	1800mm from FFL
5/15 Amp. receptacle	:	300mm from FFL unless otherwise specified (1200 mm for process areas and industrial sheds)
Lighting fixture	:	As indicated in layout drawing
Exhaust fan	:	In the cutout provided / as indicated in Layout drawings.

4.1.7 Fixtures shall be firmly supported from the structures. Support clamps etc. may be bolted or welded to the existing steel work or metal inserts. In case of concrete structures, where metal inserts are not available, fixtures shall be suspended from concrete surfaces with the help of anchor fasteners. In such cases special care shall be taken to see that anchoring is firm. In places where ceiling fans are provided, lighting fixtures shall be suspended below the level of fan to avoid shadow effect.

4.1.8 The lighting fixtures on various circuits shall be suitably interlaced so that failure of any one circuit does not result in complete darkness.

4.1.9 Circuit cables in a group shall be cleated to structure by using galvanised strip clamps or cable run in cable trays wherever trays are available. Spacers and cleats shall be of required size to

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accommodate the cables. All hardware shall be galvanised or zinc passivated. Underground lighting cables (in paved areas) shall be taken in suitable GI sleeves buried at a minimum depth of 300mm from FFL. GI pipe sleeves shall be extended to 300mm above FFL. Exact termination/layout of GI pipes (for protection of cables) shall be decided at site as per site convenience in consultation with Engineer-in-charge.

4.1.10 Wiring for all outlet sockets shall be done with 3 cores of equal sizes for phase, neutral and earth. The terminals of switch sockets shall be suitable to receive the size of wire specified.

4.1.11 All lighting fixtures shall be provided with terminal block with required terminals suitable for connection of wire up to 2.5 sq. mm copper conductor.

4.1.12 The cable shall be straightened after unwinding it from the drum. All cables are clamped/laid in straight run without any sag and kink.

4.1.13 For location where fan points are shown, fan hooks with junction box shall be provided during concreting.

Where fan hooks and JBs. are provided separately JB shall be located within a distance of 300mm from hook for mounting of ceiling rose.

4.1.14 Industrial type plug sockets with 20A MCB or rating as per job specification shall be provided at a height close to window/split AC units so that plugging of power cable coming from AC units can be easily achieved without adding any extensions to it, however, its switch should be installed at a height of 1200 mm from FFL.

Socket outlets and plugs for installation in Sub-station building, DG shed, workshop, and maintenance shop etc. shall be of industrial metal clad type.

4.1.15 Wiring for exhaust fans shall be terminated in receptacles as specified in layout drawing and the connection from receptacle to the exhaust fan shall be by means of a flexible cord equivalent in size to the main run of wires. Switch for exhaust fan shall be located in a separate switch board along with other switches.

4.1.16 Identification of indoor receptacles shall be done through stickers/paint.

4.1.17 Wherever in process units fire proofing of structural columns has to be done, it would be the responsibility of lighting installation agency to weld adequate size of angles to such structures before its fireproofing which length should be such that it is projected at least 65 mm outside from the finished surface of fireproofing. These welded angles shall be utilized latter to install lighting cable trays, bracket & clamps of lighting fixtures, frame of lighting/power panels, welding/ conveyance receptacles, control gears & other electrical equipments as required. It should be the responsibility of lighting installation agency to coordinate with other agencies which are involved in fireproofing works to complete the all structural/welding works before completion of fire proofing works.

4.2 Conduit System

4.2.1 Surface or concealed conduit system of wiring shall be adopted, as specified in the drawings. Required number of pull boxes shall be used at intervals to facilitate easy drawing of wires. Separate conduit shall be run for lighting and power circuits. Further, conduits for Normal lighting/Emergency lighting/DC critical lighting shall be separate. Conduit layout shall be decided at site as per site conditions. Drop conduits for switch boards shall be decided by contractor as per wall locations shown in Architectural drawings. All exposed run of conduits on surface, shall be vertical or horizontal.

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4.2.2 Only threaded type conduit fittings shall be used for metallic conduit system. Pin grip type or clamp type fittings are not acceptable. Conduit ends shall be free from sharp edges or burrs. The ends of all conduits shall be reamed and neatly bushed.

Conduit shall be of minimum 25mm dia. Maximum number of wires permissible in a conduit shall be seven/nine for wire size of 2.5 sqmm/1.5 sq.mm. respectively.

4.2.3 The exposed outer surface of the conduit pipes, including all accessories forming part of the conduit system, shall be adequately protected against rusting. In all cases, bare threaded portion of conduit pipe shall not be exposed unless such bare threaded portion is treated with anti corrosive preservative or covered with approved plastic compound.

4.2.4 Conduit connection to outlet boxes shall be by means of screwed hubs or check nuts on either side. Where concealed wiring is done, junction boxes shall be used so as to rest on shuttering properly. Conduits shall be laid above reinforcement. All conduit connections shall be properly screwed and Junction box covers shall be properly fitted so as to avoid entry of concrete slurry.

4.2.5 Conduit pipes shall be fixed by 1.6mm thick GI saddles on 3mm thick GI. saddle bars of required width in an approved manner at intervals of not more than 50cms for straight run. At places near junction boxes, bends, or similar fittings, saddle and bars shall be provided on either side.

4.2.6 Where concealed wiring is to be adopted, conduits shall be laid in time before concreting of the slab. Pull wire (GI or steel) shall be provided inside conduit for the ease of wire pulling. The contractor shall coordinate his work with other agencies involved in the civil works in such a way, that the work of the other agencies is not hampered or delayed. Vertical conduit runs shall be made in wall before plastering is done so as to avoid chasing. Where chases are made for conduit run contractor shall fill these chases or any other openings made by them after completing the work and patch the surface. During installation, care shall be taken to see that proper covers are provided to prevent rusting of conduits. Locations of all point outlets, junction boxes shall be marked with brick powder or sand so that these are easily identified after shuttering removal. As built conduit layout drawing shall be submitted by contractor after completion of the work.

4.2.7 All junction boxes, bends and other accessories shall be of the same material as that of conduit and shall have the same protective coatings.

4.2.8 After erection, the entire conduit system shall be tested, for mechanical and electrical continuity and shall be permanently connected to earth by means of approved type of earthing clamps.

4.3 Hazardous Area Installation

4.3.1 Wiring in hazardous area shall be done by using minimum 2.5mm^2 copper conductor armoured cable.3rd core of the cable shall be used as earth conductor for earthing of lighting fixture. Circuit wiring feeding hazardous areas shall be controlled by two pole switches/MCBs (for phase as well as neutral isolation).Switches for lighting panels installed in hazardous area shall have a pole to break the neutral in addition to poles for phases.

4.3.2 Correct type of lighting equipment (fixtures and JBs) with regard to hazardous protection as specified in the drawing shall be installed for the areas classified as Zone 1, Zone 2 etc.

4.3.3 The terminations in the junction boxes and the lighting fittings shall be done avoiding possibility of loose connections due to vibrations. After the terminations are made the cover of the junction boxes and the lighting fittings shall be closed properly with all bolts and hard wares in correct position, retaining its explosion and weather protections. In fixtures having

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double cable entries, both the entries shall be used for looping in and looping out connection, thus minimising the use of a separate junction box. Wherever separate control gear boxes (CG box) are provided looping in and looping out connections shall be through CG box, thus avoiding the use of an additional junction box. All unused cable entries shall be sealed with suitable plugs.

4.3.4 Circuit cables shall be firmly cleated in a group along columns/ beam/ladders/side channels/platform using 1.6mm thick GI saddles on 25x3 mm GI saddle bar at intervals of 400mm to 500mm for straight run and on either side close to bending and at both termination ends as per the directions of Engineer-in-charge. Where required 3 or more of cables shall be taken in perforated150mm wide slotted channel cable tray after getting the approval of Engineer-in-charge. Minimum straight run shall be 3000mm.Cables shall not be routed along hand rails.

Where fire proofing column/structures are encountered, all cabling shall be taken in GI pipes of required size and both ends shall be sealed, well before fire proofing is done. Similarly equipment such as lighting fixture, control gear box, lighting/ power panels, field call stations, junction boxes etc. shall be installed on suitable steel mounting frame/distance bracket, thereby avoiding direct contact with the concrete used for fire proofing.

4.3.5 Cable glands for terminating cable on flameproof equipment shall be of double compression FLP type. Any material/equipment specified to be supplied by contractor for installation in hazardous areas, shall be tested by CIMFR and duly approved by CCoE or DGMS or any other applicable statutory authority. All indigenous FLP equipment shall also have valid BIS license as required by statutory authorities.

4.4 Building Lighting

4.4.1 The type of wiring system shall comprise surface/concealed conduit system or cable wiring as specified on layout drawings.

4.4.2 Mounting details of fixtures shall be indicated on the drawings. If specified on the drawings, a group of fluorescent lighting fixtures which are to be mounted end to end shall be fixed to mild steel cold rolled sections of 50mm x 50mm and of 1.2mm thick (Metsec channel). The entire assembly shall be fixed to the ceiling with necessary number of supports which may be by means of steel conduit or chromium plated chain link as required. The `Metsec' Channel shall run continuous in suitable sections from one end to other end of wall. The complete channel shall be spray painted, with approved colour as per the directions of Engineer-in-Charge. All wires inside channel shall be neatly bunched by nylon tape and buttons.

4.4.3 Wiring in areas above false ceiling shall be done in Surface Conduit (25mm dia GI conduit) suitably clamped to the true ceiling. Vertical drops from true ceiling for panels, switches, receptacles etc. shall be taken in 25mm dia PVC conduit concealed in walls upto switchboards/panels. Lighting fixtures shall be supported from true ceiling. Exact location of fixtures shall be finalised in co-ordination with air-conditioning duct diffuser layout, panel's layout and false ceiling grid layout. To facilitate easy maintenance `Looping back system` of wiring shall be followed throughout. Accordingly supply tapping's and other interconnections including for earthing are made only at fixture connector blocks or at switch boards. Required number of junction boxes shall be used at intervals for wire pulling and inspection.

4.4.4 All wires in conduit shall be colour coded as specified. Each circuit shall have independent phase neutral and earth wire. However when group of circuits are run in a single conduit the earth wire can be common.

4.4.5 Building conduit lighting system of wiring where measurement is done on point wiring basis generally consists of two parts. The first part is the circuit wiring which includes the work necessary from lighting panel up to switch box and from switch box to another switch box.

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The second part is the point wiring which shall include the work necessary from tapping point in the switch box upto various fixtures or fan outlets/ceiling roses.

4.4.6 Switches for light fixtures/exhaust fans in battery room shall be provided outside the Battery room.

4.4.7 Lighting layouts for non-plant buildings (such as ware house, cement godown, gate house, workshop, service building, rest room, etc.) shall be prepared by installation contractor as defined in the scope of work.

The following basic data/document for preparation of layouts will be provided to the contractor.

i) Architectural drawings
ii) Illumination level required
iii) Type of lighting fixture
iv) Type of wiring (concealed/surface conduit/cable wiring etc.)

Based on the above input, contractor shall prepare and submit lighting layout drawings, panel schedules, conduit layout drawings for concealed wiring, design calculations wherever required, for review by purchaser before erection work is started. The lighting layout drawing shall show the location, type and mounting details of lighting fixtures, receptacles, junction boxes, layout of circuit indicating number of wires etc. The number of points in a circuit shall not exceed ten and the load in each circuit shall be less than 1000 Watts.

The panel schedule shall include rating of incoming and outgoing feeders, number of outlets, load for each outgoing circuit, etc.

All drawings shall be prepared preferably in A0 and A1 size. Panel schedules shall be in A4 size drawings. Final submission of drawings shall be in soft copies (CD form) and in bound volumes.

4.5 Street Lighting

4.5.1 Street lighting poles to be located on road side shall be installed at a minimum distance of 300mm from the edge of the walkway of the road (road berm). Size of wires from marshalling box upto fixture shall be 1.5mm²/2.5mm², copper conductor PVC insulated.

4.5.2 Each pole shall be earthed at two points by connecting to the plant earth grid as shown on Installation standards.

4.5.3 Street lighting fixture shall be mounted on steel tubular poles as per standard drawings. The foundation for the street lighting poles will be made by electrical contractor. Street lighting poles shall be supplied with a base plate.

4.5.4 The poles shall be numbered as per the drawings/ directions of Engineer Incharge.

4.6 Mast Lighting

4.6.1 The lattice structure masts shall be installed on concrete foundations with the base plate bolted on to the anchor bolts. The lattice structure shall be painted with a coat of primer and two coats of aluminium paint, the second coat to be given just before handing over to the owner. The masts shall be numbered as per drawings. The masts shall be connected to the plant earth grid at two points

4.6.2 The main feeder upto the distribution board of lighting mast shall be through PVC insulated armoured cable of size as specified in the respective drawing. Wiring from Distribution Board to each flood-light fixture shall be by means of a 3-core 2.5sqmm, copper conductor PVC

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insulated armoured cable. All the cables shall be neatly clamped to the structure at intervals not exceeding 25 cms.

4.6.3 Exact orientation of flood lighting fixtures shall be decided at site to achieve optimum utility of these fixtures.

4.7 Telephone Wiring

Conduits for telephone wiring in buildings shall be of 1.6mm thickness. 25mm dia black enameled steel conduit/PVC as per IS 9537, installed on wall surface or concealed or as specified in job specification.

Conduit installation system shall comply with the requirements given in clause 4.2 `conduit system'. Required number of pull boxes shall be provided at interval for easy drawing of wires. The telephone wiring shall be done with 0.63mm dia annealed copper conductor PVC insulated 660V grade, twin flat wire, unless otherwise specified in job specification. One telephone socket outlet shall be provided for connection to telephone instrument.

5.0 TESTING AND COMMISSIONING

5.1 Lighting installation shall be tested and commissioned by installation contractor as per EIL specifications. Precommissioning checks and tests shall include but not be limited to the following:

(i) The insulation resistance of each circuit without the lamps (load) being in place shall be measured and it should not be less than 500,000 ohms. (Between phases, phases to neutral, phase/neutral to Earth).

(ii) Current and voltage of all the phases shall be measured at the lighting panel bus bars with all the circuits switched on with lamps. If required load shall be balanced on the three phases.

(iii) The earth continuity for all socket outlets shall be checked. A fixed relative position of the phase and neutral connections inside the socket shall be established for all sockets.

(iv) After inserting all the lamps and switching on all the circuits, minimum and maximum illumination level shall be measured in the area and recorded.

(v) It shall be ensured that switch provided for ON/OFF control of point (light/fan/socket) is only on LIVE side.

(vi) Operation of ELCB's shall be checked.

Contractor shall duly fill in all the above test results and submit the test reports to Engineer-in-Charge in triplicate.

5.2 All lighting layout drawings shall be marked by contractor for 'AS BUILT STATUS' and two sets of hard copies plus 1 set of soft copy in CD, shall be submitted to EIL.

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अर्थिंग डालने के लिए विनिर्देश

SPECIFICATION FOR EARTHING INSTALLATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	26 02 19	REVISED AND ISSUED AS SPECIFICATION	DC	RS	BRB	RKT
4	26 03 14	REVISED AND ISSUED AS SPECIFICATION	FA	SA	BRB	SC
3	25 04 08	REVISED AND ISSUED AS SPECIFICATION	RKS	SSM	JMS	VC
2	28 02 03	REVISED & ISSUED AS SPECIFICATION	HKM	RSG	VPS	SKG
1	16 07 97	REVISED & ISSUED AS STANDARD SPECIFICATION	RR	VPS	SG	AS

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Abbreviations:

BIS	:	Bureau of Indian Standards
CD	:	Compact Disc
CEA	:	Central Electricity Authority
DGMS	:	Director General Mines and Safety
GI	:	Galvanized Iron
IEC	:	International Electrotechnical Commission
IS	:	Indian Standard
MS	:	Mild Steel
OISD	:	Oil Industry Safety Directorate
PESO	:	Petroleum and Explosive safety organization.
UPS	:	Uninterrupted Power Supply

Electrical Standards Committee

Convenor: Mr. BR Bhogal

Members: Ms. S. Anand
Mr. Parag Gupta
Mr. M.K. Sahu
Mr. Saeed Akhtar (Inspection)
Ms. N.P. Guha (Projects)
Ms. NS Bhattacharya

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1.0 SCOPE

This specification defines the requirements for the supply of earthing and lightning protection materials and installation of the earthing and lightning protection systems.

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, EIL Installation Standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD Standards listed below :

SP:30 (BIS)	Special Publication-National Electrical Code
IS/IEC:62305	Protection against lightning.
IS:3043	Code of practice for earthing
IS:7689	Guide for control of undesirable static electricity.
OISD 110	Recommended practices on static electricity
OISD 147	Inspection and safe practice during electrical installation.
OISD GDN 180	Lightning protection.

2.2 In addition to the above, it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations

b. Regulations laid down by CEA/Electrical Inspectorate.

c. Regulations laid down by PESO/DGMS (as applicable).

d. The petroleum rules (Ministry of Industry, Government of India).

e. Any other regulations laid down by central/state/local authorities and Insurance agencies.

3.0 MATERIAL SPECIFICATIONS

3.1 All materials and hardware to be supplied by the contractor shall be new, unused and of best quality and shall conform to the specifications given here under and to latest specifications of Bureau of Indian Standards. Contractor shall bring material samples to site and get it approved by Engineer-in-charge before installation.

3.2 The main earth grid conductor shall be hot dip galvanised M.S. flat unless otherwise specified. Sizes for main conductors shall be as indicated on the earthing layout drawing .Amount of galvanizing shall be 610gm per sq.metre. Earth electrodes and Earth plate shall be as per EIL Installation Standards.

4.0 EARTHING NETWORK

4.1 This consists of main earth conductor (grid conductor) forming a closed ring network with required number of earth electrodes connected to it to provide a common earth for electrical devices and metallic structures. From each earth electrode two distinct connections shall be made to the main earth conductor. The earth plates shall be used for taking multiple earth connections to two or more equipments.

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4.2 The earth conductor shall be laid along cable trays/cable trench/pipe racks/ buried in pavement/ below finished grade level as indicated on the earthing layout drawing. Where lined cable trenches are available, the earth conductor shall be preferably laid in the trenches and shall be firmly cleated to the sidewall of concrete trenches using GI clamps at interval of 400 mm to 500 mm and near to the termination end. The earthing conductor shall run along one of the cable trays along the overhead cable route. The earthing conductor shall be suitably cleated and electrically bonded to all the other cable trays on the same cable route at a regular interval of 25 to 30 meter through copper flexible (insulated) . The earthing for equipment shall be tapped from the main earth conductor and not from cable tray support structure. Earth conductor when laid underground shall be at a depth of 500mm below finished grade level.

4.3 Joints and tapping's in the main earth loop shall be made in such a way that reliable and good electrical connections are permanently ensured. All joints below grade shall be welded and shall be suitably protected by giving two coats of bitumen and covering with Hessian tape. Earth strip laid above ground shall be welded across straight through joints and joints shall be suitably protected by giving two coats of bitumen to avoid oxidation and insulation film formation of the strip surface. When two earth strips are to be jointed by means of welding, lap welding with an overlapping of strip equivalent to double the width of the strip and all four sides(three on the Top and one bottom) shall be continuously welded. All joints at tappings above ground shall be by means of connector/lugs. A minimum of two bolts of adequate size shall be used for this purpose. Earthing strip joints at earth plate and equipment shall be through GI bolts, nut etc.

5.0 INSTALLATION OF EARTH ELECTRODE

5.1 Earth Electrode shall be installed as shown on installation standard and layout drawings. The location shown on the layout drawings are indicative.

The exact location of earth electrodes in the field shall be determined by contractor in consultation with the Engineer-in-charge, depending on the soil strata and resistivity. Earth electrodes shall be located avoiding interferences with road, building foundation, column, pipelines etc. The civil area drawings shall be referred for this. The distance between two electrodes shall not be less than twice the depth of electrode. However in the areas where there is physical limitation to meet the above separation distance between two electrode, the mutual spacing can be reduced to a value not less than the driven depth of each earth electrode.

5.2 Electrodes shall preferably be located in a moist soil which has a fine texture, grain size and distribution. Wherever practicable the soil shall be dug up, all lumps broken and stones removed from the immediate vicinity of the electrodes and soil packed by watering and ramming as tight as possible.

5.3 The electrodes shall have a clean surface, not covered by paint, enamel, grease or other materials of poor conductivity.

5.4 All earth electrodes shall be tested for earth resistance by means of standard earth test meter. The tests shall take place in dry months, preferably after a protracted dry spell.

5.5 The disconnect facility shall be provided for the individual earth electrode to check its earth resistance periodically.

5.6 Location of earth electrodes shall be marked by permanent markers for easy identification. All earth Electrodes shall be serial numbered and also marked on 'As Built' drawing for future reference.

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5.7 Individual earth electrodes shall be provided for each lightning arrestor, each dropper of building earthing protection system and flood light mast.

5.8 Earthing system provided for concrete paved area by other agency where applicable; shall be connected to the plant earthing system below ground by minimum two earth connections.

5.9 Top of earth pit shall be flushed with finished floor level in paved areas. In unpaved areas, top of earth pit shall be projected 100 mm above finished ground level.

6.0 CONNECTION

The earth system connections shall generally cover the following:

- Equipment earthing for personnel safety
- System neutral earthing
- Static and lightning protection

6.1 The following shall be earthed.

- System neutral
- Current and potential transformer secondary neutral
- Metallic non-current carrying parts of all electrical apparatus such as transformers, switchboards, bus ducts, motors, neutral earthing resistors, capacitors, UPS, battery charger panels, welding receptacles, power sockets, lighting/power panels, control stations, lighting fixtures etc.
- Steel structures/columns, rail loading platforms etc.
- Cable trays and racks, lighting mast and poles
- Storage tanks, spheres, vessels, columns and all other process equipment.
- Fence and Gate for electrical equipment (e.g. transformer yard etc.)
- Cable shields and armour
- Flexible earth provision for Wagon, Truck
- Shield wire
- Ladder, staircase as per layout drawing/job specification.

Conductor size for branch connection to various equipment shall be as per EIL Installation Standards unless otherwise stated on earthing layout drawings.

6.2 All process pipelines shall be bonded and earthed at the entry and exist points of unit battery limit of hazardous area.

6.3 Steel pipe racks in the process units and offsite area shall be earthed at every 24 meters.

6.4 Equipment/street light pole etc. located remote from main earth network may be earthed by means of individual earth electrode and earth conductor unless otherwise stated in job specifications/earthing layout drawing.

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6.5 Lightning protection shall be provided for the equipment, structures and buildings as shown on layout drawing. Self conducting structures shall not require separate aerial rod and down conductors. These shall however be connected to the earthing system at two or more points as shown on layout drawing. Each down conductor shall be provided with an earth electrode with test pit and all earth electrodes shall be interconnected through underground strip. Lightning protection system may be bonded to electrical safety earthing system, inside ground. Lightning down conductor shall be brought to earth electrode in shortest straight path as feasible to minimise surge impedance.

6.6 The main earthing network shall be used for earthing of equipment to protect against static electricity.

6.7 All medium and high voltage equipment (above 250V) shall be earthed by two separate and distinct connections with earth.

6.8 Plant instrument system clean earthing, UPS system clean/safety earth, Data concentrator panel, HMI etc shall be separate from the electrical earthing system, if mentioned in job specification/ layout drawings.

6.9 All paint, scale and enamel shall be removed from the contact surface before the earthing connections are made.

6.10 All earthing connections for equipment earthing shall be preferably from the earth plate mounted above ground wherever provided

Equipment foundation bolts shall not be used for earthing connection.

6.11 Earth connections shall be made through compression type cable lugs/by welded lugs.

6.12 All hardware used for earthing installation shall be hot dip galvanised or zinc passivated. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.

6.13 Lighting fixtures and receptacles shall be earthed through the extra core provided in the lighting circuit/cable for this purpose.

6.14 The reinforcements of sub-station building coulumns/beams and the sub-station floor slab shall be connected to main earth grid.

7.0 TESTING AND COMMISSIONING

7.1 Field inspection, testing and commissioning of electrical installation shall be done as per EIL standard specification.Earthing systems/connections shall be tested as follows:

7.2 Resistance of individual earth electrodes shall be measured after disconnecting it from the grid by using standard earth test meggar.

7.3 Earthing resistance of the grid shall be measured after connecting all the earth electrodes to the grid. The resistance value of an earth grid to the general mass of earth shall be as follows:

- For the electrical system and equipment, a value that ensures the operation of the protection device in the electrical circuit but not in excess of 4 ohm. However for generating stations and large sub-systems, the value shall not be more than 1 ohm.
- For lightning protection, the value of 5ohms as earth resistance shall be desirable, but in no case it shall be more than 10 ohms.

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7.4 The resistance to earth shall be measured typically at the following points:

a) At each electrical system earth or system neutral earth.

b) At each earth provided for structure lightning protections.

c) At one point on earthing system used to earth electrical equipment enclosures.

d) At one point on earthing system used to earth wiring system, enclosures, such as metal conduits and cable sheaths or armour.

e) At one point on fence enclosing electrical equipment.

7.5 All earthing layout drawings shall be marked by contractor for 'AS BUILT STATUS' and two sets of hard copies plus 1 set of soft copy, shall be submitted to EIL. For projects, where layout drawings have been prepared based on 3D modeling, contractor shall carryout necessary changes for 'AS BUILT STATUS' in the 3D model.

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SPECIFICATION FOR FIELD INSPECTION, TESTING AND COMMISSIONING OF ELECTRICAL INSTALLATIONS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	13 08 19	REVISED & ISSUED AS STANDARD SPECIFICATION	RM	RS	SA	RKT
3	10 6 14	REAFFIRMED & ISSUED AS STANDARD SPECIFICATION	AKG	SA	BRB	SC
2	03 03 09	REVISED & ISSUED AS STANDARD SPECIFICATION	RKS	NS	JMS	ND
1	14 07 03	REVISED & ISSUED AS STANDARD SPECIFICATION	HKM	RSG	VPS	SKG
0	02 08 01	ISSUED AS STANDARD SPECIFICATION	UAP	RR	VPS	MI

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Abbreviations:

AC	:	Alternating Current
AFC	:	Approved for Construction
BIS	:	Bureau of Indian Standards
CCOE	:	Chief Controller of Explosives
CEA	:	Central Electricity Authority
DC	:	Direct Current
DCS	:	Distributed Control System
DGMS	:	Director General for Mines and Safety
ECS	:	Electrical Control Station
GI	:	Galvanized Iron
HV	:	High Voltage
IS	:	Indian Standard
MV	:	Medium Voltage
OISD	:	Oil Industry Safety Directorate
PESO	:	Petroleum and Explosives Safety Organization

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1.0 SCOPE

This specification covers the requirements for the field inspection, testing and commissioning of Electrical Equipment and Installation, forming part of electrical power distribution and utilisation system.

2.0 CODES AND STANDARDS

2.1 The field inspection, testing and commissioning of electrical equipment shall be carried out in line with this specification and the latest edition of following Indian Standards and OISD standards.

SP-30(BIS)	National Electrical Code.
IS 1255	Code of practice for installation and maintenance of power cables up to & including 33 kV rating.
IS-7816	Guide for testing Insulation resistance of rotating machines.
IS 10810(Part 43)	Method of Test for cables; Part 43 Insulation resistance.
IS 10810(Part 45)	Method of Test for cables; Part 45 High voltage test.
IS 12729	HV Switchgears
OISD 137	Inspection of Electrical Equipment.
OISD 147	Inspection and safe practice during electrical installation.

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations
b. Regulations laid down by CEA / Electrical Inspectorate.
c. Regulations laid down by Tariff Advisory Committee/Loss prevention council.
d. Regulations laid down by PESO/DGMS (as applicable).
e. The petroleum rules (Ministry of Industry, Government of India).
f. Any other regulations laid down by central / state / local authorities / insurance agencies

3.0 FIELD INSPECTION, TESTING AND COMMISSIONING

3.1 Contractor shall carry out complete field inspection, testing and commissioning of electrical equipment as per Inspection & Test plans.

3.2 Before the completed installation or an addition to the existing installation is put into service, inspection / pre-commissioning checks and tests shall be carried out by contractor. In the event of defects being found out, the same shall be rectified and the installation retested as applicable.

3.3 The pre-commissioning inspection among other requirements shall include visual inspection, checking the workmanship of the installation, the rating of equipment, safety clearances, sizes of cables installed, conformance to the AFC document, soundness of switchgear bus connections, wiring properly dressed and labeled, sealing of unused cable entries, checking of all safety interlocks, control/interface functions as per requirement etc.

3.4 Visual inspection for soundness of bus bar connections of busducts, terminal connections of equipment/motor shall be carried out. It shall be ensured that no foreign materials are present inside busduct and equipment terminal boxes. After the visual inspection, all the covers of terminal boxes, inspection chambers shall be refitted with gaskets, bolts & nuts as per equipment manufacturer's instructions.

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3.5 Pre-commissioning tests shall include but not be limited to the following:

- Continuity test for each winding and power and control circuits.
- Insulation test for each winding and power and control circuit
- High voltage test for cables
- Dielectric strength test on transformer oil.
- Checking the correctness of wiring schemes, control circuit interlocks for intended functioning.
- Verification of phase sequence.
- Testing of all types of relays/releases for required operation.
- Testing of measuring instruments for proper functioning.
- Earth continuity test for all circuits.
- Checking of safety features for correctness of operation, etc.
- Checking of all wired interface contacts (analogue, digital input/output contacts) for DCS and ECS interface, at panel and equipment terminal chambers as applicable.

  (Electrical contractor shall co-ordinate with other agencies involved for the above and provide support services for checking interfaces of electrical equipment and the intended functioning)

- Earth resistance measurement for each earth electrode, and the earthing system as a whole.
- Lighting installation shall be tested for correct illumination levels, with fittings installed. Fittings shall be operated only with specified type of a lamp or tube.

3.6 After the above tests and inspection are completed, control circuits shall be tested for correct operation under all operating combinations and proved correct before applying power to main circuit.

3.7 Plant Communication, Fire alarm detection and telephone system shall be checked for correct operation and intended function.

3.8 A close visual inspection of electrical equipment in hazardous areas shall be made to ensure that equipment is suitable for the classified zone and gas group and correctly installed, with all covers, bolts, nuts and hardwares intact and there is no physical damage mark seen on the enclosure

3.9 Site Acceptance Test procedure for specific equipment shall be furnished by the respective equipment vendor in line with testing requirements as per relevant standard, this specification & relevant equipment specifications. The Site Acceptance Test Procedure/ Site Testing Procedure shall be duly reviewed by the site Engineer-in-Charge. The contractor shall provide necessary assistance to the equipment vendor to perform Site acceptance testing to enable the equipment vendor to perform the same.

3.10 All pre-commissioning checks and tests shall be carried out as per the directions of Engineer-in-charge. In addition to the equipment manufacturer's instructions, pre-commissioning check requirements shall also be complied. All tests shall be carried out by contractor in the presence of EIL/Owner's representatives

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3.11 The contractor shall bring to site all required tools, tackles, and testing instruments for carrying out field testing. Contractor shall use only calibrated measuring and test instruments and shall maintain valid calibration records.

