Energising Quality

VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION
FOR
CABLE INSTALLATION

VCS – SS – EL - 4024

Rev. No	Date	Prepared By	Checked By	Approved By	Authorized By
02	09.03.2022	SP	RD	AA	HK
01	16.10.2019	MG	VV	AD	SK
00	05.07.2017	MG	RD	AD	SK

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REVISION RECORD						
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00	05.07.2017	MG	RD	AD	SK	Issued for use as Standard
01	16.10.2019	MG	VV	AD	SK	New revision system updated
02	09.03.2022	SP	RD	AA	HK	New revision system updated

ABBREVIATION

BIS/IS	Bureau of Indian standards
OISD	Oil Industries Safety Directorate
PESO	Petroleum and Explosives Safety Organization
CCE	Chief Controller of Explosive
CEA	Central Electrical Authorities
GI	Galvanized Iron
MS	Mild Steel
FLP	Flam Proof
RCC	Reinforced Concrete Cement
PV	Poly Vinyl Chloride

CONTENTS

1.0 SCOPE

1.1 This Specification defines the requirements for supply of materials, wherever applicable, installation, testing and commissioning of cable installation.

2.0 REFERENCE DOCUMENTS

2.1 The work shall be carried out in the best workman like manner in conformity with this Specification, Installation standards, layout drawings, the latest edition of relevant Specifications, codes of practice of Bureau of Indian Standards, PESO 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 up to and including 33 KV rating.
IS:10810	Method of Test for cables; Part 43 Insulation resistance. (Part 43)
IS:10810	Method of Test for cables; Part 45 High voltage test. (Part45)
OISD 147	Inspection and safe practice during electrical installation
OISD I 73	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. Indian Electricity Act and Rules.

b. Regulations laid down by CEA/Electrical Inspectorate.

c. Regulations laid down by PESO/OISD/CCE/DGMS/DGFASLI (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 DEFINITION

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

OWNER / COMPANY	OWNER of the particular Project (Project Specific).
CONSULTANT	The party which is doing engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
BIDDER / SUPPLIER / VENDOR	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.

4.0 DESIGN

4.1 MATERIAL SPECIFICATIONS

All materials and hardware 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.

4.2 CABLE TRAYS

These shall be ladder type trays either prefabricated hot dip galvanized sheet steel trays or site fabricated angle iron painted trays as specified in job Specification.

4.3 PRE-FABRICATED HOT DIPPED GALVANISED TRAYS

The cable trays shall comply with the requirements specified in Installation std.

4.4 SITE FABRICATED ANGLE IRON TRAYS

4.4.1 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 mm MS flat for tray width up to 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.

4.4.2 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.

4.4.3 Cable racks and trays shall be covered by removable top covers on upper most tier allowing adequate ventilation in following cases where:

a. Mechanical damage of cables is likely to occur during maintenance in the plant.
b. Oil or spillage of chemicals can be expected.
c. Protection from exposure to sun is required.

4.4.4 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. Covers shall be complete with required GI hardware's.

4.5 CABLE GLANDS

4.5.1 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 and shall have PVC shroud for additional weather protection. Cable glands forming a part of relevant FLP enclosure shall be FLP type, tested by CMRI or any other recognized independent testing laboratory and approved by CCE/DGMS or any other statutory authority as applicable. Indigenous FLP glands shall have valid BIS license as per the requirements of statutory authorities. The size of the cable glands supplied shall be appropriate to the size of cable so that flame proofness of glands is retained.

4.5.2 Entry thread of cable gland shall be compatible to the entry thread provided in the equipment (BS, ET, NPT, and PG as applicable). If required, suitable reducers/adopters shall be used.

4.6 CONNECTORS

Power cable terminations shall be made with crimped type tinned copper solder less lugs which shall be suitable for the cable size mentioned in cable schedule.

4.7 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 cable by the terminal numbers to which the cores are connected, for ease of identification.

5.0 INSTALLATION

5.1 CABLE LAYING (GENERAL)

5.1.1 Cable installation shall include power, control, lighting, fire alarm, telephone and communication cables. These shall be laid in trenches/ cable trays 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 Engineering-charge.

5.1.2 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.

5.1.3 When single core cables are laid in flat formation, the individual cable fixing clamps and spacers shall be of non-magnetic material. As a general practice, the sheath of single core cables shall be earthed at one point to keep sheath at earth potential unless otherwise stated. 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.

5.1.4 If straight through joints are required to be provided on single core cables, armor shall be broken at joints as per manufacturer's recommendations. For single core cables armor shall be earthed at one end for the cable run length as per manufacturer's recommendation.

5.1.5 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 min spacing of 600mmfrom power, and control cables but in any case, such separation shall not be less than300mm.

5.1.6 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. Streetlighting cables shall be laid on the other side of road berm area.

5.1.7 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 begiven for feeder cables where required as per the directions of Engineer-in-charge to meet contingencies.

5.1.8 Cables shall be laid in directly buried trench or in RCC trench (underground trench) or in cable tray along pipe sleepers or in overhead trays as shown on cable layout drawings.

5.1.9 Overhead trays shall be installed 2700-mm (minimum) above grade level. At road crossings overhead trays shall be installed at 7000mm(minimum) above grade level or cables shall be routed 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.

5.1.10 Cable installation shall provide minimum cable bending radii as recommended by cable manufacturer.

5.1.11 Cables shall be neatly arranged in the trenches / trays in such a manner that crisscrossing 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. Pipe sleeves shall be laid at an angle of maximum 45 to the trench wall. Bending radii of pipes shall not be less than 8D. 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.

5.1.12 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 aluminum straps (2mm thick, 20 mm wide and of enough length) securely fastened to the cable-and wrapped around it.

5.1.13 Each underground cable shall be provided with cable tags of lead securely fastened every 30 m of its underground length with at least one tag at each end before the cable 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.

5.1.14 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 taped with an approved PVC end cap or rubber insulating tape.

5.1.15 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:

5.1.16 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.

5.1.17 Cables for road crossings shall be taken through ERC (Electrical Road Crossing) as shown in the cable layout drawings.

5.1.18 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.

5.1.19 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.

5.1.20 Ends of cables leaving trench shall be coiled & capped and provided with protective cover till such time the final termination to the equipment is completed.

5.2 CABLES LAID DIRECT IN GROUND

5.2.1 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 and arranged with a view of heat dissipation and economy of design. Maximum number of cable layers in trench shall be preferably limited to 5 layers.

5.2.2 Minimum depth of cable trench shall be 750 mm for medium voltage and 900 mm for H.V. Cables. The depth and the width of the trench shall vary depending upon the number of layers of cables as per Installation Standard.

