Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Voltage Transformers at LVDC Systems

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DESCRIPTION **PAGE**

Technical Specification for LVDC Systems

1- GENERAL REQUIREMENTS

This specification covers the requirements for the design, manufacturing, factory testing, marking, packing, installation and commissioning of LVDC system and their accessories for 63 to 400 kV substations.

The dc system and its various components shall conform to the requirements stated in latest edition of following standards and this specification:

IEC 60073: Coding principles of indicators and actuators.
IEC 60146: Semiconductor converters.
IEC 60149: Sockets & accessories for electronic plug-in devices.
IEC 60158-2: Low voltage controlgear.
IEC 60255: Electrical relays.
IEC 60269: Low voltage fuses.
IEC 60335: Safety in house hold & similar electrical appliances.
IEC 60439: Low voltage switchgear & controlgear assemblies.
IEC 60726: Dry type power transformers.
IEC 60947-2: Low voltage switchgear and controlgear – part 2: circuit breaker.
IEC 60947-3: Low voltage switchgear and controlgear – part3: switches, disconnectors, switch disconnectors and fuse – combination units.
IEC 60896: Stationary lead – Acid batteries – general requirements and methods of test.
BS 88: Cartridge fuses of voltage ratings up to 660 volts.
BS 89: Electrical indicating instruments.
BS 158: Marking and arrangement of switchgear busbars, main connections and small wiring.
BS 162: Electric power switchgear and associated apparatus.
BS 440: Specification for stationary batteries (lead acid planet positive type) for general electrical purposes.
BS 775: Contactors for voltage up to and including 1000 V ac and 1200 V dc.
BS 861: Air-break switches and isolators.
BS 3031: Sulphuric acid used in lead-acid batteries.
BS 3871: Miniature and moulded case circuit breakers.
BS EN50272-2: Safety requirements for secondary batteries and battery installations- Part 2: stationary batteries.
BS 6133: Safe operation of lead-acid stationary cells and batteries.
BS 6290: Lead acid stationary cells and batteries.

BS 9331: Rules for the preparation of detail specification for semiconductor devices of assessed quality medium current rectifier diodes (1-100 ampere rating).
BS 9332: High current rectifier diodes (greater than 50 ampere rating).
IEEE 450: Recommended practice for maintenance, testing and replacement of vented lead-acid batteries for stationary applications.
IEEE 484: Recommended practice for installation design and installation of vented lead-acid batteries for stationary applications.
IEEE 485: Recommended practice for sizing lead-acid batteries for stationary applications.
All amendments, supplements and reference publications listed in the above standards shall also apply.
The LVDC system shall be complete with all necessary accessories for safe and proper operation.
Basic equipment data and rating shall be as specified in schedule LVDC (I).

2- DESIGN AND CONSTRUCTION

2.1. Stationary Lead Acid Storage Battery

2.1.1. Performance Requirements

The contractor shall guarantee the capacity of the battery offered is adequate for the specified duty with regard to load requirements and minimum ambient temperature conditions. The battery shall be able to be fully charged within the specified period.
Internal resistance of battery shall be low enough to permit correct operation of battery.

2.1.2. Construction Features

The battery type shall be lead acid cells and cells shall be suitable for indoor installation. The cells shall be provided with a vent plug.
The positive plate shall be cast solid in pure lead in one piece and shall have adequate mechanical strength. It shall not be electrochemically formed and shall be capable of operating under normal working without buckling or cracking. Welding together of small size lead castings or formed plates to form larger sizes will not be accepted.
The negative plates shall normally be of box type. End negative plates, may be of the half pasted type. Pasted plates shall have adequate mechanical strength.
Cells shall be delivered dryly. Also, electrolyte shall be delivered 10% excess of required amount with vessels not be returned to supplier. Electrolyte shall be sulfuric acid suitable for batteries (conform with BS 3031).

The containers shall be made of moulded transparent plastic and be free from flaws. Sufficient space shall be provided beneath the plates to accommodate any plate deposit (which may accumulate at the bottom of the cell over a reasonable life of the battery), without short circuiting the plates.

The vent plug shall be of the antisplash type, preferably with more than one output hole. It shall allow the gases to escape freely but shall effectively prevent acid particles or spray from coming out.

On removal it shall permit drawing of the electrolyte samples, servicing and checking, but access for filling plugs shall not be provided.

The battery separator, when used, shall maintain the electrical insulation between the plates and shall allow the electrolyte to permute freely. The separators shall be of wood or other acid resisting synthetic materials. They Shall be free from knots, cracks or other imperfection, and shall have smooth faces and edges. Also chemical processes shall remove all harmful impurities on their surfaces.

Intercell, interior and interbank connectors shall be of PVC insulated solid copper. Special care for intercell connector design shall be taken to ensure high current carrying capacity for high discharge current rate cells.

The connection from the battery to the leads through terminals shall be of PVC insulated copper rod supported on insulators. All necessary fixing arrangements shall be provided. The connections shall be secured to cell terminals using a bolted type fixing.

Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the intercell connection. The top hole shall be left for terminal connections. All metal parts of the terminals shall be of lead or lead coated type.

Bolts heads and nuts shall be hexagonal and shall be lead covered.

The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte. Specially reinforced type terminal pillars shall be provided for high discharge current rate cells.

The battery shall be complete with accessories and devices including but not limited to the following:

- Instruction cards.
- One (-3,0,+3) volts dc voltmeter with suitable leads for measuring cell voltage.
- Two hydrometers for measuring specific gravity of electrolyte in steps of 0.005 g/Cm^3 .
- One filler hole thermometer fitted with cap and pocket.

- Two pocket thermometers.
- Two acid resisting funnels.
- Two acid resisting jugs of adequate capacity
- Two rubber aprons.
- Two rubber gloves.
- Two plastic filler bottle for distilled water.
- Two cell lifting straps.
- Two acid pumps.
- Two siphon tubes.
- Two trolleys.
- Two carboy for diluting acid.
- One set emergency eye washing and neutralizing apparatus.
- Four sets spare connectors.
- Four sets vent plugs.
- One set suitable spanners.

The ventilation and cooling requirement of batteries under site operating conditions and all layout and floor loading data requirements shall be forwarded to the purchaser for his building design coordination.

2.1.3. Battery Layout

If batteries are located together in two rows, there must be enough space for maintenance along two sides. The contractor shall furnish dimensioned drawings of the battery layout for employer approval.

The battery racks should be designed to withstand the specified seismic acceleration.