3.12 The **Insulation Resistance** test values for various electrical equipment shall be as below:

3.12.1 **Cables**

The insulation resistance test values for cables shall be as per following table:

Rated voltage of the Cable	**DC Test Voltage in Volts**	**Minimum Insulation resistance in Mega ohms**
Lighting and power circuit wiring	250	1
650/1100V grade cables	1,000	10
1,900/3,300V grade cables	1,000	200
3,800/6,600V grade cables	1,000	200
6,350/11,000V grade cables	5,000	200
8,700/15,000V grade cables	5,000	200
12,700/22,000V grade cables	5,000	200
19,000/33000V grade cables	5,000	200
38000/66000V (72500V) grade cables	5,000	500

3.12.2 **HV, MV and Miscellaneous Switchboards**

The insulation resistance test values for the switchboards shall be as per following table:

Rated voltage of the Switchboard	**DC Test Voltage in Volts**	**Minimum Insulation resistance in Mega ohms**
33,000V	5,000	200
11,000V	5,000	200
6,600V	1,000	200
3,300V	1,000	200
415V	1,000	100
240V	500	10
110V	500	10

3.12.3 **Generators and Motors**

3.12.4 The insulation resistance test values for Generators and Motors shall be as per following table:

Rated voltage of the Generators and Motors	**DC Test Voltage in Volts**	**Minimum Insulation resistance in Mega ohms at 40 °C**
11,000V	5,000	120
6,600V	1,000	80
3,300V	1,000	50
415V	1,000	15
240V	500	12

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3.12.5 **Transformers**

The insulation resistance test values for the Transformers shall be as per following table:

Rated voltage of the Transformers	**DC Test Voltage in Volts**	**Minimum Insulation resistance in Mega ohms at 40 °C**
Up to 600V	1,000	100
601 to 5000V	2,500	1,000
5001 to 15,000V	5,000	5,000
15001 to 35,000V	5,000	10,000
35001 to 66,000V	5,000	10,000
66001 to 132,000V	5,000	10,000

3.12.6 It shall be ensured that during insulation tests, electronic devices and components that are liable to get damaged on applied test voltage shall be disconnected from circuit. The instructions of equipment/panel manufacturer shall be followed strictly in this regard.

3.13 High-voltage Testing

3.13.1 DC high voltage test shall be conducted as per following table on all HV feeder cables and also on 1100 V grade cables where straight through joints have been made. This table shall be used as a reference and the DC high voltage test shall be conducted considering equivalent IS/ IEC voltage grades upto 66kV

Rated Voltage of Cable (kV)	**TEST VOLTAGE (kV) BETWEEN**		**Duration (Minutes)**
U_o / U*	**Any Conductor and Metallic Sheath/ Screen/Armour**	**Conductor to Conductor (For Unscreened Cables)**	
0.65/1.1	3	3	5
1.9/3.3	5	9	5
3.3/3.3	9	9	5
3.8/6.6	10.5	18	5
6.6/6.6	18	18	5
6.35/11	18	30	5
11/11	30	30	5
12.7/22	37.5	-	5
19/33	60	-	5

*U_o : Phase Voltage

U : Line Voltage

The cable cores must be discharged on completion of DC high voltage test and cable shall be kept earthed until it is put into service.

DC test voltage for old cables shall be 1.5 times rated voltage or less depending on the age of cables, repair work or nature of jointing work carried out, etc. In any case, the test voltage shall not be less than the rated voltage.

3.13.2 AC high voltage test shall be conducted as per following table on all HV Switchboards.

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Rated Voltage (rms Value in kV)	Rated 1 Min. Power Frequency Withstand Voltage (rms Value in kV)		Duration in Minutes
U	To Earth, Between Poles and Across Open Switching Device	Across the Isolating Distance	
3.6	10	12	1
7.2	20	23	1
12	28	32	1
24	50	60	1
36	70	80	1
72.5	140	160	1

The withstand voltage values across the isolating distances are valid only for switching devices, where the clearance between open contacts is designed to meet the safety requirements specified for disconnectors.

3.13.3 DC Voltage test of the cable over-sheath shall be conducted as per IEC 60840 & IEC 60229:- A D.C. voltage of 4kV per millimetre of specified thickness of extruded over-sheath shall be applied with a maximum of 10kV D.C. between the underlying metallic layers and the outer electrode, for a period of 1 min. All metallic layers under over-sheath shall be connected together.

This test requires that the over-sheath has an outer "electrode" which may be moist backfill or a conductive layer.

No breakdown of the over-sheath shall occur during the test

3.13.4 AC voltage test of the cable insulation shall be conducted as per IEC 60840, rated voltage may be applied for 24 hours.

3.14 All protective relays including thermal overload relays shall be tested by secondary injection current. Primary injection tests shall be carried out for differential protection, restricted earth fault protection at full/reduced current to ensure correctness of complete wiring.

3.15 Before energizing any equipment, 'COMMISSIONING CLEARANCE FORM' as per standard format shall be duly filled in by contractor and submitted to EIL/owner.

3.16 It shall be ensured that the electrical inspectorate approval is available before energizing the equipment

4.0 RECORDS

Contractor shall keep up-to-date records of all activities carried out and test results. Field inspection / test reports shall be submitted to EIL / Owner by the contractor in bound volumes (triplicate copies).

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DESIGN PHILOSOPHY FOR ELECTRICAL FACILITIES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	15 10 19	REVISED AND ISSUED AS STANDARD SPECIFICATION	DA/JLC	PG	SA	RKT
6	27 08 14	REVISED AND ISSUED AS STANDARD SPECIFICATION	RS	PG	BRB	SC
5	15 04 09	REVISED AND ISSUED AS STANDARD SPECIFICATION	AM	UAP	JMS	ND
4	31 03 04	REVISED AND ISSUED AS STANDARD SPECIFICATION	AKG	AAN	VPS	SKG
3	01 12 99	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	AS

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Abbreviations:

A	:	Amperes	LAN	:	Local Area Network
AC	:	Alternating Current	LCIE	:	Laboratoire Central des Industries Electriques
ACB	:	Air Circuit Breaker	LDB	:	Lighting Distribution Board
ACDB	:	AC Distribution Board	LDP	:	Local Distribution Panel
AN	:	Air Natural	LED	:	Light Emitting Diode
APFC	:	Automatic Power Factor Correction	LV	:	Low Voltage (Up to 250V)
API	:	American Petroleum Institute	MCB	:	Miniature Circuit Breaker
ASB	:	Auxiliary Service Board	MCC	:	Motor Control Centre
ATEX	:	ATmospheres EXplosibles	MCCB	:	Moulded Case Circuit Breaker
BASEEFA	:	British Approval Service for Electrical Equipment in Flammable Atmospheres	MCP	:	Manual Call Point
BIS	:	Bureau of Indian Standards	MPPT	:	Maximum Power Point Tracker
CEA	:	Central Electricity Authority	MOV	:	Motor Operated Valve
CIMFR	:	Central Institute of Mining and Fuel Research	MV	:	Medium Voltage (Above 250V and up to 650V)
CPRI	:	Central Power Research Institute	MVA	:	Mega Volt Ampere
CT	:	Current Transformer	NEC	:	National Electric Code
DB	:	Distribution Board	NFPA	:	National Fire Protection Association
DC	:	Direct Current	NGR	:	Neutral Grounding Resistor
DCDB	:	DC Distribution Board	NGT	:	Neutral Grounding Transformer
DCS	:	Distributed Control System	NIFPS	:	Nitrogen Injection Fire Protection System
DG	:	Diesel Generator	ODC	:	Over Dimension Consignment
DGCA	:	Director General Civil Aviation	OFC	:	Optical Fibre Cable
DGMS	:	Director General Mines Safety	OISD	:	Oil Industries Safety Directorate
DOL	:	Direct On Line	OLTC	:	On Load Tap Changer
ECS	:	Electrical Control System	ONAF	:	Oil Natural Air Forced
EHV	:	Extra High Voltage (Above 33 kV)	ONAN	:	Oil Natural Air Natural
ELCB	:	Earth leakage Circuit Breaker	PCC	:	Power Control Centre
ELR	:	Earth Leakage Relay	PCU	:	Power Conditioning Unit
EOT	:	Electrically Overhead Travelling	PDB	:	Power Distribution Board
EPABX	:	Electronic Private Automatic Branch Exchange	PESO	:	Petroleum and Explosives Safety Organisation
ERTL	:	Electronic Regional Test Laboratories	PMCC	:	Power Cum Motor Control Centre
FA	:	Fire Alarm	PTB	:	Physikalisch-Technische Bundesanstalt
FM	:	Factory Mutual	PV	:	Photo Voltaic
FRLS	:	Flame Retardant Low Smoke	PVC	:	Polyvinyl Chloride
GI	:	Galvanised Iron	RCC	:	Reinforced Cemented Concrete
GIS	:	Gas Insulated Switchgear	RTCC	:	Remote Tap Changing Controller
HDPE	:	High Density Poly Ethylene	RTD	:	Resistance Temperature Detector
HMI	:	Human Machine Interface	RTU	:	Remote Terminal Unit
HV	:	High Voltage (Above 650V and up to 33 kV)	RVT	:	Residual Voltage Transformer
HVAC	:	Heating Ventilation and Air Conditioning	SPV	:	Solar Rooftop Photo Voltaic
IAC	:	Internal Arc Classification	SVL	:	Surge Voltage Limiter
IEC	:	International Electro-Technical Commission	TRV	:	Transient Recovery Voltage
IEEE	:	Institute of Electrical and Electronics Engineers	UL	:	Underwriter's Laboratory
IES	:	Illumination Engineering Society	UPS	:	Uninterrupted Power Supply
IS	:	Indian Standards	V	:	Voltage
kV	:	Kilo Volt	VFD	:	Variable Frequency Drive
kVA	:	Kilo Volt Ampere	VRLA	:	Valve Regulated Lead Acid
kVAR	:	Kilo Volt Ampere Reactive	VT	:	Voltage Transformer
kW	:	Kilo Watt	XLPE	:	Cross Linked Poly Ethylene
kWH	:	Kilo Watt Hour	X/R	:	Impedance/ Resistance

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Electrical Standards Committee

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1.0 SCOPE

This specification along with the applicable project design data sheet shall form the basis for developing detailed design and engineering for electrical facilities including electrical power system, Electrical equipment, Electrical control system, Plant communication system, Fire detection & alarm system and electrical installation etc.

2.0 CODES AND STANDARDS

The main codes and standards, considered as minimum requirements, as applicable, are as mentioned below. Latest version of these shall be followed:-

IS-732	:	Code of practice for electrical wiring installations
IS-1646	:	Fire safety of buildings (General): Electrical Installations – Code of Practice
IS-2189	:	Selection, Installation and Maintenance of automatic fire detection and alarm system – Code of Practice
IS-3034	:	Fire safety of industrial buildings: Electrical generating and distributing stations – Code of Practice
IS-3043	:	Code of practice for Earthing
IS-3646	:	Code of practice for Interior Illumination
IS-3716	:	Application guide for Insulation Coordination
IS-4051	:	Code of practice for installation and maintenance of electrical equipment in mines
IS-5216	:	Recommendation on safety procedures and practices in electrical work
IS-5572	:	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installations
IS-6665	:	Code of practice for Industrial Lighting
IS-7689	:	Guide for Control of undesirable static electricity
IS-7752	:	Guide for improvement of power factor in consumer installations
IS-8478	:	Application guide for on load tap changers
IS-9676	:	Reference ambient temperature for electrical equipment
IS-10028	:	Code of practice for selection, installation and maintenance of transformer
IS-10118	:	Code of practice for selection, installation and maintenance for switchgear and control gear
IS-10561	:	Application guide for Power Transformer
IS-12360	:	Voltage bands for electrical installations including preferred voltages and frequencies
IS-13234	:	Guide for short circuit calculations in three phase AC systems
IS-16724/ IEC 60079-14	:	Explosive Atmospheres – Electrical installations design, selection and erection
SP-30	:	National Electrical Code (NEC) - BIS Publication
OISD-RP-110	:	Recommended practices on static electricity
OISD-STD-113	:	Classification of Area for electrical installation at Hydrocarbon processing and handling facilities
OISD-STD-137	:	Inspection of electrical equipments
OISD-RP-147	:	Inspection and safe practices during electrical installation
OISD-RP-149	:	Design aspects for safety in electrical systems

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OISD-STD-173	:	Fire Protection System for Electrical Installations
OISD-GDN-180	:	Lightning Protection
IS/IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres – General requirements.
IS/IEC 60079-1	:	Explosive Atmospheres: Equipment protection by flameproof enclosures "d"
IS/IEC 60079-2	:	Explosive protection by pressurized enclosures "p"
IS/IEC 60079-5	:	Explosive Atmospheres: Equipment protection by powder filling "q"
IS/IEC 60079-6	:	Explosive Atmospheres: Equipment protection by Oil immersion "o"
IS/IEC 60079-7	:	Explosive Atmospheres: Equipment protection by increased safety "e"
IS/IEC 60079-10-2	:	Explosive Atmospheres: Classification of areas: Combustible dust atmosphere.
IS/IEC 60079-11	:	Explosive Atmospheres: Equipment protection by intrinsic safety "i"
IS/IEC 60079-15	:	Electrical apparatus for explosive gas atmosphere – Construction, test and marking of type of protection ``n" electrical apparatus.
IS/IEC 60079-18	:	Explosive Atmospheres: Equipment protection by encapsulation "m".
IS/IEC 60079-20-1	:	Electrical apparatus for explosive gas atmosphere: Data for flammable gases and vapours relating to the use of electrical apparatus.
IS/IEC 60079-31	:	Explosive Atmospheres: Equipment dust ignition protection by enclosure "t".
IS/IEC 62305-1	:	Protection against lightning: General Principles
IS/IEC 62305-2	:	Protection against lightning: Risk Management
IS/IEC 62305-3	:	Protection against lightning: Physical damage to structures and life hazard
IS/IEC 62305-4	:	Protection against lightning: Electrical and electronics systems within structure
API-RP-545	:	Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids

3.0 STATUTORY REQUIREMENTS

The latest version of the following statutory regulations shall be followed for design of electrical system, as applicable for the particular project/ industry.

- Indian Electricity Act.
- Central Electricity Authority Regulations.
- The Factory Act.
- The Petroleum Rules.
- The Mines Act.
- Requirements of other statutory bodies as applicable, e.g. CEA/ State Electrical Inspectorate, PESO, DGMS.
- Oil Industry Safety Directorate.

4.0 SYSTEM DESIGN PHILOSOPHY

4.1 General

The electrical system shall be designed to provide:

- Safety to personnel and equipment both during operation and maintenance.

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- Reliability of Service.
- Minimal fire risk.
- Ease of maintenance and convenience of operation.
- Automatic protection of all electrical equipment through selective relaying system.
- Electrical supply to equipment and machinery within the design operating limits.
- Adequate provision for future extension and modification.
- Suitability for applicable environmental factors.

4.2 Area Classification and Equipment Selection

4.2.1 All the areas within the battery limits shall be classified for the degree and the extent of hazard from flammable materials. Classification of hazardous areas shall be done in accordance with Petroleum Rules, DGMS regulations (where applicable), IS-5572 (for flammable gases & vapours), IS/IEC 60079 Part 10 Sec 2 (for explosive dust atmosphere), OISD standards and Process Licensors recommendations.

4.2.2 Following factors shall be considered for proper selection of electrical equipment for use in hazardous area:

- Area classification i.e. Zone.
- Gas classification i.e. Group - The characteristic of the minimum gas or vapour involved in relation to the ignition current or minimum ignition energy & minimum safe gap data.
- Dust classification i.e. Group - The characteristic of the dust involved.
- Temperature classification - The ignition temperature of the gas, vapour or dust involved or the lowest value of the ignition temperature if more than one combustible material is present.
- Environmental conditions in which apparatus is to be installed - The selected electrical apparatus shall be adequately protected against corrosive and solvent agencies, water ingress, thermal and mechanical stresses as determined by the environmental conditions.

4.2.3 All electrical equipment installed in hazardous areas shall be selected as per IS 16724/IEC 60079-14 and OISD-RP-149 as applicable and shall meet the requirements of relevant IS & Statutory regulations. Ordinary industrial electrical equipment (even though permitted for use in Div.2 area as per NFPA-70) shall not be used in Zone-2 areas. Type of hazardous area protection to be used for individual equipment shall be as specified in the project design data sheet.

4.2.4 Electrical equipment for hazardous areas shall be certified by CIMFR/ ERTL/ Karandikar Lab or equivalent recognised independent test house such as BASEEFA / ATEX/ LCIE / PTB / UL / FM. All equipment (indigenous and imported) shall also have valid statutory approvals i.e. PESO/ DGMS as applicable for use in the specified hazardous area. All indigenous flameproof equipments shall have valid BIS license and marking as required by statutory authorities.

4.3 Power System Design

4.3.1 The distribution system shall be designed in accordance with project specification/ design data taking into account all possible factors affecting the choice of the system to be adopted such as required continuity of power supply, flexibility of operation, operational costs, space availability and reliability of supply from available power sources, total load and the concentration of individual loads.

4.3.2 In general the design intent shall also be for reduction in energy consumption through the selection and utilization of efficient electrical equipment i.e. energy efficient motors, transformers, lighting equipment and other equipment notified from time to time.

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4.3.3 Power system studies shall be performed using standard software in support of design, as required.

4.3.4 Special attention is drawn to chapter IX of CEA regulations, which includes requirements for design of electrical system as applicable to Mines and oil fields installation.

4.4 Capacity of Electrical System

4.4.1 All the components of the electrical system shall be sized to suit the maximum load, under the most severe operating conditions. The amount of electrical power consumed by each process unit shall be calculated for its operation at the design capacity. System design shall permit direct on line starting of all motors unless specified otherwise.

4.4.2 For Electrical load analysis, loads shall be classified as continuous loads, intermittent loads and standby loads based on their operation. Following factors shall be applied to calculate the total operating load, unless otherwise specified:

100% (Continuous Loads) + 30% (Intermittent Loads)[1] + 10% (Standby Loads)[2,3,4]

Notes:
1. 30% of intermittent loads such as EOT cranes, MOVs, etc. or the largest intermittent load whichever is higher.
2. 10% for only those Standby Loads which are required in emergencies only, such as fire-water pumps or those of normally not running electrically driven units in stand-by mode for normally running turbine driven loads.
3. Driven equipment 'Standby' in 'Normal-Standby' combination shall not be considered as a standby load.
4. 10% of standby loads or the largest standby load whichever is higher.

4.5 System Voltages

System voltages shall be as defined in project design data sheet.

4.6 Voltage Drops

4.6.1 The maximum voltage drops in various sections of the electrical system under steady state conditions at full load shall be within the limits stated in the following table:

Sl. No.	System Element	Maximum Permissible Voltage Drop
a)	Cable between transformer secondary and Switchboards	0.5%
b)	Cable between PCC/PMCC and MCC or auxiliary switchboard i) MCC /Auxiliary Switchboard near PCC/PMCC ii) MCC/Auxiliary Switchboard situated remote from PCC/PMCC	 0.5% (Note-3b) 2 to 2.5% (Note-3a)
c)	Cables between HV Switchboard and HV Motor	3% (Note-4)
d)	Cable between PCC/PMCC and motor	5.5% (Note-4)
e)	Cable between MCC (situated near PCC / PMCC) and motors	4.5 to 5% (Note-4)
f)	Cable between MCC (situated remote from PCC / PMCC) and motors	3% (Note-4)

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g)	Cable between Auxiliary Switchboard / LDB and Lighting Panel/ Power panel	1 to 1.5% (Note- 2)
h)	Circuit between lighting panels and lighting points	4% (Note- 2)
i)	DC Supply Circuit (Electrical Controls)	5%
j)	DCDB to Control Room	2% (Note -1)
k)	UPS outgoing circuit	5% (Note - 1)

Note-1

Minimum voltage available across any instrument in the field/ control room/ Satellite rack room shall be as per instrumentation design basis. Distribution system for instrumentation supplies shall be designed accordingly. In case of any conflict between electrical project design data sheet and instrumentation design basis, the latter shall govern regarding instrumentation power supplies.

Note-2

In case of difficulty in achieving specified voltage drops in cables up to lighting panel, total 5.5% drop from Auxiliary switchboard/ LDB up to lighting points may be permitted.

Note-3

a) Higher voltage drop may be permitted between PCC / PMCC and remote mounted MCC/ASB, if overall voltage drop up to motor (from PCC / PMCC) is limited within 5.5%.

b) For large substations 1% drop may be permitted.

Note-4

For VFD fed motors, the maximum permissible voltage drop, as specified, shall be considered between VFD Panel and Motor.

4.6.2 The maximum voltage drop at various buses during start-up of large motor and/or motor reacceleration conditions shall be within the limits stated below:

S. No	System Element	Operating Condition	Max. Permissible Voltage Drop
a)	At the busbars of the worst affected Switchboard	Start -up of the large HV motor with other loads on the bus or reacceleration of a group of HV motors (Simultaneous start-up or group reacceleration of HV motors is not envisaged)	15 %
b)	At the busbars of the worst affected MV Switchboard (PCC/PMCC/MCC)	Start up of large MV motor with other loads on the bus or reacceleration of a group of MV motors (Simultaneous start-up or group reacceleration of MV motors is not envisaged)	10 %
c)	Cables between HV Switchboard and motor	Motor start-up or reacceleration	5 % (Note-a)

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d)	Cables between MV switchboard (PCC/PMCC/MCC) and motor	Motor start-up or reacceleration	15 % (Note-a)

Notes:

a) Higher voltage drop in motor cables may be permitted, in case the conditions given in Note b), c) and d) are complied.

b) The voltage available at the motor terminals during start-up must be sufficient to ensure positive starting or reacceleration of the motor (even with the motor fully loaded, if required), without causing any damage to the motor.

c) For medium voltage motors, the voltage available at the motor terminals must not be less than 75% of the rated value during start-up or reacceleration.

d) For high voltage motors, the voltage available at the motor terminals must not be less than 80% of the rated value during start-up or reacceleration.

4.7 System Earthing

4.7.1 System earthing for incoming supply and primary/secondary EHV/ HV/MV distribution systems shall be as per project design data. The system earthing point shall always be at the power source.

4.7.2 Neutral earthing system shall be solidly earthed for voltage system up to 650 V and above 11000 V (except in case of Mines and Oil fields installations where it shall be in line with Chapter IX of CEA regulations and statutory requirements).

4.7.3 For voltages between 3300 V to 11000 V, the neutral earthing system shall be resistance earthed. NGR rating shall be selected such that earth fault current is limited to not less than system charging current and shall be sufficient for selective & reliable operation of earth fault protection relay. The HV system earth fault current shall be limited to either 100% of highest CT rating of motor feeders or 50% of highest CT rating of Delta-Star transformer feeders or 10% to 20% of incomer CT rating whichever is higher. In general, a value of 600A for earth fault current may be considered for HV system unless specified otherwise.

4.7.4 For generators connected to switchboard via step up transformer, generator neutral shall be earthed through single phase transformer with secondary resistor. For generator directly connected to switchboard without generator transformer, generator shall be earthed via its own earthing resistor.

4.8 Short Circuit Capacities

Each short circuit interrupting device shall be designed to have rated short circuit breaking capacity and making capacity equal to or higher than the maximum value of short circuit current (rms) and peak value of short circuit current respectively, calculated at its location. The short circuit calculation shall also take into account increase in short circuit level due to direct or indirect connection of expected future load and future source, if specifically agreed upon. The related switchgears and bus-ducts shall withstand the above maximum available fault current for a minimum period of one second. The minimum size of conductor & metallic screen of high voltage cables and extra high voltage cables shall also be based on the short circuit withstand capacity for a minimum time period as dictated by the protection system and defined in project design data sheet.

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4.9 Insulation System

The insulation of electrical facilities shall be designed considering the system voltage, the system neutral earthing and the over voltages resulting due to system fault, switching or lightning surges. Lightning arresters and surge absorbers shall be provided where necessary.

4.10 Protection and Metering Schemes

4.10.1 The protective system shall be selected and coordinated to ensure the following:

a) Protection of equipment against damage, which can occur due to internal or external short circuits or atmospheric discharges.
b) Uninterrupted operation of those parts of the system, which are not affected by the fault.
c) Personnel and plant safety.

4.10.2 Protection relays shall be provided as specified in project design data sheet.

4.10.3 Metering shall be provided to keep a record of power consumption and supervision of all concerned parameters like current, voltage, power, frequency, power factor etc. as specified in project design data sheet.

4.10.4 Wherever numerical relays are provided, metering shall be part of numerical relay, unless otherwise specified.

4.11 DC Power Supply

4.11.1 Independent DC power supply systems shall be provided for the following requirements, unless otherwise specified:

- Plant shutdown system including DC instrumentation control supply (if required, as per instrumentation design basis)
- Electrical switchgear controls
- Critical DC motors power supply (if required)
- Critical DC lighting system

4.11.2 Fire alarm system control panels and EPABX telephone exchange shall be provided with dedicated DC system as part of the equipment.

4.12 Emergency Power Supply

4.12.1 The emergency power supply system, wherever envisaged and required as per project design datasheet, shall feed the following:

- Electrical loads essential for the safe shutdown of the plant.
- Emergency lighting.
- Communication system.
- Fire detection and alarm systems.
- D.C. Supply systems.
- UPS Systems.
- Fire fighting equipment excluding main firewater pump.
- Loads critical for process, plant and personnel safety.

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4.12.2 Emergency power supply could be from a different power source or Emergency Generator as per Project design data sheet. Rating specified for emergency generator shall be prime rating, unless otherwise specified. Where Emergency Generator is envisaged, emergency power supply shall be made available within a time period of 30 seconds from the instant of failure of normal supply.

4.12.3 The emergency generator shall generally not be required to run continuously in parallel with the normal power supply system. However, short time paralleling facility shall be provided for transferring load to normal power supply or other operational needs e.g. periodic testing etc. as required.

4.13 Uninterrupted Power Supply (UPS)

4.13.1 Uninterrupted power supply system shall be provided, as required for meeting critical loads that cannot withstand a momentary interruption in voltage (e.g. critical instrumentation, process control, HMI for substation automation system, ECS, Plant communication system, LAN system and other loads, as defined in project design data sheet).

4.14 Power Factor Improvement

Capacitor banks shall be provided, as specified in Project design data sheet, to improve the power factor to meet the minimum stipulated power factor by the power supply authorities. Automatic power factor correction shall be provided.

4.15 Plant Communication System

4.15.1 It shall consist of the following:

- Central exchange(s)/ Distributed intelligent nodes.
- Master control station(s) with inbuilt loudspeaker, microphone etc.
- Desk type call stations with inbuilt microphone, loudspeaker for installation in buildings.
- Wall/column mounting type call stations for hazardous/safe areas with external loudspeaker as per Operational requirements.
- Flashing beacon and acoustic hood for noisy areas.

4.15.2 Each exchange/ distributed intelligent node shall be designed to have at least 10% spare capacity.

4.15.3 Plant communication system shall have interface with fire alarm & detection system, EPABX telephone system, wherever specified.

4.16 Fire Detection and Alarm System

4.16.1 The Fire Detection and Alarm System shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke/heat detectors, multisensory detectors, linear beam detectors, hooters, exit signs, main panel, zonal panel, battery, battery charger and other hardware. Detail design, selection and installation of fire detection and alarm system including quantity and location of detections, MCP, etc. shall be as per IS 2189.

4.16.2 The system shall be designed to provide audio-visual indication at the main fire alarm panel to be located in fire station and zonal panels. Repeater panels shall be provided as specified in project design data sheet.

4.16.3 Electrical sirens shall be provided to cover entire plant area.

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4.16.4 Each panel and each loop / Zone shall have at least 10% spare capacity.

4.16.5 The fire detection system shall be interfaced with fire suppression system, HVAC system, pressurization system and plant communication system, wherever specified.

4.16.6 Heat detectors to be installed in battery room shall be intrinsically safe, gas group IIC type. Zener barrier shall be provided to limit the ignition energy.

4.17 Electrical Surface Heating System

4.17.1 Electrical surface heating system shall be provided for temperature maintenance of process pipes and associated equipments, if required as per process design basis.

4.17.2 The electrical equipments i.e. heat tracers, thermostat/ RTD, LDP, PDB, Junction boxes, connectors, splice boxes, etc. shall be suitable for applicable area classification, though PDBs shall be preferably located in safe area.

4.17.3 In general, the system shall be suitable for maintaining the temperature, unless otherwise specified. In case process fluid heating is desired, time duration and other parameters shall be as per process design data.

4.17.4 Skin effect electrical heat tracing system shall be provided for pipelines, if specified in project design data sheet.

4.17.5 In general, double/ sandwich insulation technique shall not be utilized for electrical heat tracing.

4.18 Substation Automation System

4.18.1 Substation Automation system shall be provided, if specified in project data sheet. The Substation Automation system shall broadly comprise of numerical relays, data concentrator panels (as required), Ethernet switches, interconnecting cables, HMI, laptop, printers and their associated software for monitoring of the Electrical system.

4.18.2 The communication protocol shall ensure transfer of all information including time stamping data from relay to Data concentrator/ HMI. Generally IEC-61850 based communication shall be provided, unless otherwise specified.

4.19 Electrical Control System

4.19.1 Electrical control system shall be provided (as required) to monitor and control electric power generation and distribution network of the plant. ECS shall broadly include distributed RTUs, Interface panels, I/O panels, servers, HMI, printers, fiber optic data highway, network switches etc. Base functionalities and advanced functionalities as specified in project design datasheet shall be provided.

4.19.2 If specified, there shall be provision of redundant connectivity of ECS system with DCS for serial data transfer.

4.20 Rooftop Solar Photovoltaic Power System

4.20.1 The grid connected photovoltaic (PV) solar system for converting solar energy to generate electricity shall be provided on the building rooftop. The solar system shall be photovoltaic based in which arrays of photovoltaic (PV) modules shall be installed on building roof top under clear sky, shade free, tilted towards south at an optimum inclination.

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4.20.2 The Grid connected Solar Rooftop Photo Voltaic (SPV) system shall consists of PV modules/ panels, Module Mounting Structure, Power conditioning Unit (PCU) having Maximum Power Point Tracker (MPPT), controls and protection, junction boxes, AC distribution board, data acquisition & monitoring system including weather monitoring instruments, cables, pipe conduits, earthing, lightning protection, overvoltage and surge protection, etc.

4.20.3 The system shall be without battery and shall be designed with necessary features to supplement grid power during day time.

4.20.4 Solar PV module array shall consist of high efficiency Solar Modules utilizing Crystalline Silicon solar PV cells

4.20.5 The power conditioning unit (PCU) shall be either located indoor or outdoor as specified in project design datasheet.

4.20.6 For specific applications, battery may be provided as part of solar photovoltaic (PV) system, if specified in project design data sheet.

5.0 EQUIPMENT DESIGN PHILOSOPHY

5.1 General

The equipment shall in general conform to EIL standard specifications. Equipments shall be selected and sized as per philosophy given below:

5.2 Transformers

5.2.1 All transformers except lighting transformers & isolation transformers shall generally be three phase, oil immersed, double wound type suitable for outdoor use, unless otherwise specified. Lighting transformers & isolation transformers shall be dry type, unless otherwise specified. Preferably transformers of variable frequency drive system and soft starter system shall be dry type located indoor adjacent to VFD/ soft starter panels.

5.2.2 100% standby transformers (for power, distribution and lighting) shall be provided in all unit, offsite and utility substations, unless otherwise specified.

5.2.3 In general kVA rating & percentage impedance ratio of each transformer shall be selected to limit the rated current and short circuit current to values which are within the current rating and interrupting capacity of associated switchgear available.

The kVA rating for power, distribution and lighting transformers shall be decided on the following basis and shall be as far as possible a standard value.

a) In systems having redundancy for transformers, with transformers having natural cooling i.e. ONAN/AN, each transformer shall be rated equal to or greater than the 8 hour maximum demand of the load plus 10% margin for future load growth.

b) In systems having redundancy for transformers, with transformers having forced cooling i.e. ONAF, each transformer shall be rated equal to or greater than the 8 hour maximum demand of the load plus 10% margin for future load growth (within 110% of it's self cooled (ONAN) rating) and shall be fitted with automatic forced air cooling fans.

c) Where redundancy in number of transformers is not provided, rating shall be equal to or greater than 8 hour maximum demand plus 10% margin for future load growth. Fan

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cooled rating, where provided, shall be reserved as spare capacity for further future load growth.

d) Where switchboard with three incomers and two bus coupler fed from three transformers is provided, transformer rating shall be finalized considering the load distribution pattern on the three buses of downstream switchboard during normal operations & also during outage of any one of the transformer. However in no case, transformer rating shall be less than 2/3rd of 8 hour maximum demand of the load plus 10% margin for future load growth.

