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1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of three phase medium voltage squirrel cage induction motors.

2.0 REFERENCE DOCUMENTS

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

IS – 5:	Colors for ready mixed paints and enamels.
IS – 325:	Three phase induction motors.
IS – 1076:	Preferred numbers.
IS – 1231:	Dimensions of three phase foot mounted induction motors.
IS – 1271:	Thermal evaluation and classification of electrical insulation.
IS – 2148:	Flame proof enclosures of electrical apparatus
IS – 2223:	Dimensions of flange mounted AC Induction motors.
IS – 2253:	Designation for type of construction and mounting arrangement of rotating electrical machines
IS – 2254:	Dimensions of vertical shaft motors or pumps
IS – 2968:	Dimensions of slide rails for electric motors.
IS – 2968:	Guide for testing three phase induction motors.
IS – 4691:	Degrees of protection provided by enclosure for rotating electrical machinery.
IS – 4722:	Rotating electrical machines.
IS – 4728:	Terminal marking and direction of rotation for rotating electrical machinery.
IS – 4889:	Method of determination of efficiency of rotating electrical machines.
IS – 6362:	Designation of methods of cooling of rotating electrical machines.
IS – 7816:	Guide for testing insulation resistance of rotating machines
IS – 6381:	Construction and testing of electrical apparatus with type of protection "e"
IS – 7389:	Pressurized enclosure of electrical equipment for use in hazardous area

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IS – 8223:	Dimensions and output series for rotating electrical machines.
IS – 8289:	Electrical equipment with type of protection 'n'.
IS – 8789:	Values of performance characteristics for three phase induction motors.
IS – 9283:	Motors for submersible pump sets.
IS – 9628:	Three phase induction motors with type of protection 'n'
IS – 12065:	Permissible limits of noise level for rotating electrical machines
IS – 12075:	Mechanical vibration of rotating Electrical Machines with shaft heights 56 mm and higher - measurement, evaluation and limits of vibration severity.
IS – 12802:	Temperature rise measurement of rotating electrical machines
IS – 12824:	Type of-duty and classes of rating assigned to rotating electrical machines
IS – 13529:	Guide on effects of unbalanced voltages on the performance of three phase cage induction motors.
IS – 13555:	Guide for selection and application of three phase induction motors for different types of driven equipment
IS – 14568:	Dimensions and output series for rotating electrical machines, frame numbers 355 to 1000 and flange numbers 1180 to 2360

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

2.3 The motors 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, 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 priority shall govern:

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

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3.0 DEFINITIONS

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

4.2 Anti-loosening, anti-vibration, type of terminals shall be provided in case of increased safety (type Ex e) and non-sparking (type Ex n) motors.

5.0 DESIGN

5.1 GENERAL REQUIREMENTS

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

5.1.2. Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 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 and Consultant before phasing out the product/spares to ensure the end user for placement of order for spares and services.

5.2 OPERATING CONDITIONS

5.2.1 AMBIENT CONDITIONS

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

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5.2.3 FREQUENCY AND VOLTAGE VARIATIONS

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

5.2.5 The terminal voltage differing from its rated value by not more than ± 6 % or

5.2.6 The frequency differing from its rated value by not more the ± 3 % or any combination of 5.2.4 and 5.2.5.

5.3 STARTING

5.3.1 Unless otherwise specified, motors shall be designed for direct-on-line starting.

5.3.2 Motors shall be designed for re-acceleration under full load after a momentary loss of voltage with the residual voltage being 100% and is in phase opposition to the applied voltage.

5.3.3 Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. The starting time of the motor shall be less than the hot thermal withstand time (time t_E in case of increased safety i.e. Ex-e motors) to permit application of conventional bimetal relays or thermal released against locked rotor and overload conditions.

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

5.3.5 Motors shall be designed to allow the minimum number of consecutive starts indicated-in table below:

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

5.4 DIRECTION OF ROTATION

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

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

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5.5 PERFORMANCE

5.5.1 Motors shall be rated for continuous duty (S1), unless otherwise specified.

5.5.2 Unless otherwise specified, the starting current (as % rated current) shall not exceed 600% subject to tolerance.

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

5.5.4 For heavy duty drives such as blowers, crushers etc. high starting torque motors shall be provided.

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

5.5.6 The pull out torque at the rated voltage shall be not less than 175 percent of the rated load torque with no negative tolerance. Unless otherwise agreed, the pull out torque shall not exceed 300 percent of the rated load torque.

5.5.7In case of motors driving equipment with pulsating loads (e.g. reciprocating compressors) the minimum value of pull out torque at 75 percent of the rated voltage shall be more than the peak value of pulsating torque and the current pulsation shall be limited to 40%.

5.5.8 The minimum values for performance characteristics of motors rated up to and including 37 kW shall be as per IS-8789 TABLE-1 to TABLE-8.

5.5.9 The minimum value for product of efficiency and power factors of 2 pole, 4-pole, and 6-pole motors rated above 37 kW shall be as given in Table below.

Rated output	**Product of efficiency & power factor at rated load (minimum)**		
	2-Pole	**4- Pole**	**6-Pole**
45 kW	0.82	0.80	0.79
55 kW	0.82	0.80	0:79
75 kW	0.82	0.80	0.80
90 kW	0.82	0.80	0.80
110 kW	0.86	0.80	0.80
125 kW	0.86	0.80	0.80
160 kW	0.86	0.81	0.80
180 kW	. 0.86	0.83	0.80
200 kW	0.86	0.83	0.80

5.5.10 Efficiency and power-factor figures for motors having synchronous speeds of 750 RPM and below shall be as agreed between the Purchaser and the Manufacturer.

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6.0 FABRICATION

6.1 WINDINGS

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

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

6.1.3 Windings shall be adequately braced to prevent any relative movement during operation. In this respect, particular care shall be taken for the stator windings for direct on line starting squirrel cage motors. Insulation shall be provided between coils of different phases that lie together. Core laminations must be capable of withstanding burnout for rewind at 400 °C without damage or loosening.

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

6.1.5 The windings shall be connected in delta. However, for motors rated 2.2 kW and below, star connection may be accepted.

6.1.6 In case of motors with star delta starting, the motor windings shall be fully insulated for delta connection.

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

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

6.1.9 All terminals shall be thoroughly insulated from the frame with material resistant to tracking.

6.1.10 Anti-loosening, anti-vibration, type of terminals shall be provided in case of increased safety (Type Ex e) and non-sparking (Type Ex n) motors.