The cells shall be numbered and mounted on battery racks. These battery racks shall be constructed from good quality, hard wood, painted with two coats of approved acid resisting paint or shall be of plastic coated metal (preferably steel). The construction of the racks shall be suitable for fixing to a flat concrete floor. The racks shall be rigid and free from warp and twist. The completed racks shall be suitable for being bolted and to form a continuous row.

2.1.4. Charging

The proposed method of charging of the battery shall be specified. The contractor shall state recommendations whenever the equalizing charge is required for the battery.

2.1.5. Life

The cells shall be capable of maintaining full ampere hour capacity for a life of 20-25 years under site operating conditions, however the contractor shall indicate the guaranteed life of the battery when operating under the specified conditions.

2.1.6. Marking

Each cell shall be marked in a permanent manner to indicate the following information:

- Cell number
- Type of positive plate
- AH capacity at 8 hour rate
- Min. and Max. acid level
- Type of container
- Manufacturer's name
- Year of manufacture

2.2. Battery Charger and Accessories

2.2.1. Performance Requirements

Each charger along with all switches, relays, diodes, meters, fuses, transformers, indicator, float and boost chargers, AVR systems and all its accessories as detailed in this specification shall be mounted in a free standing cubicle.

Each charger shall be designed for operation with other chargers under automatic mode and with batteries. Under manual mode the required voltage output shall be manually adjusted from the front of panel. Charger voltage shall be controlled continuously in both automatic and manual cases.

The automatic constant voltage regulator of the float mode shall regulate the charger output dc voltage to within +0.5% of the set value from 0-100% of the rectifier rated current under the individual and combined fluctuations in the specified supply frequency and voltage, as well as under specified ambient temperature.

The charging rectifier shall be controlled by the battery terminal voltage and not by the rectifier output voltage. The controlled voltage shall therefore be obtained at the battery via separate fuses.

The float mode shall have built in current limiting feature to drop the output voltage on currents more than 110% of the rated current such that battery will be supplying the required excess current.

The ripple content of the boost mode shall be limited to such a value that excessive battery overheating does not occur. The boost mode shall be selected manually for boost charging the battery.
The output of the charger in boost mode shall be adjustable from 90% to 140% of the rated battery voltage. The output of charger in float mode shall be adjustable from 110% to 115% of the rated battery voltage.
The boost charger shall automatically disconnect itself from battery after a period adjustable between 8 to 12 hours.
The charger shall be equipped with filters to confine the noise below acceptable limits.
All component equipment shall be capable of delivering rated output in continuous operation throughout the specified temperature range.

2.2.2. Construction Features

The battery charger shall be of static type preferably composed of silicon controlled rectifiers (SCR's) connected in full wave bridge circuits complete with all control features. The voltage for charger shall be specified.
The SCR's diodes used in the chargers shall be liberally designed and provided with specially designed safety devices.
The annunciation system provided for the battery charger shall be of fascia type with translucent plastic windows engraved with appropriate function for each alarm point.
Charger wiring, drawing, wire colors and wire codes shall be provided.
All potential free fault contacts for various battery charger trouble conditions shall be connected in parallel for summary annunciation at control system, event recorder and scada.
The rectifier transformer of charger shall be of indoor, two winding, dry type with adequate number of primary and secondary off circuit taps located in an accessible position. The transformer shall be capable of carrying the specified continuous output on all tappings. The rectifier transformer shall be enclosed in a ventilated sheet steel charger case.
The rigidity of the panel shall be such as to prevent mal-operation of equipment and devices due to impact loads and earthquakes.
Each battery charger shall generally, includes the following:

- One set of silicon controlled rectifiers.
- Two winding dry type transformer.
- One set of automatic voltage regulator unit with auto/manual selector switches for float mode.
- Ability of controlling voltage with A.V.R.
- One set of automatic constant current regulator (ACCR) unit (for boost mode) with auto/manual selector switch and similar facilities as in the float mode for auto and manual modes.

- One set of coarse and fine control knobs for manual control of float and boost mode voltages.
- One set of 8-12 hours timer and associated devices for switching of the boost mode automatically.
- One position, 1 pole, on-load, fast acting, rotary type selector switch for selecting mode of charging.
- Set of multiple input and output moulded case circuit breakers (MCCB's) with suitably rated adjustable overload, short circuit and shunt- trip releases having auxiliary contacts for annunciator, scada and event recorder. The MCCB's shall be capable of interrupting specified fault current.
- One set of HRC and special fuses to protect diodes / SCR's etc. All fuses shall be provided with kick-fuses (with 1 NO contact) for annunciation of fuse failure.
- One set of off-load tap changing switch for changing the taps of the transformer.
- One dc voltmeter with fuses and a two position selector switch for measuring charger voltage (float/boost).
- One dc ammeter with shunt for measuring float mode current.
- One center zero double range ammeter with shunt for boost and float mode.
- One thermostatically controlled cubicle space heater with 230 V, single phase, 50 Hz, ac supply.
- One 230 V switched socket for connection to hand lamps.
- One single pole switch fuse unit or MCB for switching of 230V single phase 50 Hz, ac incoming supply for the space heater and socket.
- Suitable input and output filters.
- Equipment for battery charger adjustment.
- Output voltage regulation.
- Security against radio noise.

2.2.3. Capacity

The ratings of charger shall be adequate to supply the normal float charging currents of batteries and the specified DC loads with sufficient spare capacity to supply recommended initial charging rate of associated batteries. Also, future substation extension shall be considered.

The boost mode shall be designed for supplying the boost charging current of batteries such that batteries are boost charged in the specified duration. The battery charger shall completely meet the requirements of the battery supplied in respect of float/boost charging currents and voltages.

2.2.4. Indication, Annunciation and Protection

Each battery charger shall be provided with the following indication and protective devices:

- Three indicating lamps on the ac incoming supply of the charger.
- One indicating lamp on dc output side of the charger to show the presence of the dc voltage.

- One indicating lamp for charge condition (boost, float,…)
- One dc overvoltage relay set at about 110% of the battery voltage with contacts used for tripping the charger output MCCB after preset time delay.
- One dc under voltage relay with two contacts.
- One set annunciators with annunciation windows, hooter, audible alarm, push buttons and suitable inscriptions for various annunciation windows.

Generally following annunciations shall be provided:

- Charger trip – overvoltage in float made
- Charger under voltage
- Charger trip
- Boost mode auto-off
- Ac supply under voltage
- Spare

Three sets of changeover contacts for common alarm shall also be considered on charger.