5.2.3 Cables shall be laid in buried trenches depth as shown in the cable layout drawings. It is to be insured 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. This sand 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 of75 mm thick second-class red bricks shall then be laid and the remainder of the trench shall then be back filled with soil, rammed and leveled.

5.3 CABLES LAID IN CONCRETE TRENCH

5.3.1 Cables shall be laid in 3 or 4 tiers in concrete trench as shown on layout drawings. Concrete cables trenches shall be filled with sand in hazardous area 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.

5.3.2 All wall openings/pipe sleeves shall be effectively sealed after installation of cables to avoid seepage of water.

5.4 Above ground cables

5.4.1 Cables installed above grade shall run in cable trays, clamped on walls, ceiling or structures and shall be run parallel or at right angles to beams, walls or column. 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 shall contain only one layer of cables as far as possible for power cables. However control may be laid in double layer in the cable trays.

5.4.2 Individual cable or small group of cables (up to 3 to 4 cables) which run along structures / walls etc. shall be clamped by means of 16 SWG GI saddles on 25 x 6 mm saddle bars. Alternatively small group of cables can be taken through 100/150 mm slotted channel tray / ISMC 100. Cables shall be supported so as to prevent sagging. In general, distance between supports shall be approximately 300mm for cables upto25 mm diameter and maximum 450 mm for cables largerthan25mm dia. To prevent the sagging of cables.

5.4.3 Cable laid on supporting angle in cable trenches structures, columns and vertical run of cable trays shall be suitably clamped by means G.I. 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.

5.4.4 All cable trays (other than galvanized trays) and supporting steel structures. shall be painted before laying of cables. The under surfaces shall be properly degreased, dedusted, descaled and cleaned. The painting shall be done with one coat of red oxide zinc chromate primer. Final painting shall be done with two coats of approved bituminous aluminum paint unless otherwise specified.

5.4.5 Where cables rise from trench to motor, lighting panel, control station, junction box etc., they shall be taken in GI pipe for mechanical protection up to a minimum of 300 mm above grade. Cable ends shall be carefully pulled through conduit to prevent damage to cable.

5.4.6 All G.I. 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 shall be undertaken well before paving is completed and necessary coordination with paving agency shall be the responsibility of Electrical Contractor.

5.4.7 Following guide shall be used for sizing of G.I. 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 cables in a pipe - 43% of pipe cross-sectional area occupied by cables

d) And above cables in a pipe - 40% of pipe cross-sectional: area occupied by cables.

5.4.8 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

5.5 TERMINATIONS

5.5.1 All PVC cables up to 1100V grade shall be terminated at the equipment by, means of compression type cables glands suitable for the cable size. They shall have a screwed nipple with conduit 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 aluminum 2mm thick and securely fastened to the cable, Wrapped around it) and also along the, route at recommended intervals, by cable tag numbers.

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

5.5.3 Power cables cores wherever color coding is not available shall be identified with red, yellow and blue PVC tapes. Where copper to aluminum connections is made, necessary bimetallic washers shall be used.

5.5.4 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. For trip circuit identification additional red ferrules shall be used only in the particular cores of control cables at the termination points in the Switchgear/ Control panels and Control Switches

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

5.5.6 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 armor shall not be exposed after termination is complete.

5.5.7 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 center line of holes. After fixing bottom plate, uncovered cable holes/gaps shall be sealed with cold settings compound.

5.5.8 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.

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

5.5.10 The cable joints in-power and control tables shall be avoided as far as possible. In case a joint is unavoidable, the following shall be insured:

a. The number of joints shall be restricted to minimum as far as possible,
b. The location of joints shall be identified with permanent markers.
c. No joints shall be allowed in hazardous areas without the approval of Engineer-in charge

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

5.5.12 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 bring to the notice of Engineer-in-charge by Contractor. After termination is complete all the bolts, nuts, hardware of terminal box shall be properly placed in its position and tightened.

5.5.13 Where required, cable sealing boxes intended to be used with the apparatus shall be filled with solid setting type bituminous compound unless otherwise specified.

6.0 TESTING AND COMMISSIONING

6.1 Field testing and commissioning of electrical installation shall be carried out as per Standard Specification.

6.2 Before energizing 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.

6.5 For cables up to 1.1 kV grade 1000VMegger and for H.V. Cables 2.5 kV / 5 kV Megger shall be used.

6.6 D.C. High Voltage test shall be conducted on cables given below after installation. .

6.7 All 1100 volts grade cables in which straight through joints have been made.

6.8 All cables above 1100 V grade.

6.9 The D.C. High Voltage test shall be performed as detailed below in the presence of the Engineer in charge or his authorized representative only,

6.10 Cables shall be installed in final position with all the 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.

6.11 In each test, the metallic sheath/screen/armor shall be connected to earth.

6.12 All checks and tests shall be made as per consultant standard test Performa available with site engineer.

6.13 All test readings shall be recorded and submitted to Consultant / Owner in triplicate sets.

6.14 Cable schedule, cable layout drawings, Interconnection drawings shall be marked by contractor for `AS BUILT STATUS' and two sets of copies shall be submitted to Consultant / Owner.

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STANDARD SPECIFICATION
FOR
EARTHING & LIGHTNING INSTALLATION

VCS – SS – EL - 4025

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ABBREVIATION

BIS/IS	Bureau of Indian standards
IEC	International Electro-Technical Commission
BS	British Standards
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
OISD	Oil Industries Safety Directorate
CCE	Chief Controller of Explosive
DGMS	Director General Mines Safety
IE Rules	Indian Electricity Rules
CPRI	Central Power Research Institute
GI	Galvanized Iron
MS	Mild Steel

CONTENTS

1.0 SCOPE

1.1 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 REFERENCE DOCUMENTS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, consultant 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
IEC/IS: 62305:	Code of practice for the protection of buildings and allied structures against lightning
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 180:	Lightning Protection
OISD 149:	Design Aspects For Safety In Electrical System
IEEE Std 80	IEEE Guide for Safety in AC Substation Grounding

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. Indian Electricity Act and Rules.
b. Regulations laid down by CEA/Electrical Inspectorate.
c. Regulations laid down by OISD/PESO (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.

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management.

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4.0 MATERIALS

4.1 MATERIAL SPECIFICATIONS

4.1.1 All materials and hardware's 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.

4.1.2 The main earth grid conductor shall be hot dip galvanized 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. meter. Earth electrodes and Earth plate shall be as per job specification.

5.0 DESIGN

5.1 EARTHING NETWORK

5.1.1 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 equipment.