5.2.4 Transformers connected directly to grid power supply shall be provided with OLTC to take care of variations in grid supply voltage.

5.2.5 For transformers having oil quantity equal to or above 2000 liters, Nitrogen Injection Fire Protection System (NIFPS) shall be provided, unless otherwise specified.

5.2.6 Distribution transformers shall be energy efficient type having energy efficiency level as specified in project design data sheet.

5.3 Switchgear

5.3.1 HV and EHV switchgears directly connected to grid/ power plant shall be provided with double bus arrangement, if justifiable in terms of operating flexibility, system extension and connection of differing priority loads to different buses.

5.3.2 Gas Insulated Switchgear (GIS) shall be provided for EHV system and HV system if specified in project design datasheet. In general, GIS may not be considered for voltages below 22 kV.

5.3.3 All switchgear and associated equipment fed from generators and transformers shall have rating at least equal to the rating of respective generators and transformers feeding it, under any circuit configuration. Generator incomer shall be rated w.r.t. maximum power output of the generator set over entire operating temperature range. Transformer incomer shall be rated at least equal to forced cooled rating of transformer or 110% of ONAN rating, whichever is higher.

5.3.4 Generator Circuit Breaker directly connected to generator shall be as per IEEE/IEC 62271-37-013.

5.3.5 Bus tie circuit breakers shall have rating higher of the following:

a) Largest incoming circuit breaker.

b) Maximum running load on either side of bus section.

The tie breaker rating shall not be less than the bus-bar current rating, unless otherwise specified.

5.3.6 HV and MV switchgears including components shall be natural air cooled type for achieving the required current rating inside the panel/cubicle at design ambient temperature. In case, natural cooled design is not available, forced cooling of components i.e. bus bars, circuit breaker etc. can be considered if specifically agreed upon.

5.3.7 All other switchgears not directly fed from generator and transformers shall have rating at least equal to the maximum demand under any circuit configuration plus a provision for 10% future load growth. Incomers of these switchgears shall be designed to cater to the complete load including 10% margin for future load growth.

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5.3.8 Spare outgoing feeders shall be provided in all switchgear. At least one number of each type of outgoing feeder or 10% of each type of outgoing feeder, whichever is more, shall be provided as spare in the HV and MV switchboards, except for capacitor feeder in HV switchboard.

5.3.9 Circuit breakers/contactors controlling motor feeders shall have a rating of at least 125% of the maximum continuous rating of the connected motors.

5.3.10 Separate feeders shall be provided in the switchboard for each load/motor. However, as an exception maximum two numbers welding receptacles or flood light masts may be connected to one power feeder.

5.3.11 All circuit breakers shall be of single break type having one pole per phase. Circuit breakers for all MV switchboards incomers and bus couplers including generator incomer shall be with four poles.

5.3.12 Rated short circuit breaking capacities and making capacities for all breakers and MCCBs shall be equal to or higher than the maximum specified value of the short circuit current and peak specified value of short circuit current respectively at the point of installation. MCCBs with backup fuses shall not be acceptable.

5.3.13 Air circuit breakers (ACB) shall be provided in MV switchboards for all feeders rated above 400A and switch fuse/MCCB/ACB shall be considered for feeder rated up to 400A. However in the feeders feeding power to small rated MCCs/ASBs/LDBs, switch-fuse feeders shall not be used.

5.3.14 Circuit breakers/Switch fuse units for capacitors shall, have a current rating of at least 135% of the capacitor rated current. Circuit breakers capability to interrupt applicable capacitive current shall be specifically verified.

5.3.15 The switchboard components viz. circuit breakers, main horizontal and vertical bus-bars, bus-bar joints, bus-bar supports etc. shall be designed to withstand the maximum specified short circuit current for a minimum time of 1 second, unless otherwise specified. Further, the switchboard shall be rated for Internal Arc Classification (IAC) for the short circuit current and duration as specified.

5.3.16 In general, for motors rated above 5.5 kW, CT in Y phase shall be provided in the switchgear for ammeter on the local control station/local control panel. Project design data sheet shall be referred for exact motor kW rating above which CT & ammeter need to be provided.

5.3.17 The maximum rating of bus bars for MCCs/ASBs/LDBs shall be limited to 1250 A or 40% of the feeding switchgear incomer rating, whichever is lower. Heavy duty type load break switch/ACB/MCCB for MCCs/ASBs and ACB/MCCB for lighting transformer fed LDBs, rated for maximum specified short circuit current & duration shall be used for incomer and bus coupler as specified in project design data sheet and these shall have suitable interlocks.

5.3.18 Special attention is drawn to Chapter IX of CEA regulations, which includes requirement of additional protective elements in switchgear applicable to Mines and Oil fields installations.

5.4 Bus Duct

The rating of bus ducts connected to breakers shall have same continuous and short circuit rating as that of breakers. Similarly bus ducts connecting two bus sections shall have same continuous and short circuit rating as that of main bus bars.

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5.5 Neutral Grounding Resistor

The NGRs shall be rated to withstand the fault current for 10 seconds.

5.6 Batteries

Batteries shall be of adequate capacity to meet the back-up requirements as envisaged in the duty cycle. While sizing the battery, temperature correction factor and ageing factor shall be considered in addition to the maintenance factor. Batteries shall be complete with battery racks and accessories.

5.7 DC Power Supply System

5.7.1 DC power supply system shall include battery bank, charger-cum-rectifier, DC distribution board and cell booster.

5.7.2 The battery charger/rectifier shall feed the load and keep the batteries under fully charged condition. Provision shall also be made for necessary boost charging/initial charging of battery.

5.7.3 The DC system shall have at least 10% spare capacity for future load growth.

5.7.4 Each battery charger and DCDB shall be sized to cater to selected battery capacity.

5.7.5 Each DCDB shall have at least 10% spare feeders with one no of each rating for future use.

5.7.6 Three pole power switch/ isolator outside battery room shall be provided for local isolation of battery during maintenance.

5.7.7 For dual redundant system, each system shall be provided in separate compartment with the common components mounted in another separate compartment, so that it is possible to do maintenance on one system while the other system is in operation.

5.8 Uninterrupted Power Supply System

5.8.1 UPS system shall include battery bank, rectifier transformer, rectifier-cum-charger, inverter, set of filter circuits, static switches, bypass transformer, facility for manual transfer between inverter supply & bypass line, facility for bypassing inverter & static switch for maintenance, AC Distribution board, cell booster and other associated accessories.

5.8.2 Each branch circuit of the UPS distribution system shall have a fused disconnect switch. The fuse shall be fast clearing semiconductor type and the fuse rating shall be co-coordinated with the rating of the UPS system. Normally the largest branch circuit rating shall not exceed 25% of the UPS system rating for feeders without isolation transformer and 10% of the UPS system rating for feeders with isolation transformer.

5.8.3 UPS system shall be sized to have at least 10% spare capacity for future load growth.

5.8.4 Each UPS ACDB shall have at least 10% spare feeders for future use by owner.

5.8.5 Power switch/ isolator outside battery room shall be provided for local isolation of battery during maintenance.

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5.9 Motors

5.9.1 In general, three phase squirrel cage induction motors designed for direct on line starting shall be used. Motors shall be totally enclosed, fan cooled type and suitable for continuous use. Synchronous motors and motors with variable frequency operation shall be designed for special application.

5.9.2 All motors shall be continuous maximum rated with possible exception of crane and hoist motors, soot blowers, turbine/engine starting motors etc. which may be rated for the envisaged duty cycle.

5.9.3 DOL start high voltage motors shall be suitable for starting under specified load conditions with 80% of the rated voltage at the terminals and DOL start medium voltage motors shall be suitable for starting under specified load conditions with 75 % of the rated voltage at the terminals. If required, large rated motor starting shall be through soft starter/ dedicated transformer as per project design data sheet. Voltage available at the motor terminals which are started through dedicated transformer shall be decided considering the speed torque characteristics of the driven equipment and ensuring the voltage dip at the source bus does not exceed the permissible limits as per project design data sheet.

5.9.4 MV Motors shall be energy efficient type having energy efficiency level as specified in project design data sheet.

5.9.5 VFD fed motor shall be suitable for converter duty application.

5.10 HV Capacitor Banks

5.10.1 The capacitor banks shall be supplied with series reactor and RVT (residual voltage transformer). All the capacitor bank equipment except APFC panel shall be suitable for outdoor location unless otherwise specified.

5.10.2 The capacitor bank in conjunction with series reactor shall provide minimum net required kVAR at rated nominal voltage. The insulation system shall be designed to withstand continuous over voltage of 110%.

5.10.3 Capacitor bank rating shall be sized considering the power factor correction requirement. The maximum rating of capacitor bank unit shall be restricted by the available capacitive breaking capacity of feeding switchgear in APFC panel.

5.11 Emergency Generator

5.11.1 The emergency generator set shall be designed to start automatically on power failure and feed the selected loads. It shall be capable of taking care of the load variations including the starting of the largest rated motor with specified base load. However, DG sizing shall not include boost charging loads for UPS and DC system batteries but shall only include float charging and service loads.

5.11.2 The regulation of generator voltage shall be automatic and necessary instruments for metering viz., Ammeter, Voltmeter, frequency meter, kWH meter, power factor meter, hour run counter etc. shall be included in control panel. Warning of abnormal conditions shall be incorporated prior to automatic trip to prevent unnecessary shutdown.

5.11.3 The unit shall be complete with necessary engine starting equipment, associated control panel and shall be suitable for remote starting. Emergency Generator shall have auto-starting

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arrangement but only with manual switching off feature. 'Fail to start' annunciation shall be provided, in case the engine fails to start.

5.11.4 The load shall be automatically switched on to the generator only after the requisite voltage build-up.

5.11.5 The Emergency generator set shall have at least 10% spare capacity for meeting future requirements.

5.11.6 Local line side circuit breaker shall be provided in DG control panel. Further isolation switch shall be provided for generator system neutral if specified in project specification.

5.12 Annunciation Panel

5.12.1 Audio-visual annunciation panels shall be provided, where specified in project design data sheet, to monitor the switchgear and other electrical equipments. In case hardwired panel is not envisaged, audio visual annunciations shall be provided as part of the HMI system.

5.12.2 Detailed annunciation schedule shall be based on but not limited to the following:

a) EHV & HV Switchgear
- Breaker-wise fault trip alarm
- Auto-changeover completed
- Auto-changeover failure
- Trip circuit status for each breaker
- Differential and restricted earth fault relay operation alarm
- Transformer trouble alarm
- DC supply failure alarm (Bus wise)
- PT secondary MCB trip alarm for all line and bus PTs
- Bus wire supervision alarm
- Alarms for SF6 gas system

b) MV Switchgear
- Incomer/ Bus coupler fault trip alarm
- Auto-changeover completed
- Auto-changeover failure
- Bus-wise group fault trip alarm for outgoing feeder breakers
- D.C. supply failure alarm (Bus-wise)
- PT secondary MCB trip alarm for all line and bus PTs

c) Operating status/fault conditions for UPS system.

d) Operating status/fault conditions for DC supply system.

e) Operating status/fault condition for DG sets.

f) Fault alarm for VFD panels

5.12.3 Annunciation panel shall be complete with acknowledge, test and reset pushbuttons. 10% spare windows for future use shall be provided in the panel. Generally, annunciation panel shall be fed from the UPS system/ DC system.

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5.13 Cables and Wires

5.13.1 Unless otherwise specified, EHV cables shall be single core type, copper/ aluminum conductor, XLPE insulated, corrugated Aluminium sheathed, unarmored, FRLS, PVC outer sheathed with overall conductive graphite coating. The exact type & construction of EHV cables shall be as specified in project design data sheet.

5.13.2 HV cables shall be dry cured XLPE insulated, armoured, extruded FRLS PVC outer sheathed with aluminum/copper conductor, as per project design data sheet. All cables rated 3.3 kV and above shall be provided with both conductor screening and insulation screening.

5.13.3 MV power cables shall be PVC/ XLPE insulated, armored/ unarmored, extruded FRLS PVC outer sheathed with aluminum/copper conductor, as per project design data sheet.

5.13.4 The control cables shall be twisted pair, copper conductor, PVC/ XLPE insulated, armoured, extruded FRLS PVC outer sheathed and overall shielded.

5.13.5 The power cables shall be sized based on the maximum continuous load current, the voltage drop during running & start up, system voltage, system earthing and also short circuit withstand criteria if applicable. The derating due to design ambient air temperature, ground temperature, depth of laying, grouping & proximity of cables with each other, thermal resistivity of soil, laying conditions etc. shall be taken into account.

5.13.6 Cables connected in parallel shall be of the same type, size, cross-section and terminations.

5.13.7 All power and control cables shall be in continuous lengths without any splices or intermediate joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals. Unless otherwise agreed, cable joints in hazardous areas shall not be permitted.

5.13.8 All incoming cables to switchgear/UPS/DC system/DBs and other equipment shall be sized for maximum anticipated load including 10% future growth. Cable for capacitor banks shall be sized for 135 % of the rated capacitor current.

5.13.9 The incoming cable for heat tracing power distribution panel shall be with four cores, the neutral conductor being of same size as the phase conductors.

5.13.10 All control cables shall have minimum 10% spare pairs/ cores.

5.13.11 Optical fiber cable (OFC) for data highway of Fire Alarm system, Plant communication system & Electrical control system (ECS) and for feeder differential relay etc. shall be laid in heavy duty flame retardant HDPE duct. The HDPE duct for each service shall be unique color coded as per project design data sheet for ease of identification of service.

5.14 Control Station

5.14.1 Each motor shall be provided with a control station/control panel in the field, unless otherwise agreed upon. Additional emergency stop push button station for air cooler motors, cooling tower motors and other motors located at higher elevations shall be provided at grade level. Further, emergency stop control station for transformers in transformer bay and at intermediate levels for conveyers shall also be provided. If specified, emergency open/ close control station located outside dyke wall for tank body MOVs shall be provided.

5.14.2 The control station shall include the following equipment as per individual requirement:

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- Start/stop push button
- Ammeter (as applicable)
- Local/ Off/ Remote selector switch (if specified)
- Speed lower/ raise switch, speed indication (for VFD motors, if specified)

5.14.3 Stop push button shall generally have stay put feature except in the case of critical drives such as lube oil pump etc.

5.15 Convenience Receptacles

5.15.1 These shall have the necessary mechanical interlocks and earthing facilities. The enclosure shall have suitable protection for site conditions specified (flame proof, weather proof, dust proof, corrosion resistant, etc.).

5.15.2 Adequate number of welding receptacles shall be provided at suitable locations to ensure accessibility with a 50 m length of trailing cable to any point in the process area and in substations & control rooms. These shall be rated for 63A suitable for 415V, 3 phase system with a scraping earth.

5.15.3 Adequate number of three-pin sockets for lamps and portable tools shall be provided at suitable locations to ensure accessibility with a 15 m length of cable to all manholes of process equipments, other important areas in the process units and in substation, control rooms and other buildings. These shall be rated for 15A, 240 V single phase with earth connection. Hand lamps and portable tools shall be earthed through flexible cords. In hazardous areas, flameproof hand lamps shall be rated for 24V.

5.15.4 If specified in project specification, dedicated 415V TPN load break switches/ receptacles shall be provided in the process units at suitable locations and elevations for feeding loads during shut down & maintenance activities.

5.16 Actuators for Motor Operated Valve

5.16.1 MOVs shall be provided with integral starters. MOV actuators shall be non- intrusive type unless specified otherwise. The necessary local/remote selector switch, open/ close control switches or push buttons, torque limit switches etc. shall be provided on actuator for local/remote control depending on the mode of selection. In case of failure of torque limit switches, the mechanical design shall be adequate to stall and trip the motor without damage.

5.16.2 The type of MOV control i.e. conventional type or 2 wire control or compatible with instrumentation field bus, etc. shall be as per instrumentation design basis.

5.17 EHV System

The EHV power supply arrangement shall be provided with either conventional switchyard having CT, VT, disconnector, circuit breaker, lighting arrestor, etc. located in outdoor fenced area or Gas Insulated Switchgear (GIS). The GIS panels shall be located indoor inside the substation building however, outdoor GIS can also be provided as per project specific requirement.

5.18 Variable Frequency Drive

5.18.1 VFD shall be provided with bypass as a standard practice, unless prohibited due to process requirement. In exceptional cases, wherein DOL starting of motor is not possible due to power system limitations, bypass complete with soft starter or no bypass can be considered as specified in project specification.

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5.18.2 Control supply to VFD shall be provided from either DC system or UPS system, as specified in project design data sheet.

5.18.3 VFD sizing shall be done to take care of voltage variation in the incoming power supply, voltage drop inside VFD module & equipment and voltage drop in outgoing cables to motor. Further minimum fault level of the incoming power supply shall be considering for harmonics analysis and sizing of associated components.

5.19 Generator

5.19.1 Generators shall be installed in Non-Hazardous area and shall be installed close to their step up transformer if provided. Further generator cooling system shall be independent of its acoustic enclosure ventilation system.

5.19.2 The generator rated power factor shall be 0.8 lagging, unless otherwise specified.

5.19.3 Bus ducts, if provided for connection between generator and transformer shall be phase segregated or phase isolated type to minimize the possibility of short circuits.

5.19.4 Generators shall be provided with its own MV auxiliary switchboard to cater its motor driven auxiliaries & other loads.

5.19.5 Generators shall be provided with necessary controls & protection devices for synchronizing, voltage control system suitable for island & parallel operation, reactive power control system to control generator power factor, devices to protect the generator & its prime mover and other features as specified in project design data sheet.

5.19.6 The synchronizing controls shall preferably be located from where control of voltage and frequency of generating system can be exercised.

6.0 SUBSTATION / MCC ROOM DESIGN PHILOSOPHY

6.1 The sub-stations shall be located in a safe area close to the load center. Proper access shall be provided/ ensured for operation/ maintenance of indoor and outdoor equipment.

6.2 EHV and HV sub-station switchgear floor shall be raised above grade level and the space below the switchgear room shall be utilized as cable cellar. The cable cellar floor shall be at least 300 mm above the approach road level and shall be paved and cemented. The cable cellar shall have a minimum clear height of 3.5 m and shall house all cable trays & their supports. Further, the cable cellar height of sub-station housing EHV GIS panels may be increased beyond 3.5 m as required to facilitate bending and termination of EHV cables.

6.3 The substation switchgear floor shall have a minimum clear height of 4.5 m. For switchgear floor provided with false ceiling, the minimum clear height below false ceiling shall be 4.5 m. Further, for switchgear floor without false ceiling, the clear height may be increased beyond 4.5 m, as required to accommodate bus duct, air conditioning duct/ pressurization duct etc.

6.4 MV sub-stations and MCC rooms shall be elevated by compacting the soil so that

- The finished floor level shall be above the approach road level to the building.
- The finished floor level shall be minimum 1000 mm above the surrounding grade level.
- The bottom of the cable trench within sub-station is minimum 150 mm above the surrounding grade level.

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6.5 In addition to the entry to substation for operating personnel, a separate entry of minimum 3m (W) x 3.5m (H) with rolling shutter shall be provided for drawing in all equipment for installation. The main entry for operating personnel for pressurized and air conditioning substations shall be provided with double door system with an airlock lobby. The Sub-station shall also have an emergency door opening outwards.

6.6 Sub-station wall adjacent to the transformer bays and walls separating transformers shall be 355 mm thick (inclusive of plastering) in case of brick construction or 230 mm thick in case of RCC construction.

6.7 Sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization, unless otherwise specified.

6.8 Battery banks shall be located in a separate adequately ventilated room in the sub-station building, along with the necessary exhaust system and water connection with sink. Floor of the battery room and walls up to 1.5 m height shall have acid/alkaline resistant protective epoxy coating. Separate battery room may not be required for VRLA batteries, as the VRLA battery stack can be located in the air-conditioned room housing chargers and UPS systems. The battery room shall be provided with minimum two exhaust fans (flameproof, gas group IIC) and louvered opening in opposite wall/door.

6.9 UPS system and other electronics equipment e.g. Data concentrator, Substation Automation System, ECS, HMI, RTCC, variable frequency drive panels, soft starter panels, battery chargers, thyristor heater control panels, control & relay panels, excitation panel, digital voltage regulator panels, etc. shall be located in air-conditioned area, unless otherwise specified in project design data sheet.

6.10 Sub-station shall have fire extinguishers, first aid boxes and other safety equipment as per statutory requirements. Insulating mats of required voltage rating shall be provided in front and rear of switchboards and GIS panels. Further illuminated Single line diagrams depicting power supply arrangement of the sub-station shall be provided in the switchgear room.

6.11 Separation walls between transformers in all substations and safe inter transformer distances for switchyard transformers shall be as per OISD-STD-173. Fire protection for transformers and switchgear room shall be provided to comply with requirements of OISD-STD-116, 117 and 173.

6.12 Equipment like transformers, neutral grounding resistors, reactors and HV capacitor banks shall be located in outdoor bays adjacent to the sub-station building. The requirement of roof for bays shall be as defined in project design data sheet. All bays shall have well drained floor, surfaced with gravel or other suitable material.

6.13 In order to prevent oil, whether from a small leakage or outflow from transformer tank, from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer -

6.13.1 Oil Capacity upto 2,000 litres:

Transformers installed adjacent to sub-station/buildings or in Switchyards shall be provided with a layer of 100 mm deep stones of about 40 mm granulation, all around the transformer, for a width of 20% of the transformer height subject to minimum width of 800 mm. However complete transformer bay/ fenced area shall be provided with stone gravels.

6.13.2 Oil Capacity exceeding 2,000 litres:

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Transformers installed adjacent to sub-station/building or in Switchyards shall be provided with oil containing pits. Also Nitrogen Injection Fire Protection System (NIFPS) shall be provided for transformers, unless otherwise specified.

The oil containing pit may be shaped as per OISD STD-173. The pit shall extend all around the transformer for a width of 20% of the transformer height, with a minimum width of about 800 mm around the transformer tank/radiator. In case oil capacity exceeds 9,000 litres, in any chamber, provision shall be made for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.

6.14 NIFPS control panel shall not be kept in the same bay as of transformer, which is being protected by that panel. Piping from transformer to panel shall not block/ obstruct free movement.

6.15 The substation building shall be sized to maintain adequate clearances between equipment for ease of maintenance. The following minimum clearances around various equipment shall be maintained:

Sl. No.	Location	Clearance
a)	Front clearance for HV switchboard including HV GIS	2000 mm
b)	Front clearance for various switch boards/panels	1500 mm
c)	Clearance between front to front of two switchboards facing each other	2000 mm
d)	Rear clearance for panels having maintenance access from front only	Less than 200 mm or more than 750 mm
e)	Rear clearance for panels requiring maintenance from rear	1500 mm (HV swbd) & 1000 mm (MV swbd)
f)	Side clearance between two switch boards or from nearest obstruction	1000 mm after considering space for future panels as per cl. 6.16
g)	All around clearance for transformers	1000 mm
h)	All around clearance for NGR	1000 mm on two sides, 200 mm on other two sides
i)	All around clearance for capacitor bank/ series reactor	1000 mm
j)	Battery rack to wall clearance for - Single row, single/double tier - Double row, single tier - Double row, double tier - Multistep racks	 100 mm 100 mm 750 mm 750 mm
k)	Battery rack to rack clearance	750 mm
l)	Head room clearance below bus ducts or any other overhead equipment	2000 mm
m)	Front clearance for wall mounted equipment	1000 mm
n)	Front clearance for operation work station/ annunciation/ control panel/ HMI	2000 mm

Clear vertical clearance above the top of the highest equipment shall be minimum 1000 mm measured from the bottom of the lowest roof beam. However for the areas with false ceiling, minimum clearance of 750 mm shall be provided between false ceiling and top of any equipment.

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For EHV GIS, minimum all around clearance and vertical clearance shall be as per manufacturer recommendation.

6.16 In all Substations/ MCC rooms, space for future extension of switchboards shall be provided. One panel extension space on each side (for each Bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all GIS, HV Switchboards, PCCs, MCCs, ASBs and LDBs. In addition, space for future extension of the substation/ MCC room building shall be considered, as specified in project design data sheet.

6.17 Necessary arrangement shall be provided in switchgear room for routing of pressure relief duct of switchboard, if provided, after co-ordination with pressurization/ air conditioning ducts/ bus ducts, in case the exhaust gases are required to be released outside substation building as per manufacturer's design. In case gases can be released inside switchgear room as per manufacturer design, absorber shall be provided at the end of pressure relief duct.

6.18 The DG sets shall be preferably located in a separate building other than the substation, in a safe area to reduce noise level in substation. However in case the same is located in the substation building, the DG set foundation shall be structurally delinked from the slab/floor of the rest of the substation building. Exhaust of diesel engine shall be kept away from the process/hydrocarbon handling areas and diesel day tanks shall be located outside the DG room. Suitable ventilation system shall be provided to avoid heat accumulation in the DG room.

6.19 Fire protection for transformers and substation shall be provided to comply to requirements of OISD-STD-173.

6.20 Exhaust fans shall be provided in the cable cellar for ventilation. However, fire integrity of wall between transformer bays and cable cellar/ switchgear hall shall not be compromised.

6.21 Overhead EOT crane of required capacity shall be provided in switchgear hall housing EHV GIS panels. However where EHV GIS isolating breaker panels are only envisaged, monorail arrangement can be considered in-lieu of EOT crane, if specifically agreed upon.

7.0 INSTALLATION DESIGN PHILOSOPHY

7.1 General

The installation work for equipments, cabling system, earthing system and lighting system shall generally conform to EIL standard specifications and installation standards.

7.2 Cabling System

7.2.1 Cabling system for various areas shall be as specified in Project design data sheet.

7.2.2 The cable trenches shall be sized depending upon the number and voltage grade of cables. The cable trenches in hazardous areas and in transformer bays/ substation cellar shall be filled up with sand/ stone dust. Where underground cables cross road ways, pipe sleepers at grade etc. they shall be protected by being drawn through sleeves/ culvert to provide a permanent crossing.

7.2.3 RCC cable trenches shall be sealed against ingress of liquid and gases wherever the trenches leave or enter a control room or substation. Pipes laid for mechanical protection shall be sealed at both ends. In case of direct burial, cable route markers shall be installed at 30 m interval all along the cable routes and where the direction of cable trench changes.

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Additionally, markers shall be provided at cable straight through joint locations. In cable trenches, earthing conductor shall also be installed and shall be regularly bonded to the earthing system.

7.2.4 Above ground cables shall be well supported on cable trays and suitably protected against mechanical damage. Routing shall be decided to avoid interference with hot surfaces or places subject to undue fire risk. Requirement of walkway for cable trays on overhead piperack shall be as specified in project design data sheet.

7.2.5 Cable trays, racks and trenches shall be sized to allow for 10 % space for future cables. Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer. Separate trays shall be provided for EHV cables, HV Cables, MV power cables, MV control cables and plant communication cables to the possible extent. However, where specifically agreed upon in exceptional cases, HV and MV power, control cables may be laid together, with a barrier plate separating HV and MV cables. EHV, HV and MV power cables shall be laid in single layer on cable trays. MV power cables can be laid in maximum two layers in case of space constraint, if specifically agreed upon.

7.2.6 For EHV cables, the radius of cable trays bends and vertical distance between cable trays shall be finalized based on EHV cable sizes & laying requirements.

7.2.7 Separate cables shall be provided for AC and DC signal/control circuits, except for cables to Local control stations/ local control panels/ MOVs. Separate control cables shall be provided for status and command signals to ensure that mixing of two separate voltage sources shall not occur in a multi core cable.

7.2.8 Cables connected in parallel shall run together so that their length remains the same.

7.2.9 Type of cable tray and accessories shall be as specified in project design data sheet. For tray system design, in addition to self load and wind forces, following guidelines for design shall be considered.

a) Maximum Support span : 3000 mm

b) Cable load for

i.	150 mm wide cable tray	:	30 kg/linear meter
ii.	300 mm wide cable tray	:	60 kg/linear meter
iii.	600 mm wide cable tray	:	75 kg/linear meter
iv.	750 mm wide cable tray	:	75 kg/linear meter.

c) In addition to this, 70 kg concentrated load at center span shall be considered. All structural steel design shall be as per Indian Standards.

7.2.10 Bends, tees, reducers, crosses, droppers etc. shall have the required bending radii as required for various cable sizes.

7.2.11 All cables shall carry the cable tag numbers for easy identification.

7.2.12 Signal cables i.e. Instrumentation, communication, fire alarm, LAN and data highway, etc. shall preferably not be laid in the same trench/ tray along with electrical cables. In case these are laid in the same trench/ tray, a clearance of minimum 300 mm from electrical cables shall be provided. The overall cable layouts shall be designed for minimum interference between signal and power cables.

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7.2.13 For single core cables rated 33 kV and above, the armour and metallic screen shall have either single point bonding or cross bonding scheme. Both side bonding scheme shall not be considered due to reduction in cable current carrying capacity. The screen bonding scheme for complete cable route shall be finalized considering link boxes with/ without SVL as per screen/ sheath voltage calculation. Single core cables laid in trefoil formation, shall be braced with non-magnetic clamps suitable to withstand short circuit dynamic forces.

7.2.14 Cable tray covers shall be provided for top most cable trays and for the outermost tray of vertical droppers. Further, bottom cable tray covers shall be provided for cable trays crossing above hydrocarbon pipelines.

7.2.15 All above ground cable tray entries into buildings shall be properly sealed.

7.2.16 Fire proofing paint on cables shall be provided near end terminations of cables upto 1 meter.

7.2.17 Ariel Bunched Cables, wherever used, shall be erected with the minimum clear height of 6.0 m on roads with vehicular traffic and 3.5 m on roads where vehicular traffic is prohibited. These shall not pose any restriction for movement of ODC consignment, cranes and construction work.

7.3 Earthing and Lightning Protection System

7.3.1 All electrical equipment shall be suitably earthed. Earthing system shall, in general cover the following:

- Equipment earthing for personnel safety.
- System neutral earthing.
- Protection against Static and Lightning discharges.
- Separate clean earth system for Instrumentation, DCS, ECS etc. as per vendor specified requirements.

7.3.2 Plant earthing design shall generally be carried out in accordance with the requirements of CEA regulations and IS: 3043. The earthing system shall have an earthing network with required number of earth electrodes connected to it. The following shall be earthed:

- System neutral
- Current and potential transformer secondary neutral.
- Metallic non-current carrying parts of all electrical apparatus such as transformers, switchgears, motors, lighting / power panels, terminal boxes, control stations, lighting fixtures, receptacles, feeder pillars, NGT/ NGR Panels, etc.
- Steel structures, loading platform etc.
- Cable trays and racks, lighting mast and poles.
- Storage tanks, spheres, vessels, columns and all other process equipment.
- Electrical equipment fencing (e.g. switchyard, compact substation etc.)
- Cable shields and armour.
- Flexible earth provision for wagon, truck.
- Driven equipment handling Hydrocarbon if its base Plate is separate from motor base plate.
- Turbo driven equipment handling hydrocarbon.

7.3.3 Unless adequately connected to earth elsewhere, all utility and process pipelines should be bonded to a common conductor by means of earth bars or pipe clamps and connected to the earthing system at a point where the pipelines enter or leave the hazardous area except where conflicting with the requirements of cathodic protection.

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7.3.4 Lightning protection system for buildings shall be provided in accordance with IEC 62305 to protect structures from fire or mechanical destruction. External lightning protection comprising of air termination for intercepting lighting strikes, down conductors to safely conduct lightning current to ground and earth terminations to distribute lightning current in the ground shall be provided.

7.3.5 Lightning protection of storage tanks handling flammable liquids including floating roof tanks shall be done in accordance with OISD-GDN-180 and API-RP-545 complete with bypass conductors, shunts and accessories, etc. Self-conducting structures having metal thickness of more than 4.8 mm may not require air termination and down conductor, but shall be connected to earthing system, in line with OISD-GDN-180.