2.3. DC Distribution Boards

2.3.1. Constructional Features

Design and battery(s), charger(s), LVDC distribution board and input and output feeders shall be in such a way that that every charger can supply referred loads and charge the battery.

Input feeders shall be controlled and protected by MCCB and output feeders shall be controlled and protected by MCB or MCCB. Rated or adjusted short circuit rupturing capacity shall be within limits for providing appropriate protection against results of fault occurrence on output terminals.

Charger, distribution board wire diagrams, color of wires and wires numbering shall be given.

Board shall be metal clad, indoor, floor mounted module type, with appropriate height and single proof execution.

Board shall be free from vibration, twists and bends, dust, moisture and vermin proof of IP4X.

In hot and dusty areas if higher protection degree is required, it's better to equip boards by ventilation system with filter.

The board shall be made up of frames fabricated by the use of suitable mild steel sections or pressed and shaped cold rolled sheet steel of thickness not less than 2.0 mm and shall be enclosed by cold rolled sheet steel of thickness not less than 2.0 mm and provided with gaskets all round the perimeter of covers, gland plates and doors.

Colour layer thickness of board shall be resist against corrosion.

Board shall have appropriate entry for incoming cable. For providing this subject, gland plate, with enough number and enough dimension of holes created on it shall be used.

Board shall be provided with busbars and labels on the front and rear of board, these indicating plates shall be made of metal with appropriate dimension and referred text shall be engraved with black colour on these plates. Before construction dimensions, numbers and texts of these indicating plates shall be asked from contractor.

Selector switches, push buttons, indicating instruments, lamps and protective relays shall be mounted on the front doors of the respective compartments.

Board rear plate shall be separable and it's doors capable of taking apart and have joint, bolted handle and lock.

Every part of board shall be provided with suitable cutouts as necessary to permit operation of MCCB's from the front without having to open the compartment door. Such cutouts shall be provided with spring loaded gaskets for the purpose of dust and vermin proofing.

Board design shall be in such a way that all equipments operate appropriately and their temperature shall not exceed their maximum permissible temperature in accordance to ambient temperature.

The board shall be equipped with thermostatically controlled space heater.

Installation place of all equipments and parts shall be in such a way that performing all referred operations is easily possible. Measurement devices shall be placed where they are simply readable. If several measurement quantities shall be compared together, their referred measurement devices shall be installed on board closely together.

Mounted bulbs inner board used for lighting during inspection and maintenance, shall be turned on and off automatically with opening and closing board door.

Every board inner part, terminal block and terminals shall be specified with appropriate labels stick under these parts. Associated numbers to these parts have represented on single line diagrams. Contractor shall be informed by these numbers before construction.

All wires, cables and board inner equipments shall be non-flammable, minimally, by open circuiting them, flame is extinguished.

All wires have two numbers in their two ends. These numbers shall be resisted to weather conditions.

2.3.2. Buses

Busbars shall be made of copper and shall have uniform section throughout the length of the switch board. The busbars, bus taps and joints shall be sleeved by PVC.

Busbars shall be mounted on separate supports. Number of supports and their specifications depend on short circuit current and distance between positive and negative buses. Single supports (one support for each bus) are preformed to common supports (one support for two buses). Buses shall be withstand against forces produced by short circuit currents. If a common support is provided for the both busbars, antitracking barriers shall be provided.

Busbar joints shall be of the bolted type. Busbars shall be thoroughly cleaned at the joint locations and a suitable contact grease shall be applied just before making a joint.

2.3.3. Moulded Case Circuit Breakers (MCCB's) and Miniature Circuit Breakers (MCB)

MCCB's shall have specified rupturing capacity and shall operate fast for fault clearing. Also, they shall have auxiliary contacts to initiate annunciation of faults and in the case of fault occurrence at furthest location, shall capable of fault sensing and clearing.

MCCB's and MCB's shall have an auxiliary contact for open- state annunciation and shall be mounted on suitable height easily be opened and closed.

2.3.4. Protective and Auxiliary Relays

The protective relays shall be enclosed in dust proof flush mounting plug-in type cases and shall be accessible for setting, resetting and testing from front.

In addition to above, the following particular requirements shall be met for individual relays:

2.3.4.1. Earth Fault Relay

The battery earth fault relay shall be provided in switchboard for each battery set and connected via 2 HRC fuses.

In the case of earth faults and deterioration of wiring insulation in either pole of battery supply below the set point, relay shall provide appropriate alarm.

The relay shall be immune to ripple up to 50% on the dc voltage.

The relay shall be complete in all respect and shall provide continuous monitoring of the insulation level with center zero milliammeter connected in series between earth and load. The direction of deflection shall determine the faulty pole.

2.3.4.2. Under Voltage Relay

Under voltage relays shall be provided for monitoring the each bus voltage and initiating an alarm when the busbar voltage is lower than 92.5% of the rated voltage.

The alarm contact shall be time delayed for 60 to 100 msec such that the undervoltage relay shall not initiate any spurious alarm for any transient drop of dc voltages due to faults on the system.

Pick up to drop-off ratio of the under voltage relays shall be less than 103%.

Auxiliary relays shall be rated to operate satisfactorily between 80% and 110% of rated auxiliary voltage.

The relay shall be designed for continuous overvoltage withstand of 1.4 p.u.

2.3.5. Instruments, Meters and Annunciators

Each incoming feeder should be equipped with ammeter and each section of busbars should have a voltmeter with suitable ranges.

Window alarm annunciators shall comprise following equipments and features:

- A common alarm bell.
- Acknowledge, reset, and lamp test push buttons.
- "Alarm supply failure scheme" with audible alarm of different tone.
- Suitable for operation on the specified dc supply available in the switchboard.
- Facility for a separate visual alarm to indicate "Alarm supply failure", suitable for operation on 230 V ac.
- Facility for summary annunciation in the electrical control room, event recorder and scada.

2.3.6. DC Emergency Lighting Board

2.3.6.1. General

The dc emergency lighting board shall consist of one separate switchboard for the whole substation. The design, operational flexibility, reliability and components of this board shall be similar to the main dc board.

This board will receive the power from dc distribution board and distribute emergency lighting supply by means of various outgoing feeders.

Heat generated by losses of electrical devices shall be transferred to adjacent air. For assuring of correct operation of devices, temperature shall not exceed at inner board from specified limits.

Heat generating devices shall be installed near adjacent surface to exchange produced heat, Also, electronic devices placed inner board shall be mounted far from heat generating devices.