5.1.2 The earth conductor shall be laid along cable trays/cable trench/pipe racks as indicated on the earthing layout drawing. Where lined cable trenches are available, the earth conductor shall be 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 a 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. 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.

5.1.3 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 joined by means of welding, lap welding with an overlapping of strip equivalent to double the width of the strip and all four sides shall be continuously welded. All joints at tapping's

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.

6.0 INSTALLATION

6.1 INSTALLATION OF EARTH ELECTRODE

6.1.1 Earth Electrode shall be installed as shown on installation standard and layout drawings. The location shown on the layout drawings are indicative.

6.1.2 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.

6.1.3 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.

6.1.4 The electrodes shall have a clean surface, not covered by paint, enamel, grease or other materials of poor conductivity.

6.1.5 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.

6.1.6 The disconnect facility shall be provided for the individual earth electrode to check its earth resistance periodically.

6.1.7 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.

6.1.8 Individual earth electrodes shall be provided for each lightning arrestor and flood light mast.

6.1.9 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.

6.2 CONNECTION

6.2.1 The earth system connections shall generally cover the following:

a. Equipment earthing for personnel safety
b. System neutral earthing
c. Static and lightning protection
d. System neutral

e. Current and potential transformer secondary neutral

f. 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.

g. Steel structures/columns, rail loading platforms etc.

h. Cable trays and racks, lighting mast and poles

i. Storage tanks, spheres, vessels, columns and all other process equipment.

j. Fence and Gate for electrical equipment (e.g., transformer, yard etc.)

k. Cable shields and armor.

l. Flexible earth provision for Wagon, Truck

m. Shield wire

6.2.2 Conductor size for branch connection to various equipment shall be as per consultant Installation Standards unless otherwise stated on earthing layout drawings.

6.2.3 All process pipelines shall be bonded and earthed at the entry and exist points of battery limit of hazardous area. Earth continuity conductors across pipe line flanges shall not be provided as per OISD 110.

6.2.4 Steel pipe racks in the process units and offsite area shall be earthed at every 24 meters.

6.2.5 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.

6.2.6 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. An independent earthing network shall be provided for lightning protection and this shall be bonded at least at two points with the main earthing network below ground. Lightning down conductor shall be brought to earth electrode in shortest straight path as feasible to minimize surge impedance.

6.2.7 The main earthing network shall be used for earthing of equipment to protect against static electricity.

6.2.8 All medium and high voltage equipment (above 250V) shall be earthed by two separate and distinct connections with earth.

6.2.9 Plant instrument system clean earthing, UPS system clean/safety earth shall be separate from the electrical earthing system.

6.2.10 All paint, scale and enamel shall be removed from the contact surface before the earthing connections are made.

6.2.11 All earthing connections for equipment earthing shall be preferably from the earth plate mounted above ground wherever provided.

6.2.12 Equipment foundation bolts shall not be used for earthing connection.

6.2.13 Earth connections shall be made through compression type cable lugs/by welded lugs.

6.2.14 All hardware used for earthing installation shall be hot dip galvanized or zinc passivated. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.

6.2.15 Lighting fixtures and receptacles shall be earthed through the extra core provided in the lighting circuit/cable for this purpose.

6.2.16 The reinforcements of sub-station building and the sub-station floor shall be connected to main earth grid.

7.0 INPSPECTION AND TESTING OF EARTHING SYSTEM

7.1.1 Field inspection, testing and commissioning of electrical installation shall be done as per specification.Earthing systems/connections shall be tested as follows:

7.1.2 Resistance of individual earth electrodes shall be measured after disconnecting it from the grid by using standard earth test meggar.

7.1.3 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:

a. 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.
b. For lightning protection, the value of 5ohms as earth resistance shall be desirable, but in no case, it shall be more than 10 ohms.

7.1.4 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 each 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 armor.
e. At one point on fence enclosing electrical equipment.

8.0 LIGHTNING PROTECTION

Lightning protection system shall generally comprise lightning finials (air terminals or collector rods), roof conductors or collector lines, down conductors, test links, and earth electrodes. The number, types, materials and sizes shall be in accordance with the drawings.

8.1 Air terminals shall be mounted on top of buildings or structure as required. All air terminals shall be inter-connected with roof conductors, pipes, hands rails or any other metallic projection above the roofs shall also be bonded to the roof conductors.

8.2 Down conductors from air terminals or from roof conductors shall be routed as directly as possible to the test links on earth buses, with minimum bends.

All provisions regarding connections of conductors for equipment earthing system shall also apply to lightning protection system

8.3 In corrosive atmospheres, plumbing metal for corrosion protection shall cover lightning finials or air terminals.

8.4 The layout and design of lightning protection systems for building extensions or new buildings and structures provided within existing station areas shall match the existing design.

8.5 All connections between the different parts of lightning protection systems and the connections to the earthing system must be performed in a manner such that the arising of chemical elements will be avoided.

9.0 COLLECTORS

Collectors shall be determined in accordance with the lightning ball method. Collectors may comprise a combination of the following components:

- Collector lines
- Collector rods

9.1 Natural Components Of Collectors

Metal cladding, metal roof structures, metal components of roof Structures, gutters and railings may be considered as natural components of collectors.

The requirements of the standards, such as the following, have to be considered:

- Parts must be permanently conductively connected,
- Minimum thickness of the metal involved,
- Cross-sections of the parts.

Installations with metal casings need not to be fitted with collectors taking into consideration the above-mentioned minimum requirements.

Protective coatings or insulation between metal parts shall be electrically bridged.

9.2 Mesh Type Collectors

Buildings shall be provided with mesh-type collector lines. The collectors have to be configured in a way such that no point of the roof is at a distance of more than 5 m from a collector.

The maximum permitted mesh size is as follows:

- Buildings with telecommunication or control rooms 10 x 10 m

- Other buildings 10 x 20 m

Protruding roof superstructures, such as ladders, chimney stacks, pipes, antenna mounting brackets, etc. and other metallic parts of buildings which are located near the roof (e.g. louvers of ventilation openings) must be directly connected to the collector lines.

9.3 Collector Rods

Collector rods shall be used for roof superstructures featuring mechanically or electrically operated equipment, such as ventilators and non-conductive parts projecting from the mesh plane by 0.3 m. The angle of protection and a certain minimum distance have to be observed.

Outdoor electrical facilities for HVAC or other purposes not located in the protective area of earthed structures, installations or buildings, including exposed electrical equipment shall be protected by collectors.

Buildings with sheet metal roofs where the thickness of the sheet is smaller as the required value, the collector mesh must be equipped with collector rods of sufficient quantity and length to avoid lightning strokes in the sheet metal.