6.2 TERMINAL BOX AND CABLE ENTRIES

6.2.1 Unless otherwise agreed, the terminal box shall be located on the right hand side as viewed from the driving (coupling) end. However, as a special case, terminal box- located on top may also be accepted, particularly for hazardous area motors, in case manufacturer has only TOP mounted terminal box design which is duly tested/certified by CIMFR and approved by PESO/CCE for installation in hazardous area. The terminal box design shall allow rotation in steps of 90° to facilitate cable entry from any direction.

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6.2.2 The terminal box shall be of robust construction and large enough to facilitate easy connection of the cables. The terminal box shall be with necessary clearances, creepage distances between live parts and between live parts to earth considering air insulation and without any compound filling. Terminal box cover shall be provided with handles to facilitate easy removal. However for terminal box covers weighing less than 5 kg., terminal box covers without handles can be accepted.

6.2.3 An adequately sized earth terminal shall be provided in the motor terminal box for termination of the fourth core' of specified cables.

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

6.2.5 Equipment and accessories provided shall conform to the hazardous area classification and the environmental conditions as specified in the motor Data Sheet.

6.2.6 Unless otherwise specified, the terminals, cable lugs, terminal box, cable entries and cable glands shall be suitable for the cables sizes is specified below in Table for 2 pole, 4 pole or 6 , pole motors:

Motor rating up to and including	Size of phase conductor (mm^2)
22 kW and below	4 AI / 2.5 cu
3.7 kW	6 AI / 4 cu
5.5 kW	10 Al / 6 cu
7.5 kW	16 Al / 6 cu
9.3 kW	25 Al / 10 cu
11.0 kW	25 Al / 16 cu
15.0 kW	35 Al
18.5 kW	50 Al
22.0 kW	50Al
30.0kW	70Al
37.0Kw	95Al
45.0kw	95Al
55.0kW	120Al
75.0kW	185Al
90.0kW	2x95Al
110.0kW	2x120Al
125.0 kW / 132.0 kW	2x150Al
150.0kW	2x185Al
160.0kW	2x185Al
180.0kW	2x240Al
200.0kW	2x300Al

6.2.7 Cable sizes for motors having synchronous speeds 750 RPM and below shall be as agreed between the Purchaser and Manufacturer.

6.2.8 Cables used are of 650/1100 V grade aluminum conductor, PVC insulated, PVC extruded inner sheath, armored with overall PVC sheath. However for cables up to & including 16-mm2 cross-section, cables used may be with copper or aluminum conductor as indicated in the motor Data Sheet.

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6.2.9 The terminal box shall be capable of withstanding internal short circuit conditions without danger to personnel or plant from the emission of hot gases or flame or due to excessive distortion or damage to the terminal enclosure.

6.2.10 Appropriate phase markings as per IS shall be provided inside the terminal box. The marking shall be non-removable and indelible.

6.3 MOTOR CASING AND TYPE OF ENCLOSURE

6.3.1 Motors for use in safe areas shall be industrial type meeting the specified ambient conditions, starting and operating requirements.

6.3.2 Motors for use in hazardous areas (Zone-I or Zone-2) shall have type of protection Ex d or Ex e or Ex n as specified in the motor Data Sheet and shall meet the requirements of applicable Indian Standards.

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

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

6.3.5 Vertical motors with downward shaft shall be provided with suitable canopies covering the motor fully. Vertical motors with upward shaft e.g. on fin-fan coolers, shall be adequately protected, (such as cowls/canopies) against ingress of water into the enclosure or the bearing housing even when standing still for long periods of time. Motors designed to handle external thrust from the driven equipment shall be supplied with a thrust bearing at the non-driving end.

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

6.3.7 Unless otherwise agreed, motors shall have standard frame sizes for various output ratings as stipulated in IS.

6.4 BEARING AND LUBRICATION

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

6.4.2 Unless otherwise specified, the bearings shall be adequate to absorb axial thrust produced by the motor itself or due to shaft expansion.

6.4.3 Vertical motors shall be provided with thrust bearings suitable for the load imposed by the driven equipment.

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

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

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

6.5 COOLING SYSTEM

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

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

6.6 ROTOR

6.6.1 The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and long service life for the bearings. The accepted values of peak to peak-vibration amplitudes for a motor at rated voltage and speed on a machined surface bedplate with the motor level and with half-key or coupling fitted shall not exceed those given in IS. Die cast aluminum rotors for motors in hazardous areas may be accepted provided the same are type tested and approved by competent authorities.

6.2 SHAFT EXTENSION

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

6.3 LIFTING HOOKS

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

6.4 EARTH TERMINALS

6.4.1 Two earth terminals located preferably on diametrically opposite sides shall be provided for each motor. The size of each earth stud shall be as given below in Table:

Motor Rating	Stud size
Up to and including 7.5 kW	6 mm
11 kW to 30 kW	10 mm

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Above 37 kW	12 mm

Necessary nuts and spring washers shall be provided for earth connection.

6.5 MISCELLANEOUS ACCESSORIES

6.5.1 ANTI-CONDENSATION HEATERS

a. Unless otherwise stated, all motors rated above 22 kW shall be provided with 240V anti condensation heaters, sized and located so as to prevent condensation of moisture during shut down periods. The heaters shall permanently remain 'ON' when the motor is not in service and as-such shall not cause damage to the windings.

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

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

6.5.2 NAME PLATES

a. A stainless steel name plate manufactured from series 300 stainless steel and having information as per IS shall be provided on each motor.

b. In addition to the motor rating plate, a separate number plate for motor tag number shall be fixed in a readily visible position. This number shall be as per the motor Data Sheets.

c. Additional information as stipulated in applicable Standards shall be included in the nameplate for motors meant for use in hazardous atmospheres.

6.5.3 NOISE LEVEL

The permissible noise level shall not exceed the stipulations laid down in IS, unless otherwise specified in the motor Data Sheet.

6.5.4 MOTOR VIBRATIONS

Motor vibrations shall be with-in the limits of IS, unless otherwise: specified for the driven equipment.

6.5.5 CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 125% of the synchronous speed. For flexible rotors this shall be between 60% and 80 % of the synchronous speed; the second actual critical' speed shall be above 125 % of the synchronous speed.

6.5.6 PAINTING

Internal and external parts of the casing and all metal parts including the canopy likely to come in contact with the surrounding air shall be protected with anti-acid paint that will resist the specified environment conditions.

All external surfaces of the motor and its canopy shall be given a coat of epoxy based paint. Paint shade shall be 632 as per Indian Standard-IS-5.