Mounted position of contactors and switches shall not be close together to exchange produced heat easily. For reducing possibility of short circuit occurrence or arc creation due to setting dust and also for appropriate heat exchange, equipments and current carrying buses shall not be mounted close together.
The contactor shall be switched on incoming feeder automatically when ac substation supply is interrupted.

2.3.6.2. Contactors

Contactors shall be of the electromagnetic air-break type rated for uninterrupted duty.
The switch and contactor ratings for respective circuit shall be selected to meet the requirements of the circuit.
Contactor shall also be capable of making and breaking all emergency lighting normal load.

3- TESTS

All tests mentioned in this standards except those agreed between manufacture and purchaser shall be performed on LVDC system equipment, optional tests shall be performed only by agreement between manufacturer and purchaser and by uttering in contract.

3.1. Battery Charger tests

All type and routine tests stipulated in IEC 60146 should be performed to ensure that the design, material and workmanship of semiconductors confirm the specification. These tests are as follows:

3.1.1. Routine Tests

- Insulation test
- Light – load and functional test
- Checking of auxiliary devices
- Checking the protective devices
- Checking properties of the control equipment

3.1.2. Type Tests

- All of routine tests
- Rated current test
- Power loss determination for assemblies and equipments
- Temperature rise test

3.1.3. Optional Tests

- Power factor measurement
- Measurement of inherent voltage regulation
- Immunity test
- Overcurrent capacity test
- Radio frequency generated interference and conducted noise
- Audible noise
- Measurement of ripple voltage and current
- Additional tests

3.2. Lead Acid Stationary Battery tests

All tests stipulated in IEC 60896 should be performed to ensure that the design, material and workmanship confirm the specification of lead acid stationary batteries. These tests are as follows:

- Capacity test
- Test of suitability for floating battery operation
- Endurance test in discharge – charge cycles
- Short circuit current and internal resistance test
- Charge retention test

3.3. LVDC Panel

All type and routine tests stipulated in IEC 60439 should be performed to ensure that the design, material and workmanship of LVDC panel confirm the specification. These tests are as follows:

3.3.1. Type Tests

- Verification of temperature rise limits
- Verification of dielectric properties
- Verification of short circuit withstand strength
- Verification of effectiveness of the protective circuit
- Verification of clearance and creepage distances
- Verification of mechanical operation
- Verification of the degree of protection

3.3.2. Routine Tests

- Inspection of panel, including inspection of wiring and, if necessary, electrical operation test
- Dielectric test
- Checking of protective measures and of the electrical continuity of the protective circuit

4- DRAWINGS AND DOCUMENTS

4.1. Documents to be Given By Tenderer

- Filled schedule LVDC (II)
- Catalogue and technical pamphlets
- Dimensional drawings
- Summary of type test reports
- Reference list
- Detailed summary of exceptions to tender specifications
- List of special tools
- List of spare parts

4.2. Documents to be Given By Contractor / Supplier

The electrical and mechanical design, fabrication, factory testing, marking, packing, transportation, warehousing, erection, site tests, operation and maintenance documents and manuals shall be submitted not limited to the following:

- Calculation sheets to establish adequacy of protection and rating of equipment in any respects.
- Outline dimension including components, arrangements and terminals.
- Assembly drawings.
- Shipping, packing and warehousing details.
- Name plate drawings.
- Routine test certificates.
- Site test instruction manuals.

- Shipping, warehousing, assembly, erection, commissioning, operating and maintenance instruction manuals.
- Type test documents.
- List of components.
- Work schedules and monthly progress report.
- Drawing list.
- Final as built Doc./Dwg.
- Dismantling, reassembling and adjusting manuals.

5- TRANSPORTATION, STORAGE, INSTALLATION AND COMMISSIONING FOR LVDC EQUIPMENTS

5.1. Batteries

5.1.1. Transportation

The battery with all necessary accessories will be transported without acid in dry charged condition.
The acid shall be transported in separate nonreturnable containers.

5.1.2. Receiving Inspection

Manufacturer instructions on receipt stages, opening boxes and warehousing shall be considered.
Upon receipt, and at the time of actual unloading, packages shall be positional vertically and each package should be visually inspected for apparent damage and electrolyte leakage. If either is evident, a more detailed inspection of the entire shipment should be conducted and results noted on the bill of lading.
Cell repair or replacement should be instituted as required. Record receipt date and inspection data results.

5.1.3. Unpacking

When lifting cells, a strap and strap spreader should be used, if applicable.
Always lift cells by the bottom, never by the cell posts.
Check electrolyte levels for evidence of leakage and to ensure that the plates are covered; any cell should be replaced if the electrolyte level is approximately 13 mm or more below the top of the plates. If the level is less than approximately 13 mm below the top of the plates, add electrolyte of appropriate strength, or water, and fill to cover the plates.

All cells with visible defects such as cracked jars, loose terminal posts, or improperly aligned plates, shall be repaired or replaced.

5.1.4. Storage

Cells should be stored indoors in a clean, level, dry, and cool location; extremely low ambient temperatures or localized sources of heat should be avoided.

Cells should not be stored for more than the time period recommended by the manufacturer, without applying a charge to the battery; in all cases, a period of three months storage is allowable between charges if the recommendations of above item are followed.

For charging during storage or special conditions, the battery manufacturer should be consulted. Record dates and conditions for all charges during storage.

5.1.5. General Safety precautions for installing and commissioning of lead- acid batteries

The safety precautions listed herein shall be followed during battery installation. Work on batteries shall be performed only by knowledgeable personnel with proper, safe tools and protective equipment.

The following equipment for safe handling of the battery and protection of personnel shall be available:

- Goggles and face shields
- Acid – resistant gloves
- Protective aprons and overshoes
- Portable or stationary water facilities for rinsing eyes skin in case of contact with acid electrolyte
- Bicarbonate of soda mixed approximately 0.1 kg/L of water to neutralize acid spillage. The use of bicarbonate of soda to neutralize acid spills may result in production of a hazardous waste. Users should be a ware of their responsibilities for handing waste.
- Class C fire extinguisher (some battery manufacturers do not recommend the use of CO_2 class C fire extinguishers due to the potential of thermal shock)
- Adequately insulated tools
- Lifting devices of adequate capacity, when required

5.1.5.1. Precautions During Installation

The following safety precautions shall be followed prior to and during installation:

- Keep cells upright
- Ensure that metal racks are connected to ground in accordance with applicable codes