9.4 Down Conductors

Down conductors shall -be selected in a manner such that there are several parallel current paths between the collector and the earthing system. The length of each down conductor is to be kept as short as possible.

Steel structures and steel columns of buildings may be used as down conductor, if the minimum sizes according to the standards are guaranteed. In each case the connections with the earthing system and collectors respectively must be visible and removable.

Starting from the corners of the structure involved, conductors should be distributed around the exterior as evenly as possible. They must be configured in such a way as to constitute the direct continuation of the collector. The minimum distance between conductors and doors, windows and other apertures must be 0.5 m.

If not already connected with the collectors or with the internal potential equalisation, larger metal parts mounted in/on the building outer walls (e.g. frames of doors, ventilation louvers) shall be terminated on the down conductors. The number of down conductors and the minimum distance between the conductors is given as follows:

a) Buildings containing telecommunication and control systems

b) Minimum number of conductors: 4

c) Maximum distance between conductors: 10 m

d) Other buildings

e) Minimum number of conductors: 2

f) Maximum distance between conductors: 20 m

All down conductors which are connected to the earthing system must be provided with an accessible isolating point for measuring purposes. For termin_ation the grounding bars of grounding loops shall be used, preferably. No conductors are required for outdoor metal structures of adequate size.

9.5 Inadmissibly Short Distances

Inadmissibly short distances between the lightning protection system and metal installations or electrical equipment shall be prevented. In the event of potential hazard due to flash-over or disruptive discharge caused by lightning, appropriate measures shall be taken.

Admissible distances between lightning protection systems and metal installations, electrical wiring and equipment shall be determined in compliance with the standards. This also applies to the use of special roof-mounted collectors.

10.0 TESTS OF LIGHTNING PROTECTION SYSTEM

After erection of the earthing and lightning protection system all installations shall be tested in accordance with applicable regulations

The following tests shall be carried out, at least:

Measures against corrosion protection and arising of chemical elements,

a) Check of all connections,

b) Measurements of earthing system resistance,

c) Measurements of lightning protection system conductivity,

d) Check of mechanical details,

e) Compliance with specifications.

The aim of the tests is to ensure the proper function of the complete scope. The measuring results and the locations of the measuring points have to be indicated in respective drawings as a basis for future measurements

Energising Quality

I.

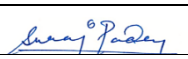
VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION

FOR

BATTERY CHARGER

VCS – SS – EL - 4008

					
02	25.02.2022	SP	RD	AA	HK
01	16.10.2019	MG	VV	AD	SK
00	05.07.2017	MG	RD	AD	SK
Rev. No	Date	Prepared By	Checked By	Approved By	Authorized By

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CONTROLLED COPY	**:**	**If in soft and signed**

REVISION RECORD

Rev.	Revision Date	Prepared by	Checked by	Approved by	Authorized by	Revision Description
00	05.07.2017	MG	RD	AD	SK	Issued for use as Standard
01	16.10.2019	MG	VV	AD	SK	New revision system updated
02	25.02.2022	SP	RD	AA	HK	New revision system updated

ABBREVIATION

BIS/IS:	Bureau of Indian standards
IEC:	International Electro-Technical Commission
BS:	British Standards
IEEE:	Institute of Electrical and Electronics Engineers
NEMA:	National Electrical Manufacturers Association
OISD:	Oil Industries Safety Directorate
CCE:	Chief Controller of Explosive
DGMS :	Director General Mines Safety
IE Rules:	Indian Electricity Rules
CPRI:	Central Power Research Institute
DCDB:	Direct Current Distribution Board
CRCA:	Cold Rolled Cold Annealed
PCB:	Printed Circuit Board
VRLA:	Valve Regulated Lead Acid
LED :	Light Emitting Diode
MCCB:	Moulded Case Circuit Breaker

CONTENTS

1.0 SCOPE

This Specification covers the design, manufacture, testing at manufacturer's works, packing and supply to site of Battery Chargers and Distribution Boards.

2.0 REFERENCE DOCUMENTS

2.1 The equipment shall comply with the requirements of 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 1248:	Direct acting indicating analogue electrical measuring instruments and (Parts-1, 2, 8, 9) accessories.
IS 3700:	Essential rating and characteristics of semi-conductor devices (Parts-1 to 11).
IS 3715:	Letter symbols for semi-conductor devices (Parts-1 to 4).
IS 4411:	Code of designation of semi-conductor devices.
IS 5001:	Guide for preparation of drawings for semi-conductor devices and integrated (Parts-1, 2) accessories.
IS 5469:	Code of practice for the use of semi-conductor junction devices. (Parts-1 to 3)
IS 6619:	Safety code for semiconductor rectifier equipment.
IS 7204:	Stabilized power supplies dc output (Parts-1 to 4).
IS 12021:	Control transformers for switchgear and control gear for voltages not exceeding 1000VAC.
IS 13703:	Low voltage fuses for voltages not exceeding 1000VAC or 1500VDC.(Parts-1 to 4).
IS 13947:	Low voltage switchgear and control gear. (Parts-1, 3, 4, 5).
IEC 60146:	Semiconductor converters

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

2.3 The equipment shall also conform to the provisions of Indian Electricity Rules 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 Standards/ Specifications Data Sheets and statutory regulations, the following order of decreasing priority shall govern:

a. Statutory Regulations
b. Data Sheets
c. Job Specifications
d. Standard Specification
e. Codes and Standards.

3.0 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

OWNER / COMPANY	OWNER of the particular Project (Project Specific).
CONSULTANT	The party which is doing engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
BIDDER / SUPPLIER / VENDOR	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.

4.0 MATERIALS

4.1 The Chargers, DCDB and Cell Booster enclosures shall be fabricated from structural/ CRCA sheet steel. The frames shall be fabricated by using minimum 2mm thick CRCA sheet steel while the doors and covers shall be made from minimum 1.6 mm thick CRCA sheet steel.

4.2 PCBs used in the chargers shall be made of glass epoxy material.

4.3 Power cables shall be with aluminum/ copper conductors and control cables shall be with copper conductors.

5.0 DESIGN

5.1 GENERAL REQUIREMENTS

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

5.1.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

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

5.1.4 The Battery Charger system shall be an integrated system comprising of static rectifiers, DC Distribution Board, isolating and protection devices and all other equipment/ accessories required for completeness of the system. whether specifically mentioned herein or not, but necessary for completeness and satisfactory performance of the system. The Battery Charger equipment shall be properly coordinated with the selected Battery to ensure complete compatibility.