7.3.6 The resistance values of an earthing system to the general mass of earth should be as below:

- For the electrical system and equipment a value that ensures the operation of the protective device in the electrical circuit but not in excess of 4 Ohms. However, for the generating stations and large sub stations, this value shall not be more than 1 Ohm.
- 10 Ohms in the case of all non-current carrying metallic parts of major electric apparatus or any metallic object.
- For lightning protection, the value of 4 ohms as earth resistance shall be desirable but in no case it shall be more than 10 ohms.
- Earthing of Tanks shall comply to OISD-STD-173, API-RP-545. Earth resistance value for storage tanks shall not exceed 7 Ohms.
- All joints in pipelines, valves, plants, storage tanks and associated facilities and equipment for petroleum shall be made electrically continuous by bonding or otherwise; the resistance value between each joint shall not exceed 1 Ohm.
- Earth resistance of individual electrode to general mass of earth shall not exceed 2 Ohms in line with OISD-STD-137.

7.3.7 Earth rods and conductors shall be designed to cope with the conditions imposed. The earth conductor shall be adequately sized to carry the applicable maximum earth fault current without undue temperature rise. All joints shall be protected against corrosion.

7.3.8 All the electrical equipment operating above 250 volts shall have two separate and distinct connections to earth grid. Transformers, including lighting transformers shall be provided with two dedicated earth electrodes for earthing of neutral and transformer tank earthing.

7.3.9 All earth connections shall be visible for inspection to the extent possible. In all cases, connection to earth should be made in accordance with IS: 3043.

7.3.10 The main earthing network shall be used for earthing of equipment to protect it against static electricity. The lightning protection system shall be bonded with the main earthing network below ground, minimum at two points.

7.3.11 An approach for removing fire or explosion danger is to provide means for adequate dissipation and prevention of accumulation of static electricity, thereby ensuring that static discharges do not occur. One of the methods to eliminate risk of static electricity build up is earthing and bonding.
The subject of static accumulation caused by flow of petroleum products and the mitigation methods are dealt in detail in OISD-STD-110 and same shall be followed.

7.3.12 The earthing system shall comprise of earth conductors, earthing clamps, earth plates, earth electrodes in test pit etc. Normally earthing system shall have main earth grid alongwith suitably located disconnecting plates to provide multiple earth connections between earth grid & equipment and for connections between main earth grid & earth electrodes in test pit.

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All connections shall be adequately secured against loosening.

Connections between earth electrode and the disconnecting plates shall be done by GI strip. Connection between the disconnecting plate and various equipments shall be done by GI strip, GI wire or GI wire rope or cable as specified in project design data sheet.

7.4 Lighting System

7.4.1 Plant lighting system shall comprise:

a) Normal lighting
b) Emergency lighting
c) Critical lighting.

Normal and emergency lighting shall be fed by AC supply (415/240V, three phase four wire except in case of Mines and Oil fields where it shall be in line with Chapter IX of CEA regulations and statutory requirements) while critical lighting shall be fed by DC supply. Additional precautions as per Chapter IX of CEA regulations to be adopted in mines and oil fields shall not apply to apparatus above the ground level except where such apparatus may directly affect the safety of the persons employed in underground mines, open cast mines and oil fields.

7.4.2 All emergency and DC critical lighting fixtures and associated Junction Boxes in Hazardous areas shall be Flameproof type.

7.4.3 Normal lighting system shall provide enough illumination so as to enable plant operators to move safely within the accessible areas of plant to perform routine operation including reading of field instruments, operation of all valves etc. and to carry out all the necessary maintenance and adjustment to equipment.

7.4.4 Areas requiring AC emergency lighting shall include, but not be limited to, the following:

- All Areas requiring DC critical lighting.
- Strategic locations in process, utility areas where specific safety/shutdown operation are to be carried out.

Generally 20-25 % of the total lighting fixtures shall be fed from AC emergency supply.

7.4.5 Areas requiring DC critical lighting shall include, but not be limited to, the following:

- Control rooms
- Substations
- DG shed
- Central fire station
- Fire water pump house
- Compressor houses
- First aid center
- Emergency escape routes
- Non plant buildings as specified in project design data sheet.

DC critical lighting shall be provided in the pipe rack, exit/entry point only in case considered for process units

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Adequate number of self contained portable hand lamps and battery operated emergency lighting units shall be provided for immediate use for buildings where no DC supply is available.

7.4.6 During normal operation, both emergency and normal lighting shall be fed by normal power source. On failure of normal supply, emergency lighting load shall be transferred to emergency power supply source. Critical (DC) lighting shall be normally kept 'ON' and during failure of AC power; battery bank shall feed the critical lighting system.

7.4.7 Complete lighting shall be through LED lamps only, unless specified otherwise. Accordingly, LED lamp fixtures shall be provided for all types of lighting i.e. AC & DC lighting, indoor & outdoor lighting, hazardous area lighting, building lighting, decorative fixtures, street lighting, high mast lighting, etc. The chemical handling facilities shall be provided with chemical resistant fixtures.

7.4.8 Tall structures shall have aviation obstruction marker lighting as per DGCA civil aviation statutory regulations, Type C Medium intensity lighting fixtures, i.e. Red, fixed (not flashing), 2000cd.

7.4.9 Telescopic tubular high masts shall be provided for illumination of tank farm/general area. Generally street lighting poles may be avoided where lighting high masts can provide adequate illumination. The high masts shall be of continuously tapered polygonal cross section and fabricated out of steel plates. The masts shall be provided with motorized racking mechanism for lowering and hoisting lantern carriage.

7.4.10 Lighting system shall consist of lighting transformers, lighting distribution boards (LDBs), lighting and power panels, lighting fixtures, junction boxes etc. as required. All outdoor lighting shall be automatically controlled by means of photoelectric cell/synchronous timers with manual overriding control as specified. Lighting and power panels shall be fed from LDB through 415/415V, Dyn-11, dry type lighting transformer having taps up to +5%/ -7.5% (Refer clause 7.4.1 above for mine and Oil fields installations).

7.4.11 The lighting and power panels shall be provided with MCB & ELCB as incomer and Miniature Circuits Breakers (MCBs) for outgoing feeders control & protection of lighting circuits. ELCB may not be provided at the incomer of lighting and power panels, in case ELCB is provided in the outgoing feeders of LDBs/ASBs feeding to these lighting and power panels. MCBs shall not be loaded beyond 80% of rated capacity. A minimum of 20% of miniature circuit breakers of each panel shall be left as spares. In general, the load on each circuit shall be limited to 1.5 kW and MCB rating shall not be more than 16A. In areas having less lighting load, lighting transformer can be avoided subject to meeting the fault level rating at lighting panels within permissible limits, if specifically agreed upon

7.4.12 **Lighting Lux Levels**

Lighting system design shall be based on minimum illumination levels as specified below:

S NO.	AREA	LUX
a)	Main roads (along process units, power houses, workshops, etc.)	7-10
b)	Secondary roads (along storage tanks, settling basins, etc.)	3-5
c)	Tank farm	10
d)	Pump houses, Sheds	100
e)	Main operation platforms & access stairs	60
f)	Ordinary platforms	20
g)	Process areas, pipe racks, heat exchanger, heater, separators,	60

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	cooling tower, columns, pig launching/ receiving loading area, flare etc.	
h)	Switchgear room, Rack room	150-200
i)	Cable cellar	70
j)	Transformer bay	100
k)	Battery room	150
l)	Control room (Console Area), Laboratory	400
m)	Boiler house	150
n)	Charger/ UPS rooms	150-200
o)	Cooling Tower	60
p)	Switchyard	
	Operating area	100
	Other areas	50
q)	Warehouse	100
r)	Office, Operator Room	300
s)	Compressor operating area	200
t)	Watch room	100
u)	Stairs	50
v)	Corridors/ lifts	70
w)	Tube well, Gate & watchman booth	100
x)	Fire house, Garage	100-150

However, lighting levels in all areas shall take into consideration the requirements from point of view of safety, ease of operation and maintenance.

7.4.13 Lighting design shall conform to relevant Indian and International Codes and Standards, IES Hand Book and shall take into consideration the requirements from point of view of safety and ease in operation and maintenance. Maintenance factor (Light Loss Factor) shall be calculated considering lamp lumen maintenance factor, lamp survival factor and luminaire maintenance factor. Utilization factor (coefficient of utilization) shall be calculated considering reflectance from ceiling, wall and floor in case of indoor lighting and from nearby equipment/ structure in case of plant lighting. Maintenance factor shall not be more than 0.65 for indoor lighting and shall not be more than 0.6 for outdoor lighting. Utilization factor shall not be more than 0.8, however depends on light reflecting property of the material. Further, for dusty areas, maintenance factor as per relevant codes and standards shall be considered.

7.4.14 Wiring for lighting and convenience outlets in outdoor areas shall be carried out with PVC/ XLPE insulated armored FRLS cables run along the column/platforms and structures. Double compression cable glands required for terminating of armoured cables in lighting fixtures and junction boxes in hazardous areas shall meet the requirements of IS/IEC 60079-0. For outdoor/ indoor safe area equipment, double/single compression cable glands shall be used respectively.

7.4.15 Adequate number of ceiling fan points shall be provided in Administration Building, Offices, rooms allocated for operating and maintenance personnel etc.

7.4.16 Two pole isolation devices shall be used for controlling lighting fixtures and sockets in hazardous areas to isolate phase as well as neutral. (For all Mine and Oil field installations refer clause 7.4.1 above).

7.4.17 For buildings with false ceiling, concealed conduit wiring shall be employed below the false ceiling and surface conduit wiring above the false ceiling. Metsec channel shall be used above false ceiling for lighting circuit wiring in Sub-stations and control rooms.

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7.4.18 Adequate number of pull boxes shall be used to aid wire pulling and inspection. No joints shall be allowed inside these pull boxes.

7.4.19 Battery room shall have lighting fixtures mounted on wall in order to facilitate easy replacement of lamps. Switches controlling the lighting fixtures and exhaust fans shall be installed outside the battery room. Lighting fixtures, sockets and exhaust fans in battery room shall be flameproof type suitable for gas group IIC.

7.4.20 Locally mounted lighting fixtures on platforms, walkways, stairs shall be installed in such a way that maintenance can be done without the use of ladders.

7.4.21 Telephone wiring/ sockets and LAN wiring/ sockets (as required) shall be provided in plant and non plant buildings/ rooms which are normally manned during operation and maintenance of the plant.

7.4.22 LED solar lighting system shall be provided for street lighting purpose, if specified in project design data sheet.

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STANDARD SPECIFICATION FOR INSTRUMENT TUBE FITTINGS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	30.12.24	Revised and Reissued as Standard Specification	TNK	AJS	MN	MN
6	05.09.19	Reaffirmed and Re-issued	JJ	AJS	RG	RKT
5	06.06.14	Revised and Reissued as Standard Specification	JJ	MN	RG	SC
4	09.11.10	Revised and Reissued as Standard Specification	CS	RP	TGM/JMS	ND
3	03.05.05	Revised and Reissued as Standard Specification	RG	HCJ	PM	VJN

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Abbreviations:

HRB	:	Rockwell Hardness - Scale B
NPT	:	National Pipe Thread

Instrumentation Standards Committee

Convenor	:	Mr. Mainak Nandi
Members	:	Mr. Arupjyoti Saikia
		Mr. Sachin Garg
		Ms. Rimpa Saha Chakraborty
		Mr. Ankit Tiwari
		Mr. Gaurav Kumar
		Mr. Bharath Chandrasekar
		Mr. Ravindra Kumar Gupta (Projects)

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ANNEXURE – 1 : HYDROSTATIC TEST PRESSURES FOR INSTRUMENT TUBE FITTINGS

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1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the requirements for the design, materials, inspection, testing and shipping of instrument tube fittings which includes the following types:

a) Stainless steel compression fittings (for stainless steel tube)
b) Brass compression fittings (for copper tube)

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions unless otherwise specified : -

ASME	American Society of Mechanical Engineers	
	B 1.20.1	Pipe Threads General Purpose (Inch).
	B 16.11	Forged Fittings – Socket-Welding and Threaded.
	B 16.5	Pipe Flanges and Flanged Fittings.
ASTM	American Society for Testing and Materials	
	F 1387	Standard Specification for Performance of Piping and Tubing Mechanically Attached Fittings.
EN	European Standards	
	10204	Inspection Documents For Metallic Products.
IS	Indian Standards	
	319	Specifications for Free Cutting Leaded Brass Bars, Rods and Sections.
ISA	International Society of Automation.	
	RP 42.00.01	Nomenclature for Instrument Tube Fittings.
NACE	National Association for Corrosion Engineers.	
	MR 0175	Petroleum and natural gas industries – Materials for use in H2S-containing Environments in oil and gas production.

1.1.3 In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached along with the Material Requisition.

1.2.2 All documentation submitted by vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals etc., shall be in English language only.

2.0 DESIGN AND CONSTRUCTION

2.1 Stainless Steel Tube Fittings

2.1.1 Nomenclature of all tube fittings shall be as per ISA RP 42.00.01.

2.1.2 Fittings shall be of flare less compression type having four-piece (for double compression type) construction consisting of two ferrules, nut and body or three piece (for single

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compression type) construction consisting of single ferrule, nut and body suitable for use on tubes of specified material for example stainless steel tubes conforming to ASTM A269 TP 316L with hardness in the range of HRB 70 to 79.

2.1.3 All parts of the tube fittings shall be of 316 Stainless Steel unless specified otherwise.

2.1.4 The ferrule hardness shall not be less than HRB-90.

2.1.5 Nuts and ferrules of a particular size shall be interchangeable for each type.

2.1.6 Spanner hold shall be metric.

2.1.7 Threaded ends of fittings shall be NPT as per ASME B 1.20.1.

2.1.8 Specific techniques like silver plating shall be used over threading in order to avoid jamming and galling.

2.1.9 Ferrule finish and fitting finish shall be such that there is no abrasion/galling when the nut is tightened.

2.1.10 All instrument tube fittings in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride. End connection shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2 Copper Tube Fittings

2.2.1 Nomenclature of all tube fittings shall be as per ISA RP 42.00.01.

2.2.2 Fittings shall be of flare less compression type and of three-piece construction consisting of ferrule, nut and body suitable for use on copper tubes conforming to ASTM B68 /B68M, hardness not exceeding HRB 50.

2.2.3 All parts shall be manufactured from brass as per IS 319 bar stock and nickel plated.

2.2.4 For better grip, vendor shall maintain hardness difference between tube and ferrule and indicate the same along with the offer.

2.2.5 Threaded ends of fittings shall be NPT as per ASME B 1.20.1.

2.2.6 Spanner hold shall be metric.

3.0 NAMEPLATE

No separate nameplates are required on the fittings. However, manufacturer's name/trademark should be punched on a visible place on the body of each fitting for easy identification.

4.0 INSPECTION AND TESTING

4.1 Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan and approved quality documents. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

4.2 The fittings should qualify all the standard qualification tests mentioned in ASTM F 1387. Supplementary test requirement shall apply only when particularly specified in requisition.

5.0 SHIPPING

5.1 All threads/ends shall be protected with plastic caps to prevent damage/entry of foreign matter.

5.2 All the fittings in oxygen and chlorine service shall be separately packed along with a certificate indicating 'SUITABLE FOR OXYGEN/CHLORINE SERVICE', as applicable.

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6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.

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Sr. No.	Size of Tube Fittings	Material	Line Pressure Class	Maximum Working Pressure	Hydrostatic Test Pressure
1	6mm, ¼" ,12 mm and ½"	Stainless Steel SS 316	≤ Class 600	102 Kg/cm^{2}g	153 Kg/cm^{2}g
2	6mm, ¼" ,12 mm and ½"	Stainless Steel SS 316	≥ Class 900 to ≤ Class 1500	253 Kg/cm^{2}g	383 Kg/cm^{2}g
3	¼", 3/8" and 10 mm [for steam tracing application]	Brass	≤ Class 300	53 Kg/cm^{2}g	80 Kg/cm^{2}g

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इंस्ट्रूमेंट ट्युबिंग के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR INSTRUMENT TUBING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	21.12.20	Revised and Reissued as Standard Specification	RRS	KS	MN	SM
4	26.02.16	Revised and Reissued as Standard Specification	PR	MA	RG	SC
3	14.12.10	Revised and Reissued as Standard Specification	SMK	RG	TGM/JMS	ND
2	03.05.05	Revised and Reissued as Standard Specification	RG	HCJ	PM	VJN
1	01.11.96	Revised and Reissued as Standard Specification	RK	BRS	RB	AS

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Abbreviations:

HRB	:	Rockwell Hardness - Scale B
OD	:	Outer Diameter
PVC	:	Polyvinyl Chloride

Instrumentation Standards Committee

Convener: Mr. Mainak Nandi

Members:
Mr. Arupjyoti Saikia
Mr. Sachin Garg
Mr. Jerry Johnson
Mr. Mayank Kaushik
Mr. Sourav Mukharjee
Ms. K. Pratheepa
Mr. R.K. Gupta(Proj.)

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ANNEXURE – 1: MAXIMUM WORKING PRESSURE AND HYDROSTATIC TEST PRESSURES FOR INSTRUMENT TUBING

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1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets, covers the requirements for the design, materials, inspection, testing and shipping of Instrument Tubing which includes the following types: -

a) Stainless steel tubes

b) Copper tubes

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the date of purchaser's enquiry;

ASTM American Society for Testing and Materials.

A269/A269M	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
A632	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service
B 251	Standard Specification for general requirements for wrought seamless copper and copper alloy tube.
B 251M	Standard Specification for general requirements for wrought seamless copper and copper alloy tube (Metric)
B 68/B 68M	Standard Specification for seamless copper tube, bright annealed.
E 243	Standard Practice for Electromagnetic (Eddy – Current) Examination of Copper and Copper – Alloy Tubes

EN European Standards

10204	Inspection Documents for Metallic Products

1.1.3 In the event of any conflict between this standard specification, job specification/data sheets, statutory regulations, related standards, codes etc. the following order of priority shall govern:

a) Statutory regulations

b) Job specification

c) Standard specification

d) Codes and standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 All documentation submitted by the vendor including their quotation, drawings, installation and maintenance manuals shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets attached with requisition. The required number of prints and soft copies shall be dispatched to the address mentioned adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data by the vendor shall be submitted by vendor after placement of purchase order, as per vendor data requirements and shall include the following as a minimum:

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a) Specification sheet for each type of tube.

b) Copy of test certificates of all tests indicated in clause 4.0 of this specification.

2.0 DESIGN AND CONSTRUCTION

2.1 Stainless Steel Tubes

2.1.1 The tubes shall be 316L Stainless Steel fully annealed, seamless and cold drawn as per ASTM A 269/A269M.

2.1.2 The hardness of the tubes shall be limited to HRB 70-80. Equivalent hardness as Rockwell superficial scale (30T/15T) or Vicker's hardness scale shall also be acceptable.

2.1.3 Tubes shall have good surface finish and shall be free from scratches burrs etc. and suitable for bending.

2.1.4 Tubes shall have Molybdenum content of minimum 2.5%.

2.1.5 Tubes shall preferably be supplied in length of 4 to 7 metres without welding in between. Tube length less than 4 meters shall be rejected.

2.1.6 All tubes in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride and tube ends shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2 Copper Tubes

2.2.1 Copper Tubes (PVC Jacketed)

a) The tube shall be soft annealed copper with 6mm OD and a wall thickness of 1.0mm as per ASTM B68/B68M copper No. C12200.

b) The tube shall be jacketed with black PVC. The jacket thickness shall be 1.6mm. The PVC jacket shall confirm to ASTM D-1047.

c) The tube shall be continuous length without any brazing in between.

d) The length of single tube shall preferably be 100 metres. However any tube length less than 25 meters shall be rejected unless specifically required otherwise in job specification.

e) The dimensional tolerances shall be as per ASTM B 251/B251M.

2.2.2 Bare Copper Tubes (For Steam Tracing)

a) The tube shall be soft annealed copper with 3/8" (10mm) OD with wall thickness of 0.049" or 1/4" (6mm) OD with wall thickness of 1.0mm as per ASTM B68/B68M copper No. C12200.

b) The tube shall be continuous length without any brazing in between.

c) The length of single tube shall preferably be 100 metres. However any tube length less than 50 meters shall be rejected unless specifically required otherwise in job specification.

d) The dimensional tolerances shall be as per ASTM B 251/B251M.

2.3 Maximum working pressure and hydrostatic test pressure shall be as per Annexure - 1 attached with this specification

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3.0 NAMEPLATE

The following information shall be marked on the stainless steel tubes:

a) Name of manufacturer

b) Type and material grade of tube

c) Tube outer diameter and wall thickness.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan. All the tests, marking, dimensional tolerance as per applicable code shall be duly completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

5.0 SHIPPING

5.1 The tube shall be plugged at both ends prior to transportation to prevent entry of foreign matter.

5.2 The tubes shall be packed carefully so as to avoid damage during transport.

5.3 All tubes in oxygen and chlorine service shall be separately packed along with a certificate indicating 'SUITABLE FOR OXYGEN / CHLORINE SERVICE', as applicable.

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Sr. No.	Size of Tube (OD)	Material	Line Pressure Class (lbs per sq. inch)	Thickness	Maximum Working Pressure	Hydrostatic Test Pressure
1	1/8", 3mm	Stainless Steel	≤ Class 600	0.028" (0.8mm)	102 Kg/cm^{2}g	153 Kg/cm^{2}g
2	¼", 6mm	Stainless Steel	≤ Class 600	1.00mm	102 Kg/cm^{2}g	153 Kg/cm^{2}g
			≥ Class 900 to ≤ Class 1500	0.065" (1.65mm)	253 Kg/cm^{2}g	383 Kg/cm^{2}g
3	5/16", 8mm	Stainless Steel	≤ Class 600	0.049" (1.2mm)	102 Kg/cm^{2}g	153 Kg/cm^{2}g
4	3/8",10mm	Stainless Steel	≤ Class 600	0.049"(1.2mm)	102 Kg/cm^{2}g	153 Kg/cm^{2}g
5	½",12mm	Stainless Steel	≤ Class 600	0.049" (1.2mm)	102 Kg/cm^{2}g	153 Kg/cm^{2}g
			≥ Class 900 to ≤ Class 1500	0.065" (1.65mm)	253 Kg/cm^{2}g	383 Kg/cm^{2}g
6	¾", 20mm	Stainless Steel	≤ Class 600	0.049" (1.2mm)	102 Kg/cm^{2}g	153 Kg/cm^{2}g
			≥ Class 900 to ≤ Class 1500	0.065" (1.65mm)	211 Kg/cm^{2}g	317 Kg/cm^{2}g
7	1", (25mm)	Stainless Steel	≥ Class 900 to ≤ Class 1500	0.095" (2.5mm)	211 Kg/cm^{2}g	317 Kg/cm^{2}g
8	3/8",10mm	Copper	≤ Class 300	0.049"(1.2mm)	53 Kg/cm2g	80 Kg/cm2g
9	¼", 6mm	Copper	≤ Class 300	1.00mm	53 Kg/cm2g	80 Kg/cm2g

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गैस संसूचक प्रणाली के लिए मानक विनिर्देशन

STANDARD SPECIFICATION FOR GAS DETECTION SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	15.03.23	Revised and Reissued as Standard Specification	DKY/JJ	SMK	MN	SM
4	26.02.18	Revised and Reissued as Standard Specification	SP	AR	RG	RN
3	22.03.12	Revised and Reissued as Standard Specification	AR	RG	RP/JMS	DM
2	09.03.07	Revised and Reissued as Standard Specification	AR	TGM	HCJ	VC
1	01.04.98	Revised and Reissued as Standard Specification	RK	BRS	RB	AS

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Abbreviations:

DCS	Distributed Control System
GA	General Arrangement
GPS	Global Positioning System
HART	Highway Addressable Remote Transducer
HVAC	Heating Ventilation & Air Conditioning
LEL	Lower Explosive Limits
LOS	Line of Sight
MOS	Metal Oxide Semiconductor
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NPT	National Pipe Thread
PFD	Probability of Failure on Demand
PLC	Programmable Logic Controller
SIL	Safety Integrity Level

Instrumentation Standards Committee

Convener : Mr. Mainak Nandi

Members :
Mr. Arupjyoti Saikia
Mr. Sachin Garg
Mr. Jerry Johnson
Mr. Mayank Kaushik
Mr. Sourav Mukherjee
Ms. K.Pratheepa
Mr. R.K Gupta (Projects)

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1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets describes the requirements for the design, manufacture, nameplate making, inspection, testing and shipping of the complete gas detection system.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of purchaser's enquiry:

API	American Petroleum Institute	
	RP-55	Recommended Practice for Oil and Gas Producing & Gas Processing Plant Operations Involving Hydrogen Sulphide.
	RP-552	Transmission Systems
EN	European Standard	
	10204	Inspection Documents for Metallic Products
	61779-1	Electrical Apparatus for the Detection and Measurement of Combustible Gases - General Requirements and Test Methods.
	61779-4	Electrical apparatus for the detection and measurement of flammable gases. Performance requirements for group II apparatus indicating a volume fraction up to 100% lower explosive limit.
IS/IEC	Indian Standards/International Electro Technical Commission	
IS/IEC 60079-0	Equipment - General requirements	
IS/IEC 60079-1	Equipment protection by flameproof enclosures "d"	
IS/IEC 60079-10-1	Classification of areas - Explosive gas atmospheres	
IS/IEC 60079-10-2	Classification of areas - Explosive dust atmospheres	
IS/IEC 60079-11	Equipment protection by intrinsic safety "i"	
IS/IEC 60079-25	Intrinsically safe electrical systems	
IS/IEC 60079-29-1	Gas detectors- Performance requirements of detectors for flammable gases	
IS/IEC 60079-29-2	Gas detectors- Selection, installation, use and maintenance of detectors for flammable gases and oxygen	
IS/IEC 60079-29-4	Gas detectors- Performance requirements of open path detectors for flammable gases	
IEC 60331	Testing of Fire Resisting Cables	
IEC 60332	Tests on bunched wires and cables.	
IEC 60617	Graphical Symbols for Diagrams	
IS/IEC 60529	Degree of protection provided by Enclosures (IP code).	
IEC 61000-4	Electromagnetic compatibility (EMC) –Part 4: Testing and measurement techniques	
IEC 61131	Programmable Logic controllers	
IEC 61508	Functional Safety of electrical/electronic/programmable electronic safety related systems	
IEC 61511	Functional Safety – Safety Instrumented Systems for the Process Industry Sector.	

1.1.3 In the event of any conflict between this standard specification, job specification/datasheets, statutory regulations, related standards and codes the following order of priority shall govern:

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a) Statutory Regulations

b) Job Specifications / Data Sheets

c) Standard Specifications

d) Codes and Standards

1.1.4 In addition to compliance to purchaser's specifications in totality, vendors' extent of responsibility shall include the following:

a) Purchaser's data sheets indicate the maximum distance between the sensor and the receiver instrument. Vendor shall be responsible to ensure that the offered sensor is suitable for the specified distance requirements. Cable size requirement shall be indicated by vendor in their offer.

b) Selection of proper hardware along with model nos and software to meet functional requirements specified in the material requisition.

c) Engineering of complete system, when specified, including that of addressable gas detector systems, data logger, monitoring system etc.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached with the material requisition.

1.2.2 Vendor's quotation shall include the following;

a) Compliance to the specifications.

b) Wherever Gas Detectors are specified,

i) A detailed specification sheet for each item, which shall provide information regarding type of detector, portable detectors, portable calibrator, aspirator, hooter, beacon, pushbuttons etc., as applicable. The material specifications and the units of measurement for various parts in vendor's specification sheet shall be to the same standards as those indicated in purchaser's data sheets. Selection of correct Model number to meet the specifications shall be vendor's responsibility and vendor shall replace with the correct model if at any stage, the selected model is found deficient in meeting the specifications.

ii) Proven reference for each offered model number in line with clause 1.2.3 of this specification.

iii) Availability calculation along with MTBF data used for each component with basis.

iv) Deviation on technical requirements shall not be entertained. In case vendor has some valid technical reason to deviate from the specified requirements, they must include a list of components tag number wise, summing up all the deviations, if any, from the purchaser's data sheets along with the technical reasons for these deviations.

v) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of gas detector and gas detection system covered in the bid.

vi) Cable size calculation, Power Consumption and Minimum voltage level for proper operation of the gas detectors for each type/model of detectors offered.

vii) Minimum shelf life of the gas detector's sensor.

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viii) Vendor shall indicate calibration frequency (Time period after which recalibration of gas detectors is required) along with offer. Vendor to indicate drift in the calibration of offered detectors

ix) Calculation for quantity of calibration gas required for calibration of detector.

c) Wherever Gas Detection System is specified, in addition to the details specified in 1.2.2b), It shall also include detailed specification sheet for each item, which shall provide information regarding monitor, data logger, gas detection panel, monitoring console with MMI, gas detection system with PLC etc as applicable.

d) A copy of approval for gas detectors for installations in electrically hazardous area, wherever specified, from local Statutory authority as applicable such as Petroleum and Explosives Safety Organization (PESO), Nagpur India:

i) Test certificate from recognized test house like Central Institute of Mining and Fuel Research (CIMFR) / Electronics Regional Testing Laboratory (ERTL) etc. for the specified hazardous protection class, in the data sheet, as per relevant Standard for all Indian manufactured equipments.

ii) Certificate of conformity from agencies like Laboratorie Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (Baseefa), Factory Mutual (FM), Physikalisch-Technische Bundesanstalt (PTB), Canadian Standards Association (CSA), Underwriters Laboratories (UL) etc. for compliance to ATEX directives or certificate of conformity from IECEx or other equivalent recognized standards for all equipments manufactured outside India.

1.2.3 All items as offered shall be field proven and should have completed operation for a period of minimum 6 months on the bid due date in the similar application with the process conditions similar to those as specified in the purchaser's data sheet. Items with proto type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 Whenever specified, vendor must furnish tested values of failure rates, probability of failure on demand (PFD) and test intervals for the safety integrity level (SIL) analysis from third party certification agency.

1.2.5 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation manual, operation and maintenance manuals etc shall be in English language only.

1.2.6 Vendor shall also quote for the following:

a) Two year's operation spares for gas detection system and its accessories covered in the bid, which shall include the detectors, transmitters, monitors, electronic modules, power supply modules etc. of each type, as a minimum.

b) Any special tools needed for maintenance work on the gas detection system including gas detectors and its accessories. Vendor must confirm in their offer if no special tools are needed for maintenance of offered gas detection system.

c) Aspirator assembly wherever specified in the data sheet.

d) Quantity of calibration gas required for calibration of detector. Volume of calibration gas cylinder and no. of calibration gas cylinders shall be based on the requirements specified in 2.2.3.

1.3 Drawings and Data

1.3.1 Detailed drawings, data and catalogues required from the vendor are indicated by the purchaser in vendor data requirement sheets.

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1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. submitted by the vendor after placement of purchase order, shall include the following, as a minimum:

Wherever Gas Detectors are specified,

a) Specification sheets for gas detectors along with model nos as applicable.

b) Maximum and minimum supply voltage required for the detector to function within the stated performance characteristics and power consumption.

c) Power supply distribution drawing and Wiring diagram.

d) Calibration gas sample details along with correlation factors, as applicable.

e) Copy of test certificate including type test certificates.

f) Copy of test certificate for all the tests indicated in clause 4.0 of this specification.

g) Installation procedure for gas detectors and its accessories.

h) Calibration and maintenance procedure for complete gas detectors including replacement of parts, as applicable and recommended calibration frequency.

Wherever Gas Detection System is specified, In addition to the requirements specified in 1.3.2, following shall be included.

a) Specification sheets for gas detection system.

b) Certified drawings of complete gas detection system including each detector, monitor, panel etc. as applicable, which shall provide:

i) Dimensional details in mm.

ii) Material of construction.

iii) GA drawing for Panel / Cabinet, man-machine interface.

iv) Channel base details

v) Panel / Cabinet weight (with or without packing)

c) Wiring diagram of Panel / Cabinet.

d) Purchaser's interface details including details of serial interface.

e) Complete application program as configured, wherever applicable.

f) Number of user's licenses as per job requirements, wherever applicable.

g) Installation procedure for gas detection system including detectors and its accessories.

h) Calibration and maintenance procedure for complete gas detection system including replacement of parts, as applicable and recommended calibration frequency.