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7.0 INSPECTION AND TESTING

7.1 During manufacturing of motors, the motors shall be subject to inspection by Consultant / Owner's Inspector or, by an agency authorized by the Owner. The manufacturer; shall, provide all Necessary information concerning the supply to Consultant's / Owner's inspector.

7.2 The manufacturer shall give prior notice of minimum 4 weeks to the Inspector for witnessing the tests Witness of acceptance test shall he applicable for motors rated above 1:1 kW. In case of motors rated up to 11 kW, routine test records shall be provided as part of final documentation.

7.3 All tests shall be carried out at manufacturer's shop under his care and-expense.

7.4 Tests certificates duly signed by the Consultant / Owner's Inspector shall be a part of final documentation.

7.5 The manufacturer shall submit all internal test records of the tests carried out by him on the bought-out items, motor sub-assembly and complete motor assembly to the Inspector before offering the motors for final inspection and-testing. The manufacturer shall periodically carry out the following type tests as per applicable Indian Standards for the entire frame -sizes and ratings of motors.

a. Full load test and measurement of voltage, current, power & slip.
b. Measurement of starting torque,: starting current, full load torque and pull out torque.
c. Measurement of efficiency and p.f.at 100%, 75% and 50% load.
d. Temperature rise test.
e. Momentary overload test.
f. Measurement of vibration.
g. Measurement of noise level.
h. Over speed test.

7.6 The above tests must be witnessed and approved by reputed inspection agencies. The manufacturer shall maintain test records and submit to the Consultant / Owners Inspector at the time of final inspection & testing. In no case, the test records shall be more than 5 year old.

7.7 In special cases where the type tests are asked to be carried out, VCS/ Owner's Inspector shall witness these.

7.8 The manufacturer shall carry out routine tests as per applicable Indian Standards on all the motors. Routine tests not limited to the following shall form part of acceptance testing:

a. General visual checks, nameplate details, mounting, terminal box location and cable gland sizes
b. Measurement of shaft center height dimensions
c. Measurement of clearances in the terminal box
d. Verification type of terminals (for Ex-e & Ex-n motors)

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e. Verification of direction of rotation
f. Measurement of winding resistance
g. Insulation resistance test (before & after high voltage Test)
h. High voltage test
i. No load test and measurement of voltage; speed; current & power input
j. locked rotor test at reduced voltage and measurement of voltage, current & power input
k. Reduced voltage starting & running
l. Tests on the Ex d enclosures as per IS

7.9 The manufacturer shall submit the following certificates for verification by the Consultant / Owner's Inspector:

a. Test certificate for degree of protection of enclosure
b. Test certificates issued by the recognized independent test house for hazardous area motors
c. Approval certificates issued by Statutory Authorities for hazardous area motors
d. BIS license and marking as required by Statutory Authorities for Ex d motors

7.10 Though the motors shall be accepted on the basis of the satisfactory result of the testing at the shop, it shall not absolve the Vendor from liability regarding the proper functioning of the motors coupled to the driven equipment at site.

8.0 CERTIFICATION

8.1 The hazardous area motors and associated equipment shall have test certificates issued: by recognized independent test house (CIMFR/Bassefa/LCIEIUL/FM or equivalent). All indigenous motors shall conform to Indian standards and shall be certified by Indian testing agencies. All motors (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location. All indigenous flameproof motors shall have valid bis license & marking as required by statutory authorities.

8.2 Ex n motors shall be supplied with manufacturer's certificate of conformity to IS 9628 or equivalent International Standard and Indian statutory approval.

9.0 MARKING, PACKING AND DESPATCH

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

9.2 The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed.

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Energising Quality

VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION
FOR
MEDIUM AND HIGH VOLTAGE CABLES

VCS – SS – EL - 4007

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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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

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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
PVC	Polyvinyl chloride
XLPE	Cross Linked Poly Ethylene

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1.0 SCOPE

This Specification along with Data Sheets covers requirements for design, manufacture, testing at works and supply of Flame Retardant PVC/XLPE cables and cable jointing / terminating accessories for medium and high voltage systems.

2.0 REFERENCE DOCUMENTS

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

IS: 1554:	PVC insulated (heavy duty) electric cables.
IS: 7098:	cross linked polyethylene insulated PVC sheath
IS: 8130:	Conductors for insulated electric cables and flexible cords
IS: 5831:	PVC insulation and sheath of electric cables
IS: 3975: 10810 (Part 41)	Mild steel wires, strips and tapes for armoring of cables Methods of testing cables: Mass of zinc coating on steel armor.
IS: 209:	Specification of zinc
IS: 3961:	Recommended current ratings for cables: part-2 PVC Insulated and PVC sheathed heavy duty cables.
IS: 10418:	Drums for electric cables
IS: 10462(Pt-1):	Fictitious calculation method for determination of dimension of protective coverings of cables: part – I electrometric and thermoplastic insulated cables.
IS: 10810(Pt-58):	Oxygen index test
IS: 10810(Pt-61):	Flame retardant test
IS: 10810(Pt-62):	fire resistance test bunched cables.
IS: 13573:	Joints and termination for polymeric cables for working voltages from 6.6 KV up to and including 33 KV.
IEC: 60332-3:	Test on electric cables under fire conditions
IEC: 60502:	Extruded solid dielectric insulated power cables for rated Voltages from 1 KV up to 30 KV.
IEC: 60540&60540A:	Test methods for insulation and sheaths of electric Cables.
ASTM: D2863:	Standard method of test for flammability of plastics using oxygen index method.

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ICEA S-61-402:	Thermoplastic insulated wire and cable for transmission and Distribution of electrical energy
NEMA-WCS:	Distribution of electrical energy
ICEA. S-66-S24:	Cross-linked thermosetting polyethylene insulated wire
NEMA-WC7:	Cable for transmission of electrical energy.

2.2 The cables and accessories shall also conform to the provisions of Indian electricity rules and other statutory regulations as applicable.

2.3 In case of any contradiction between various referred Standard/Specification/Data sheet and statutory regulations, the following order of priority shall govern:

a. Statutory regulations
b. Data Sheets
c. Job specifications
d. Standard specification
e. Codes and standards

3.0 DEFINITIONS

3.1 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 PVC CABLES

4.1.1 The core insulation shall be with PVC compound applied over the conductor by Extrusion and shall conform to the requirements of type 'A' compound as per IS: 5831.

4.2 XLPE CABLES

4.2.1 The core insulation shall be with cross linked polyethylene insulating compound dry cured, applied by extrusion it shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.