5.1.5 All equipment and components shall be of excellent quality and reliability for providing secure DC power required for vital equipment performance, controlling, monitoring and safeguarding functions in continuously operating process units and utility installations of petroleum refineries, petrochemical and gas processing facilities and other industrial plants. Components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short circuits and circuit switching operations etc. The design of the equipment shall be such as to minimize the risk of short circuits and shall ensure personnel and operational safety.

5.1.6 The Vendor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent and requirements of this Specification and attached Data Sheets.

5.1.7 The Battery shall meet the requirements of Data Sheets and Specifications attached with the Material Requisition/ Bid document.

5.2 TECHNICAL REQUIREMENTS

5.2.1 INPUT POWER SUPPLY

a. The Battery Chargers shall be suitable for input power supply as defined in the Data Sheet. If not specified therein, they shall be suitable for the following input power supply:

Voltage	415V ± 10%
Frequency	50 Hz ± 5%

b. In addition to the above variations, the input voltage may be subject to transient variations comprising of voltage dips up to 20% of normal voltage during motor start-up, voltage interruptions during short circuits as well as frequency variations due to large motor start-up. The Battery Chargers shall operate satisfactorily with a total harmonic distortion of up to 5% in the input power supply.

c. The Battery Chargers shall also be designed to operate satisfactorily while drawing input power from an emergency diesel generator set. The incoming power supply to the Battery Charger system shall be provided by 2 independent feeders. One feeder shall supply power to each rectifier.

5.3 BATTERY CHARGER

5.3.1 DESIGN BASIS

a. The Battery Charger system shall have two chargers (Charger-1 & Charger-2). Both chargers shall be of identical design and rating. The battery to be connected to the chargers shall be of Nickel Cadmium/ flooded electrolyte Lead Acid/ VRLA type as indicated in the Data Sheet. Battery Chargers for flooded Lead Acid and Nickel Cadmium batteries shall be sized to provide quick charging of the battery within duration of 10 hours, unless specified otherwise. Battery Chargers for VRLA battery shall be sized to provide quick charging of the battery up to 90% of rated Ampere hours within duration of 24 hours and to 100% within 4 days. Each charger shall be sized for the most stringent of the following duty conditions, whichever is higher:

i. Offline quick charging of the battery assembly. The charger shall be sized as under:

Charger rating in Amps. = 0.14 Ah (C10) of battery (for Lead Acid battery)
= 0.2 Ah (C10) of battery (for VRLA battery)
= 0.2 Ah (C5) of battery (for Nickel Cadmium battery)

ii. Online float charging of the battery assembly while feeding the complete DC load. The charger shall be sized as under:

Charger rating in Amps. = 1.15 x Average DC load + float charging current (Average DC load = Area under the battery duty cycle/ battery duty cycle duration).

iii. Initial charging of the uncharged battery assembly to fully charged condition.

b. Each charger shall have a 3 phase full wave, controlled rectifier bridge with protective devices.

c. Independent current limits shall be provided for charger load current and battery charging current. Subsequent to a discharge cycle and completion of quick charging, when battery is connected to charger under float mode, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the value of load current. Fast acting semi-conductor fuses shall be provided for protection against internal short circuits. In case of external short circuits, the chargers shall be protected by rapid shutdown of the semi-conducting power devices. The high speed semi-conductor fuses used for rectifier protection shall be complete with trip indication.

d. Filter circuits consisting of smoothing choke and condenser, complete with protection to limit the ripple content at the output, shall be provided.

e. Silicon blocking diodes shall be provided in the charger output circuit to prevent back-feed from battery into the charger and filters.

f. Protection against reverse battery connection and DC earth fault relay for earth leakage protection shall be provided.

g. Silicon blocking diodes (min. 4 nos.) connected to 80% tap of the battery bank shall be provided to maintain continuity in the DC supply to the load.

h. Internal cooling of the charger unit shall preferably be by natural ventilation. If forced air cooling is necessary, a redundant air cooling fan shall be provided for each service. The charger components shall be capable of delivering their rated output with one forced air cooling fan out of service. Under this condition, maximum continuous temperature of components shall not exceed the permissible limits. In case of chargers with forced cooling, loss of ventilation alarm/ trip with override facilities shall be provided.

i. Selection, sizing and suitability of all components used for various applications shall be Vendor's responsibility and the rating of components shall be increased, if required, to suit associated components during execution of the order without any claim for extra price or time. All electronic power devices including thyristors , transistors, diodes etc. shall be rated under operating conditions for at least 150% of the maximum current carried by the device. All electrical components such as transformers, reactors, contactors, switches, bus bars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall experience a PIV greater than 50% of its rated value.

j. The DC system shall be unearthed, unless mentioned otherwise in the Data Sheet. However, a high impedance earth fault relay shall be provided for the protection of the battery.

k. Each charger shall be galvanically isolated from the input power supply by providing a double wound transformer at its input. The transformer shall be natural air cooled, dry type suitable for location inside a panel.

l. Suitable protection shall be provided in the control circuits to guard against the instability of the controlled rectifiers due to electrical oscillations which may be present in the input supply as caused by an emergency DG set.

m. An R.F.I. filter shall be provided to suppress the radio frequency interference to permissible limits. The production of radio frequency interference voltages shall not exceed the value of suppression grade N' as defined in VDE-0875. The performance of the Battery Charger system shall not get affected or in any way be degraded by the use of portable radio transmitter receivers in the vicinity of the chargers.

n. Transient/ surge protection devices shall be provided in the input circuit of chargers to protect them against surges & voltage spikes.

o. The Chargers shall be designed to draw power from main supply at a minimum power factor of 0.85 lag while sharing the rated load in normal operating configuration.

p. The chargers shall be designed to ensure that the harmonic component in the input currents are limited so as not to cause undue harmful effects on other sensitive equipment operating on the same supply bus. Suitable filters/ harmonic traps shall be provided, as required, for this purpose.

q. All breakers shall be adequately rated for the required continuous rating and breaking capacity as applicable. Paralleling of breaker/ switch Contactor poles to achieve the required current rating is not acceptable. All output isolating devices shall be double pole type. The DC contactors shall be operated with a DC control supply using ON/ OFF selector switches and not push buttons. All DC contactors must have a tested/

published DC rating equal to or exceeding the most stringent current carrying and breaking requirements while considering adequate design margins.

r. All the thyristors, diodes and other power electronic devices shall be protected with high speed semiconductor fuses. I^2t co-ordination between fuse and semi-conducting power devices shall be ensured. The Battery Chargers shall be specifically designed to limit float and quick charging voltages to the battery to limits recommended by the battery manufacturer. Output voltage shall be limited to maximum +10% of nominal system voltage when the battery is float charged while feeding the load. Vendor shall specifically ensure that the charger output voltage does not exceed the recommended limits of operation under any conditions of internal/ external fault or operation, including:

   i. Filter capacitor fuse failure of either charger.
   ii. DC output switch OFF of either charger.
   iii. DC output fuse blown of either charger.

s. Other specific current/ voltage limits during normal charging/ operation of the chargers shall also be incorporated in the design of the chargers.