2.0 DESIGN AND CONSTRUCTION

2.1 Gas Detectors

2.1.1 All gas detectors shall be suitable for outdoor installation certified for use in electrically hazardous area. The detectors shall be weather proof to IP65 in accordance with IS/IEC60529, as a minimum and certified flameproof (EExd) or certified intrinsically safe (EEx i) in accordance with IS/IEC 60079 for the area classification specified in purchaser's data sheet.

2.1.2 All gas detectors shall be provided with dust guard and splashguard.

2.1.3 All gas detectors shall be provided with terminal box for terminating incoming cabling. Flying leads shall not be acceptable. The cable entry in the terminal box shall be ¾" NPTF.

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2.1.4 Gas detectors shall have an integral transmitter, which shall provide 4-20mA outputs with HART (latest version) Gas Detectors with HART protocol shall be capable of implementing commands from universal Hand Held HART Communicator. RS485 MODBUS (RTU) etc. shall be offered when Smart detectors or Addressable detectors are specified in the purchaser's data sheets.

2.1.5 All detectors shall be supplied with local LED/ LCD digital display, which shall indicate currently detected gas concentration.

2.1.6 Mounting accessories like mounting bracket (Stainless Steel) required for the installation of gas detectors for 2" pipe mounting shall be supplied by the vendor. For open path (line of sight) detectors, 4" pipe mounting accessories shall be supplied by vendor. For the detectors to be mounted on HVAC ducts, suitable mounting accessories like backup flange (SS316) of size & rating 6"x150# along with gasket, nut & bolts, mounting plate, along with calibration valve etc. shall be supplied by vendor.

2.1.7 For 'EExd' detectors, intrinsically safe port shall be provided for connecting the Hand Held Communicator.

2.1.8 Flammable Gas Detectors (Hydrocarbon)

2.1.8.1 Flammable Hydrocarbon gas sensors shall be Non-Selective Infra-Red (IR) type. "Dual beam" with heated optics or other suitable arrangements to overcome environmental effects of fogging/fouling shall be provided.

2.1.8.2 Flammable gas detector including terminal box shall have Stainless Steel body / casing.

2.1.8.3 Detectors installed in pressurized lines e.g. HVAC duct etc., shall be provided with in-situ calibration facility (facility to calibrate the gas detectors externally without removing from the duct).

2.1.8.4 IR detector lamp shall be replaceable type. Detector shall be compensated for lamp intensity variation due to dust, humidity, sun-light, wear & tear etc.

2.1.8.5 Aspirator shall be supplied wherever specified in the data sheet.

2.1.8.6 Range

a) The range of the Flammable gas detectors shall be as follows:

Point detector: 0-100% LEL

Open-path detector: 0-5 LEL meters

(LEL meter is equal to %LEL/100 x length of gas cloud obstructing the beam path).

The gas detectors shall have an over range protection in case of sudden exposure to large quantity of Hydrocarbon gases.

2.1.8.7 Detector failure/sensor failure alarms shall be provided and hardwired contact shall also be provided for the same. In addition, the infrared detector shall provide diagnostic alarms for dirty or misaligned optics and blocked beam.

2.1.8.8 Performance requirements:

The flammable gas detectors shall meet the following performance requirements:

Repeatability: ±2% of full scale

Response time (T90): Less than 30 seconds with splash guard and dust guard.

2.1.8.9 The minimum life expectancy of flammable gas detectors shall be five (5) years.

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2.1.8.10 Once calibrated using a standard gas, Hydrocarbon gas detectors shall be capable of sensing any Hydrocarbon gas by applying a suitable correction factor and without the need of recalibration again with the measurement gas specified in the requisition.

2.1.9 Flammable gas detectors (Hydrogen)

2.1.9.1 Flammable gas sensor for hydrogen shall be poison resistant catalytic diffusion type and shall be specific for hydrogen gas only.

2.1.9.2 Catalytic type detector shall incorporate a plug-in type sensor and metallic flame arrestor.

2.1.9.3 The flammable gas detector shall meet all requirements specified in clause 2.1.8.2, 2.1.8.3, 2.1.8.6, 2.1.8.8.

2.1.10 Toxic gas detectors (Hydrogen Sulphide)

2.1.10.1 The toxic gas sensor for Hydrogen Sulphide shall be either Electrochemical type or Solid-state Semiconductor type, as specified in job specifications.

2.1.10.2 The Electrochemical cell requiring replenishment of electrolyte shall not be offered.

2.1.10.3 The field life of electrochemical type of sensor shall be 2 years as a minimum. The cell shall be able to be replaced in-situ.

2.1.10.4 The semiconductor type sensor shall be the thin film MOS type. Life expectancy shall be a minimum of five years. Zero and span adjustment shall be automatic.

2.1.10.5 Toxic gas detector and its terminal box shall preferably have Stainless Steel body. Alternately vendor's standard proven material of construction (metallic) shall also be acceptable.

2.1.10.6 Range

a) Unless otherwise specified in purchaser's data sheet, the range of the toxic gas detectors for Hydrogen Sulphide shall be 0-20ppm

2.1.10.7 Performance Requirements

a) The toxic gas detector for Hydrogen Sulphide shall meet the following performance requirements:

Repeatability: ±2 ppm

Response time (T90): Less than 60 seconds with splashguard and dust guard.

2.1.11 Toxic gas detectors (Chlorine, Sulphur Dioxide, Ammonia, others) and Oxygen gas detector

2.1.11.1 The gas detectors for Chlorine, Sulphur Dioxide, Ammonia, Oxygen and other Toxic gases shall be of electrochemical cell type.

2.1.11.2 The detectors shall meet all the requirements specified in clauses 2.1.10.2, 2.1.10.3, 2.1.10.4 and 2.1.10.5 of this specification.

2.1.11.3 Range

Unless otherwise specified in the purchaser's data sheets, the range of toxic gas detectors shall be as follows:

Chlorine detectors, Sulphur Dioxide, Ammonia: 0-10ppm

Oxygen detector: 0-25% v/v

Other detectors: As per purchaser's data sheet

2.1.11.4 Performance Requirements

The offered toxic gas detectors shall meet the following performance requirements:

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Repeatability: ±2 % of full scale

Response time (T90): Less than 60 seconds with splashguard and dust guard.

The performance of the sensor shall not be affected by the presence of other gases like Methane or Hydrogen.

2.1.12 Toxic gas detectors (Volatile Organic Compound (VOC)/Benzene)

2.1.12.1 The toxic gas detectors for VOC/Benzene shall be of photo ionization detection type (PID).

2.1.12.2 The field life of PID type of sensor shall be 2 years as a minimum. The cell shall be able to be replaced in-situ.

2.1.12.3 Toxic gas detector and its terminal box shall preferably have Stainless Steel body. Alternately vendor's standard proven material of construction (metallic) shall also be acceptable.

2.1.12.4 Range

Unless otherwise specified in purchaser's data sheet, the range of toxic gas detector for VOC/Benzene shall be 0-25 ppm.

2.1.12.5 Performance Requirements

The offered toxic gas detectors shall meet the following performance requirements:

Repeatability: ±2 % of full scale

Response time (T90): Less than 60 seconds with splashguard and dust guard.

2.1.13 Addressable gas detectors

2.1.13.1 Addressable detectors, when specified, shall be similar in mechanical construction, range and performance requirements of detectors specified in clauses 2.1.1 to 2.1.10 as applicable. These detectors, in addition, shall provide two-way communications with the gas detection system.

2.1.13.2 Addressable gas detectors shall be connected over a system communication bus with each detector having a unique address code, which shall be programmed on each device. The detector address shall be programmable from the gas detection system.

2.1.13.3 The communication protocol for data transfer between detector and host shall be deterministic. The protocol shall ensure reliable data transfer and verify the data integrity using parity data bit error checking subroutines for address code and check sum routine for the data transmission.

2.1.13.4 All addressable devices shall have capability of being disabled or enabled individually.

2.1.13.5 It shall be possible to replace failed detector on-line with a similar device without any specific tools and without data interruption.

2.1.13.6 The addressable system digital communication network shall be continuously monitored for detection and isolation of network communication failure and shall also provide an alternative path in case of a single failure of a gas detector in the network.

2.2 Portable Calibrator

2.2.1 Portable purge calibrators (one each required for different type of gas detectors as specified above) each consisting of a volume bottle containing a known gas/air mixture, a pressure regulator, a flexible hose, adapter cap (to fit the sensing head) and carrying case shall be supplied to enable calibration of the sensors in the field without dismantling them.

2.2.2 Calibration range for all sensors will be 0-100% LEL for Hydrocarbon, 0-20 ppm for Hydrogen Sulfide, 0-100% LEL for Hydrogen, 0-10 ppm for Toxic Gas (Chlorine, Sulphur

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dioxide, Ammonia), 0-25% v/v for Oxygen, 0-25 ppm for VOC/ Benzene and as per job specifications for other toxic gases.

2.2.3 Vendor to furnish quantity of calibration gas required for calibration of detector. Volume of each calibration gas cylinder and no. of calibration gas cylinders shall be based on the requirements specified below:

a) Sufficient quantity of calibration gas cylinders shall be supplied to enable calibration of all sensing heads at least thrice considering minimum 3 minutes for each detector. Vendor to ensure that the composition and stability of the calibration gas provided in the gas cylinders shall be suitable for minimum six months periods.

b) In case vendor's standard product requires higher calibration time, vendor to indicate the same and calculate the gas quantity accordingly.

Gas cylinders, self-regulating valves, pressure gauges, hose, interconnecting tubing, fittings etc. shall be supplied by the vendor. The delivery of gas cylinders shall be staggered in such way that the composition and stability of gas do not deteriorate. Date of supply shall be intimated to the bidder and shall be prior to commissioning.

2.2.4 All detectors shall be supplied pre-calibrated at vendor's works either with the gas to be detected or by applying cross sensitivity factors.

2.2.5 HC Detectors shall be calibrated for gas for which they are least sensitive. Vendor shall indicate the gas with which the gas detectors shall be calibrated.

2.2.6 Gas detector sensors shall be capable of non-intrusive calibration.

2.2.7 Vendor to furnish calibration procedure for the detectors along with make/model no. with catalogue/technical details of calibration kit.

2.3 Portable Gas Detectors

2.3.1 The portable gas detectors shall be supplied for Hydrocarbon, Hydrogen, H_2S, Chlorine, Sulphur Dioxide, Ammonia, Oxygen, VOC/Benzene and other toxic gases specified in the requisition, complete with its controller and audio-visual alarm. The portable gas detectors shall be suitable (preferably intrinsically safe) for use in hazardous area specified. These units shall be supplied with rechargeable batteries and 240 V, 50 Hz AC battery chargers. Sufficient number of battery charger/number of points per charge shall be provided based on quantity of such portable units. These units shall be supplied complete with its accessories like carrying case, maintenance kit, calibration kit etc.

2.4 Beacon and Hooter

2.4.1 Beacon and Hooter shall be supplied by the vendor as per the requirements specified in the purchaser's data sheets

2.4.2 Unless otherwise specified, the Beacons and Hooter shall meet the following functional requirements:

a) The Beacon colour shall be 'ORANGE' for flammable gas detection while 'BLUE' for Toxic gas detection.

b) Beacon light shall follow the following sequence:

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Sequence step	Detector Alarm State	Push buttons status	Hooter with Hi Tone	Hooter with Hi Hi Tone	Beacon
1.	Normal		OFF	OFF	OFF
2.	HI		ON	OFF	ON
3.	HH		ON	ON	ON
4.	HI / HH	Acknowledge button pressed	OFF	OFF	ON
5.	Normal	Reset button pressed	OFF	OFF	OFF

Reset shall be activated only after acknowledge and leakage stop.

2.4.3 The beacon shall be of stroboscopic type and shall be of sufficient intensity to provide visibility and clear contrast during full daylight.

2.4.4 The hooter shall be electronic type and shall have sound intensity of 100dBA, as a minimum. Different tones shall be provided for Flammable gas and Toxic gas releases.

2.4.5 Both Beacon and hooter units shall operate at 110V AC / 110 V DC / 24 V DC as specified in the data sheet and shall be certified explosion proof (flame proof) when installed in hazardous area.

2.4.6 Hooter/ Beacon shall be flameproof and shall be supplied with test / Acknowledge / reset push-buttons which shall be rated for 110V AC, 0.5 A / 110V DC, 0.5 A/ 24V DC, 2 A as per the requirement specified in the data sheets.

2.5 Gas Detection System

2.5.1 General

2.5.1.1 Purchaser's requisition shall specify the functional requirements of gas detection system. Vendor shall size their system as per the specified requirements and shall be responsible to consider all hardware and software necessary to meet these requirements based on the offered system.

2.5.1.2 Gas detection system shall be a stand-alone microprocessor based system fully compatible with the type of sensors specified in the data sheet.

2.5.1.3 The system shall be designed to avoid common cause of any failure. Redundancy shall be provided for all common mode failure modules/ components/ subsystems, unless otherwise specified in the purchaser's specifications.

2.5.1.4 The system shall be designed considering normally energized with normally closed concept to make it fail-safe. Monitored inputs/outputs shall be provided whenever the purchaser's data sheets specify normally de-energized/normally open system.

2.5.1.5 System Reliability and Availability:

The system shall be designed to avoid unrevealed failures ensuring maximum reliability, safety and integrity. The system design availability shall meet the requirement of 99.7%, as a minimum where system availability shall be defined as follows:

$$\% \text{ System Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}} \times 100$$

Vendor shall consider the following points while calculating the system availability:

a) MTBF values for detectors and corresponding system components i.e. detector, input and output module, power supply module, display unit, alarm annunciator etc.

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b) Items like data logger, serial outputs to purchaser's systems, hooters and beacons shall not be considered for availability calculation.

c) MTTR value of 4 hours shall be considered uniformly for all items.

2.5.1.6 Redundancy shall be provided such that single revealed or unrevealed failure shall not affect the performance of the system.

2.5.1.7 All contacts provided by the vendor for purchaser's use from the system shall be potential free and shall be rated for 110V DC 0.5A / 240V AC 5.0A / 2 A, 24 V DC as specified in the data sheets.

2.5.1.8 Bypass Philosophy

Whenever the system is specified with a dedicated panel, vendor shall provide by-pass switches with by-pass indication lamp on the panel for the output contacts from the system which are used in shutdown system. The by-pass contacts shall be logged in the data logger.

2.5.1.9 Whenever the gas detection system is specified with man-machine interface, vendor shall provide the following:

a) By-pass switches with lamps in the system cabinet.

b) Separate graphic display for by-pass contacts with a red flashing group alarm, which shall appear on each screen on the top or bottom message area of each display screen area.

c) Historical logging of all by-passed contacts for a period of minimum one month.

d) Password protection for bypassing any contact from the man machine interface screen along with an audit trail.

2.5.1.10 Whenever the gas detection system is interfaced serially with the purchaser's Control System, all by-pass status shall also form part of serial signal transfer to Control System.

2.5.1.11 Interface with purchaser's Control System

Gas detection system shall be interfaced with purchaser's control system e.g. Distributed Control System, Shut down system etc. Following outputs shall be provided for interface:

a) A redundant serial MODBUS (RTU) output with RS485 physical interface for complete data transfer and display in purchaser's Distributed Control System. The data shall include tag wise concentration, high & high high alarms, diagnostic, status alarms and bypass status etc.

b) Potential free contacts for shutdown system as per purchaser's specification.

c) Potential free contacts for High-High group alarms for connection to purchaser's Distributed Control System.

2.5.1.12 Power Supply

The Gas detection system shall operate at 110V, 50Hz. AC / 240 V, 50 Hz AC power supply. The system performance shall be within specified requirements for a voltage variation of ±10% and frequency variation of ±3 Hz of the specified value. In addition system shall be unaffected by a power fluctuation / power dip up to one cycle i.e. 20 millisecond. This power supply shall be made available to the vendor at one point i.e. in control panel or system cabinet, as applicable. Further distribution of this power supply for the equipments being supplied by vendor shall be in vendor's scope. The detailed power supply distribution requirements shall be as follows:

a) Distribution of power supply within the Control Panel/ Cabinet shall be by vendor.

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b) For the equipments installed outside the Control Panel / Cabinet i.e. monitors, printers, gas detector etc., vendor shall provide outlet feeders of suitable size in the Panel/ Cabinet.

c) The system shall be capable of accepting two power feeders either from the same source or from two different power sources. The distribution of power supply to other system consumers shall be through dedicated switch-fuse unit. Circuit breakers can also be used in place of switch-fuse unit.

d) The system power supplies shall be dual redundant each of which shall be sized for 150% of the total load of the power supply under the worst loaded condition. Redundant power supplies shall be supplied power from the different power feeders.

e) Power supply units shall be replaceable on-line without switching-off the power. The system shall remain operational uninterruptedly under single power supply unit failure and during failed power supply unit replacement.

2.5.1.13 The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4.

2.5.2 Gas Monitors/Controllers

2.5.2.1 Type

The gas monitors/controllers shall be microprocessor based and shall have panel or standard rack mounted modular plug-in type construction.

2.5.2.2 No. of channels per gas monitor/controller

Each gas detector shall either have dedicated single channel module or 1:1 redundant multi-channel module to maintain single loop integrity.

2.5.2.3 Monitor/Controller facia

When specified with indicating type of monitor/controller, it shall meet the following requirements:

a) Monitor/controller shall have either dedicated monitor/controller for each detector or a common indicator selectable for a maximum of 16 detectors. In either of the case, the requirements specified in clause 2.5.2.3 (b) of this specification shall be complied.

b) Following indications shall be available on each monitor/controller for each detector channel:

Power-on light

Alarm high light (default setting at 20% of LEL or 20 ppm)

Alarm high-high light (default setting at 60% of LEL or 50 ppm)

Malfunction light (this shall include short circuit, line-breaking, over-range and earth fault).

c) Latched type of relay contacts shall be provided for each channel for

Alarm high

Alarm high high

Malfunction alarm

d) Each channel shall also have calibration switch to allow sensor calibration without alarm output.

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2.5.3 Data logger

2.5.3.1 When specified in purchaser's specification, data logger shall be supplied complete with a dedicated printer and necessary software to:

a) Store and print out all analog data and alarms.

b) Generate reports like daily alarm report, faulty detector report, on-demand reports etc.

c) Alarm and event printing.

2.5.3.2 Type

Data logger shall be microprocessor based, rack mounted and modular in construction.

2.5.3.3 No. of channels

Data logger shall have a minimum of 256 channels. In case the number of inputs (as per detectors specified in the purchaser's data sheets) exceeds 256 nos., vendor shall offer data logger of suitable higher capacity. Number of inputs to data logger per detector shall be:

a) Analog input corresponding to LEL/ H_2S / Toxic Gas level.

b) High and High-High level.

c) Gas monitor / controller fault alarm.

However, the number of inputs per Input module shall not exceed 16.

2.5.3.4 Scan time

Data logger shall scan various inputs, analog as well as contacts, as per following rate:

100 mSec. for alarm inputs.

500 mSec. for analog inputs.

2.5.3.5 Printer

Laser printer shall be provided to print out alarms, events and reports.

2.5.3.6 Programming Terminal

It shall be possible to perform following functions either from the data logger front facia or from a PC connected to data logger:

a) Configuration and re-configuration

b) Program modifications

c) Add/delete inputs

d) Compilation of reports and generation of new reports.

2.5.3.7 Diagnostic alarms

LED indication on each I/O module.

2.5.3.8 Software features

The data logger shall meet the following software requirements:

a) Data-acquisition and data manipulation.

b) System configuration and configuration modification.

c) Diagnostic software and printout of diagnostic alarms.

d) On-demand reports for high/ high-high/ fault alarms.

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e) Daily reports for high/high-high/fault alarms and Gas concentration levels.

f) Faulty detector report.

g) Printing of alarm and events.

h) Printing of reports

2.5.4 Gas Detection Panel

2.5.4.1 The Gas detection panel when specified shall be designed to house the following instruments/accessories:

a) Monitors/controllers for the gas detectors being supplied

b) Addressable Gas Detection System Monitors / Modules, when specified in Purchaser's specifications.

c) Alarm annunciator

d) Data logger

e) Semigraphic

f) Relays/logic cards for shutdown/protection system.

g) Pushbuttons/Switches as required (including lamp test Pushbuttons)

h) Any other items which are not listed above but essential to make the system operational and to meet requirements specified in purchaser's specification.

Whenever multichannel gas monitor/controller is offered, hydrogen sulfide gas monitors and other toxic gas monitors shall be segregated from hydrocarbon and hydrogen gas monitors.

2.5.4.2 Construction

a) Panels shall have self-supporting free standing cubical construction with back doors made up of sectional steel panels. Two doors shall be provided for each panel, as standard.

b) Each panel section shall have the following dimensional details:

Height	:	2000mm
Width	:	1200mm (maximum)
Depth	:	1000mm (maximum)

Panel shall be rigidly mounted on 100mm high channel base.

c) The panel shall be fabricated using angle iron frame section of minimum 50mm x 50mm x 4.0mm size. The control panel front shall be fabricated preferable from 3.0mm cold rolled carbon steel sheet.

d) Unless otherwise specified the panel shall be straight face type. Desk type panel shall be supplied where specified. Care shall be taken to ensure that the face of the panel is truly flat and smooth.

2.5.4.3 Painting

Panel painting procedure shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high grade lacquer with wet sand blasting between coats. Two coats of paint in the panel colour shall be provided for non-glossy high satin finish. Final coat shall be given after assembly at site when specified in the job specifications. Colour of the panels shall be as per job specifications.

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2.5.4.4 Cutouts

Panel cutout sizes, instrument supports and panel reinforcements shall be strictly in accordance with the instrument manufacturer's recommendations. Cutouts shall not be made with flame producing devices.

Normal mounting heights of instruments (center lines of instruments to floor) on panel shall confirm to the following, with minor adjustments depending upon instruments selected.

1	Miniature and sub-miniature instruments. (3 rows)	Bottom Row Middle Row Top Row	1100 mm 1350 mm 1600 mm
2	Annunciators		1950 mm
3	Electrical push buttons		700 mm

2.5.4.5 Auxiliary Equipment

All rear of panel equipment (terminal blocks, auxiliary relays, PLC cards etc.) shall be physically located off the exterior walls of the panel by means of suitable mounting brackets/plates welded to the wall prior to finishing the painting. Drilling and tapping on sidewalls of the enclosure for mounting internal equipment is prohibited. The auxiliary equipment shall be located and arranged for easy access for calibration and maintenance. It shall not be necessary to remove any item in order to gain access to check or remove any other item.

All cable runs shall be grouped, routed and secured to provide a neat appearance and prevent interference with the operation and maintenance of auxiliary equipment. Auxiliary relays, if used, shall be plug-in, enclosed type.

2.5.4.6 Electrical Construction

Code Compliance

The installed electrical equipment component parts and associated wiring in the panel shall be in accordance with the practices outlined in the National Electric Code, latest edition, for non-hazardous area.

Panel Wiring

For panel internal wiring, interconnecting wires shall be stranded copper conductor, with 600 volt rated fire retardant insulation. Minimum size shall be 1.0 mm2 except for power wiring which shall be 1.5 mm2. The size and type of wires shall be confirmed by vendor. Each wire shall be distinctly colour coded or tagged at both ends with full ring type labels, colour coding/tagging corresponding to that used on panel schematic drawings. The panel shall be designed for field wiring entry from the bottom. Vendor shall provide removable gland plate for this purpose.

2.5.4.7 Terminals

Terminals shall be non-hygroscopic type made up of unbreakable, fire-retardant, safe extinguishable, halogen free polyamide compound. Terminal strips shall be spring-loaded, screw locked with all terminals clearly labeled. All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off. Terminals shall be suitable for wires up to 2.5 sq. mm base solid or stranded conductor in general. For power cables, higher size terminals shall be used. The metal parts of terminals shall be of high quality (pure electrolytic) copper

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and shall be tin or nickel plated (of thickness up to 15 micron). A minimum of 10% spare shall be provided.

2.5.4.8 Earthing

Each cubical (panel / cabinet / console) shall be provided with earth bus bars of at least 15 x 5 square mm cross-section for the following:

i) Electrical earthing (non-isolated earth) where all metal components like all cabinet panels, doors etc shall be connected.

ii) System earthing (isolated earth) where cable shielding of all cables shall be earthed. System earth bus bar shall be isolated from electrical earth and also from metallic doors, panels etc.

2.5.4.9 Power Supply and Distribution

The main power supply feeder to the panel shall be protected by a suitably sized circuit breaker with manual trip lever. The breaker shall be housed in a suitable surface-mount enclosure. Power distribution to controllers and associated group of auxiliary relay or solid-state logic circuits shall be via fused terminals.

2.5.4.10 Lighting

Internal illumination shall be provided for all panels / cabinets / consoles to ensure proper illumination level of 250 lux for performing maintenance activities.

LED lamps shall be provided in each cabinet / console / panel which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at least 1000000 operations. A manual over-ride switch shall be provided inside the panel / cabinet / console which shall keep the lamp deactivated even when the door is open.

The cabinet / panel / console lighting shall operate on 240V AC power supply.

2.5.4.11 Alarm Annunciator

i) Alarm annunciator shall be provided at top of panel to display group alarms, shutdown alarms etc. as indicated in job specification. In addition, following system alarms shall be provided:

- Malfunction in hydrocarbon gas detection system.
- Malfunction in hydrogen sulfide gas detection system.
- Malfunction in hydrogen gas detection system.
- Malfunction in any other toxic gas detection system

ii) Alarm annunciator shall be solid state electronic type or microprocessor based provided with single input type logic module and solid-state audio alarm unit. It shall be provided with first out type sequence (ISA F3A) with function test, acknowledge and reset push buttons. The visual display shall be cluster LED type. Each facia window shall be provided with at least two sets of super bright cluster LEDs in parallel to ensure highly reliable visual annunciation of adequate light intensity.

iii) No alarm/shutdown contacts shall be derived from alarm annunciator unit.

2.5.4.12 Spares

i) The panel shall be provided with 5% installed spare (minimum one number) for items like monitors/controllers, relays/logic cards etc.

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ii) Also, 5% usable spare space shall be provided in the panel for installing items like monitors/controllers, relays/logic cards etc. in future. However internal wiring for the same shall be completed in the panel up to the terminals blocks. This shall include all hardware like Rack, Terminals, and Wiring etc. that would be necessary to install these items in future.

iii) Alarm annunciator shall have 10% spare points.

2.5.4.13 Utility Sockets

Each cabinet / panel / console shall have at least one number each of 240V AC and 110V AC (UPS) power socket. The sockets shall be rated for 10A as a minimum.

2.5.4.14 Ventilation

In order to effectively remove dissipated heat from the cabinets / panels / consoles, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets / panels / consoles where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10°c above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel / cabinet / console in part or in complete.

Ventilation fan assembly shall operate at 240V AC power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the numbers of panels / cabinets / consoles are compacted (supplied in mechanical joined conditions), each panel / cabinet / console shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

2.5.4.15 Lifting lugs

All control panels and system cabinets shall be provided with removable lifting lugs to permit lifting of panels / cabinets. The panel structure / frame shall be designed to permit panel / cabinet lifting without deformation. The normal working load of the lifting lugs shall be more than 1.5 time the panel / cabinet load. The eye bolts shall be certified for their normal working load.

Panels / cabinets shall also be supplied with plugs which can be fitted after the lifting lugs are removed after their placement.

2.5.4.16 Name Plates

All panels / consoles / cabinets shall have name plates fixed on the front, back and inside with following details:

Front and Back	:	Tag number and description
Inside	:	Manufacturer's name, purchase order number and year of manufacture, part number of manufacture.

2.5.5 Monitoring Console with Man Machine Interface

2.5.5.1 In addition to the Gas Detection panel, Monitoring Console with Man Machine Interface shall be supplied for presentation of complete data related to gas detection, when specified in the purchaser's specifications. The console shall meet the following functional requirements:

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a) Provide all data online for all gas detectors distributed in the unit in a pre-defined or user definable format. The data includes the actual concentration of each detector and the gas detector data in alarm.

b) Provide all maintenance data, which shall include system alarms (hardware and software) and graphic representation of failed module.

c) Provide facility to configure complete system including detectors.

d) Report Generation

d) Data storage and archival

e) Multi-user access with multi-level protection shall be provided for programming, monitoring and maintenance software.

f) Time synchronization

When specified, the system shall be time synchronized with GPS or with host system i.e. DCS. The DCS / GPS shall send time synchronization pulses at predetermined times and shall automatically reset the system clock.

2.5.5.2 Gas Detection Displays

2.5.5.2.1 The system shall have a powerful set of user-friendly displays for gas detection and monitoring. User shall be able to navigate through the displays in a logical manner.

2.5.5.2.2 The displays shall be structured in hierarchical manner, which shall allow operator to select the display of choice with minimum keystrokes.

2.5.5.2.3 For the purpose of easy monitoring, gas detectors shall be arranged in logical groups. Each group shall represent a set of gas detectors related as per the process equipment or process area.

2.5.5.2.4 Software shall facilitate windowing of displays in such a way that any display can be opened-up as a window. In general the system shall allow opening up of upto 4 windows in any display.

2.5.5.2.5 The displays shall be arranged as per following requirements:

2.5.5.2.6 Overview Display

a) The overview display shall summaries the complete plant, arranged in the logical groups. Each group shall preferably be identified by a different colour for clear understanding.

b) Each group area shall have Smart buttons, which shall represent the type of detector. The colour for these smart buttons shall be as follows:

i) Flammable gas detector shall have orange colour and Toxic gas detector shall have blue colour button for clear identification.

ii) The colour of the healthy device / network except detectors shall be green while faulty device / network shall be 'Red' flashing before acknowledgement and steady 'Red' when acknowledged.

2.5.5.2.7 Group Display

Operator can navigate into any group by selecting the smart button. Generally single group display shall display both flammable and toxic gas detectors. In case the density of detectors is large, each flammable and toxic gas detectors may have independent sub groups.

a) The group display shall have process layout of the area as per the plant PFD identifying the location of the detectors with respect to their physical location.

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b) Each detector shall be identified with a Smart button, the colour of which shall be as per clause no. 2.5.5.2.6 of this specification.

2.5.5.2.8 Detailed Display

Operator can open a window by selecting any detector in-group display. The detailed display window shall indicate:

a) Tag number of the selected detector

b) A bar graph showing concentration in the scale of 0-100% of LEL in case of flammable gas detector and actual detector range in case of Toxic detectors.

c) Configuration/program modification

d) Logic generation, if applicable, using ISA or IEC-61131 Complaint Logic Symbology.

e) Defining/redefining user keys

f) Any other programming/program modification facility necessary but not specifically indicated.

2.5.5.2.9 Trend Display

a) Historical trending display shall be provided for all the gas detectors. The trend shall be available for a period of minimum 30 days with an automatic removal facility after the specified time period.

b) The data shall be archived every one minute for each detector. The disc space shall be sized accordingly.

c) Trend display shall either be provided for individual Tag number or for a group of Tag numbers. Each group trend display shall have trend of at least six (6) detectors, each identified with a separate colour.

d) It shall be possible to scroll the display by expanding or compressing the time base.

2.5.5.2.9 Alarm and Event Display

a) All alarms shall be displayed in the sequence of their occurrence. Alarm and Events shall be displayed in following sub-displays.

(i) Gas alarms and Events

(ii) System alarms

b) A minimum of 25 numbers of latest alarms/events shall be available in each current alarm display.

c) Historical alarm display shall be provided, which shall display alarms for a period of minimum 30 days.

d) Alarms and Events in the current alarm display or in historical alarm display shall be clearly identified by colour or by other means.

Following actions shall be considered as events:

(i) alarm acknowledge

(ii) change in set point

(iii) Addition or deletion of a detector from the configuration

(iv) Calibration of detector

(v) Forcing any input i.e. inhibiting or overriding an alarm.