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5.0 DESIGN

5.1 PVC CABLES

5.1.1 All power/control cables for use on medium voltage systems shall be heavy-duty type, 650/1100 V grade with aluminum / copper conductor, PVC insulated, inner-sheathed, armored and overall PVC sheathed unless specified otherwise in Data Sheet.

5.1.2 The conductors shall be solid for conductor of nominal area up to and including 6mm² and stranded beyond 6mm². Conductors of nominal area less than 16 mm2 shall be circular only. Conductors of nominal area 16 mm² and above may be circular or shaped as per IS 8130. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS 1554 (Part-1).

5.1.3 The core insulation shall be with PVC compound applied over the conductor by extrusion and shall conform to the requirements of type 'A' compound as per IS: 5831. The thickness of insulation and the tolerance on thickness of insulation shall be as per Table 2 of IS: 1554 (Part-1). Control cables having 6 cores and above shall be identified with prominent and indelible numerals on the outer surface of the insulation. Color of the numbers shall contrast with the color of insulation with a spacing of maximum 50 mm between two consecutive numbers. Color coding for cables up to 5 cores shall be as per Indian Standards.

5.1.4 The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of Type ST-1 PVC compound as per IS: 5831. The minimum thickness of inner sheath shall be as per IS: 1554 (Part-1). Single core cables shall have no inner sheath.

5.1.5 If armoring is specified for multicore cables in the Data Sheet, the same shall be by single round galvanized steel wires where the calculated diameter below armoring does not exceed 13 mm and by galvanized steel strips. where this dimension is greater than 13 mm. Requirement and methods of tests for armor material and uniformity of galvanization shall be as per IS - 3975 and IS -10810 (Part 41). The dimensions of Armor shall be as per method (b) of IS - 1554 (Part -1). If armoring is specified for single core cables in the Data Sheet, the same shall be with H4 grade hard drawn aluminum round wire of 2.5 mm diameter.

5.1.6 For mining cables, the size and type of armor shall be such that the combined conductance of armor shall be equivalent to 75 percent of the conductance of the largest conductor of the cable.

5.1.7 The outer sheath for the cables shall be applied by extrusion and shall be of PVC compound conforming to the requirements of type ST-l compound as per IS 5831. The minimum and average thickness of outer sheath for unarmored cables and minimum thickness of outer sheath for armored cables shall be as per IS:1554 (Part-I).

5.1.8 If Heat Resisting PVC cables are specified in the Data Sheet, the following shall be the requirements:

a. It shall be possible to continuously operate the cable at a maximum conductor temperature of 85°C. PVC compounds used for HR PVC cables shall be as follows:

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i. Conductor insulation Type C
ii. Inner sheath Type ST 2
iii. Outer sheath Type ST 2

5.2 XLPE CABLES

5.2.1 Power cables for 3.3kV up to and including 33kV systems shall be aluminum/copper conductor, XLPE insulated, sheathed, armored and overall PVC sheathed.

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

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

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

5.2.5 The insulation screen shall consist of non metallic extruded semi conducting compound in combination with a non magnetic metallic copper screen. Unless specified otherwise, the copper screen for all the three cores together shall be capable of carrying the single line to ground fault current value and the duration specified in the Data Sheet.

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

5.2.7 The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST 2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness. In case of single core cables, there shall be extruded inner sheath between insulation metallic screen and armoring.

5.2.8 For multicore cables, the armoring shall be by galvanized steel strips as per method (b) of IS7098 (Part-2). If armoring is specified for single core cables in the Data Sheet, the same shall be with H4 grade hard drawn aluminum round wire of 2.5 mm diameter.

5.2.9 The outer sheath of the cables shall be applied by extrusion over the armoring and shall be of PVC compound conforming to the requirements of Type ST 2 compound of IS: 5831. The minimum and average thickness of outer sheath for unarmored cables and minimum thickness of outer sheath for armored cables shall be as per IS: 7098 (Part-2)

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

5.2.11 Where specified, 1100V grade power cables shall also be XLPE insulated and shall meet the requirement specified in IS-7098 (Part-1).

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6.0 FABRICATION

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

6.2 Outer sheath of all PVC and XLPE cables shall be black in color and the minimum value of oxygen index shall be 29 at 27 + 2 ° C. In addition suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

6.3 All cables covered in this Specification shall be flame retardant (FR) unless specified otherwise in the Data Sheet. The outer sheath of PVC and XLPE cables shall possess flame propagation properties meeting requirements as per IS-I0810 (Part-62) category AF.

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

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

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

6.7 The cables used in installations under, the jurisdiction of Director General of. Mines and Safety (DGMS) shall be of copper conductor only, and. shall have valid DGMS approvals. for the specified locations. The word “Mining Cable" shall be embossed /engraved on the cable outer sheath as per the applicable Indian Standards.

7.0 INSPECTION AND TESTING

7.1 The cables shall be tested and inspected at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected, both before and after manufacture, to examination, testing and approval by Consultant /Owner Manufacturer shall furnish all necessary information concerning supply to Consultant/ Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and he will have the power to reject any material, which appears to him to be of unsuitable description or of unsatisfactory quality. The Vendor shall give at least 2 weeks advance notice to the Purchaser, regarding the date of testing to enable him or his representative to witness the tests.

7.2 CABLES

7.2.1 After completion of manufacture of cables and prior to dispatch, the cables shall be subjected to type, routine, acceptance and special tests as detailed below. Consultant/Owner reserves the right to witness all tests with sufficient advance notice from Vendor. The test reports for all cables shall be got approved from the Engineer before dispatch of the cables.

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7.2.2 All routine tests, acceptance tests, type tests and additional type tests for improved fire performance shall be carried out as listed in IS:1554 (Part 1), and IS:1098 (Part 2) on PVC and XLPE insulated cables respectively.

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

7.2.4 Test for Resistance to Ultra Violet Radiation: This test shall be carried out as per DIN 53387 or ATM-G-53 on outer sheath. The retention value of tensile strength and ultimate elongation after the test shall be minimum 60% of tensile strength and ultimate elongation before the test. Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by Consultant before dispatch clearance of cables. In case test certificates are not available, test is to be conducted by Vendor at his own cost in any recognized test laboratory or in house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided outer sheath remains same.