5.3.2 OPERATION AND PERFORMANCE

a. Operation

   i. Normal operation requires that the battery assembly shall be float charged simultaneously by both Chargers-1 & 2 while feeding the DC load, the chargers thus operating in parallel and equally sharing the total load.

   ii. However in case of failure of either of the chargers, the other charger shall float charge the battery while feeding the complete DC load. Faulty charger shall automatically get disconnected from the healthy system.

   iii. In case of AC mains failure, the battery shall continue to supply the load.

   iv. The process of changeover from float to quick charging and reverting from quick to float charging shall be selectable in Automatic or Manual mode by means of an Auto/ Manual selector switch. In Automatic mode, the changeover from float to quick charging shall be initiated through a current sensor, set at a preset value. Similarly, the changeover from quick to float charging shall also be automatic based on current sensing. In Manual mode, both changeovers from float to quick charging and from quick to float charging shall be performed manually using push buttons. When quick charging mode is selected, the battery charger shall Initially charge the battery under constant current mode followed by constant voltage (finishing charging) mode or as per the battery manufacturer's recommendation. Changeover from constant current to constant voltage (finishing charging) mode shall be fully automatic. A backup synchronous or digital timer shall also be provided for initiating the changeover to float mode by default after a preset time period. The timer range shall be 0 to 24 hours or the nearest available as per manufacturer's standard range.

   v. In the event of failure of the charger feeding the load, when battery is being quick charged by the other charger, continuity in DC supply shall be maintained from the battery to the load through 80% tap of the battery bank followed by full battery supplying the load through contactor.

vi. Interlock shall be provided to ensure that when either of the chargers is selected in quick charging mode, it will be disconnected from both the DC load and the other charger operating under float charging mode.

vii. The chargers shall have facility for manual mode of operation in the event of failure of controller under closed loop control. The selection shall be done through Auto/ Manual selector switch.

viii. Energisation of contactor for DC critical lighting shall be initiated by means of an AC mains failure relay complete with Auto/ Manual selector switch, on/ off push buttons etc.

ix. Facility for initial charging of the uncharged battery shall also be provided

b. **Performance**

i. Both chargers shall be of solid state design, constant voltage and current limit type. The output voltage shall be stabilized to within ±1% of set value in float charging mode for mains steady state voltage and frequency variation of ±10% and ±5 % respectively, and load variation of 10 to 100% at any temperature up to the design ambient temperature specified in the Data Sheet. However, the variation in output voltage can be up to ±2% for chargers with rated output voltage up to 24V.

ii. Under constant current boost charging condition, the DC output current shall be maintained within ±2% of set value.

iii. The output voltage dynamic response of the charger unit with battery disconnected shall not vary more than ±10% of nominal output voltage in the event of step load of up to 50% of the rated output. The output voltage shall be restored to a value within the steady state limits within 250 msec. Voltage feedback shall generally be derived from charger output while current feedback from the DC ammeter.

iv. The maximum allowable RMS ripple voltage, with battery disconnected, shall be equal to or less than 2% of the nominal output voltage.

v. The maximum noise level from the chargers measured at 1 meter distance in any position, at any load between 0- 100% with all normal cooling fans running shall not exceed 75 dB(A).

c. **Controls**

i. Controls shall include but not be limited to the following:

-ON/ OFF control switch for AC supply to charger (push buttons are not acceptable).

-Push buttons for float/ quick charging mode selection

-Potentiometers under float mode for voltage and current adjustment

-Potentiometers under quick mode for voltage and current adjustment

-Auto/ Manual selector switch to select mode of operation

-Others as required.

d. **Panel Metering and Indication**

These shall include but are not limited to the following:

i. **Meters**

Charger-1

-AC input Voltmeter with selector switch

-AC input Ammeter with selector switch

-DC output Voltmeter

-DC output Ammeter

-DC Voltmeter with selector switch (battery voltage)

-DC Ammeter (battery)

-DC Earth Leakage Ammeter (mA).

Charger-2

-AC input Voltmeter with selector switch

-AC input Ammeter with selector switch

-DC output Voltmeter

-DC output Ammeter.

DC Distribution Board

-DC Voltmeter

-DC Ammeter.

ii. **Lamps**

Chargers-1 & 2

-AC power ON (1 lamp for each phase)

-Float charger ON

-Quick charger ON

-Charger fault.

DC Distribution Board

-DC power ON

-Outgoing feeder ON (for each outgoing feeder).

All indicating lamps shall be provided with series resistors. Clustered/ Jumbo LEDs of minimum 10mm diameter may be provided in place of lamps subject to their having at least equal luminance.

e. **Annunciation**

i. Static type audio-visual enunciator with annunciation windows, acknowledge, test and reset push buttons and hooter shall be provided on each charger for the following annunciations. Any additional relays/Components, including DC under voltage relay and current sensors, required for this purpose shall be provided in the chargers. Facility for bypassing the audio alarm on each charger shall also be provided.

-DC under voltage

-DC overvoltage

-DC earth leakage

-AC incoming power supply failure

-AC input fuse blown-off

-Thyristor/ diode failure

-DC output fuse blown-off

-DC battery fuses blown-off

-Filter Capacitor fuse blown-off

-Load on Battery (using current direction sensing with time delay)

-Battery under voltage/ Disconnected during discharge (using zero current sensing)

-Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

-One summary alarm potential-free contact each for Battery, Charger-1 and Charger-2 shall be wired to terminal block for remote annunciation.

f. **Printed Circuit Boards (PCBs)**

i. PCBs used in the chargers shall be made of glass epoxy material. Components shall be properly mounted without undue stress, torsion, bends, twists etc. All PCBs shall be provided with a transparent epoxy coating on both sides for environmental/ anti-fungus protection and tropicalisation. Industrial grade components shall be used in the PCBs and electronic circuits. PCBs shall preferably be wave soldered. Copper strips/ prints on PCBs shall have smooth edges free from hair line cuts and shall be provided with tin coating. Plug-in PCBs shall preferably be mounted in a standard rack and shall be suitable for easy replacement. They shall be located away from heat sources. The rack shall have PCB guides which shall allow the insertion of PCBs smoothly without requiring undue force. The rack shall l be mounted on hinged pivots to enable it to be turned for access to the back side terminals. The PCBs shall be firmly clamped in position so that vibration or continued usages do not result in loose contacts. All PCBs shall be fitted in a manner to avoid replacement of a PCB by a wrong spare card. The PCBs shall be provided with visual light emitting diode (LED) status indications, monitoring points/ test connections and setting potentiometers in a readily accessible location which is visible without removing the PCBs. Visual fault diagnostics shall preferably identify faults up to various sections in the card.

ii. Vendor shall provide adequate protection to the system, even if not specifically mentioned.