- Inspect all lifting equipment for functional adequacy
- Restrict all unauthorized personnel from the battery area.
- Prohibit smoking and open flame, and avoid the chances of arcing in the immediate vicinity of the battery
- Keep the top of the battery clear of all tools and other foreign objects
- Ensure that illumination requirements are met
- Ensure unobstructed egress from the battery area
- Ensure that the battery area is ventilated during charging
- Avoid the wearing of metallic objects such as jewelry while working on the battery
- Avoid excessive tilting of the cells so as to prevent spillage
- Neutralize static buildup by having personnel contact the nearest effectively grounded surface just before working on the battery

5.1.5.2. Installation Design Criteria

Considerations that should be included in the design of the battery installation depend upon the requirements or function of the system of which the battery is part. The general installation design criteria for all vented lead-acid batteries are provided in the following:

- Space and floor supports allocated for the battery and associated equipment should allow for present and future needs. Calculations should be performed to ensure that floor loading capabilities are not exceeded.
- The location should be as free from vibration as practical.
- The general battery area should be clean, dry, and well ventilated, and provide adequate space and illumination for inspection, maintenance, testing, and cell/battery replacement. Space should also be provided to allow for operation of lifting equipment, addition of water, and taking measurements (e.g., temperature, specific gravity, etc).
- The battery should be protected against natural phenomena such as earthquakes, winds, and flooding, as well as induced phenomena such as fire, explosion, missiles, pipe whips, discharging fluids and CO_2 discharge.
- The optimum cell electrolyte temperature is 25°C and is the basis for rated performance. A location where this temperature can be maintained will contribute to optimum battery life, performance, and cost of operation. Extreme ambient temperatures should be avoided because low temperatures decrease battery capacity, while prolonged high temperatures shorten battery life and increase maintenance cost. Installation in a location with an ambient below the optimum temperature will affect sizing.
- The location and arrangement of cells should result in no greater than a 3°C temperature differential between cells at a given time. Avoid conditions that result in spot heating or cooling, as temperature variations will cause the battery to become electrically unbalanced.

- Portable or stationary water facilities should be provided for rinsing spilled electrolyte. Provisions for neutralizing, containing, and safely disposing of acid electrolyte should be included.
- The charger and main power distribution center should be as close as practical to the battery, consistent with below item.
- Nearby equipment with arcing contacts shall be located in such a manner as to avoid those areas where hydrogen pockets could form. Also, arcing contacts shall not be existed in battery room.
- Illumination in the battery area should be at a suitable level.

5.1.5.3. Mounting of Batteries

The most common practice is to mount cells on a steel rack with acid-resistant insulation between the cells and the steel of the rack. Metal racks should be connected solidly to the grounding system if grounding is part of the design requirements and applicable codes. The cells may also be mounted on adequately insulated supports secured to a floor or base.

Not more than two tiers or two steps should normally be considered for large batteries; this choice of rack results in a minimum temperature differential between cells and will facilitate maintenance. A three-tier rack is acceptable provided the requirements of previous section about temperature difference between cells are met, and maintenance is not adversely affected.

Cells in clear jars are usually mounted so that one edge of each plate is plainly visible for inspection and so that the electrolyte withdrawal tubes or vent plugs are easily accessible.

Electrical connections to the battery and between cells on separate levels or racks should be made so as to minimize mechanical strain on battery posts.

5.1.5.4. Requirements Related to Seismic In Battery Installation

Where applicable building codes require seismic protection, the racks, cabinets, anchors, and installation thereof shall be able to withstand the calculated seismic forces. To minimize the effect of seismic forces, the battery should be located at as low an elevation as practical. The following criteria should be observed regarding mounting:

- All cells should be restrained. Side and end rails with spacers between cells is one method that can be used to prevent loss of function due to a seismic event.
- Where more than one rack section is used, the rack sections should be rigidly joined, or the adjacent end cells in each rack should be connected with flexible connectors as provided by or recommended by the manufacture. Connections between cells at different levels of the same rack should also be flexible.

- Racks shall be firmly connected to the building structure by using approved fastening techniques such as embedded anchor bolts or racks welded to structural steel face plates (sized to accommodate a range of battery rack sizes).

Note: Anchoring a rack to both the floor and the wall may cause stress due to conflicting modes of vibration.

5.1.5.5. Ventilation

The battery room shall be ventilated, either by a natural or mechanical ventilation system, to prevent accumulation of hydrogen. The location should be free of areas that might collect pockets of hydrogen. Maximum amount of Hydrogen is produced on charging duration. Hydrogen production stop one hour after charge finalization.

Maximum hydrogen evolution rate is 1.27×10^{-7} m^3/s per charging ampere per cell at 25°C at standard pressure. The worst-case condition exists when forcing maximum current into a fully charged battery.

A battery room that meets the above ventilation requirements should not be considered a classified (hazardous) location; thus special electrical equipment enclosures to prevent fire or explosion should not be necessary.

Fan motor shall be explosion proof and its vanes make preferably from anti-acid plastic.

5.1.5.6. Instrumentation and Alarms

Each battery installation should include the following instrumentation and alarms:

- Voltmeter
- High and low battery voltage alarm
- Earth fault relay
- Instrumentation to measure current through the battery

5.1.5.7. Battery Assembly

Rack Assembly

The assembly of the rack should be in accordance with the manufacturer's recommended procedure.

Cell Mounting and Connections

The following sequence should be used:

- Lift the individual cells onto the rack following the procedures outlined in first and second paragraph of section 5.1.3. mount the cells in accordance with the manufacturer recommendations. Do not apply lubricant on rack rails unless approved by manufacturer(s).
- Remove shipping plugs and install flame arrester vent plugs.

- Check cell polarity for positive to negative connections throughout the battery.
- Unless otherwise instructed by the manufacturer, clean all terminal posts and connecting hardware areas showing evidence of corrosion, dirt, or acid with a nonmetallic brush or pad; then coat all areas with a thin film of manufacturer's approved corrosion- inhibiting compound to all contact surfaces.
- The intercell connector contact surfaces should be cleaned by rubbing gently with a nonmetallic brush or pad; care should be exercised in cleaning to prevent removal of the plating. Apply a thin film of manufacture's approved corrosion – inhibiting compound to all contact surfaces.
- Make intercell connections using manufacturer's approved connectors.
- When more than one intercell connector per cell post is required, mount the intercell connectors on opposite sides of the post for maximum surface contact.
- Tighten both ends of connection bolts to the battery manufacturer's recommended torque values.
- Clean all cell covers and containers; for dust and dirt, use a water- moistened clean wiper; for electrolyte spillage, use a bicarbonate of soda and water- moistened wiper. Do not use hydrocarbon-type cleaning agents (oil distillates) and strong alkaline cleaning agents, which may cause containers and covers to crack or craze.
- Read the voltage of the battery to ensure that individual cells are connected correctly (i.e., the total voltage should be approximately equal to the number of cells multiplied by the measured voltage of one cell). If the measurement is less, recheck the connections for proper polarity.
- For future identification, apply individual cell numbers in sequence beginning with number one at the positive end of the battery.
- Read and record intercell connection resistance and the method of measurement to determine adequacy of initial installation and as a reference for future maintenance requirements. Review records of each connection detail resistance measurement; remake and remeasure any connection that has a resistance measurement more than 10% or 5 $\mu\Omega$, whichever is greater, over the average for each type of connection (i.e., intercell, interior, interrack).
- When plates in above items have been satisfactorily completed, make connections from the battery to the charger in preparation for the freshening charge.