7.2.5 Acceptance tests as per IS-1554 (Part-I) and IS-7098 (Part-2) and the following special tests to be performed on the cables as per sampling plan. These tests are required to be witnessed by Consultant/owner before dispatch of cables.

a. Accelerated water absorption test for insulation as per NEMA - WC - 5. (For PVC insulated cables) and as per NEMA WC - 7 (for XLPE insulated cables). Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by Consultant before dispatch clearance of cables. In case test certificates are not available, test is to be conducted by Vendor at his own cost in any recognized test laboratory or in house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided type of insulation remains same.

b. Dielectric Retention Test: The dielectric strength of the cable insulation tested in accordance with NEMA WC - 5 at 75 ± 1° C shall not be less than 50 % of the original dielectric strength. (For PVC insulated cables). Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by Consultant before dispatch clearance of cables. In case test certificates are not available, test is to be conducted by Vendor at his own cost in any recognized test laboratory or in house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly and once for each order.

c. Oxygen Index Test: The test shall be carried out as per ASTM D2863 or applicable Indian Standard specifications. Sampling to be done for every offered lot/size as per sampling plan.

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

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

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

e. Test for rodent and termite repulsion property: The Vendors shall furnish the test details to analyses the property by chemical method. Sampling to be done for every offered lot / size as per sampling plan.

7.3 CABLE ACCESSORIES

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

8.0 MARKING, PACKING AND SHIPMENT

8.1 Cables shall be dispatched in non-returnable wooden or steel drums of suitable barrel diameter, securely battened, with the takeoff end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit or storage.

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

Unless otherwise specified, Cables shall be supplied in drum lengths as follows:

8.2.1 MV CABLES

a. Multicore power cables up to 6mm² : 1000m
b. Multicore power cables from 10mm² up to 300mm² : 500m
c. Single core power cables up to 630 mm² : 1000m
d. Control cables up to 61 cores : 1000m

8.2.2 HV POWER CABLES – UPTO 11KV (E) GRADE

a. Three core cables up to 400 mm² : 500m
b. Single core cables up to 400 mm² : 1000m
c. Single core cables above 400 mm² and up to 630 mm² : 750m

8.2.3 HV POWER CABLES – ABOVE 11KV(E) GRADE AND UPTO 33KV(E)

a. Three core cables up to 300 mm² grade : 350 m
b. Single core cables up to 400 mm² : 1000m
c. Single core cables above 400 mm² and up to 1000 mm² : 500m

8.2.4 A tolerance of plus or minus 3 % shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to ±2%. Offers with short/non-standard

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lengths are liable for rejection. If non-standard drum lengths are-specified.in the Data Sheet, the same shall be supplied.

9.0 SPARES & ACCESSORIES

9.1 The termination and straight through jointing kits for use on the systems shall be suitable for the type of cables offered as per this Specification.

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

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

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

9.5 TERMINATING KITS

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

9.6 JOINTING KITS

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

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Energising Quality

I.

VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION
FOR
BATTERY CHARGER

VCS – SS – EL - 4008

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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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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

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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

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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.

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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.

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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.

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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/

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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.

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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:

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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

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-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.

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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.

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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.

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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/

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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

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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.

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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.

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Energising Quality

VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION
FOR
MOTOR OPERATED VALVE

VCS – SS – EL - 4010

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01	16.10.2019	MG	VV	AD	SK
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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
HRC	High Rupturing Capacity
MOV	Motor Operated Valve
DCS	Distributed Control System
LED	Light Emitting Diode
PVC	Poly Vinyl Chloride

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1.0 SCOPE

1.1 This Specification covers the requirements for design, manufacture, testing and supply of electrical motor operated valve actuators intended for fully / partially opening / closing valve duty. This Specification does not cover the actuators for flow regulating duty.

2.0 REFERENCE DOCUMENTS

2.1 The design, manufacture and performance of equipment covered by this Specification shall conform to the relevant Indian / International Standards and Codes. In particular the equipment offered shall conform to the latest revision of the following Standards:

IS :325	Three-phase Induction Motors.
IS :13947	Low Voltage Switchgear and Control gear
IS : 2148	Flame proof enclosure for electrical apparatus.
IS : 4691	Degree of protection provided by enclosure for rotating electrical machinery.
IS : 4722	Rotating electrical machines
IS : 9334	Electric Motor Operated Actuators.

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 DESIGN

4.1 SERVICE AND SITE CONDITIONS

4.1.1 The electrical motor operated valve actuator shall be suitable for operating under service conditions and system conditions as specified in the Data Sheet. If not specifically mentioned therein a design ambient temperature of 40°C and altitude not exceeding 1000 meters above mean sea level shall be considered.

4.2 POWER SUPPLY

The electrical motor operated valve actuator shall be suitable for power supply at 415V±10%, 50 Hz ± 3%, 3 phase, unless otherwise specified in the Data Sheet.

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4.3 MOTOR

4.3.1 Motor shall be 3 - phase squirrel cage induction type unless otherwise specified in the Data Sheet.

4.3.2 The motor shall be rated for S2 - 15 minute duty and shall conform to IS: 325, or equivalent International Standard.

4.3.3 The motor shall be provided with thermostat(s)/thermistor(s) embedded in hot spot of motor windings.

4.3.4 The motor shall be able to operate the actuator at 75 % of rated voltage.

4.3.5 Motor shall have class 'F' insulation with temperature rise limited to class `B' limits. Winding shall be treated to resist corrosive agents and moisture.

4.3.6 Motor rotor shall preferably be of die cast aluminum and if brazed shall be free from phosphorous.

4.4 INTEGRAL STARTER AND CONTROL TRANSFORMER

4.4.1 The reversing starter, control transformer and local controls shall be integral with the valve actuator, unless specified otherwise in the Data Sheet. Solid state control of valve actuator and opto-isolated interface for remote control requirement may be provided, wherever these features exist in manufacturer's design.

4.4.2 The integral starter shall be supplied with following devices:

a. Electrically and mechanically interlocked reversing contactors for opening and closing operations.
b. Control transformer with necessary tapings and protected with easily replaceable type HRC fuses.
c. Terminal block for external cable connection fully prewired for internal devices of valve actuator.

4.5 INTEGRAL PUSH BUTTON, SELECTOR SWITCHES, INDICATIONS AND CONTROL DEVICES

4.5.1 Following local control devices shall be provided, integral with MOV actuator:

a. Push buttons for "Opening/closing/stop" or alternatively 'open/close' selector switch.
b. Local/off/Remote selector switch, pad lockable in each position.
c. Indication lamps/LEDs or mechanical indication for `valve fully open', `fully closed'.
d. Local continuous position indication from fully open to fully closed status, which may be of mechanical analogue or electronic digital type.