5.3.3 **CELL BOOSTER**

a. Cell booster shall be suitable for charging one to six cells within the time duration specified. It shall be suitable for charging not only new cells before being introduced to the battery bank but also for any treatment to be given to individual weak cells. Cell booster shall be suitable for 240 V ± 10%, 50 Hz ± 5% SPN input power supply. Cell booster output voltage shall be in the range of 0-18V and 0-12V for Lead Acid and Nickel Cadmium batteries respectively. Cell booster shall be sized as under:

For Lead Acid battery = 0.14 x AH (C10) of cell

For VRLA battery = 0.2 x AH(C 10) of cell

For Ni-Cd battery = 0.2 x AH (C_5) of cell.

b. Cell booster shall have a heavy duty switch fuse or MCCB on both AC incomer and DC output sides, along with AC voltmeter, DC ammeter, DC voltmeter and indicating lamps for AC/ DC power ON. The output voltage and current of cell booster shall be manually controlled using a suitably rated variac or a full wave controlled rectifier bridge. Suitable interlock shall be provided so as to ensure that the variac / controlled rectifier is at its minimum position while switching on the cell booster. Cell booster shall be portable type with wheels. Each cell booster shall be supplied with 5 m long flexible copper conductor PVC insulated braided cables for both AC incoming power supply and DC output connection to the battery. An industrial type 3 pin 15A plug shall be provided on AC incoming cable end and lugs shall be provided on DC outgoing cable end.

5.3.4 **RELIABILITY**

a. All necessary care shall be taken in selection, design, manufacture, testing and commissioning of the equipment for ensuring high system reliability. The following design considerations shall be taken into account to ensure maximum availability of the system. There shall be no common device between the two units, the failure of which could cause shutdown of more than one charger.

b. It shall be possible to attend to any individual power circuit for maintenance without affecting the total DC supply. Series-parallel combination of smaller devices to achieve specified rating shall not be acceptable. All the components used shall be time tested and standardized. Vendor shall state the safety factors used in selecting such items as semi-conductors, electrolytic capacitors, transformers etc.

6.0 FABRICATION

6.1 Each Battery Charger and DC distribution board shall be housed in a separate free standing cubicle. All panels shall be of the same height so as to form a panel lineup which shall have good aesthetic appearance. Chargers-1 & 2 shall be installed side by side whereas DCDB may be located separately and interconnected to the charger through cables. The DCDB shall accommodate outgoing feeders as specified in the Data Sheet. Each panel shall be provided with an 11W CFL light with a door operated switch and a thermostatically controlled MCB protected space heater.

6.2 Unless specified otherwise in the Data Sheet, the DCDB shall be compartmentalized with each outgoing feeder housed in a separate compartment. Cable alley of minimum 200mm width with suitable supports shall be provided for the termination of cables for each vertical arrangement of outgoing feeders in DCDB.

6.3 The Chargers, DCDB and Cell Booster enclosures shall be fabricated from structural/ CRCA sheet steel. The frames shall be fabricated by using minimum 2mm thick CRCA sheet steel while the doors and covers shall be made from minimum 1.6 mm thick CRCA sheet steel. Wherever required, suitable stiffeners shall be provided. The panels shall be provided with suitable louvers for ventilation backed by wire mesh. They must be suitable for use in a tropical climate. Hinged doors shall be provided at the front and back as required. Inter panel sheet steel barriers shall be provided.

6.4 The charger panels and DC distribution board shall be provided with minimum IP-42 degree of ingress protection as per IS-13947 (Part-1).

6.5 Bus bars shall be colour coded and live parts shall be shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall have suitable nameplates and device tag numbers as per the schematic diagram. All wires shall be ferruled and terminals shall be numbered.

6.6 The DCDB incomer and main bus bars shall be rated based on the maximum load current considering an additional 10% design margin for contingencies. The rating shall be selected from standard available ratings and shall be adequate for the expected short circuit current. The bus bar voltage shall be higher than the recommended boost voltage for the system. The insulation for all equipment where provided shall be heat resistant, moisture proof and tropicalised.

6.7 All power and control switches shall be rotary/ cam operated type. All power switches shall be air insulated load break type. Vendor shall ensure that all equipment/ components such as incomer switches, outgoing DC switches, MCCBs, push buttons, indicating lamps, charger mode selector switches, voltage control switches, annunciator windows etc. are suitably located on the charger and distribution board door such that they can be operated without opening the front door. Power switches shall be provided with a door interlock. In case of difficulty in installation on the charger front panel door, the AC incoming power switches, DC outgoing switches and MCCBs may be installed within the panel provided that they are operable after opening the front panel door. However, all other selector/ control switches, push buttons, indicating lamps, annunciators, meters etc. shall necessarily be installed on the front panel door as specified above.

6.8 All instruments shall be switchboard type, back connected and (72 x 72) mm square size. Accuracy class of all meters shall be 1%. Digital meters capable of displaying different parameters can be considered subject to Owner's/ Consultant approval. Analogue instrument scales shall have a red mark indicating maximum permissible operating rating.

6.9 All fuses shall be link type and shall be located inside the panel. Diazed fuses shall not be accepted.

6.10 All power and control wiring connections within the panels shall be carried out with 660V grade, PVC insulated, BIS marked wires having stranded copper conductors. However, copper strip connections shall preferably be used for currents exceeding 100A. Wires of 1.5mm^2 size shall normally be used for control circuits with fuse rating of 10 Amps. or less. For control circuits with fuse of 16 Amps. or more, 2.5 mm^2 size wire shall be used. Control wiring for electronic circuits/ components shall be through flat ribbon cable or copper wire of minimum 0.5mm diameter. All control wiring shall be enclosed in PVC channels or otherwise neatly bunched together. Each wire shall be suitably identified at both ends by PVC ferrules. Ferruling of wires shall be as per relevant IS.

6.11 For all cabling external to panels, power cables shall be with aluminum/ copper conductors and control cables shall be with copper conductors. All cable connections shall be from the bottom of the panel, unless specified otherwise in the Data Sheet.