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2.5.5.2.10 Special Graphic Displays

a) In addition to the hierarchal displays, the system shall also provide the following displays:

(i) Multiple Bar Graph Display

Bar graph display of a group of selected Tag numbers to present relative concentration of the gas. The display shall have a typical of twelve (12) bar graphs placed adjacent to each other. The detectors shall be selected from the group display, in general, in the sequence of their relative position in multiple bar graph display.

(ii) Graphic Displays

It shall be possible to configure and display the user specific graphics. The graphic may be a block diagram, a process flow diagram or an equivalent. The colour of lines, equipments etc. shall be selected by the user, however the colour and alarm sequence of the detectors shall be same as per clause 2.5.5.2.6 of this specification.

(iii) Diagnostic Display

The system shall provide a detailed diagnostic display, which shall show:

- Status of each detector-the colour of faulty detector shall be displayed with 'Yellow' colour.
- Status of the network - the network shall include status of network switches/ hubs also.
- Status of each server/PC connected over the network for each type gas detectors.

b) In case of gas detection beyond the high set point or high-high set point, the Smart button shall start flashing. On acknowledgement, these buttons shall turn to steady red status identifying group in alarm in case of high alarm while shall keep flashing in case of high-high alarm.

The button shall assume the normal colour if the detector indicates concentration below high set point.

2.5.5.3 System Engineering/Programming

The system configuration shall be possible either from a separate PC (i.e. engineering console) or from the operator PC, as specified in the purchaser's specification.

In either of these cases, the engineering function shall be protected against unauthorized operation either by password protection or by key lock switch.

Following functions shall be possible in engineering mode:

a) Configuration/assignment of detectors

b) Configuration of network / network devices and servers / PCs

c) Display configuration including graphic / groups / trends etc. formation.

d) Historical trend and alarm configuration

e) Program modification

f) Report generation and assignment

g) Maintenance aids

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h) Set point value as configured for the Tag number

i) The actual concentration and set points shall also be indicated in digital form

2.5.5.4 Data Storage and Archival

a) It shall be possible to store data and retrieve the same when required. System data like Historical data and System configuration data shall be stored in dual discs including dual disc drives.

b) In general, the system shall have facility to retrieve data from the storage disc to archive disc when the storage disc is full. In addition, the system shall also alert the operator whenever the storage disc is 80% full.

2.5.5.5 System Licenses and Software copies

a) All software, system as well as application, shall be supplied fully installed on the equipment.

A master copy on a suitable portable media like DVD shall be provided for purchaser's safe custody.

b) The number of user licenses shall be as specified in purchaser's specification. When no requirement is indicated, vendor shall supply at least six (6) numbers of licenses.

2.5.5.6 Log Reports

a) The system shall facilitate generation of Reports based on the data available. The type and format of each report shall be user definable. Following reports shall be possible.

b) Current alarm report showing detector in alarm (High or High-High), time of occurrence, time of acknowledgement etc.

c) Daily report showing detectors, which are or which have been in alarm during the day. The report shall indicate Tag number, Type of alarm (Hi or Hi-Hi) time of occurrence, time of acknowledgement and time to clear the alarm etc.

d) Weekly Report and Monthly Report

Same as 'Daily Report' except the time period shall be either a week or a month as the case may be.

e) Alarm Inhibiting Report shall indicate the alarms inhibited/overridden/forced along with date & time of enforcement, time of return to logical state etc.

f) In addition to above user shall also be able to generate reports as per their standard operational requirements

g) Reports shall be printed on the log printer or any other multi-function printer as applicable, or as specified in the purchaser's specification.

2.5.5.7 The Monitoring Console shall be Personal Computer (PC) based with 21" size active matrix TFT type LCD display unit with backlit LED (Full HD) and having one operating cum programming keyboard and a laser printer. Unless the vendors have their own proprietary machine, the Personal Computer shall have processor of latest version with following minimum specification:

Hard Disc Capacity	1TB
Clock Speed	2.8 GHz
RAM Size	16 GB
Monitor Size	21" TFT type LCD display unit with backlit LED

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2.5.6 Gas Detection System Programmable Logic Controller (PLC)

2.5.6.1 When specified in the purchaser's specifications, Gas Detection system with Programmable Logic Controller (PLC) shall be supplied along with a Monitoring Console as Man Machine Interface (MMI), Hardwired console with pushbuttons/ switches, as required and a coloured laser printer for printing alarms and reports. The PLC shall receive the following from all gas detectors:

a) (4-20 mA) for gas concentration levels,

b) Serial link RS485 for the diagnostics, programming and calibration information, when specified.

2.5.6.2 The PLC shall perform the following functions:

a) Display the gas concentration levels from each detector in engineering units on the MMI

b) Generate high alarm, high-high alarm as specified under the Gas Monitors/ Controllers section (clause No. 2.5.2 of this specification) and display the same on the MMI.

c) Printing of alarms and events on the printer.

d) Display diagnostic messages from each detector on the MMI and printout of diagnostic alarms.

d) Dynamic graphic displays for each area on the MMI.

e) In addition, the monitoring console shall meet all the requirements specified in clause 2.5.5 of this specification.

f) Calibration/test switches on the hardwired console to allow for sensor calibration without alarm outputs.

g) Provide actuation signal and reset signals to Hooters in the field and Hooter & Beacon in the control room.

h) Provide serial RS485 output with 'MODBUS RTU' protocol for interfacing with purchaser's Distributed Control System (DCS)

i) Provide isolated hardwired contacts to purchaser's Emergency Shutdown System (ESD).

2.5.6.3 All other specification of the PLC shall be as per 'Standard Specification for Programmable Logic Controllers' 6-52-0040.

3.0 NAMEPLATE

3.1 Wherever Gas Detectors are specified,

Local mounted instruments shall have a stainless steel nameplate attached firmly to it at a visible place, furnishing the following information:

a) Tag number as per purchaser's data sheets.
b) Manufacturer's serial number and /or model number
c) Manufacturer's name/trade mark.
d) Body material.
e) Measuring element material.
f) Range of measurement.
g) Area classification in which the equipment can be used, this shall be to the same code as per purchaser's data sheets.

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3.2 Wherever Gas Detection System is specified, In addition to the details specified in 3.1, Following shall also be noted.

a) Nameplates shall be constructed of black laminated plastic plates with engraved lettering and securely fastened with 316 Stainless Steel screws. One screw hole for each nameplate shall be elongated to provide for expansion and contraction of the nameplate.

b) The nameplates shall be mounted below the controllers, identifying the location of their respective sensors. If a multi-channel controller is used, each sensor shall be tagged on the nameplate using the corresponding point number.

c) Front panel-mounted control switches shall also be tagged. Nameplates shall be located directly below the corresponding switch with the size and lettering proportional to the front panel mounting dimensions of the device.

d) All front panel-mounted instruments shall also be identified with a metal or plastic nameplate attached to the rear of the device and easily visible from the rear of the panel.

e) Tagging for these nameplates shall be identical to that used in the panel front. All rear panel auxiliary equipment shall be similarly identified. The tagging for this equipment shall correspond to that used on the applicable schematic diagrams.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing of all the items at the vendor's works in line with the inspection test plan and approved quality documents for gas detection system. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

5.0 SHIPPING

5.1 Wherever Gas Detectors are specified,

a) All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

b) Instruments shall be supplied individually, in suitable sealed packing.

c) All electronic instruments in oxygen and chlorine service shall be separately packed along with a certificated indicating 'CERTIFIED FOR OXYGEN / CHLORINE SERVICE', as applicable.

d) Loose supplied accessories shall be packed with proper tag numbers of their respective instruments.

5.2 Wherever Gas Detection System is specified, In addition to the details specified in 5.1, following shall also be noted.

a) After initial acceptance of the panel at the vendor's shop by the purchaser, the sensors and all panel components, which the vendor considers liable to be damaged during shipment or storage, shall be packaged for separate shipment. If instruments are removed from the panel, panel and their connections shall be suitably tagged to ensure simple re-installation at the job site. Each instrument shall be sealed in plastic bags containing moisture-absorbing desiccant.

b) Spare parts shall be packaged separately and clearly marked as "Spare Parts".

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STANDARD SPECIFICATION FOR AIR CONDITIONING SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	08/07/2020	REVISED AND REISSUED	AA	KCP	PPP	SKS
0	25/09/2013	ISSUED AS STANDARD SPECIFICATION	SD/AA	PPP	PB	DM

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Abbreviations:

AHU	:	Air Handling Unit
AMCA	:	Air Movement and Control Association
ANSI	:	American National Standards Institute
AHRI	:	Air-conditioning & Heating Refrigeration Institute
ASME	:	American Society of Mechanical Engineers
ASHRAE	:	American Society of Heating, Refrigerating and Air Conditioning
ASTM	:	American Society for Testing and Materials
BS	:	British Standards
CFC	:	Chlorofluorocarbons
CRCA	:	Cold Rolled Closed Annealed
DX	:	Direct Expansion
GI	:	Galvanised Iron
GSS	:	Galvanised Steel Sheet
HVAC	:	Heating, Ventilation & Air-conditioning
IS	:	Indian Standard
ISHRAE	:	Indian Society of Heating, Refrigerating and Air Conditioning
MCC	:	Motor Control Centre
NC	:	Noise Criterion
ODP	:	Ozone Depletion Potential
OISD	:	Oil Industry Safety Directorate
QA	:	Quality Assurance
SS	:	Stainless Steel
SMACNA	:	Sheet Metal and Air Conditioning Contractor's National Association
TR	:	Ton of Refrigeration
TEMA	:	Tubular Exchanger Manufacturers Association
TPI	:	Third party Inspection
VOC	:	Volatile Organic Compound
UL	:	Underwriters Laboratories

Packaged Equipment Standards Committee

Convenor : Mr. P.P. Pandey

Members :
Mr. Sanjay Mazumdar
Mr. Shishupal Choudhury
Mr. R. R. Shrivastava
Mr. K. C. Paikar
Mr. A. Natarajan
Mr. Plaban Dan
Mr. Ayush Mathur (Projects)

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1.0 GENERAL

1.1 This specification outlines the minimum requirements for design, engineering, manufacture, inspection, testing, painting, supply, erection, commissioning and performance testing of air-conditioning system, complete with all accessories.

1.2 The Heat Load Calculation shall be carried out individually room wise for all the Building as listed in Job Specification as per ASHRAE / Carrier Standards.

2.0 CODES, STANDARDS AND REGULATIONS

2.1 This standard specification is based on the following standard specifications and the standards referred therein, which shall be deemed to be part of this standard specification:

IS:659	Safety code for Air conditioning.
IS:660	Safety code for Mechanical Refrigeration.
IS:655	Specification for Air ducts
IS:2494 (Part-1)	V-Belts - Endless V-Belts for Industrial Purposes - Part 1 : General Purpose - Specification
IS:2494 (Part-2)	V-belts - Endless V-belts for industrial purposes-Part 2 Fire resistant and antistatic V-belts - Specification
IS:3142	Pulleys-V-Grooved Pulleys for Endless V-Belts Sections Z, A, B, C, D and E and Endless Wedge Belts Sections SPZ, SPA, SPB and SPC - Specification
IS:1239 (Part 1)	Steel Tubes, Tubular and Other Wrought Steel Fittings - Specification - Part 1 : Steel Tubes
IS:3589	Steel Pipes for Water and Sewage (168.3 to 2 540 mm Outside Diameter)
IS:277	Galvanized Steel Sheets (Plain and Corrugated)
IS:2062	Hot Rolled medium and high tensile structural steel
IS:4894	Centrifugal fans
IS:8148	Packaged Air Conditioners
IS:3615	Glossary of terms used in Refrigeration and Air Conditioning
ISO:15138	HVAC for Offshore Production and Installation
OISD STD 163	Safety of Control Room for Hydrocarbon Industry
ANSI/ISA-S71.04	Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants
AHRI-450	Performance Rating of water cooled refrigerant condensers, Remote Type
AHRI-460	Performance Rating of remote mechanical draft air cooled refrigerant condensers.
AHRI-480	Performance Rating of Remote Type Refrigerant-Cooled Liquid Coolers
AHRI-520	Performance Rating of Positive Displacement Condensing Units
AHRI-550/590	Performance Rating of Water Chilling Packages using Vapour Compression Cycle.

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AHRI-560	Absorption Water Chilling and Water Heating Packages.
ATC-105	Acceptance test code for water-cooling tower
ASME Section VIII Div.I	Boiler and Pressure vessel code- Pressure Vessels.
TEMA	Tubular Exchanger Manufacturers Association.
ASTM B-111	Standard Specification for Copper and Copper Alloys Seamless Condenser Tubes and Ferrule Stock.
ASTM B-359	Standard Specification for Copper and Copper Alloys Seamless Condenser and Heat Exchanger Tubes with Integral Fins.
ASTM B-280	Standard Specification for Seamless Copper Tubes for Air Conditioning and Refrigeration Field Service.
ASTM A516	Specification for pressure vessel plates, carbon steels, for moderate and low temperature service. SMACNA Sheet Metal and Air Conditioning Contractors' National Association-HVAC Duct Construction Standards-Metal and Flexible.
AMCA-210	Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
ASHRAE	Handbooks of: - Fundamentals. - HVAC Systems and Equipment. - HVAC Applications. - Refrigeration.
ISHRAE	Indian Society of Heating, Refrigerating and Air Conditioning
BS EN 779	Particulate air filters for general ventilation – Determination of the filtration performance.
UL-555	Specification for safety for fire dampers
UL-555S	Specification for safety for smoke dampers
NFPA-90A	Standard for Installation of Air-conditioning and Ventilation Systems
6-41-0003	Standard Specification for Centrifugal Pumps (Water Service)
6-36-0007	Standard Specification for Vapour Absorption Refrigeration Package
NBC	National Building Code of India

Latest revisions of the above mentioned standards as on the date of enquiry shall be applicable.

2.2 Other international standards may also be acceptable subject to their being equivalent or superior to those listed above, with prior approval of Purchaser.

2.3 For provisions not covered by the above codes & standards, applicable good engineering practices and norms shall govern.

2.4 National laws and statutory provisions, together with any local by-laws for the state wherein the Air-conditioning system is required to be installed shall be complied with.

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3.0 TECHNICAL REQUIREMENTS

3.1 Duty

All major equipment shall be designed for minimum 20 years life unless otherwise specified elsewhere in bidding documents.

3.2 Refrigerant

Refrigerant shall be non-CFC, non-ODP environmental friendly unless otherwise specified elsewhere in bidding documents.

3.3 Vapour Compression System

3.3.1 Refrigerant Compressor

Based on the capacity & selection criteria as specified in job specification, the compressor shall be one of the following types:

- Reciprocating or Scroll Compressor
- Screw Compressor
- Centrifugal Compressor

3.3.1.1 Special Requirement for Screw Compressor :

i) The compressor shall be equipped with automatic unloaded starting arrangement. It shall have automatic sliding valve capacity control arrangement actuated through suction pressure sensor.

ii) Economiser port may be used to improve the system efficiency & performance.

3.3.1.2 Special Requirement for Centrifugal Compressor :

i) Casing hydrostatic test pressure shall be at least 130% respectively of design pressures.

ii) Lubrication system shall be provided as per proven vendor standard.

iii) Variable inlet guide vanes shall be provided in the suction of compressor. Variable inlet guide vanes shall be operated by hydraulic oil pressure/separate electric/pneumatic motor/solenoid valve, for capacity regulation purposes. Automatic capacity regulation feature is required on compressor along-with manually operated device.

3.3.1.3 Purge recovery unit, if required, shall be provided to efficiently separate out non-condensable gases and moisture from refrigerant as per Manufacturer's Standard.

3.3.2 Electric Drive

3.3.2.1 All Electric drivers rating for mechanical equipment shall be rated minimum 110% of the maximum power required at motor shaft (including transmission losses) at operating conditions.

3.3.2.2 All electric drives shall be in accordance with the specified Electrical Specifications/Requirements.

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3.3.3 **Condenser**

3.3.3.1 The tubes shall not be less than 12.5 mm diameter and shall be adequately supported to prevent tube vibration.

3.3.3.2 Condensers for 160 TR & above rated AC machines shall have water boxes & covers so that each tube sheet can be exposed without disturbing the piping connections.

3.3.3.3 Air cooled condensers, if specified, shall have seamless tubes and shall be complete with all accessories including fan with drive motor, refrigerant receiver (for condensing unit), refrigerant headers, supports etc.

3.3.4 **Evaporator**

3.3.4.1 Tubes shall not be less than 9.52 mm diameter. Tubes shall be adequately supported to prevent tube vibration.

3.3.4.2 Gas superheating in DX-evaporator it-self shall be ensured. Liquid entrainment to compressor shall be restricted by suitably designed arrangement for flooded chiller.

3.3.4.3 Evaporators for 160 TR & above rated water chillers shall have water boxes & covers so that each tube sheet can be exposed without disturbing the piping connections.

3.3.4.4 In case of chilled water system, chiller/evaporator shall be of shell and tube type (as per TEMA standard) with shell and tube sheet material as carbon steel and tubes in copper construction.

3.3.5 **Vapour Compression Package Assembly**

3.3.5.1 Refrigeration package using reciprocating/scroll/centrifugal compressor shall be mounted on a single skid comprising of compressor, drive motor, gear box, condenser, and evaporator (applicable for chilled water system), local control panel with gauges/indications. However, refrigeration package using screw compressor may be furnished in two skids - One compressor skid and other comprising condenser, evaporator (applicable for chilled water system), local control panel with gauges/indications.

3.3.5.2 Skid shall be designed so as to provide maintenance accessibility and operation ease of valves and controls. Instruments shall be easily readable.

3.3.5.3 Lifting hook/eye shall be provided for handling of equipment during maintenance.

3.3.5.4 Steel structural members of the skid shall conform to IS-2062/ASTM A 36.

3.4 Vapour Absorption Refrigeration (VAR) System

For VAR System, EIL Standard Specification no. 6-36-0007 shall be followed.

3.5 Air Handling Unit

3.5.1 The air-handling unit shall be of double skin construction with sandwiched insulation between the two sheets/skins. The air handling unit shall comprise of filter section, damper section, heating section (if required), humidifier section (if required), cooling coil section, fan section and drain pan.

3.5.2 Cooling coil shall be minimum 4 rows deep and shall be selected for a maximum face velocity of 2.5 m/s. Coils tube shall be of copper with aluminium fins (12-14 fins/inch). In case of chilled water system, water velocity in cooling coil shall not exceed 1.80 m/s.

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3.5.3 For part load operation of DX units, Condensing units shall be with multiple independent refrigeration circuits which are switched on/off depending upon the actual load. The AHU coil shall be designed and manufactured accordingly to facilitate part load operation.

For part load operation of Chilled water system, Chilled water cooling coil shall be equipped with flow control valve with modulating temperature controller and globe valve in bypass.

3.5.4 Fan section will have centrifugal type backward curved bladed fan with electric motor. Fan rotating assembly shall be dynamically balanced.

3.5.5 Fan outlet velocity shall be restricted within 9.2 m/s.

3.5.6 Fire resistant canvas connection with metallic flanges shall be provided between fan outlet & duct.

3.5.7 Taper lock pulleys shall be provided with antistatic V-belts for drive. Direct driven fan shall also be acceptable.

3.5.8 Drain pans for condensate shall be of stainless steel construction and thermally insulated. Water seal shall be provided in the drain outlet.

3.5.9 All damper linkage arrangement (automatic/manual) shall be of SS 304 material.

3.6 Air Filters

3.6.1 **Pre-filter at AHU / Package/ Precision AC Unit Inlet** :

3.6.1.1 Filter section shall be provided with cleanable synthetic media filters

3.6.1.2 Filters shall be selected for a pressure drop of 4 mm WG maximum in clean condition.

3.6.1.3 Filters shall have filtering capacity of 90% efficiency upto 10 microns for AHU and 80% efficiency upto 20 microns for Package Units.

3.6.1.4 For precision AC, pre filter shall be provided in case fresh air supply is envisaged. Pre filter for fresh air can be provided inside or outside the unit as per manufacturer's design. Fresh air fan (if required) to take care of the pressure drop shall be provided.

3.6.1.5 Magnehelic mechanical gauge shall be provided for measuring pressure drop across filters.

3.6.2 **Fine Filter** :

3.6.2.1 Fine filters, if specified in Data Sheet/Job Specification shall be provided within AHU/downstream of Package Unit/within Precision Unit. Filters shall be capable of filtering dust up to 5 microns particle with an efficiency of 95%.

3.6.2.2 Fine filters shall be selected for a pressure drop of 6.5 mm WG maximum in clean conditions.

3.6.2.3 Magnehelic mechanical gauge shall be provided for measuring pressure drop across filters.

3.6.3 **Chemical Filter :**

3.6.3.1 Chemical Filter shall be provided in fresh air circuit of AC system wherever specified in Job Specification. Filtered fresh air shall be mixed with room-recirculated air before passing through air handling unit (AHU) /Package AC unit/ Precision AC unit.

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3.6.3.2 Chemical filter unit shall be skid mounted accommodating pre filter, after filter, fresh air fans with motors (one no. working & one no. standby) and accessories. Outdoor located chemical filters (if specified in Job Specification/ Data Sheet) shall be provided with suitable dismantling rain-cover and rain-hood and bird screen at air intake.

3.6.3.3 Chemical filter unit in panel form shall also be acceptable provided the same is of double skin construction.

3.6.3.4 Unless otherwise specified in Job specification, Chemical filters shall be selected to capture Group-A gases as per ISA-71.04 standard (From GX environment at outlet to G1 environment at inlet).

3.6.3.5 Chemical filter shall be designed for the chemical media life of minimum one (1) year. Chemical filter supplier shall furnish required chemical media quantity calculations which shall be duly vetted (signed, stamped with relevant date of submission) by media manufacturer at post order stage.

3.6.3.6 Chemical Media shall be nonflammable, suitable to work under extreme humidity and temperature conditions as per applicable site conditions & Environmental norms/regulations.

3.6.3.7 For Refinery and Petrochemical environment: - Two stage deep bed chemical filters shall be provided - first bed shall contain required quantity of chemical media of activated carbon and activated alumina as a base material, together made into number of single pellets (i.e. each pellet made up of a mixture of activated alumina + activated carbon) with alkali impregnation as per media manufacturer standard. Second bed shall contain required quantity of chemical media of activated alumina pellets impregnated with oxidizing agent such as Potassium Permanganate or Sodium Permanganate etc. as per media manufacturer standard. Activated Carbon shall not be used in isolation in any bed and it is not permitted either as impregnated form or as separate pellet in blend media. Chemical media in both beds must have min. 15% moisture for effective neutralization & oxidation reactions to take place.

3.6.3.8 The pre-filters at inlet shall be capable of removing dust particles of size above 10 microns with minimum 90% efficiency and fine filters at outlet shall be capable of removing particles of size above 5 microns with minimum 95% efficiency.

3.6.3.9 Chemical filter unit shall be designed/sized considering the velocity across filter media as ~0.51 m/sec (100 FPM). Quantity of chemical media shall be calculated considering above velocity with residence time furnished and guaranteed by chemical media manufacturer for the proposed media.

3.6.3.10 Unit shall be suitable for outdoor/indoor installation (as applicable) & for continuous operation.

3.6.3.11 For outdoor located chemical filter units, fan shall be in blow through mode (Forced Draft) with respect to chemical filter media. For indoor installations fan shall be in Induced Draft mode with respect to chemical filter media. Intake of Fresh Air only through main HVAC blower is not acceptable.

3.6.3.12 Chemical filter unit should have adequate provision for easy removal & servicing of filter packs. Necessary handholes / Media filling nozzles with blind flange, gaskets and fasteners along with 1 set of spare gaskets & fasteners for each size and type shall be provided.

3.6.3.13 Chemical Filter Unit shall be provided with Magnehelic mechanical gauge for measurement of differential pressure across filters.

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3.6.3.14 Fan shall be selected corresponding to air density at lowest ambient temperature as per site conditions. Fan curves and Motor power selection calculations shall be furnished accordingly.

3.6.3.15 Chemical media shall be supplied in separate air tight, water proof packed containers for filling at site. Vendor shall furnish the procedure for media filling for Purchaser's reference. Chemical media shall be identified with authentic documents which shall be furnished from media manufacturer indicating type of media, year of manufacture, batch number of media and test certificates.

3.6.3.16 A Certificate/undertaking from Media manufacturer shall be furnished indicating the suitability of the proposed media for the specified application along with guaranteed gas removal capacity values with guaranteed life against applicable corrosive gas (H_2S, SOx, NOx, Cl_2 etc.). Type test certificates of H2S gas removal capacity for the offered media in accordance with ASTM D6646 or Equivalent from an independent laboratory shall be furnished by vendor which shall establish the guaranteed H_2S removal capacity of the proposed media. Gas removal capacity of H_2S for the chemical media should not be less than 12%. Purchaser/EIL reserve the right to get the supplied chemical media tested independently at their end to ascertain the quality of the media. Non conformance to the indicated/offered specifications/quality may lead to severe penalties including blacklisting of the chemical filter supplier for any future EIL projects.

3.7 Heating Unit

3.7.1 Heater shall be re-heating type as per psychometric process requirement.

3.7.2 Heating shall be electric/hot water as specified in Job Specification/Data Sheet.

3.7.3 Heater rated capacity shall have a minimum 10% margin over required capacity.

3.7.4 Electric strip heaters, if provided, shall be complete with heating thermostats, safety thermostats. Hot water coils shall be complete with control valve and proportionating thermostat etc.

3.8 Humidifier Unit

3.8.1 Humidifier shall be steam pan type / Electrode type/ Infrared Type or water spray type as per Job Specification/Data Sheet.

3.8.2 Pan humidifier shall be complete with immersion type electric heaters actuated by humidistat, water float valve, stop valve in water make up line, level switch interlocked with heaters. Pan shall be in stainless steel construction. The outer surface shall be thermally insulated.

3.8.3 Water spray type humidifier shall comprise of spray header, nozzles, arms, etc; fractional H.P pump set, humistat, solenoid valve, etc. Make-up tank, water collecting trough complete with drain, quick fill, overflow, strainer, make-up connection with ball and float valve shall be provided.

3.8.4 Drain pan / water collecting trough of water spray humidifier shall be of SS-304/16G GSS / CRCA and thermally insulated.

3.8.5 The humidifier shall have a minimum 10% margin over required capacity.

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3.9 Cooling Tower

3.9.1 Cooling tower, if required as per Job Specification, shall be of induced draft and counter flow type. The air inlet design W.B. temperature will be as specified in the Job Specification/data sheet.

3.9.2 In counter flow cooling tower, cells having more than one louver face, longitudinal partition wall shall be provided from water level to top air inlet louvers to prevent air from blowing through the louvered portion of the tower.

3.9.3 Material of construction of cooling tower components shall be as follows:

Structure	:	FRP
Casing	:	FRP/ GRP
Louvers	:	FRP/ Vacuum formed virgin PVC
Packing/ fill	:	Vacuum formed virgin PVC / PP
Fill supports	:	GRP grid / PVC coated steel wires
Drift eliminators	:	Extruded PVC
Spray nozzles	:	PP/ Bronze
Hot water distribution basin	:	FRP/ GRP
Basin cover	:	FRP / HDG steel
Fan stack	:	FRP
Fan blades	:	FRP/ Cast aluminium alloy
Fan hub	:	CI/ HDG steel / Cast aluminium alloy
Ladder :	:	HDG steel
Nuts/ bolts/ washers	:	SS304
Structural connections	:	HDG Steel / SS304.
Anchor bolts and brackets	:	SS 304

3.9.4 **Framework**

3.9.4.1 Cooling tower framework shall not be stressed greater than the maximum allowable values.

3.9.4.2 Non framework members such as casing, louvers, partitions and fill shall not be used for the structural loads. Structural frame of tower shall be designed to withstand the specified wind and seismic conditions.

3.9.4.3 Steel components such as the mechanical equipment support members, shall be heavy gauge steel and protected against corrosion by hot dip galvanizing.

3.9.5 **Casings and louvers**

3.9.5.1 Casing shall be of bolted constructions.

3.9.5.2 Louvers, if provided, shall be spaced to minimise air resistance and prevent water splash out.

3.9.5.3 Leakage shall not be permitted through casing.

3.9.6 **Fill**

3.9.6.1 Fill shall be easily removable. Movement or sagging of fill assembly shall be prevented.

3.9.6.2 Material of fill shall be impervious to rot, decay, fungus or biological attacks.

3.9.6.3 Maximum allowable drift loss shall be 0.05% of total throughput.

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3.9.7 **Stacks and deck**

3.9.7.1 Fan stack shall be of self-supporting type designed to withstand applicable wind load without external support ties or cable bracing. HDG steel bird screen shall be provided at stack discharge.

3.9.7.2 Maximum tip clearance shall be 13 mm or 0.5% of the fan diameter, whichever is greater.

3.9.8 **Water Distribution System**

3.9.8.1 The distribution system shall operate satisfactorily at one half the design water circulation rate and also be designed to operate under at least 1.25 times the design water circulation rate without excessive head loss or overflow of the water distribution basin.

3.9.8.2 FRP/ HDG steel distribution basin cover shall be provided to prevent the accumulation of debris and algae in the hot water distribution basin.

3.9.9 **Access**

3.9.9.1 Cat ladder shall extend from fan deck to grade level to access the fan, motor and drive assembly for maintenance.

3.9.9.2 Doors and walkways shall be provided at basin level for access to the tower internals and interior walls.

3.9.10 **Fan blades, drivers and transmission**

3.9.10.1 Fan blades and hubs shall be statically and dynamically balanced and have provision for field balancing. The noise level of the fan and the drive unit shall be limited to 85 dB(A) at one meter periphery from noise source.

3.9.10.2 Motor shall be located outside the moist air stream. Suitable gearbox and cardan shaft of HDG steel construction (or V-belt for small size) shall be provided.

3.9.10.3 Service factor for coupling, shaft and gearbox shall be 2.0 minimum on motor rating.

3.9.10.4 Speed reducer shall be helical type. Oil level indicator and filling connections shall be located outside the fan stack. Proper care shall be taken to avoid leakage of lube oil.

3.9.10.5 Metal safety guards shall be provided on all rotating equipment. Guards shall be provided at each end of the floating shaft to protect against shaft whip in the event of shaft failure. Shaft and coupling shall be dynamically balanced.

3.9.10.6 Motor shall be dual speed, specially designed for cooling tower duty. Motor rating shall have at least 15% margin over fan shaft power consumption. Motor shall be furnished with special moisture protection on windings, shaft and bearing.

3.9.10.7 Motor shall be in line with relevant Indian standard.

3.9.10.8 Bearings shall have an L10 life of not less than 1,00,000 hours, unless otherwise specified.

3.9.10.9 Fan and shaft shall be supported by heavy duty self-aligning, grease packed bearings with moisture proof seals. Vibration monitoring switch shall be provided for fan. Acceptable vibration level shall be 100 micron. Potential free contact shall be provided for indication in control panel.

3.9.10.10 Necessary cable tray supports of FRP shall be provided from fan to basin curb. Also necessary FRP support for installing push button station shall be provided.

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3.9.11 Local push button station in weatherproof enclosure with a canopy cover shall be provided.

3.10 Water Pumps

3.10.1 The pumps shall conform to EIL standard specification no 6-41-0003.

3.10.2 Pumps shall be provided with mechanical seal.

3.10.3 The pumps shall be complete with drive motor, coupling with non-sparking guard, common base plate, fixing and hold down bolts.

3.10.4 Pump assembly shall be dynamically balanced.

3.11 Refrigerant Piping for Vapour Compression System

3.11.1 Refrigerant piping shall be of copper as per manufacturer's standards.

3.11.2 All piping network shall be leak tested with nitrogen at 1.1 times of design pressure using soap water solution for minimum 24 hours. After establishing the capability to withstand test pressure, the piping network shall be dried and vacuumised to 2.5 mm Hg absolute. Vacuum shall be broken with dry nitrogen and the system shall be re-vacuumised to 2.5 mm Hg absolute. This vacuum shall be held for 12 hours before charging the refrigerant. After charging of refrigerant, leak detection shall be done using electronic or halide torch leak detector.