4.6 TORQUE & TRAVEL LIMIT SWITCHES:

4.6.1 Torque limit switches shall be provided to protect the motor from over loading by cutting-off the supply to motor during opening and closing operations. The switch shall be provided with potential free contacts of requisite number for valve actuator operation and of specified number for indication on remote panels, as per data sheet. It shall be

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possible to set the value of torque during closing from 50 % to 100 % of rated torque of actuators. Travel limit switch shall be provided to cut-off the supply to the motor at the end of preset limit of valve travel and shall be provided with potential -free contacts of requisite number for valve actuator operation and of specified number for indication on remote panels, as per Data Sheet. Instead of mechanical torque limit switches, magnetic pulse counter to measure and control the stroke of actuator may be provided, wherever this feature exists in manufacturer's design.

4.7 CONTROL FACILITIES

4.7.1 The internal controls and monitoring circuits shall be incorporated within integral starter with transformer and control unit of valve actuator.

4.7.2 The remote control facility, if specified in the Data Sheet shall be provided. The remote control may be powered from internally derived control supply voltage unless specified in Data Sheet for using external supply for remote control. In order to cater to remote control and indication requirement for `valve open', `valve closed', remote/local/off position of selector switch, etc., as specified in the Data Sheet, the additional monitoring relay/auxiliary relay, if required shall form part of valve actuator supply.

4.7.3 One number handheld infrared remote programming device (where applicable) required for site commissioning and reconfiguring without the need of removal of the MOV cover, shall be supplied for each group of 5 valve actuators (or minimum one infrared remote setting device, even if number of valve actuators are less than five).

4.7.4 As an alternative common status contact for availability of the MOV actuator for remote control may be provided by monitoring the following:

a. Loss of one or more phases of power supply
b. Loss of control circuit supply
c. Selector switch in local mode
d. Local stop push button set to `off'
e. Motor thermostat tripped
f. Any other local fault/abnormal condition

4.8 HAND OPERATION

4.8.1 A hand wheel with hand/auto lockable lever shall be provided for emergency operation, of the MOV. The energization of the motor shall automatically re-engage power operation.

4.9 TWO WIRE CONTROL SYSTEM

4.9.1 Where specified on the Data Sheet of the MOVs shall be suitable for 2 wire control system. These MOVs shall have individual field units connectable to a master station through a single 2 core cable loop for control and monitoring of MOVs. The maximum number of field units that can be connected to a master station and the maximum distance from the field unit to the master station shall be indicated by the Vendor. The maximum number of control input and control/status output from each field unit that can be handled through the 2wire control system shall be indicated by the Vendor.

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4.9.2 Each field unit/MOV shall be addressable from the master station through a unique address code. Unless otherwise specified in the Data Sheet, all the field settable/adjustable parameters of the MOV shall be settable from the master station. Similarly all the indications available on the MOV shall be available at the master station. Full diagnostic feature for the MOV shall be available from the master station as well.

4.9.3 In case of a fault at any location in the cable loop the field units shall still have the accessibility to/from the master station through the other side of the cable loop. The master station shall be suitable for hook-up with the plant DCS system.

4.10 POSITION INDICATOR

4.10.1 The position indicator shall continuously indicate the position of travel of the valve. If specified in the Data Sheet a 4-20 mA remote position transmitter shall be provided in the valve actuator and one number continuous position indicator for mounting in Purchaser's remote panel shall be supplied as a loose item.

4.11 NAME PLATE

4.11.1 Each motorized valve actuator shall be provided with a stainless-steel name plate attached firmly to it at a place convenient for reading, furnishing the following details. A separate name plate shall be provided for hazardous area application.

a. Actuators tag number as per Data Sheet.
b. Motor KW rating, motor time rating, motor supply voltage, phase nominal motor current, auxiliary switch rating.
c. Max. Torque setting.
d. Actuator enclosure type, lubricant type.
e. Actuator type, wiring diagram number/catalogue number, actuator serial number.

4.11.2 The enclosure of complete MOV actuator, including motor, integral starter and control transformer unit and all control devices shall have minimum IP-65 ingress protection.

4.11.3 WIRING AND TERMINALS

4.11.4 All devices provided in the actuator shall be wired up to the terminal block. The contacts for the remote operation and indication shall be wired up to the terminal block. 20% spare terminals shall be provided for future interlocks. Internal wiring for power and controls circuits shall be appropriately sized for MOV actuator rating. Each wire shall be identified at both ends using PVC ferrules. The terminal compartment shall be separated from the inner electrical components of the actuator by means of water tight seal so that the actuator electrical components are protected from the ingress of moisture and foreign materials when the terminal cover is removed during installation and maintenance.

4.11.5 Vendor shall be solely responsible for selection and sizing of various electrical devices.

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4.12 EQUIPMENT FOR CLASSIFIED AREAS

4.12.1 Actuators meant for hazardous area shall meet the requirements of IS:2148, IEC 79 or equivalent International Standard and shall be suitable for gas group IIB, temp. class T3 (200°C). Indigenous equipment shall be certified by CMRI and approved by CCE and shall carry the BIS license marking. Imported equipment shall be tested and certified by an independent certifying agency of country of equipment origin.

5.0 INSPECTION AND TESTING

5.1.1 The equipment shall be subject to inspection by Consultant/Owner or by an agency authorized by the Owner. All necessary information concerning the supply shall be furnished to Consultant’s/Owner's inspectors. Two weeks’ notice shall be given to Consultant/Owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of the MOV.

5.1.2 Routine tests shall be carried out at the manufacturer’s works under his supervision and at his own cost. Type test certificates shall be furnished with bids. Final acceptance of MOV at site shall be subject to successful testing of the MOV actuator with valve.

6.0 MARKING, PACKING AND SHIPMENT

6.1.1 The electrical motor operated valve actuator shall be shipped to site packed in wooden crates. They shall be wrapped in polyethylene sheets before having placed into the crates to prevent damage to the finish. Crates shall have skid bottom for handling.

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STANDARD SPECIFICATION
FOR
UNINTERRUPTED POWER SUPPLY

VCS – SS – EL - 4011

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REVISION RECORD

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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
CRCA	Cold rolled cold annealed
UPS	Uninterrupted Power Supply
DCS	Distributed Control System
IGBT:	Insulated Gate Bipolar Transistor
SMPS	Single Mode Power Supply
RMS	Root Mean Square
LCD	Liquid Crystal Display

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1.0 SCOPE

1.1 The scope of this Specification is to define the requirements of design, manufacture, testing, packing and dispatch of static Uninterrupted Power Supply (UPS) system.

1.2 Deviation from this specification shall be acceptable only when the manufacturer shall inform the deviation in quotation before placing the order & shall take the necessary written approval for deviation from the Consultant / Owner. In absences of a list of deviation, it will be assumed that the Manufacturer complies fully with this specification.