Removable bolted undrilled gland plates shall be provided along with single compression type nickel plated brass cable glands for all external cable connections. Clamp type terminals shall be used for connection of wires up to 10mm^2. Bolted type terminals suitable for cable lugs shall be provided for wire sizes above this. Separate test terminals shall be provided for measuring and testing the equipment to check performance. All panels shall be supplied complete with tinned copper cable termination lugs.

6.12 All potential free metallic parts shall be earthed using soft drawn copper conductor wire. A suitably sized earth bus shall be provided at the bottom of the panels running through the panel lineup with provision for earth connections at both ends to Owner's main earth grid. The minimum size of earth bus shall be (25 x 6) mm copper (or equivalent aluminum). All potential free metallic parts of equipment shall be suitably earthed to ensure safety.

6.13 The maximum height of the operating handles/ switches shall not exceed 1800 mm and the Minimum height shall not be below 300 mm.

6.14 All components/devices/ feeders shall be provided with screwed nameplates. Nameplates shall Be 3 ply white-black-whites 2 colour laminated plastic type. Lettering shall be of minimum 6 mm Height and edges shall be beveled at 45°.

6.15 The sheet steel used for fabrication 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 prepared by applying a coat of phosphate paint and a coat of zinc oxide/ phosphate primer. The undersurface shall be free from all imperfections before undertaking the finishing coat. After preparation of the undersurface, the panels shall be either spray painted with two coats of epoxy paint or epoxy powder coated to a uniform thickness suitable for rugged industrial use.

6.16 Colour of final paint shall be shade 631 as per IS 5, unless specified otherwise. The finished panels shall be dried in stowing ovens in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, run off paint etc. All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust corrosion.

7.0 INSPECTION AND TESTING

7.1 During fabrication, the equipment shall be subjected to inspection by Consultant / Owner or by an agency authorized by the Owner. Manufacturer shall furnish all necessary information concerning the supply to Consultant / Owner's inspector. Tests shall be carried out at manufacturer's works under his care and expense.

7.2 Each Battery Charger/ DCDB/ Cell Booster shall be tested in accordance with applicable standards. The following acceptance tests shall be performed on each Battery Charger and DCDB as a minimum. Detailed test schedule and procedures shall be formulated by the vendor and submitted for Consultant / Owner's approval. Vendor shall indicate the maximum allowable tolerance against each test parameter in line with applicable standards. All tests shall be witnessed by Owner or his authorized representative and 4 weeks prior notice shall be given before the date of commencement of tests. In case the equipment fails to meet any requirements of the Specifications, necessary modifications/

corrections shall be made by the Vendor to ensure compliance to the Specifications, and the equipment shall be retested before acceptance. Test certificates indicating the test results shall be submitted to Owner.

7.3 INSULATION TESTS

7.3.1 Insulation tests shall be performed as per IEC 60146-1-1.

7.3.2 The insulation tests shall be carried out using an AC power frequency voltage or a DC voltage at the choice of the manufacturer. In the case of AC power frequency voltage test, the test voltage at the frequency available in the test facility or at the rated frequency, but not exceeding 100 Hz, shall be increased to the full value shown in the following table in not less than 10 seconds continuously or in maximum steps of 0.05 p.u. of the full value starting at a maximum of 0.5 p.u. The unit on test shall withstand the specified voltage for 1 minute. In case DC voltage is used for the test, the value of DC voltage shall be equal to the crest value of the test voltage specified in the table**.**

V P / √ 2 (VP is the highest crest voltage to be expected between any pair of terminals)	Test Voltage (AC RMS value)
≤60V	500V
≤ 125 V	1000 V
≤250 V	1500 V
≤ 500 V	2000 V

7.4 PRINTED CIRCUIT BOARDS

PCBs and other electronic circuits shall undergo a burn-in test for 96 hours at 50°C at a voltage varied between the maximum and minimum supply voltage. In case of failure of any component during testing, the tests shall be repeated after replacement of the faulty component.

7.5 HEAT RUN TEST

Prior to execution of functional tests, each of the two chargers of each Battery Charger set shall be subjected to a Heat Run test performed at rated load and voltage for a period not less than 8 hours. The other charger of the set shall be energized under zero load current condition throughout the test period. The temperature of electronic power devices shall be measured and the device junction temperature shall be calculated. The calculated value shall be at least 10-20°C lesser than the maximum rated junction temperature of the device with proper ambient temperature correction applied.

7.6 FUNCTIONAL TESTS

Functional tests shall be performed on each charger. If during execution of functional tests, an electronic component of the charger is required to be replaced, e.g. due to charger malfunction or failure of the unit to fulfill the performance requirements of the

Specification, then the heat run test shall be repeated at rated current following which functional tests shall be carried out.

7.7 CHARGER TESTING AT CONSTANT OUTPUT VOLTAGE

Measurements shall be carried out in the float charging mode and in the quick charging mode. In each mode, measurements shall be carried out at nominal AC input voltage and at zero, 50% and 100% of rated output current. Measurements at 100% rated load current shall be repeated at 90% and 110% of nominal AC supply voltage. Measurements shall include input AC phase voltage, frequency, current and power and DC output voltage, current and output voltage ripple.

7.8 CHARGER TESTING AT CONSTANT OUTPUT CURRENT LIMIT

Measurements shall be carried out both in the float charging and quick charging mode. In each mode, measurements shall be carried out when the charger is operating under DC current limiting conditions with DC output voltage between zero and set value corresponding to constant voltage operation. Measurements shall include DC output voltage and current.

7.9 AUXILIARY EQUIPMENT AND CONTROL CIRCUIT TESTS

The correct functioning of all measuring instruments, alarms, indications, protections and controls mentioned in the Specification shall be verified.

7.10 PARALLEL OPERATION

Parallel operation of both chargers, sharing of the load and automatic isolation of faulty charger shall be checked.

7.11 CHARGER EFFICIENCY

This shall be determined by measurement of the active power input and output at 50%, 75% and 100% load.

7.12 AUDIBLE NOISE TEST

Audible noise shall be measured around each charger at 1 meter distance in at least 4 to 5 positions and its value shall be within the permissible limits.

7.13 SITE ACCEPTANCE TEST

The Battery Chargers, DCDB and Cell Booster shall be tested at site along with the battery. Vendor shall furnish a Site Acceptance Test (SAT) procedure for Owner's approval and all tests shall be performed as per the approved SAT procedure.

8.0 MARKING, PACKING AND SHIPMENT

8.1 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. It shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as `Fragile', `This side up', 'Center of gravity', `Weight', `Owner's particulars', 'PO no.' etc., shall be clearly and indelibly marked on the packages together with other details as per purchase order.

1.0 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 and high ambient temperature unless otherwise agreed.