3.11.3 Refrigerant piping shall be arranged in a manner so as to avoid tripping or headroom problem. If pipes are routed on the floor, proper protection cover for pipes shall be provided.

3.12 Water Piping

3.12.1 All water piping shall be of Carbon steel as per project Piping Material Specification.

3.12.2 Isolation valve with reducer / expander (as required) along with companion flanges shall be provided by vendor for all battery limit connections with purchaser utility lines.

3.12.3 Piping shall be arranged in a manner so as to avoid tripping or headroom problem.

3.12.4 UPVC pipe with 9 mm Closed Cell Flexible Elastomeric Nitrile Rubber insulation shall also be acceptable for drain piping.

3.13 Combination Fire & Smoke Dampers

3.13.1 Combination fire & smoke dampers shall be installed in supply air and return air path. These shall be tested and certified as per UL-555 and UL-555S for 1.5 hour fire rating and smoke leakage class-I with temperature category 176 °C. Type test certificates for the same shall also be provided.

3.13.2 Dampers shall be spring return, motorized (pneumatically operated in control room / SRR buildings as per OISD requirement) & fail safe type with indication for open / close position.

3.13.3 Damper operation shall be interlocked (through HVAC Panel) with the signal from purchaser's fire and gas panel.

3.14 Closed Pressurised Expansion Tank

3.14.1 Closed expansion tank shall be of minimum 500 liter capacity (unless otherwise required because of system design requirement)

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3.14.2 The closed expansion tank will be of M.S. construction (finished with EPOXY coating) of 6 mm thick with interchangeable EPDM-BUTYL rubber membrane. The expansion tank shall be complete with safety relief valve, pressure reducing valve and pressure gauge.

3.14.3 The tank will be of pressure rating to suit the system pressure and will be sized to adequately compensate for water expansion due to operating temperature variations. The tank shall be fabricated as per IS 2825-1969 for "non-fired pressure vessels" and the flanges shall be as per IS 6392-1971.

3.14.4 For chilled water application, it will be insulated with 32mm thick insulation to the specifications and cladded with 26G-aluminium cladding.

3.14.5 The expansion tank shall be supplied along with pressurization unit. The pressurization unit shall consist of two nos. (one working + one stand by) high pressure pumps of suitable pressure rating mounted on M.S. frame, complete with interconnecting piping, isolation valves, NRV, Y-strainer, pressure gauge, pressure transmitter, auto-logic panel (IP 55) with dry-run protection, electrical MCB and interconnecting wiring.

3.14.6 The unit shall be housed in powder-painted canopy suitable for external installation, if required.

3.14.7 Tank shall have rigid supporting arrangement of structural steel per IS-2062/ASTM A 36.

3.15 Plant Room Ventilation

3.15.1 A.C. Plant room shall be ventilated by wall mounted exhaust fan(s) complete with electric motor, louver shutter and galvanised expanded wire-mesh protection guard on intake side of exhaust fans.

3.15.2 The capacity shall be decided based on 15 air changes per hour.

3.15.3 In case of air intake through wall, weather protection louvers along-with bird protection screen shall be provided with suitable structural steel frame in wall.

3.16 Air Distribution, Ducting, Diffusers / Grilles

3.16.1 Ducts shall be designed, fabricated and flanged as per IS-655 for static pressure up to 65 mm WG. In case, static pressure is more than 65 mm WG, SMACNA code shall be followed for design and fabrication of duct.

3.16.2 Ducts shall be fabricated using GI sheets having minimum 120 g/m^2 of zinc coating.

3.16.3 Duct hangers shall be supported with anchor fasteners in the roof. Anchor fasteners shall be provided by vendor.

3.16.4 All flange joints shall have 6 mm thick Neoprene packing as gasket stuck to the flanges with adhesive (viz., resins like araldite or equivalent).

3.16.5 All the duct shall be made air tight with the help of sealant. Leak test shall be conducted on the duct before insulation.

3.16.6 Ductwork shall be provided with following accessories.

- Turning Guide Vanes.
- Extractor with operating lever (if required).
- Volume control Damper in main and branch duct (opposed bladed type with 18 gauge 150 mm wide blades and 16 gauge casing of GSS).
- Fire resistant flexible connection between duct chute and diffuser (if required).

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- Access doors for heaters, fire & smoke dampers and filters.

3.16.7 Supply air diffusers shall be provided and shall be fitted with sponge foam tape. Grilles/linear grilles may be used for supply if considered essential during detailed engineering subject to approval of owner/consultant. Volume control damper shall be provided with each supply air diffuser/grille. Volume control damper shall be key operated from the front of diffuser/grille. Supply air grilles shall be provided with vertical & horizontal adjustable louvers.

3.16.8 All return air diffusers/grilles, if required, shall be without volume control damper.

3.16.9 Diffusers shall be with outer frame of extruded aluminium for gypsum ceiling and stamped aluminium for grid ceiling. The inner core shall be of stamped aluminium. The diffuser finish shall be powder coated as per required colour shade.

3.16.10 Grilles shall be fixed bar type with extruded aluminium bar and aluminium angle frame. The grille finish shall be powder coated / anodized.

3.16.11 Diffusers/grilles shall not be supported from False Ceiling.

3.16.12 Both horizontal branch and low-pressure ducts shall be designed by the "Equal Friction" method with a pressure drop less than 2.5 mm WG/30 m. Duct velocity shall not exceed 9.2 m/sec for main supply air duct and 66% of supply duct air velocity for return air duct. For branch ducts leading to diffusers, velocity shall be restricted to 5.1 m/sec. Booster fan shall be provided if static pressure conditions by AHU/Package Unit blower are not met.

3.16.13 All outlets / diffusers shall be designed with a terminal velocity not exceeding 3.0 m/sec. Manufacturers' published data shall be taken into account for proper air throw/distribution, noise, and pressure drop. Selection must be made to ensure sound levels below NC 35. Sound attenuators shall be installed in ducts, as required.

3.16.14 Transition sections should be constructed such that the included angle for a converging section is less than 15 degrees and for diverging section, less than 10 degrees. When space limitations require transitions using larger angles, guide vanes shall be installed in the transition (except for fan discharge). Duct transition through fire rated wall should not impair the rating of wall.

3.16.15 Duct work shall be suitably supported with a maximum spacing of 2.0 meter. Hangers shall be provided for all fittings.

3.16.16 All damper linkage arrangement (automatic/manual) shall be of SS-304 material.

3.17 Insulation

3.17.1 The application, insulation material and recommended thickness are summarised in APPENDIX 1

3.17.2 The surfaces to be insulated shall be thoroughly cleaned and allowed to dry. Leak test shall be carried out before insulation.

3.17.3 **Hot Insulation**

3.21.2.1 Insulation is not desired for piping and equipment for which heat loss is desired except for personnel protection and to avoid thermal stress problem. Bare surfaces of pipe/equipment shall be provided with one coat of 20 micron min. (dry film thickness) heat resistant primer up to 120°C operating temperature. Insulation for personnel protection is applicable where exposed surface temperatures exceed 65°C in normal and short term operating conditions.

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3.21.2.2 The material for hot insulation shall be flexible silica-aerogel (mineral fibre) blanket compliant to ASTM C 1728, Type III, Grade 1A or Equivalent Standard with thermal conductivity of not more than 0.024 W/mK at mean temp of 24 deg C as per ASTM C 177 or Equivalent Standard. The density of the material shall be 160 – 240 Kg/m3.

3.21.2.4 Hot insulation shall be cladded with 26 SWG aluminium sheeting.

3.21.2.5 The hot insulation installation procedure for pipes shall be as per APPENDIX 2

3.17.4 **Cold Insulation**

3.17.4.1 The cold insulation shall be provided for Ducts, Pipes, Suction Line, Pumps and Expansion Tank etc. The insulation material shall meet the following requirements:

i) Closed Cell Flexible Elastomeric Foam Nitrile Rubber based Insulation complying to EN 14304/ASTM C518-15 or Equivalent Standard with thermal conductivity not to exceed 0.037 W/m-K at 20°C mean temperature differential tested as per EN 12667 / EN ISO 8497 or Equivalent Standard.

ii) Water vapor diffusion resistance (μ) not less than 7000 minimum for the plain material without any vapor barrier like aluminium foil etc.

iii) Density of the nitrile rubber shall be between 40-60 Kg/m3, The product shall have temperature range of -40^0C to $+105^0$C.

iv) Fire rated for Class 0 as per BS 476 Part 6:1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test.

v) Tested for Smoke Toxicity and Smoke Density

vi) CFC / HCFC free.

3.17.4.2 Nitrile Rubber with single side factory laminated 12 micron (minimum) thick Aluminum foil.

3.17.4.3 For Exposed ducts (without false ceiling or exposed to open atmosphere) extra cladding with 26 SWG aluminum sheeting.

3.17.4.4 The Cold insulation installation procedure for Pipes shall be as per APPENDIX 3.

3.17.4.5 Duct Insulation Installation Procedure shall be as per APPENDIX 4

3.17.5 **Acoustic Insulation**

3.17.5.1 Duct acoustic insulation shall be provided on the inner surface of ducting for a minimum distance of 6 m from AHU / Package/ Precision Air-conditioning Unit outlet.

3.17.5.2 Thickness of the acoustic insulation inside the duct shall be minimum 15mm. The insulation material shall meet the following requirements:

i) Duct liner material shall be Flexible Elastomeric Nitrile Rubber Open Cell Engineered Foam with a density between 140 - 240 Kg/m^3 with thermal conductivity not to exceed 0.047 W/m-K at 20 Deg C mean temp as per EN12667 or Equivalent Standard having Class 1 Fire Performance as per BS 476 Part 7 and tested as per UL 94

ii) Noise Reduction Coefficient should not be less than 0.48 for 15mm Thickness as per ASTM or Equivalent Standard.

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iii) In-built resistance to fungal growth and bacterial growth.

iv) Operating temperature range of -20 deg C to +85 deg C as per ISO/EN/BS Standard.

v) Acoustic Lining (Inside The Duct) Installation Procedure shall be as per APPENDIX 5

3.18 Controls And Instruments

3.18.1 Vendor shall include all controls & instruments as required for safety & operational requirements of the plant.

3.18.2 **Main HVAC Control Panel**

3.18.2.1 Automatic operation of all controls, wherever feasible, is required, with manual overdrive for maintenance etc. The "Manual/Off/Auto" select switch shall be located on the front of HVAC Control Panel. The "Auto" mode means that HVAC equipment are controlled by a standalone PLC/Microprocessor based HVAC control panel/DDC (Direct Digital Controller). The "Manual" mode shall be used only for testing purpose & manual operation & control of HVAC system.

3.18.2.2 Electric duct heaters shall be controlled in one or more steps by the return air temperature and interlocked with the flow switch installed on each electric duct heater so that electric duct heater can not be operated without the supply air flow. An automatic reset thermal cut-off shall stop the electric duct heater when the high limit temperature is reached. Electric duct heater shall restart automatically when the related return air temperature drops below the setting point.

3.18.2.3 Humidistat shall also be provided for monsoon reheat control. One humidistat shall activate the electric heaters (reheat) in case the space humidity rises beyond the preset limit. Another humidistat shall energize the humidifier when the humidity falls below the preset limit. These humidistats shall also de-energize these devices when the desired humidity is reached. Humidifier heaters shall be actuated by humidistat located in return air duct.

3.18.2.4 Monsoon re-heaters /winter heaters shall operate only on running of Package AC / AHU blower.

3.18.2.5 Potential free contact shall be provided by vendor for closing of fire & smoke dampers and simultaneously tripping the AHU/Package AC blower motor on receiving the fire/smoke alarm signal from relevant Fire & Gas Panel.

3.18.2.6 On expiry of fire signal, fire & smoke dampers shall be opened manually through reset button.

3.18.2.7 Upon receiving of a gas high alarm signal from the relevant fire and gas panel, outdoor air intake into the building shall be shut off automatically. Also upon receiving of a gas high high alarm signal from the relevant fire and gas panel, all HVAC system shall be automatically shut down.

3.18.2.8 Potential free contact shall be provided in control panel for duplication of alarm in Purchaser's main panel. The necessary wiring beyond this contact shall be done by Purchaser.

3.18.2.9 Supply air fan of AHU/Package AC & chemical filter unit (if required) shall be started from the HVAC control Panel. If standby fan is provided, standby fan shall be change over automatically by the failure signal of the running fan.

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3.18.2.10 Units shall be equipped with automatic switchover as per planned operation sequence.

3.18.2.11 **Special requirement for Central Air-conditioning System :**

i) All controls shall be suitably interlocked for safe & sequential operation of plant generally in the following order:

a) Start AHU blower.
b) Start cooling tower fan.
c) Start Condenser water flow /condenser fan.
d) Start Chilled water pump.
e) Start Refrigeration unit/chiller

While shutting down the plant, equipment will stop in the reverse order as listed above.

ii) Chilled water circulation pumps shall be started manually or automatically at HVAC control panel in the sequence as stated above. The standby chilled water circulation pump(s) shall be changed over automatically by the failure signal of the running chilled water pump(s).

iii) Flow control valve at chilled water coil with modulating temperature controller shall be controlled by return air temperature.

iv) Flow meters in chilled water and condenser water lines with signal to control panel shall be provided. Temperature and Pressure Gauges in inlet and outlet of cooling water and chilled water shall also be provided locally. Chilled water temperature shall be maintained constant at chiller outlet, the control for the same shall be provided accordingly.

3.18.2.12 **Special requirement for Packaged Air-conditioning System :**

1) The standby Packaged Unit shall be changed over automatically by the failure signal of the running Packaged Unit.

2) Flow meters in condenser water outlet lines (for water cooled systems) with signal to control panel, temperature and Pressure Gauges in inlet and outlet of cooling water shall be provided locally.

3) Calibration of all instruments shall be done by Vendor.

4) Pressure gauges shall be provided with bleed and block valves.

3.18.3 **Machine Control Panel**

3.18.3.1 Control panel shall consist of indications, controls and annunciation.

3.18.3.2 The control panel shall be fully wired and factory tested before dispatch. The Control panel shall contain at-least the following control for the automatic operation of chilling unit.

i. Compressor capacity control device.
ii. Start/stop push button station for the machine.
iii. Automatic temperature controller for oil temperature and chiller water temperature.

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3.18.3.3 **Requirements for Reciprocating or Scroll Chiller / Condensing Units**

3.18.3.3.1 Control Panel shall be either machine mounted or floor mounted as per manufacturer's standard and shall provide the following indications as a minimum:

i. Suction & Discharge Pressure indicator.
ii. Lubricating oil pressure indicator.
iii. Oil temperature indicator.
iv. Chilled water in & out temperature indicator
v. Condenser cooling water in & out temperature (in case of water cooled condenser) indicator
vi. All safety interlocks

3.18.3.3.2 Control panel shall have protection against following situation as a minimum:-

i. Low chilled water temperature
ii. High Condenser Pressure
iii. Low lube oil pressure
iv. Low Evaporator Pressure
v. Low/No chilled water flow
vi. Low condenser cooling water flow
vii. Overload protection for all motors.
viii. Sensor Failure/Diagnostics

3.18.3.4 **Requirements for Centrifugal Chiller Package**

3.18.3.4.1 Control Panel shall be either machine mounted or floor mounted as per manufacturer's standard and shall provide the following indications as a minimum:

i. Suction & Discharge Pressure indicator.
ii. Lubricating oil pressure indicator.
iii. Oil temperature indicator.
iv. Chilled water in & out temperature indicator
v. Condenser cooling water in & out temperature (in case of water cooled condenser) indicator
vi. Vane opening indicator calibrated in percent
vii. All safety interlocks

3.18.3.4.2 Control panel shall have protection against following situation as a minimum:-

i. High condenser pressure.
ii. Low lube oil pressure.
iii. High bearing temperature for compressor.
iv. Low evaporator pressure.
v. Low/No chilled water flow.
vi. Low condenser cooling water flow
vii. Overload protection for all motors.
viii. Low chilled water temperature.
ix. High lube oil temperature to cut off heater supply.
x. High Compressor discharge temperature.
xi. Low Compressor discharge temperature.
xii. Oil Filter differential pressure.
xiii. To ensure opening of inlet guide vanes after compressor motor has stabilized.
xiv. To ensure close guide vanes at start-up.
xv. Sensor Failure/Diagnostics

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3.18.3.5 **Requirements for Screw Chiller Package**

3.18.3.5.1 Control Panel shall be either machine mounted or floor mounted as per manufacturer's standard and shall provide the following indications as a minimum:

i. Suction & Discharge Pressure indicator.
ii. Lubricating oil pressure indicator.
iii. Oil temperature indicator.
iv. Chilled water in & out temperature indicator
v. Condenser cooling water in & out temperature (in case of water cooled condenser) indicator
vi. All safety interlocks

3.18.3.5.2 Control panel shall have protection against following situation as a minimum:-

i. High condenser pressure
ii. Low lube oil pressure.
iii. High bearing temperature for compressor motor.
iv. Low/No chilled water flow.
v. Low evaporator pressure
vi. Low condenser cooling water flow.
vii. Overload protection for all motors.
viii. Low chilled water temperature.
ix. High lube oil temperature to cut off heater supply.
x. High Compressor discharge temperature.
xi. Low Compressor discharge temperature.
xii. Oil Filter differential pressure.
xiii. To ensure minimum position of slide valve at start-up.
xiv. Sensor failure/Diagnostics

3.18.3.6 **Requirements for Packaged Air-conditioning Units**

3.18.3.6.1 Control Panel shall be either machine mounted or floor mounted as per manufacturer's standard and shall provide the following indications as a minimum:

i. Suction & Discharge Pressure indicator.
ii. Condenser cooling water in & out temperature (in case of water cooled condenser) indicator
iii. All safety interlocks

3.18.3.6.2 Control panel shall have protection against following situation as a minimum:-

i. High Condenser Pressure
ii. Low Evaporator Pressure
iii. Low condenser cooling water flow (in water cooled system)
iv. Overload protection for all motors.
v. Sensor Failure/Diagnostics

3.18.3.7 **For VAR System, EIL Standard Specification no. 6-36-0007 shall be followed.**

3.18.4 **Audio-visual Annunciation Panel**

3.18.4.1 It shall consist of facia type Annunciators having translucent plastic window of 35 mm x 50 mm (min.) size engraved with appropriate function in block letters for each alarm trip point. Annunciators shall be suitable for operation on 24V D.C. and shall have a single alarm buzzer common to all points. Three push buttons for audible alarm acknowledge, reset and test with appropriate name plates shall be provided common to all alarm points.

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Annunciators shall be solid state type of reputed make. Annunciators shall operate satisfactorily between 80 and 110% of rated supply voltage. Annunciators may be a part of HVAC control panel itself.

3.18.4.2 Annunciators shall be provided for all faults (as applicable for the system) covering atleast the following:-

i. Low oil pressure.
ii. Low chilled water flow.
iii. Low condenser cooling water flow.
iv. Low chilled water temperature
v. Low evaporator pressure.
vi. High condenser pressure.
vii. Compressor motor overload.
viii. Low water level in humidifier tank.
ix. Chilled water pump motor over load.
x. Condenser cooling water pump motor over load.
xi. Air handling unit motors overload.
xii. Cooling tower fan motors overload.
xiii. Treated water pump motors overload (in case water softening plant is furnished).
xiv. Crankcase heater.
xv. Open/close position of fire/smoke dampers.
xvi. Water Chiller/Air-conditioning unit status-Run/Stop.
xvii. Fresh Air fan(Chemical Filter Unit) status-Run/Stop.
xviii. AHU fan status-Run/Stop.
xix. Chilled water pumps(s)-Run/Stop
xx. Auto change-over of standby pump, fan & air-conditioning unit
xxi. Any other as necessary.

In the event of a fault, the particular window shall glow and the window will remain lighted till the fault is rectified.

Minimum 20% spare windows shall be provided on annunciator.

3.19 Specific Requirements for Offshore Applications

3.19.1 The system shall be centralized chilled water type with the chilled water circulating in a closed-loop through the Air handling units. The required pressure in the air conditioned areas shall be maintained by pneumatically controlled purge/exhaust dampers through pressure switches.

3.19.2 **Standard Operating Cycle: -** As a standard operating cycle, the system is to maintain a space pressurisation of minimum 5.0 mm WG by modulation of the outside air and relief dampers unless specified otherwise. In air-conditioned areas, pressurization takes a foremost role. If one fan of AHU fails, the standby fan should be energized automatically, and the outlet damper of the failing fan shall automatically close.

3.19.3 **Purge Cycle: -** A purge cycle of the air-conditioned space shall occur upon start up and upon a loss of pressurization (less than 3.0 mm WG). To purge the pressurized space of undesirable air, the fresh air damper should be full open. During the purge cycle return air damper of air conditioning system shall be in closed position. The remote purge dampers will fully open to exhaust the purge air. This cycle should operate a minimum of 5 air changes per hour to assure a complete purge. In such a situation air conditioning becomes non critical. Humidity and temperature control are not necessarily maintained during the purge cycle. Purge cycle switching shall be automatic.

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3.19.4 Non explosion proof electrical equipment shall be energized only after the purge cycle is complete.

3.19.5 All air conditioned areas (other than spot-cooled) shall have minimum three (3) fresh air changes/hour besides the air lost through exhausted areas. In addition to AHU blowers, fresh air fans shall be installed to meet the fresh air requirements. Necessary filtration arrangement with coalescer filters shall be provided at fresh air intake. All intakes and exhausts shall be protected with weather covers and removable 12.5 mm mesh screen and adjustable louvers etc. of corrosion resistant material. Suitable provision shall be made for installation of gas detectors at the outside air intake ducts.

3.19.6 The fresh air consideration for heavy occupancy areas shall also be cross-checked from human-occupancy considerations as per ASHRAE norms.

3.19.7 Fresh air requirements shall be based on the worst of above considerations.

3.19.8 The fresh air intake (through necessary filtration arrangement) shall be taken from safe areas. Air intake in all cases shall be away from exhausts. Safe areas for this purpose would be considered as minimum 3.0 m away from the edge of platform or 7.6 m away from the nearest source of hazard, whichever is more.

3.19.9 For dining room, Kitchen, laundry, TV room, Recreation room and Tea room, ASHRAE norms and heat dissipation details to be considered, keeping in view the equipment/appliances located in these areas.

3.19.10 Toilet room / washroom (laundry) areas shall be spot cooled and inside condition shall be exempted from guarantee. Return air shall not be taken from kitchen, dinning hall, toilets, washrooms, laboratories and battery charger room etc.

3.19.11 Besides air conditioning, toilets & wash rooms shall be provided with exhaust fans designed for 12 air changes per hour and the area shall be maintained on a slightly negative pressure so that any obnoxious / foul smell does not get transmitted to the adjoining air conditioned spaces, but instead it is vented off. Air from Corridor/ Room shall be sucked in and vented through toilets.

3.19.12 All skid mounted equipment located outside pressurised areas shall be suitable for operation in a hazardous area as defined by Class 1, Zone 2, Gas Group II A, II B, Temperature Class T3 as per IEC and Category B of the Air Moving and Conditioning Association. Building interiors shall be considered unclassified or safe after purging and pressurisation. All rotating equipment shall be of spark-proof construction.

3.19.13 All equipment of Air Conditioning, Ventilation and pressurisation plant, installed outdoor, shall be capable of withstanding the corrosion and other deleterious effects of a saliferous, humid environment.

3.19.14 There shall be 100% standby for chilled water package(s). Each package shall comprise compressor, driver, chiller, air cooled condenser and associated hook-up piping, fittings and valves etc. Condenser fans shall have their independent motors. Condenser shall be mounted to discharge hot air horizontally, away from the platform. The number of working units shall be decided such that the compressor motor rating does not exceed the purchaser's acceptable KW limit for LT motor.

3.19.15 Condenser shall be air cooled by electric motor driven fans having direct drive. If located in hazardous area, fans shall be of spark-proof construction as per AMCA category B. Condenser coils shall be constructed of Copper Tubes Electrotinned and Copper Fins Electrotinned. Heresite coated coils will also be acceptable, if this is vendor's standard proven design. Impeller shall be of cast aluminium bronze/high tensile brass. To minimize

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the noise, only low rpm (preferable750 rpm) fan shall be used. Condenser fan wire guard shall be of SS-304 material.

3.19.16 Heat transfer areas for Condenser Coils and evaporator tubes shall have minimum 10% margin over and above the calculated surface areas required (This shall be over and above the safety margin taken for sensible and latent heat in heat load calculations)

3.19.17 AHU shall be equipped with two nos. (1 working + 1 standby) centrifugal, double inlet double width (DIDW) type blowers each of 100% capacity, mounted within the fan section of the AHU. The working and the standby fans within the AHU shall be isolated by providing separate chambers with pneumatic dampers on the chamber suction and back draft damper at blower outlet to prevent short circuit of air flow, as well as to facilitate the maintenance of one blower while the other is working. Air flow switch shall be provided at outlet of the blower to sense the pressure and the blower shall be interlocked such that in the event of one blower failing the respective pneumatic damper at the suction shall close and the other blower shall start with pneumatic damper open automatically so as to maintain the desired pressure in the system. In the event of failure of the air conditioning system, the operating blower would continue to run to maintain the specified positive pressure. AHU casing shall be minimum 50 mm thick double skin construction with 1.5 mm thick SS-316L outer sheet and 1.0 mm thick SS-316L inner sheet with thermal insulation sandwiched in between to prevent casing deformation, and coil face velocity shall not be more than 2.5 m/s. Cooling coils are to be chilled water type constructed of Copper Tubes Electrotinned with externally bonded Copper Electrotinned Fins.

3.19.18 All automatic modulating dampers and fire dampers shall be pneumatically operated.

3.19.19 Fire dampers shall be automatic, fail safe type (i.e. damper shall automatically close by spring action in case of failure of pneumatic air supply) and shall operate pneumatically.

3.19.20 All sheet metal duct work shall be constructed of tested quality Stainless Steel (SS-304) sheets. All ductwork and thickness shall be as per SMACNA.

3.19.21 Insulation of chilled water piping, ducts and equipment for offshore applications shall be covered with SS-304 0.25 mm thick cladding. This shall supersede insulation cladding material specified in clause 3.21.2.4, 3.17.4.2 & 3.17.4.3

3.19.22 Material of construction of major HVAC equipment shall be as follows. All other items shall be as per manufacturer's standard design suitable for outdoor saliferous and humid environment of an offshore platform.

Equipment	M.O.C.
Condenser Tubes	Copper with electro tinning/Copper with Herisite coating if vendor's proven standard design
Condenser Tubes fins	Copper with electro tinning/Copper with Herisite coating if vendor's proven standard design
Condenser Casing	SS-316L
Condenser fan casing	SS-316L
Condenser fan Impeller	Cast Aluminium Bronze/High tensile brass
Chiller Tubes	Copper ASTM-B-111
AHU Cooling Coil Tubes/Fins	Copper with electro tinning
AHU Casing	SS-316L
AHU and ventilation fan Impellers	Steel epoxy coated with brass ring/lining for spark proof design/Aluminium Bronze Blades
Fan Shafts	SS-304

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Equipment	M.O.C.
AHU Filters	SS Mesh
Filter Casing	SS-304
Chilled Water Pump	
- Shaft	SS-304
- Shaft Sleeve	Al. Bronze ASTM # B111
- Casing	Cast Iron ASTM#A159
- Impeller	Cast Bronze ASTM # B 584
- Impeller Key	SS304
- Wearing Ring	Bronze
Refrigerant Piping	Cu / Cu-Ni
Grilles/Diffusers	Zn Electroplated or Heavy gauge anodised aluminium
Duct material	SS-304
Insulation on ducts	Fiber Glass
Insulation Cladding	SS 304 0.25mm thk
Chilled water pipe, fittings & valves	As per project Piping Material Specification
Instrument Air Tube	SS-316
Structural Steel	ASTM-A-36 or IS-2062 Grade-A
Expansion Tank	SS-304
Damper Casing	SS-304
Damper Bush	Bronze
Damper shaft and other operating linkages	SS-304

3.19.23 **Instrumentation, Controls and Electrical Work**

3.19.23.1 Control System for HVAC shall be PLC (Programmable Logic Controller) based. Vendor shall supply PLC based control system, software and hardware for meeting the requisite functional requirements. PLC based HVAC control panel shall be interfaced to platform safety shut down system encompassing (fire & gas) detection system. HVAC control panel shall also provide repeat indication for critical parameters for further wiring by contractor to the platform control room for remote monitoring.

3.19.23.2 Electric Heaters shall be U.L. listed.

3.19.23.3 The Vendor shall also provide all necessary pressurization control equipment. This shall consist of room mounted, low differential pressure sensors, with panel mounted controllers for 0-100% modulation of respective pneumatic dampers. The Vendor shall also provide the pneumatic actuators with complete mounting kit. Dial type gauges shall be provided to show over pressure (5 mm WG) inside air-conditioned space.

3.19.23.4 The chilled water system shall be provided with panel mounted on/ off/ auto and duty/ standby selector switches. The pump packages shall be provided with a differential pressure switch to automatically changeover to the standby pump on duty pump failure.

3.19.23.5 On pump start the chiller may enter its start time sequence from its own integrated control system which shall include flow switches and low water temperature cut out switches mounted in the chilled water line on the skid. These shall be interlocked to the compressors to prevent start up or cause shutdown due to no flow or low temperature.

3.19.23.6 **Control Panel**

Control panels shall be suitable for the area classification in which they are located as specified elsewhere.

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4.0 INSPECTION AND TESTING

Equipment shall be subjected to expediting, inspection and testing at vendor's/sub-vendor's Works by Purchaser/its authorised inspection agency. Vendor shall perform tests and inspection necessary to ensure that the material and workmanship conform to the requirement of this specification. Vendor shall submit Quality Assurance (QA) plan before commencement of fabrication. Approved QA plan shall form the basis for equipment inspection. Following equipment/items shall be subject to inspection/test at works as a minimum:

i. Package AC units shall be subjected to Type Test as per applicable Indian Standard, Production Routine Test as per approved QAP.
ii. Condensing units shall be subjected to Type Test as per applicable Indian Standard, Production Routine Test as per approved QAP.
iii. Vapour compression chiller units shall be subjected to Acceptance Test as per ARI-550/590, Production Routine Test as per approved QAP.
iv. Mechanical Run test of AHU at shop for 30 minutes – one of each type and size.
v. Other items, equipment shall be inspected/ tested at shop as per approved QAP.
vi. For VAR System, EIL Standard Specification no. 6-36-0007 shall be followed.

4.1 For Inspection and Testing at Site, vendor must perform all inspection and tests of the system as a whole and of components individually as required, in accordance with the provisions of the applicable ASHRAE standards. Vendor shall comply with the following procedures:

i. Inspection of raw materials to be used for fabrication and assembly and inspection of manufacturer's test certificates.
ii. Inspection of welding including welder's qualification as desired by inspection engineer. Inspection of fabricated items.
iii. Pressure testing of pipe fit ups for refrigerant (Pneumatic test with dry nitrogen) and water services (hydro test).
iv. Pressure testing, leak testing of complete piping network for chilled water/brine, condenser water & refrigerant services (helium leak test, for details refer clause-3.15.2).
v. Inspection of air distribution system for proper location and installation against design drawings. Inspection of ducting supports, its location. Leak testing of ducting system before application of insulation.
vi. Inspection of duct insulation for its material, thickness and finish.
vii. Balancing of air distribution system to obtain the air quantities across various air terminals as called for in the engineering drgs.
viii. Noise level test for various rotating/reciprocating equipment.
ix. Checking of electrical circuits (Power and control) and checking functioning of controls of refrigerant system and other circuits of air conditioning plant.
x. Checking of assemblies for MCC, control panel, local panel, annunciation panel etc.
xi. Checking of calibration of controls and instrumentation.
xii. Inspection of complete electrical installation at site and clearance from local authorities.
xiii. Installation of main equipment like compressor, condenser, chiller, evaporator, AHU etc.