2.0 REFERENCE DOCUMENTS

2.1 The equipment shall comply with the requirements of latest revision of 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 (Part1,2, 4 and 9) instruments and their accessories
IS: 2147:	Degree of protection provided by enclosures for low voltage Switchgear and control gear.
IS: 3700:	Essential ratings and characteristics of semi-conductor (Part I to 11) devices.
IS: 3715:	Letter symbols for semi-conducting devices. (Part 1 to 4)
IS: 4411:	Code for designation of semi-conductor devices.
IS: 5001:	Guide for preparation of drawings of semi-conductor devices (Part I & 2) and integrated circuits.
IS: 5469:	Code of practice for the use of semi-conductor junction (Part 1 to 3) devices
IS: 7204:	Stabilized power supplies D.C. output (Part 1 to 4)
IS: 12021:	Control transformers for switchgear and control gear for voltages not exceeding 1000V AC
IS: 13314:	Solid state inverters run from storage batteries
IS: 13703:	Low voltage fuses for voltage not exceeding 1000V AC or (Part 1 to 4) 1500V DC
IS: 13947:	Specification for low voltage switchgear and control gear (Part-4 / Sec-1)

2.2 In case of imported equipment's Standards of the country of origin shall be applicable Standards are equivalent or 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 Sheet and statutory regulations, the following order of priority shall govern:

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a. Local Statutory Regulations
b. Data Sheets
c. Job Specification
d. This 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 UPS panels, ACDB 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 1.6mm thick CRCA sheet steel. Wherever required suitable stiffeners shall be provided.

4.2 The panels shall be free standing, fitted with suitable louvers for ventilation and cooling fans as required. Hinged doors shall be provided at the front and back with dust tight gaskets. Inter panel sheet steel barriers shall be provided. The enclosure shall provide minimum IP-42 degree of protection, if not specified otherwise in the Data Sheet. The maximum and minimum operating height of the switches shall be 1800 mm and 300 mm respectively.

5.0 DESIGN

5.1 GENERAL REQUIREMENTS

5.1.1 The offered equipment shall be brand new with state of art technology and 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 for placement of order for spares and services.

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5.1.4 The UPS system shall be an integrated system comprising static rectifiers, battery, static inverters, static switches, auto / manual by pass switch, AC distribution board, voltage stabilizer in bypass, 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.

5.1.5 The UPS system shall be suitable to feed all loads connected to the output which are primarily instruments, (DCS), computers, disc drives and other SMPS equipment leading to high crest factor of the load.

5.1.6 The inverter shall be thyristor / transistorised (IGBT) type or with the latest proven technology. All components shall be of a high quality and reliability that satisfy with the requirements of a secure AC power to vital equipment with respect to performance, controlling, monitoring and safeguarding function in continuously operating petrochemical process units, petroleum refineries, gas processing facilities, utility and other miscellaneous industrial plants. Components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short circuits and switching surges etc.

5.1.7 The design of the UPS shall be such as to minimize the risk of short circuits and shall ensure human and operational safety.

5.1.8 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 enclosed data sheets. Selection, sizing and suitability of all equipment and components used for UPS system shall be Vendor's responsibility.

5.1.9 The UPS shall be single phase or three phase system as indicated in the Data Sheets.

5.1.10 For the Batteries detail see technical requirement.

6.0 TECHNICAL REQUIREMENTS

6.1.1 INPUT POWER SUPPLY

a. The UPS shall be suitable for input power supply as defined in the Data Sheet. If not specified therein the UPS shall be suitable for the following input power supply.

   Voltage 415V ± 10%

   Frequency 50 Hz ± 3%

b. In addition to above variations, the input voltage may be subjected to transient variations comprising voltage dip to 20% of normal voltage during motor start-up as well as voltage variations due to fault condition. UPS system shall be designed to operate satisfactorily while deriving the input power from an emergency diesel generator set.

c. UPS system shall also operate satisfactorily on input power supply having:

   i. the ratio of negative to the positive sequence components not exceeding 5% and

   ii. Total harmonic distortion of not more than 5%.

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d. Total Harmonic Distortion is the ratio in percentage of r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component of alternating quantity.

e. The incoming power supply to UPS will be provided by 2 Nos. feeders. one feeder shall feed the rectifier(s) while other shall supply power to stabilized bypass supply.

6.1.2 UPS CONFIGURATION AND OPERATIONAL REQUIREMENTS

The UPS system shall have one of the following basic configurations as specified in Data Sheet and drawings:

a. Single UPS with Bypass

i. In UPS system having this configuration a single rectifier and inverter shall be provided. Under normal conditions when AC mains power is available, the rectifier shall simultaneously feed DC power to inverter as well as for float/rapid charging of the battery. The AC supply to loads shall be fed from inverter output. In case of any fault in the inverter, the load shall be automatically transferred to stabilized bypass supply and retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

ii. In case of AC input power failure or battery charger failure, the battery shall supply power to inverter without any interruption. The charger shall be designed for simultaneously feeding complete inverter load and for float/rapid charging the battery to its rated capacity. Charger shall be equipped with 'On Line' automatic as well as manual charging facility.

b. Parallel Redundant UPS with bypass

i. In UPS system having this configuration two sets of rectifiers and inverters shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the battery and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the battery without any interruption. In case of incoming supply failure or failure of both rectifiers the battery shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the battery to its rated capacity. Each rectifier shall be equipped with 'On Line' automatic as well as manual charging facility.

ii. Normally both inverters will be synchronized with each other and with stabilized bypass supply. Both inverters shall operate in parallel and share the load equally. When a disturbance/fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

c. Parallel Redundant UPS

i) In UPS system having this configuration two sets of rectifiers and inverters shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the battery and simultaneously to inverters. In case of failure in one rectifier, the other

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rectifier shall feed the complete load and the battery without any interruption. In case of incoming supply failure or failure of both rectifiers the battery shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the battery to its rated capacity. Each rectifier shall be equipped with 'On Line' automatic as well as manual charging facility.

ii) Normally both inverters will be synchronized with each other. Both inverters shall operate in parallel and share the load equally. When a disturbance/fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter.

d. Hot stand-by Redundant UPS with bypass

i. In UPS system having this configuration, the arrangement of rectifiers/inverters and the operating philosophy is same as described above, except that only one inverter shall be operating at one time. The other inverter shall not be sharing the load but shall be synchronized with the running inverter and stabilized bypass supply and remain ready to accept the load in case of fault in the running inverter. Retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

ii. In all UPS configurations, the facility for uninterrupted manual transfer in either direction through static switches shall also be provided.

iii. For ease of maintenance, it shall be possible to isolate inverters and static switches from load through manually operated make before break switches. In case of larger rating UPS, where it is not possible to provide one power switch with make before break feature, combination of breakers with the control scheme having make before break logic may be provided which ensures momentary paralleling before tripping of selected breaker.