5.1.5.8. Freshening Charge, Data Collection, and Testing

Freshening Charge

Since a battery loses some of its charge during shipment and storage, a freshening charge be applied after installation and before connection to the system. Follow the manufacturer's recommendation for application and duration. Typically this consists of the following:

- Prior to applying the charge, read and record the open circuit voltage of all cells, and the electrolyte temperature and specific gravity of every tenth cell. Select the cell with the lowest specific gravity as a pilot cell for the freshening charge.
- Inspect all cells to ensure that the electrolyte level is above the top of the plates. If required, add enough electrolyte to cover the plates.
- Apply the freshening charge per the manufacturer's recommendations. If the freshening charge voltage exceeds the system voltage limit, perform the freshening charge offline from the dc system.
- Read and record at least once per day during the freshening charge: battery voltage individual cell voltage, electrolyte temperature of every tenth cell, and the specific gravity and electrolyte temperature of the pilot cell.
- Return charger to float voltage.

5.1.5.9. Data Collection

- At the end of 72h on float, read and record all individual cell voltages, electrolyte temperatures, specific gravities, and levels.
- Any cell that shows a specific gravity or voltage outside the manufacturer's specified limits requires corrective action in accordance with the manufacturer's instructions.
- As necessary, use approved water, (or electrolyte if approved by the manufacturer) to adjust the electrolyte level of all cells to a level specified by the manufacture.
- Record new electrolyte levels.

5.1.5.10. Battery Capacity Test

When required, an acceptance test shall be conducted in accordance with IEEE std 450.

5.1.5.11. Batteries Information Record

Data obtained from receiving, storage, assembly, and freshening charge are pertinent to the maintenance of the battery. The recommended records should be in accordance with cell identification. The data that should be dated, recorded, and maintained in a suitable permanent file for record purposes and future reference includes:

- Receiving inspection data and conditions of charge
- Initial resistance values of the intercell connections
- Individual cell specific gravities (corrected for temperature), voltage measurements, and electrolyte levels
- Battery capacity

5.1.6. Battery Commissioning Initial Checks and Commissioning Tests

- Measuring and recording of every battery cell voltage
- Measuring and recording of specific gravity of every battery cell
- Inspection for tightness of battery connections
- Inspection for assuring that battery is clean and connections are vaselined
- Inspection of electrolyte level
- Inspection of battery room ventilation system
- Inspection of battery room thermal system
- Inspection of battery room safety system
- Inspection of every cell temperature

5.2. Installation and Commissioning Of Chargers

5.2.1. Installation

- Charger box shall be lifted by a hooked crane, near installation site.
- Top and adjacent sections of wooden box and bolts tightened panel to bottom section of wooden box shall be unscrewed.
- Charger shall be sited a horizontal aligned place which have enough tightness to withstand device weight.
- Because charger is cooled by air flowing, installation place of charger shall have appropriate ventilation.
- For providing enough space, for air flowing inner charger assembly, it's essential to provide enough space between charger and wall.

5.2.2. Charger Initial Inspections

Chargers may be utilized, instantaneously after installation or after several months from installation time. In both cases following inspection shall be performed:

- Dusts shall be cleaned by dry clean wiper.
- With an eye inspection, it shall assure all components are healthy and not be defected during transportation and installation.
- In weather condition, suitable for herb growth and in a place, insects exist there, assure that there is not any herb growth and insect nest trace. If any trace be observed then all units shall be cleaned completely and painted with varnish or similar materials. Inspect carefully that all electrical connection nuts be tightened (such as buses, cables and …)

5.2.3. Commissioning Method Of Chargers

- Assure that device state is off
- Fuses of charger must be checked
- Batteries shall be prepared according to charger nominal voltage capacity.
- Connection cables shall be sized with respect to charger connection cables for loads and battery shall be selected from two colors, preferably red for connection to the positive pole and black for connection to the negative pole.
- Wires related to the battery shall be first connected to the battery terminals of charger and next be connected to the terminals of battery.
- Load wires shall be connected to the terminals related to the loads.
- Be sure that connections are correct and ground connection provided.
- Before applying supply, all switches shall be adjusted in off-state.
- For supplying rectifier, input switch shall be closed.

5.2.4. Charger Information Record

Information from receiving, storage, mounting and commissioning of changer is used for charger maintenance. Recorded information shall accord with charger characteristics. Following information shall be recorded with related date and shall be maintained in a suitable file for future usage:

- Inspection information during receiving, storage and installation period.
- Situation of load and battery wires.
- Situation of indicating lamps, alarms, switches, wires and charger terminals.
- Charger ammeters and voltmeters situation.

- Nominal value of ac input voltage.
- Voltage and current calibration for normal and boost charging.

5.2.5. Charger Commissioning Initial Checks and Commissioning Tests

- Disconnection and isolation of charger.
- Controlling and cleaning of heater, lighting, fuses and circuits and if required, replacement of defected lamps and fuses.
- Tightness of dc and ac circuits terminals.
- Inspection of correct operation of micro switches, potentiometers and fuses.
- Inspection and calibration of boost and normal charging current and voltage.
- Inspection and calibration of measuring indicators.
- Inspection of earthing system of various sections of charger.
- Earth fault, undervoltage and overvoltage, correct operation test.
- Signals and alarms test.
- Output voltage regulation based on battery cell number.

5.3. Installation of LVDC panels

Installation of LVDC panels shall be performed according to manufacturer instructions.