NOTE:

Inspection & testing procedure mentioned above is for general guidance & information of vendor and inspection by purchaser/consultant is strictly not limited to these. Inspection engineer of Purchaser/consultant will have full right to have detailed inspection of project as desired by inspection engineer. Co-ordination of inspection agency of purchaser/consultant with his factory/erection site will be sole responsibility of successful

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vendor after placement of order for complete air conditioning plant covered under these specifications.

4.2 For VAR System, Standard Specification no. 6-36-0007 shall be followed.

4.3 Any or all the tests, at Purchaser's option, shall be witnessed by Purchaser/its authorised inspection agency. However, such inspection shall be regarded as check-up and in no way absolve the vendor of his responsibility.

4.4 Performance Testing and Guarantees

4.4.1 **Performance Testing**

4.4.1.1 Vendor shall give three seasonal tests for (i) summer, (ii) monsoon & (iii) winter to determine the equipment capacity and performance of the system in accordance with applicable Standards. Period of each test shall be at least 72 hours and time for each test will be fixed up mutually with the Purchaser.

4.4.1.2 The vendor shall operate, test and adjust all equipment and balance the system.

Following test readings shall be recorded during the performance testing (For VAR System, EIL Standard Specification no. 6-36-0007 shall be followed):

Test Readings

1. **Compressor (for VCR Chiller / Condensing Units)**

Refrigerant gas suction pressure	(kg/cm^2 g)
Refrigerant gas suction Temperature	(^0C)
Refrigerant gas discharge Pressure	(kg/cm^2 g)
Refrigerant gas discharge Temperature	(^0C)
Operating speed	(RPM)
Power consumption at 100% load and at each step of capacity regulation.	

2. **Evaporator (for chilled water system only)**

Refrigerant liquid temperature at inlet	(^0C)
Refrigerant Gas suction pressure	(kg/cm^2 g)
Refrigerant Gas suction Temperature	(^0C)
Water flow rate	(m^3/hr.)
Water temperature - entering	(^0C)
Water temperature - leaving	(^0C)
Water pressure - entering	(kg/cm^2 g)
Water pressure -leaving	(Kg/cm^2g)

3. **Condenser**

Refrigerant gas temperature at inlet	(^0C)
Refrigerant condensing pressure	(kg/cm^2 g)
Refrigerant liquid temperature at outlet	(^0C)
Air/Cooling Water flow rate	(m^3/hr.)
Air/Cooling Water temperature - entering	(^0C)
Air/Cooling Water temperature - leaving	(^0C)
Cooling Water pressure – entering	(kg/cm^2 g)
Cooling Water pressure - leaving	(kg/cm^2 g)

4. **Water Pump**

Flow rate	(m^3/hr.)
Discharge pressure	(kg/cm^2 g)
Suction pressure	(kg/cm^2 g)

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	Operating speed	(rpm)
5.	**Air handling unit**	
	Refrigerant liquid temperature at inlet to coil	(^{0}C)
	Air temperature – entering (D.B)	(^{0}C)
	Air temperature – entering (W.B)	(^{0}C.)
	Air temperature – leaving (D.B)	(^{0}C.)
	Air temperature – leaving (W.B)	(^{0}C)
	In case of chilled water coils:	
	Water pressure - entering coil	(kg/cm^2 g)
	Water pressure - leaving coil	(kg/cm^2 g)
	Water Temperature - entering cool	(^{0}C)
	Water Temperature - leaving coil	(^{0}C)
	Blower air flow	(m^3 /hr.)
	Blower Speed	(RPM)
	Blower Static/Total Pressure	(mm WC)
	Blower outlet velocity	(m/s)
	Direction of rotation	CW/CCW
	Velocity of air across various components of air handling unit.	
6.	**Electric motor**	
	Starting current/No load current	(A)
	Motor terminal current	(A)
	Power factor	
	Supply voltage	(volts)
	kwh for compressor motor	
7.	**Supply Air Grilles/ Diffusers**	
	Air flow rate	(m^3 /hr.)
	Air temperature (D.B)	(^{0}C)
	Air temperature (W.B)	(^{0}C)
8.	**Room conditions**	
	D.B.T	(^{0}C)
	W.B.T	(^{0}C)
	Differential Pressure with respect to atmosphere/adjacent area (for pressurized area)	(mm of WC)

4.4.1.3 Vendor shall bring all required testing instruments at site duly calibrated. Plant shall be formally taken over by purchaser after witnessing the seasonal performance tests successfully.

4.4.2 **Guarantees**

The vendor guarantees that all equipment and accessories shall meet the design and operating conditions throughout the year, as specified in this specification and Job Specification/Data Sheet.

5.0 PROTECTION AND PAINTING

5.1 All exposed carbon steel parts to be painted shall be thoroughly cleaned from inside and outside to remove scale rust, dirt and other foreign materials by wire brushing and shot/grit blasting as applicable.

5.2 Non-ferrous materials, austenitic stainless steels, plastic or plastic coated materials, insulated surfaces of equipment and pre-painted items need no painting.

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5.3 Stainless steel surfaces, both inside and outside, shall be pickled and passivated.

5.4 Machined and bearing surfaces shall be protected with varnish or thick coat of grease.

5.5 Painting shall be done as per manufacturer's standard painting suitable for corrosive industrial/ marine environment unless otherwise specified in the Job Specification.

5.6 The colour of finish coat shall be intimated to vendor, after placement of order.

6.0 PACKAGING AND IDENTIFICATION

6.1 All packaging shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components, suitable for shipment and shall be properly packed to provide adequate protection during shipment. All assemblies shall be properly match marked for site erection.

6.2 Attachments, spare parts of the equipment and small items shall be packed separately in wooden-cases. Each item shall be appropriately tagged with identification of main equipment, item denomination and reference number of the respective assembly drawing.

6.3 Detailed packing list in water-proof envelope shall be inserted in the package together with equipment.

6.4 Each equipment shall have an identification plate giving salient equipment data, make, year of manufacture, equipment number, name of manufacturer etc.

6.5 Vendor shall furnish procedure for prolonged site storage of supplied equipment/material.

7.0 SPARE PARTS

7.1 Vendor shall submit list of spare parts with recommended quantities and itemised prices for first two years of operation of the equipment. Proper coding and referencing of spare parts shall be done so that later identification with appropriate equipment is facilitated.

7.2 Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.

7.3 Vendor shall supply adequate quantity of commissioning spares. The commissioning spares shall be sufficient for trouble free commissioning of the system at site. Any commissioning spares required during commissioning, over and above, the commissioning spares supplied, shall be made available by the vendor without any cost and time implication to purchaser. If for any reason, during commissioning, vendor needs to utilise spares from 2 years' operation spares (if already available at site), the same shall be replenished by vendor within a reasonable time without any cost implication to purchaser. Any unused commissioning spares shall be handed over to owner.

7.4 Vendor shall supply the Mandatory spares as listed in Job Specification.

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8.0 SPECIAL TOOLS & TACKLES

Vendor shall provide one set of following special tools & tackles as a minimum for operation & maintenance along-with each Air-conditioning plant.

S.NO.	DESCRIPTION	QTY.
1.	Flaring Tools up to 3/4" (19 mm) Size	One Set
2.	Gas Charging manifold with Cylinder Adopter	One Set
3.	Halide Leak Detector	One
4.	Digital Psychrometer	One
5.	Pressure Gauge 0-300 PSI and Compound Gauge 30" Vacuum-150 PSI for Refrigerant Line	One Set
6.	Digital Anemometer	One

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APPENDIX 1

INSULATION MATERIAL AND THICKNESS

S. No.	Application	Insulation Material (Density)	Form	Thickness
1	Supply Air Duct	Closed Cell Flexible Elastomeric Nitrile Rubber (40-60 kg/m^3)	Sheets	32 mm
2	Return Air Duct	-Do-	-Do-	13 mm
3	Supply Duct exposed to Return Air (i.e. Return Non-Ducted)	-Do-	-Do-	19 mm
4	Outdoor Exposed Supply Duct	-Do-	-Do-	50 mm
5	Outdoor Exposed Return Duct	-Do-	-Do-	25 mm
6	Refrigeration Piping	-Do-	Tubes upto 100 mm and Sheets for above 100 mm	a) **32 mm** (For NB Dia upto 25 mm) b) **38 mm** (For Pipes above 25 mm NB Dia upto 65 mm NB Dia) c) **44 mm** (For Pipes above 65 mm NB Dia upto 150 mm NB Dia) d) **50 mm** (For Pipes above 150 mm NB Dia)
7	Chiller Water Piping, Valves			
8	Chilled water pumps	-Do-	-Do-	Same as connecting Pipes
9	Expansion tank	-Do-	Sheets	32 mm
10	Chiller	-Do-	-Do-	32 mm
11	AHU Drain pipe	-Do-	Pipe Section	a) **13 mm** (For Pipes Upto 50 mm NB Dia) b) **19 mm** (For Pipes above 50 mm NB Dia)
12	AHU Drain pan	-Do-	Sheets	9 mm
13	Acoustic treatment	Open Cell Nitrile Rubber Foam (140-240 kg/m^3)	Sheets	15 mm
14	Hot Water / Steam piping	Flexible Silica Aerogel (mineral fibre) Blanket (160-240 kg/m^3)	Sheets	30 mm
15	Line / Pipe from Pan Humidifier to Duct	-Do-	-Do-	20 mm

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APPENDIX 2

HOT INSULATION INSTALLATION PROCEDURE FOR PIPES

1) Measure circumference of pipe using a strip of insulation material sheets to ensure accurate tight longitudinal butt or overlap seam (25-50 mm overlap). Either jointing method is acceptable.

2) Wrap insulation material sheets tightly around pipe to avoid gaps or voids.

3) Longitudinal seams shall be tightly closed. Bring first part of edges together and secure with wire.

4) Continue to bring longitudinal edge together and secure with wire every 200 mm so that the seam is tight, without gaps and evenly secured.

5) Each layer of sheets (or the final layer of a continuous wrap) must always be secured to the substrate using 19 mm stainless-steel bands. However for smaller diameters upto 100 mm, 1 mm diameter stainless steel wires may also be used

6) Maximum separation of wires shall be 200 mm and maximum separation of band centres shall be 300 mm

7) Always rotate the longitudinal seam to the side, never at the top.

8) Circumferential butt joints shall be pushed tightly together to avoid gaps. Joints and seams shall be staggered minimum 100 mm circumferentially, longitudinally and between layers.

9) Aerogel sheets may also be applied in multiple layers as a continuous wrap.

10) Aerogel Sheets shall always be protected by a jacketing / cladding when installed outdoors. This is also recommended for indoor applications.

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APPENDIX 3

COLD INSULATION INSTALLATION PROCEDURE FOR PIPES

1) Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc.

2) One coat of primer shall be applied over the entire surface of pipe and fitting and accessories like valves etc.

3) Insulating material in tube form shall be sleeved on the pipes upto 100 mm NB Dia.

4) On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied on the slit ends.

5) Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre.

6) Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per insulation manufacturer recommendations.

7) The insulation shall be continuous over the entire run of piping, fittings and valves.

8) Ensure all seam joints have adhesive applied on both surfaces as detailed in the Installation Manual.

9) Direct contact between pipe and hanger shall be avoided. Hangers shall pass at the outer ends of the saddle support.

10) There shall be proper thermal isolation of pipe from pipe support. Additional layer of suitable packing material/cover of adequate strength shall be provided between the insulated pipe and the Pipe support (i.e. bracket, saddle etc.) to avoid any damage to the pipe insulation at pipe support locations.

11) In locations that have many bends and fittings, first install the bend fitting and then install the straight lengths of insulation material, following the application procedures.

12) All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and procedure of installation shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

13) For all irregular shape of fittings, valves etc., procedure as per manufacturer manual shall be followed.

14) Ensure all exposed metal parts of the fittings including the "neck spindle" are insulated to prevent condensation/ice formation. In areas and locations that have exposed electrical equipment nearby, it is advised that the Valve Handle itself is also insulated with removable insulation fabrications.

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APPENDIX 4

DUCT INSULATION INSTALLATION PROCEDURE

1) Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.

2) Measurement of surface dimensions shall be taken properly to cut insulation material sheets to size with sufficient allowance in dimension.

3) Install the insulation material to the top surface of the ductwork. After installing the insulation material to the top sections, proceed to install insulation sheets to the two (2) vertical sides and finally to the bottoms of the ductwork.

4) Direct contact between duct and hanger shall be avoided. Hangers shall pass at the outer ends of the duct support.

5) There shall be proper thermal isolation of duct from duct support. Additional layer of suitable packing material/cover of adequate strength shall be provided between the insulated duct and duct support to avoid any damage to the duct insulation at duct supporting locations.

6) Material shall be fitted under compression and no stretching of material should be allowed.

7) A thin film of adhesive recommended by insulation manufacturer, shall be applied on the back of the insulating material sheet and on to the metal surface. Adhesive shall be in compliance with Indian Green Building requirement, having VOC content less than 850 g/l.

8) When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.

9) All longitudinal and transverse joints shall be sealed by self-adhesive tapes supplied by insulation manufacturer.

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APPENDIX 5

ACOUSTIC LINING (INSIDE THE DUCT) INSTALLATION PROCEDURE

1) The inside surface for the ducts shall be covered with adhesive recommended by the manufacturer.

2) Cut Foamed sheets into required sizes apply adhesive on the foam and stick it to the duct surfaces.

3) Install the insulation material sheet (acoustic lining) to the top inside surface of the ductwork.

4) After installing the insulation material to the top section, proceed to install insulation material sheet on the inside of the two vertical sides of the duct.

5) Finally install the insulation material sheet to the inside bottoms of the ductwork.

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विद्युत कर्षण लिफ्ट के लिए मानक विनिर्देशन

STANDARD SPECIFICATION FOR ELECTRIC TRACTION LIFT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	17/03/23	REVISED AND ISSUED AS STANDARD SPECIFICATION	AK	KCP	NK	SM
2	22/02/18	REVISED AND ISSUED AS STANDARD SPECIFICATION	PZ	KCP	PB/RKT	RN
1	26/03/15	REVISED AND ISSUED AS STANDARD SPECIFICATION	MS	SPC	PB	SC
0	05/09/11	ISSUED AS STANDARD SPECIFICATION	SPC	PB	AKN	DM

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Abbreviations:

ACPH	:	Air Changes Per Hour
AMC	:	Annual Maintenance Contract
ARD	:	Automatic Rescue Device
BASEEFA	:	British Approval Service for Electrical Equipment for Flammable Atmospheres
CCOE	:	Chief Controller Of Explosives
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mining and Fuel Research
CS	:	Carbon Steel
CT	:	Current Transformer
DC	:	Direct Current
DGMS	:	Director General of Mines Safety
FM	:	Factory Mutual
FRLS		Flame Retardant Low Smoke
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IS	:	Indian Standard
LCIE	:	Leboratoire Central Des Industries Electrique
LED	:	Light Emitting Diode
MCCB	:	Moulded Case Circuit Breaker
NEMA	:	National Electrical Manufacturers Association
OISD	:	Oil Industry Safety Directorate
PDB	:	Power Distribution Board
PESO	:	Petroleum and Explosives Safety Organisation
PGTR	:	Performance Guarantee Test Run
PTB	:	Physikalisch-Technische Bundesanstalt
PVC	:	Poly-Vinyl Chloride
SPN	:	Single Phase Neutral
TEFC	:	Totally Enclosed Fan Cooled
TPN	:	Three Phase Neutral
UL	:	Underwriters Laboratories
VDE	:	Verband der Elektrotechnik
VVVFD	:	Variable Voltage Variable Frequency Drive

Static & Machinery Equipment Department (Packaged Equipment) Standards Committee

Convenor : Mr. Nalin Kumar

Members: :
Mr. P.P. Pandey
Mr. Shishupal Choudhary
Mr. R. R. Shrivastava (Coordinator)
Mr. Manos Biswas
Mr. K. C. Paikar
Mr. A. Natarajan
Mr. Plaban Dan
Mr. Deepak Kumar
Mr. Venkitesh M.G.
Mr. Ayush Mathur (Projects)

Electrical Representative : Mr. Bishan Dass

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1.0 GENERAL

1.1 This specification outlines the minimum requirements for design, engineering, manufacture, inspection, testing, painting, supply and performance testing at site of Electric Traction Lift and its accessories, control and instruments, electrical and associated items.

2.0 CODES AND STANDARDS

2.1 Latest edition of the following codes and standards including amendments as on the date of enquiry shall govern:

IS 17900	:	Lifts for the Transport of Persons and Goods
BS EN 81-1	:	Safety rules for the construction and installation of lifts
ASME A17.1	:	Safety Code for Elevators and Escalators
EIL Std.- 7-76-0103	:	Instructions to Vendor for Site Performance guarantee Requirements for Package units

2.2 Other international standards may also be acceptable subject to their being equivalent or superior to those listed above, with prior approval of purchaser.

2.3 For provisions not covered by the above codes & standards, applicable good engineering practices and norms shall govern subject to prior approval of Purchaser.

2.4 National Law and statutory provisions together with any local bylaws for the state wherein lift is required to be installed shall be complied with.

3.0 TECHNICAL REQUIREMENTS

3.1 General

3.1.1 Lift shall be designed for minimum 20 years of service life under normal operating conditions.

3.1.2 Lift shall be suitable for machine rooms located above the highest landing level. The machine room shall not be pressurized. All the VVVFD/Controller shall be kept in the machine room. All electrical components for hazardous area lift shall be suitable for non-pressurized machine room, unless otherwise specified in job specification/data sheet.

3.1.3 Machine room shall be provided with requisite no. of Ventilation fans with bird screen and louvers. Minimum 12 ACPH shall be considered for ventilation of machine room.

3.1.4 All mechanical and electrical components and accessories shall be suitable for the area classification mentioned in job specifications/data sheets.

3.1.5 When the distance between consecutive landing door sills exceeds 11 m, intermediate emergency lift landing door(s) shall be provided such that the distance between landings is not more than 11 m. Rescue to these landings is permissible in case of automatic rescue device operation. Emergency door type shall be same as lift car door type.

3.1.6 No. of starts/stops per hour for motor shall be selected based on peak traffic requirement, lift speed and length of travel and no. of landings. However, in no case no. of starts/stop per hour shall be less than 120.

3.1.7 Sill gap between car sill and landing sill at each landing shall not exceed 30 mm.

3.1.8 Pit ladder shall be provided irrespective of pit depth.

3.1.9 Following details shall be displayed inside car:

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a) Name plate indicating capacity of lift.

b) Operating instructions in English, Hindi and Local language.

3.1.10 Emergency rescue procedure shall be displayed in machine room.

3.1.11 Manual override switch/key shall also be provided in the automatic door elevators so that operator can keep the door open for any period according to his need.

3.1.12 Provision shall be made to extend the alarm to nearby control room (for industrial applications) or security/guard room (for non-industrial applications).

3.1.13 Provision shall be made to connect Lift telephone to the existing telephone system. All cabling beyond telephone junction box up to telephone socket shall be in Vendor's scope.

3.1.14 Vendor shall arrange inspection and initial certification of Lift installation at site by concerned statutory authorities.

3.1.15 Car shall be provided with ventilation apertures in the upper and lower parts of the car.

3.1.16 Lift shall be designed for the ambient conditions as specified in the job specification/ data sheet.

3.2 Mechanical

3.2.1 Drive Unit

3.2.1.1 The Drive Unit shall be of traction type, and shall include an electric motor, electro-mechanical brake, gear box (if required), rope sheave/pulley and safety guards. Geared motor in place of electric motor and gear box is also acceptable. Permanent magnet type Gearless drive shall also be acceptable for safe area elevator only.

3.2.1.2 Controller shall be microprocessor based VVVFD type.

3.2.1.3 Adequate means of lubrication shall be provided for all bearings and gearbox as applicable.

3.2.1.4 Drive unit shall be placed in machine room directly above the hoist way.

3.2.1.5 Drive base plate shall be supported on suitable steel structure with anti-vibration pads in between.

3.2.1.6 All couplings, gears, pulleys, lift wire rope / belt entry and exit point and other exposed rotating parts shall be provided with adequate protection guards.

3.3 Brake

3.3.1 The brake shall be of fail -safe type and shall be designed to provide smooth stops under variable loads.

3.3.2 Brake shall be selected for 125% of the braking torque at rated load.

3.3.3 Provision shall be made for releasing the brake manually in case of emergency. As soon as hand pressure is released, brake shall be applied automatically.

3.4 Rope

3.4.1 Lift shall be provided with steel ropes of suitable construction and tensile designation. Coated steel belt in place of steel rope may also be acceptable subject to submission of sufficient PTR for similar application.

3.4.2 Factor of safety of suspension ropes / belt shall be selected as per applicable code.

3.5 Guide Rails

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3.5.1 Steel Guide rails (T- Section) of adequate strength with necessary brackets for both car and counterweight shall be supplied by Vendor.

3.5.2 Car and counter weight shall be guided by roller guides for lifts in industrial applications, irrespective of lift speed.

3.5.3 It shall be capable of taking care of forces imposed due the operation of safety gears and deflections due to uneven loading of the car.

3.6 Car

Unless otherwise specified in Job Specification/Data Sheet, car construction shall be as specified below:

Type of Lift	Components	Purchaser's requirement
Passenger Lift	Car enclosure	*Stainless Steel with hair line/chequered finish
	Car Floor	CS/MS with polished granite floor
	Car & Landing Doors	*Stainless Steel with hair line/chequered finish
	Car ceiling	*Stainless steel with hair line finish
Goods Lift (Goods Cum Passenger Lift)	Car enclosure	Painted/Powder coated CS/MS sheet
	Car Floor	Galvanized CS/MS Chequered Plate
	Car & Landing Doors	Painted CS/MS sheet
	Car ceiling	Painted CS/MS sheet

* Stainless steel sheet of adequate thickness without cladding shall be provided.

3.7 Car Operating Panel (COP)

3.7.1 Car Operating Panel shall be made from Stainless Steel plate. For hazardous area classification elevator, Vendor may also provide their standard material of construction for Car operating panel.

3.7.2 Following Push Button shall be provided as a minimum. For safe area lift, push button shall be luminous type (both digit & its border). For hazardous area lift, push button shall be luminous type as per vendor's standard. For passenger elevator, the height from lift floor level to the centre line of any button shall be between 900 mm to 1100 mm.

a) Car Movement
b) Button for all floors
c) Door open/close override push button
d) Fan on-off
e) Emergency stop
f) Emergency alarm
g) Emergency light
h) Push to talk button

3.8 Landing Door and Car Door

3.8.1 The type of door for car as well as landing shall be as specified below:

Type of Lift	Type of door (Car and Landing)
Passenger Lift	Automatic central opening horizontal sliding type door.
Goods Lift (Goods Cum Passenger Lift)	Automatic central opening horizontal sliding type door.

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3.8.2 Door shall be provided with an interlock, which shall prevent movement of car away from the landing unless all the doors are closed and locked. The interlocks shall also prevent opening of the doors except at the landing level.

3.8.3 Infrared full curtain electronic door detection system shall be provided for the automatic power operated door. For hazardous area elevator, other type of door detection system such as photo cell type is also acceptable based on Vendor's proven track record. For door detection using photo cell at different elevations, minimum five (5) photo cells for car door & for each landing door shall be considered. The protective device shall cover the opening over the distance between at least 25 mm and 1600 mm above the car door sill. The protective device shall be capable of detecting obstacles with a minimum diameter of 50 mm.

3.8.4 A timer relay shall be provided to render the car in-operative from the landing buttons for a few seconds after a stop is made.

3.8.5 For hazardous area elevator, landing and car door shall be provided with a "Sealed Toughened Glass Window" suitable for classified hydrocarbon hazardous area to facilitate the passenger of the Elevator to ascertain whether the car has landed at the desired floor properly or not. The minimum size of Glass window on each door shall be: 2 ft (long) X 1 ft (wide). The "Glass window on car door" shall coincide with the "Glass window on landing door" at each floor.

3.9 Counter Weight

Adequate counter weight moving in guided structural steel frame shall be provided.

3.10 Over Speed Safety

3.10.1 An over speed safety device to stop the car whenever the car achieves runaway speed limit resulting from high speed of the car, shall be provided. The device shall be operated by a centrifugal governor, which continuously and automatically senses the car speed. The actuation of the safety device shall cut off the power supply to the motor and apply the brake immediately.

3.10.2 Lift shall be provided with Safety gear. It should be capable of stopping the car carrying the rated load, at the tripping speed of the overspeed governor, even if the suspension devices break, by gripping the guides, and holding the car there.

3.10.3 For car having rated speed less than or equal to 0.75 m/s, instantaneous type safety gear shall be used. For car having rated speed greater than 0.75 m/s progressive type safety gear shall be used.

3.11 Pit Buffers

3.11.1 Buffers in the pit shall be mounted on steel sections placed beneath both the car and counterweight guide rails. Steel sections to support the buffers shall be provided by Vendor.

3.11.2 Energy accumulation type buffers (spring buffer) shall be used for speed up to 1.5 m/s. Energy dissipation type (Oil buffers) may be used for all speeds.

3.12 Accessories

Following accessories shall be provided as a minimum:

a) Fan/Blower inside the car.

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b) Car call push buttons at landing floors.

c) Voice Communication system inside the car.

d) Floor landing announcement system with both audio & visual indication.

e) Fireman switch with hammer at main lobby ground floor.

f) LED Car Lighting and LED Emergency light with battery and battery charger.

g) Automatic Rescue device (ARD).

h) Alarm bell at ground floor.

i) Suitable class Fire Extinguisher (Dry Chemical powder type) in Machine Room.

j) Trolley Mounted Chain Pulley Block of Adequate Capacity in Machine room (loose supply). Monorail beam inside machine room shall be provided by Contractor/others.

3.13 Indications

Minimum following indications (digital type) required at landing and inside the car:

a) Car position indicator.

b) Car travel direction indicator.

c) Car overload indicator with audio/visual alarm.

3.14 Terminal and Final Limits

Terminal limit switches shall be provided to slow down and stop the car automatically at the terminal landing. To arrest movement of car beyond the terminal landings, final limit switches shall be provided which on operation shall cut off the power and apply the brake immediately. Accuracy level of positioning of car with the landings shall be within ± 5mm.

3.15 Speed

Speed of the lift shall be selected based on the guidelines given below, unless otherwise specified in data sheet:

Type of Lift	Recommended Speed (Approx.)		
Passenger Lift	Upto 5 floors	-	1.0 m/s
	From 6 to 12 floors	-	2.0 m/s
	More than 12 floors	-	2.5 m/s
Goods Lift (Goods Cum Passenger Lift)	For Travel length <30 m	-	0.5 m/s
	30 m ≤ Travel Length < 50 m	-	0.75 m/s
	Travel Length ≥ 50 m	-	1.0 m/s
	For DCU Lift of any travel length	-	0.5 m/s

3.16 Electrical

3.16.1 Site Conditions

The equipment shall be suitable for continuous operation under the site conditions specified elsewhere. If not specifically mentioned, a design ambient temperature of 40 degree Celsius and an altitude not exceeding 1000 meters above mean sea level shall be considered.

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3.16.2 **Codes and Regulations**

3.16.2.1 The electrical equipment shall meet the requirement of this specification, in addition to the relevant Indian Standards / code of practices, statutory regulations and sound engineering practices. Complete system shall also conform to the latest revisions of following, as applicable:

a) Indian Electricity Act and rules.

b) Fire insurance Regulations.

c) Indian Petroleum rules and any other regulations laid down by chief Controller of Explosives.

d) The factory Act and any other regulations laid down by Factory Inspectorate.

e) Regulations laid down by local statutory authorities and CEA/ Electrical Inspectorate.

f) Oil Mines regulations (For Projects under DGMS jurisdiction).

g) OISD guidelines.

3.16.2.2 Where Indian Standards do not exist, the relevant IEC, British or German (VDE)/ IEEE/NEMA standards shall apply.

3.16.2.3 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or more stringent than the applicable Indian Standards.

3.16.3 **Power Supply system from Purchaser**

a)	Power supply & Frequency	:	415V±6%,, 50Hz±3%, TPN (at one point in machine room)
b)	Power supply & Frequency for Lighting	:	240V±10%,, 50Hz±3%, SPN (at one point in machine room)

3.16.4 **Utilization Voltage**

a)	Motors rated upto 160 kW	:	415V, 3 ph
b)	Anti-condensation heaters	:	240V, 1 ph
c)	Lighting	:	240V, 1 ph

3.16.5 **Design requirements for Power distribution board**

a)	Ammeter & Voltmeters in Incomer	:	Required
b)	Control supply for motor starter feeders	:	240V, A.C.
c)	Contactor & switch fuse / MCCB with overload relay	:	Upto 55 kW
d)	Field ammeters	:	Reqd. for motors > 5.5KW
e)	Clear working space for PDB	:	Front 1000mm, Rear Flush Mounted

3.16.6 **Minimum degree of protection for electrical equipments shall be as under:**

a)	Power distribution Board	:	IP-41
b)	Motors	:	IP-55
c)	Controller with Variable frequency drive	:	IP-31

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3.16.7 **Area Classifications and Equipment Selection.**

In case of hazardous area Lift, same shall meet the following requirements:

a) Electrical equipments for hazardous areas shall be certified by CIMFR or equivalent recognised independent test house such as BASEEFA / LCIE / PTB / UL / FM. All equipment shall also have valid statutory approvals from CCOE/PESO for use in the specified hazardous area. The indigenous equipment shall conform to Indian standards and shall be approved by CCOE/PESO/DGMS as applicable. All indigenous flameproof equipments shall have valid BIS license and marking as required by statutory authorities.

b) All electrical equipment including Telephone for hazardous area lifts shall be Flameproof type (Ex d), suitable for specified gas group and temperature Class T3 as minimum.

3.16.8 **Power distribution board (PDB)**

a) Vendor shall provide PDB for lift with one incomer and outgoing feeders for feeding all electrical loads of the package. Purchaser shall only provide Power Supply at the incomer of Vendor's PDB, including supply and laying of power cables upto Vendor's PDB. The PDB shall be located in machine room.

b) PDB shall house switch-fuse/MCCB, voltmeter, and CT ammeter etc. Power supply ON indicating lamps (3 Nos.) shall also be provided on the PDB. This PDB shall distribute power to micro–processor controller with VVVFD, ARD panel etc.

c) All Outgoing power & control cables from PDB to individual load shall be supplied, laid & terminated by Vendor. The interlocking between the PDB and the package equipments shall be provided by Vendor.

3.16.9 **Motors**

a) The rating of all motors shall be selected to take care of loading conditions, cyclic duration factor, service factor and de-rating factor for ambient temperature as per applicable code.

b) Motors shall be suitable for S4 duty and Cyclic Duration Factor (CDF). No. of starts / stops per hour shall be as specified elsewhere in the bid document. Wherever, lift has to operate in higher ambient temperatures, suitable de-rating factor shall be considered.

c) All motors shall have class F insulation and temperature rise limited to Class B limits. Squirrel cage induction motors shall have TEFC enclosure with IP-55 degree of ingress protection. The slip ring motors shall also have dust proof enclosure preferably of IP-5X class. All motors to be installed in hazardous areas shall be flameproof type irrespective of the area classification where the lift is to be installed.

d) The standard motor kW rating and frame sizes shall be selected as per Indian Standards, to facilitate future replacement.

e) VVVFD Controlled motor shall be provided with thermister.

3.16.10 **Microprocessor Controller with Variable Voltage Variable Frequency Drive**

Microprocessor Controller with Variable Voltage Variable Frequency drive (VVVFD) shall be provided by Vendor for smooth control of lift motor and energy saving. Make of variable frequency drive unit shall be subject to Purchaser's approval based on satisfactory past track record of the manufacturer. VVVFD shall be as per Vendor's

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Digitally signed by MD MAZHER ALI
Date: 2026.03.17 18:08:11 IST
Location: eProcure-EPROC

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