5.3.1. LVDC Panel Commissioning Initial Checks and Commissioning testes

- Inspection and tightening of earth wire connection with panels
- Inspection and tightening of terminals- earth wire and metal bases bolts
- Inspection and tightening of input and output terminals of all equipments
- Inspection of ammeters and voltmeters accuracy
- Inspection of fuses
- Microswitches test
- Test for circuits and relays of emergency lighting supply system
- Alarms test

SCHEDULE LVDC (I)
RATINGS AND CHARACTERISTICS OF LVDC SYSTEM (LOW VOLTAGE DC)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
1	**Particulars of system**		
1.1	DC system voltage		48-110-125
1.2	AC system voltage		230/400
1.3	System voltage variation		+10,-15
1.4	DC system grounding		ungrounded
2	**Service conditions**		
2.1	Max. ambient temperature	°C	40/45/50/55
2.2	Min. ambient temperature	°C	-40/-35/-25
2.3	Average value of daily temperature	°C	*
2.4	Solar radiation	W/m^2	*
2.5	Altitude above sea level	m	1000/1500/2000/2500
2.6	Pollution level		low/medium/high/very high/ special
2.7	Max. wind velocity	m/s	30/40/45
2.8	Wind velocity at ice condition	m/s	20
2.9	Ice coating thickness	mm	5/10/20/25
2.10	Seismic acceleration	m/s^2	0.2g/0.25g/0.3g/0.35g
2.11	Relative humidity	%	90/95/more than 95
3	**Battery**		
3.1	Battery type		Vented/valve regulated lead-acid
3.2	Number of battery banks required		One or two series
3.3	Number of cells in each bank in series		*
3.4	Rated voltage	V	48-110-125
3.5	Rated discharge rate	h	8-10
3.6	Rated discharge capacity at 20°C	Ah	*
3.7	Final cell voltage	V	*
3.8	Type of cables to connect battery to external circuit		Single core copper PVC insulated unarmored
3.9	Charging method required		Boost and float

SCHEDULE LVDC (I)
RATINGS AND CHARACTERISTICS OF LVDC SYSTEM (LOW VOLTAGE DC)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
4	**Battery charger and accessories**		
4.1	Type		Composite float and boost
4.2	Period adjustable for boost charging	hour	*
4.3	Supply voltage	V	400
4.4	Variation in supply voltage	%	±10
4.5	Variation in supply frequency	%	±5
4.6	Combined variation in supply voltage and frequency	%	±10
4.7	Short circuit level of 400 V supply at charger terminals for one second	kA	*
4.8	One minute power frequency withstand voltage:		
4.8.1	Power circuit	V	2500
4.8.2	Control circuit	V	2000
4.9	Charger output voltage:		
4.9.1	Boost mode	V	*
4.9.2	Float mode	V	*
4.9.3	Equalizer mode	V	*
4.10	Whether automatic device for changing the charging current of the battery from high level to low and further, to very low level is required?	Yes/No	Yes
4.11	Maximum permissible variation in output dc voltage under float charge (No load to full load)	%	±0.5
4.12	Maximum permissible variation in output dc voltage under equalizing charge (No load to full load)	%	±1
4.13	Type of tap changer for rectifier transformer		Off load
4.14	Cable entry		Bottom
4.15	Contacts for the event recording, scada and alarm system required	Yes/no	Yes
4.16	Finishing colour:		
4.16.1	Outside		RAL 9035
4.16.2	Inside		Enamel white

SCHEDULE LVDC (I)
RATINGS AND CHARACTERISTICS OF LVDC SYSTEM (LOW VOLTAGE DC)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
5	**DC Switchgear**		
5.1	Rated voltage	Vdc	*
5.2	Location		Indoor
5.3	Type of mounting		Floor
5.4	Number of panels		One set , two sets
5.5	Maximum working voltage	V	*
5.6	Protection degree		IP4X
5.7	Busbar material		Copper
5.8	Busbar type		Bar
5.9	Continuous current rating	A	*
5.10	Short circuit current	kA	*
5.11	Short circuit duration	Sec	1
5.12	Single front / double front		Single front
5.13	Fully drawout/ semi drawout/ fixed		*
5.14	Number and rating of incoming feeders		*
5.15	Number and rating of outgoing feeders		*
5.16	Type of incoming feeders		MCCB
5.17	Type of outgoing feeders		*
5.18	Thickness of panels painting layers	micron	80
5.19	Finishing color:		
5.19.1	Inside		Enamel white
5.19.2	Outside		Ral 7035

SCHEDULE LVDC (I)
RATINGS AND CHARACTERISTICS OF LVDC SYSTEM (LOW VOLTAGE DC)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
6	**DC Emergency lighting board**		
6.1	Location		Indoor
6.2	Type of mounting		*
6.3	Rated voltage	V	*
6.4	Maximum working voltage	V	*
6.5	Busbar material		Copper
6.6	Continuous current rating	A	*
6.7	Short time rating and duration	kA/sec	*
6.8	Single front/ double front	A	Single front
6.9	Fully drawout/ semi drawout/ fixed		*
6.10	Number and rating of incoming feeders		*
6.11	Number and rating of outgoing feeders		*
6.12	Type of incoming feeder		*
6.13	Type of outgoing feeder		*
6.14	Numbers of panels painting layers		*
6.15	Thickness of panels painting layers	micron	*
6.16	Finishing colour:		
6.16.1	Outside		Ral 7035
6.16.2	Inside		Enamel white

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
1	**Battery charger and accessories**		
1.1	Manufacturer		
1.2	Type designation		
1.3	Applicable standards		
1.4	Rating:		
1.4.1	Input voltage	V ac	
1.4.2	Output voltage	V dc	
1.4.3	Rated output voltage (Float)	Vdc	
1.4.4	Rated output voltage (Boost)	Vdc	
1.4.5	Rated 1 hour overload capacity after 10 hours operation at rated load	A	
1.4.6	AVR		
1.4.6.1	- Whether AVR is provided for float charger	Yes/no	
1.4.6.2	- Type of AVR	Static/other	
1.4.6.3	- percentage regulation with AVR (from no load to full load)	%	
1.4.7	TAP changer		
1.4.7.1	- Whether taps are provided on boost charger	(Yes/No)	
1.4.7.2	- Type of tap changing gear	(off load/on load)	
1.4.7.3	- Range of taps		
1.5	Guaranteed efficiency:		
1.5.1	At 20% load	%	
1.5.2	At rated load	%	
1.6	Power factor		
1.6.1	At 20% load		
1.6.2	At rated load		

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
1.7	Maximum permissible temperature rise over ambient temperature considered in design:		
1.7.1	Rectifier transformer	°C	
1.7.2	Rectifier cells	°C	
1.7.3	Smoothing reactor	°C	
1.8	Class of insulation		
1.9	Type of rectifier cell	(thyristor/diode)	
1.10	Method of cooling:		
1.10.1	Rectifier cells		
1.10.2	Transformer		
1.11	Whether smoothing filter offered	(Yes/No)	
1.12	Harmonics at rated load:		
1.12.1	With battery	%	
1.12.2	Without battery	%	
1.13	Thyristors (or diodes if applicable):		
1.13.1	Type designation		
1.13.2	RMS current rating	A	
1.13.3	One cycle surge current rating	A	
1.13.4	Repetitive surge current	A	
1.13.5	Forward current rating	A	
1.13.6	No load ceiling voltage	V	
1.13.7	Full load ceiling voltage	V	
1.13.8	Peak inverse voltage continuous	V	
1.13.9	Peak inverse voltage surge	V	
1.13.10	Quantity in charger		
1.14	Permissive ripple of battery charger	%	
1.15	Overall dimensions of charger l×w×h	mm	
1.16	Number of chargers		

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER*)*

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
2	**Stationary lead acid battery**		
2.1	Manufacturer		
2.2	Type designation		
2.3	Applicable standard		
2.4	Type		
2.5	Nominal supply voltage of system	V	
2.6	Rated discharge capacity:		
2.6.1	At 1 hr.rate	Ah	
2.6.2	At 10 hr.rate	Ah	
2.7	Particulars of cells:		
2.7.1	Voltage per cell when float charged	V	
2.7.2.	Voltage per cell at end of 1 hr.discharge period	V	
2.7.3	Voltage per cell at end of 10 hr.dicharge period	V	
2.7.4	Final voltage per cell when boost charged	V	
2.8	Charging current:		
2.8.1	Initial	A	
2.8.2	Starting (Max)	A	
2.8.3	Continuous	A	
2.9	Maximum permissible instant current one minute	A	
2.10	Total resistance of battery	Ω	

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
2.11	Battery and cell arrangement		
2.11.1	Number of cells		
2.11.2	Number of tiers		
2.11.3	Type of container (plastic, glass or steel)		
2.11.4	Mass of cell complete with electrolyte	kg	
2.11.5	Mass of battery and stands as in service	kg	
2.11.6	Type of positive plate		
2.11.7	Type of negative plate		
2.11.8	Electrolyte specific gravity at 25°C, when the cells are fully charged	gr/cm^3	
2.11.9	Complete battery dimension (l×w×h)	cm	
2.12	Expected life of battery	Year	
2.13	Battery fuses:		
2.13.1	Manufacturer and type designation		
2.13.2	Rating - amps	A	
3	**DC switchgear**		
3.1	Manufacturer		
3.2	Type designation		
3.3	Applicable standards		
3.4	Module construction (single/double front, fully drawout/ semidrawout/ fixed)		
3.5	Approx. dimensions of the board (l×w×h)	mm	
3.6	Sheet metal thickness	mm	
3.7	Numbers of panels painting layers	micron	
3.8	Thickness of panels painting layers	micron	

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
3.9	Clearances in air between busbars	mm	
3.10	Busbars:		
3.10.1	Material		
3.10.2	Cross section	mm^2	
3.10.3	Type of insulation		
3.10.4	Whether bus taps and joints have been insulated with PVC	(Yes/No)	
3.10.5	Maximum continuous current rating at site conditions	A	
3.10.6	Temperature rise over the design ambient when carrying rated current	°C	
3.10.7	Material of busbar supports		
3.10.8	Spacing between supports	mm	
3.10.9	Short time rating (1 Sec.)	kA	
3.11	Earth fault relay:		
3.11.1	Manufacturer		
3.11.2	Type designation		
3.11.3	Applicable standard		
3.11.4	Coil voltage	V	
3.11.5	Coil burden	W	
3.11.6	Setting range	Ω	
3.11.7	Operating time	m Sec	
3.12	Undervoltage relay:		
3.12.1	Manufacturer		
3.12.2	Type designation		
3.12.3	Applicable standards		
3.12.4	Voltage rating	V	
3.12.5	Burden	W	
3.12.6	Setting range	%	

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
3.13	Manufacturer and type designation of:		
3.13.1	Control and selector switch		
3.13.2	Voltmeter		
3.13.3	Ammeter		
3.14	Moulded case circuit breakers:		
3.14.1	Manufacturer		
3.14.2	Type designation		
3.14.3	Applicable standards		
3.14.4	Rated voltage dc	Vdc	
3.14.5	Rated current	A	
3.14.6	Rated breaking current	kA	
3.14.7	Temperature rise of contacts when carrying rated current under design ambient conditions	°C	
3.14.8	Number of auxiliary contacts:		
3.14.8.1	Normally open		
3.14.8.2	Normally closed		
3.14.8.3	Changeover		
3.14.9	Whether the following provided ?		
3.14.9.1	Shunt release coil	(Yes/No)	
3.14.9.2	Under voltage release	(Yes/No)	
3.14.9.3	Instantaneous release	(Yes/No)	
3.14.9.4	Overload release	(Yes/No)	
3.14.9.5	Overcurrent time delayed release	(Yes/No)	
4	**DC emergency lighting board**		
4.1	Manufacturer		
4.2	Type designation		
4.3	Applicable standards		
4.4	Module construction (single/double front, fully drawout/ semidrawout/ fixed)		
4.5	Approx, dimensions of the board (l×w×h)	mm	
4.6	Sheet metal thickness	mm	
4.7	Numbers of panels painting layers		
4.8	Thickness of panels painting layers	micron	
4.9	Clearances in air between busbars	mm	

SCHEDULE LVDC (II)
GUARANTEED TECHNICAL INFORMATION OF LVDC SYSTEM (LOW VOLTAGE DC)
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS
4.10	Busbars:		
4.10.1	Material of busbars		
4.10.2	Cross section	mm^2	
4.10.3	Type of insulation		
4.10.4	Whether bus taps and joints have been PVC shrouded	(Yes/No)	
4.10.5	Maximum continuous current rating at site conditions	A	
4.10.6	Temperature rise over the design ambient when carrying rated current	°C	
4.10.7	Material of busbar supports		
4.10.8	Spacing between supports	mm	
4.10.9	Short time rating (1 Sec)	kA	
4.11	Manufacturer and type designation of:		
4.11.1	Control and selector switch		
4.11.2	Voltmeter		
4.11.3	Ammeter		