6.1.3 UPS DESIGN AND PERFORMANCE REQUIREMENTS

a. Incoming AC supply shall be converted to DC through three phases full wave-controlled rectifiers. The rectifiers shall operate according to the constant voltage current limiting principle and shall incorporate a "Soft Start" feature to gradually accept load on initial energizing.

b. The rectifier section of the UPS system shall be capable of precise regulation to prevent damage to the battery. The output voltage of rectifier's DC bus without the battery shall be stabilized to within ± 1% of set value during load variation between 0 to 100% of the rectifiers and specified mains input supply voltage variation.

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

d. The UPS system including the stabilized by-pass shall be galvanically isolated from input power supply system by providing double wound transformers. All transformers shall be natural air cooled, dry type suitable for location inside the panel. All rectifiers shall also have a double wound transformer at its input.

e. An RFI filter shall be provided. The production of radio frequency interference voltage shall not exceed the value of suppression grade N' as defined in VDE-0875. The performance of UPS system shall not get affected or in any way be degraded by the

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use of portable radio transmitter receiver in the vicinity of the UPS system and or UPS room.

f. Transient/surge protection circuit shall be provided in the input circuit to rectifiers to protect the UPS from surges & voltage spikes.

g. The UPS system shall be designed to draw power from mains supply at a minimum power factor of 0.85 while working at rated load in normal operating UPS configuration.

h. The UPS shall be provided with automatic sequence and power walk in circuit(s) with time delay of up to 15 sec. such that the rectifiers and inverters can start operating automatically when incoming AC power is restored allowing the UPS to be loaded automatically.

i. Facility for initial charging of batteries shall also be provided. The inverters may be disconnected during initial charging of the battery.

j. For battery sizing, the following factors shall be considered unless specified otherwise in the Data Sheet:

   i. Load Power Factor of 0.8.

   ii. Minimum ambient temperature as specified in Data Sheet.

   iii. Battery Current $= \dfrac{\text{Inverter rated KVA x Rated load p. f.}}{\text{Inverter Efficiency* x End cell voltage No. of cells}}$

   * At 50 % load on each inverter for parallel redundant UPS.

   iv. Aging factor of 0.8.

   v. Back up time of 8 / 10 / 12 hours in case of mains power failure unless specified otherwise in Data Sheet.

   vi. Minimum end cell voltage for lead acid/VRLA battery 1.85 V per Cell and 1.0 V per cell for Ni-Cd battery.

   vii. Battery state of charge factor of 0.95.

k. The rectifiers/chargers shall be designed to completely charge the Lead acid and Nickel cadmium batteries in a maximum time of 8 / 10 / 12 hours after complete discharge. Facilities shall be provided to initiate battery rapid charge operation by manual & automatic means. An auto charging sequence should be provided for the rapid and float charging based on current sensing. Battery charger for VRLA battery shall be sized to provide boost charging of the battery up to 90% of rated Ampere hours within duration of 24 hours and to 100% within 4 days. In addition to above, the charging shall he transferred from rapid to float mode after a preset time adjustable through 0-24 hours timer as back up protection against overcharging.

l. The rectifiers shall be sized based on the maximum inverter input load when inverter is delivering its rated output at 0.8 p.f. lagging and recharge the battery to nominal rated capacity of the battery. The DC load imposed by the inverters shall be considered under the most severe operating conditions where only one rectifier is operating but the UPS load is equally shared by all the inverters. The rating of each rectifier shall be not less than the value calculated as follows:

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For Lead Acid Batteries = Inverter input current + 0.14Ah (10 hr. Rating of the battery)

For Nickel Cadmium Batteries = Inverter input current + 0.2Ah (5 hr. Rating of the battery)

For VRLA Batteries = Inverter input current + 0.2Ah (10 hr. Rating of the battery)

$$\text{Where Inverter input current} = \frac{\text{Rated KVA capacity of UPS x Load power factor}}{\text{Battery charging voltage x Inverter efficiency}}$$

m. The DC rectifiers shall sense the battery charging current and adjust the DC bus voltage to maintain the charging current to preset level. A separate current limit circuit shall also be provided for adjustment of battery current. The rectifiers shall be protected against reverse battery connection at DC link voltage bus. Subsequent to a discharge cycle when battery is connected to rectifier, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the inverter input current.

n. The battery may be taken out of service for maintenance, during which period it shall be possible for the inverter to continue operation by drawing power from the rectifier. Ripple content at the DC link shall not exceed 2% even with battery disconnected.

o. Battery / D.C. link shall be provided with a sensitive earth leakage protection.

p. The inverter shall be of the current limiting type (short circuit proof) and have nominal output voltage and frequency as specified in the data sheet. The inverter output voltage and frequency shall not exceed the operational tolerances, as measured at the output terminals of the unit during the following conditions of UPS loading:

i. Load variations between 0-100% of the rated output of UPS

ii. Load power factor over the range of 0.7 lagging to unity.

iii. Load current waveform having a relative harmonic content varying between zero and50% the latter waveform having a crest factor not exceeding 2.5 and individual harmonics not exceeding the following values:

- 3rd harmonic- 44% of fundamental
- 5th harmonic- 33 % of fundamental
- 7th harmonic- 1.8 % of fundamental
- 9th harmonic- 7% of fundamental
- 11th harmonic-10% of fundamental

iv. The Relative harmonic content is the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the total non-sinusoidal periodic waveform i.e. relative harmonic content =

$$\sqrt{\left[1-\left(\frac{\text{Rms value of the fundamental component of the current or voltage}}{\text{Rms value of total waveform of current or voltage}}\right)^2\right]}$$

v. The UPS output voltage waveform shall be pure sine wave under linear load conditions, and not exceeding 5% under the non-linear load conditions specified above.

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q. The inverter shall control the output voltage of the UPS such as to maintain synchronism with the mains bypass voltage during variations in mains frequency up to the limits specified.

   During variations in mains frequency exceeding these limits, the inverter shall revert to internal frequency control.

r. It shall be possible to vary the inverter output voltage steplessly within ± 5% of the specified output voltage. This adjustment shall be possible to be made when the inverter is in operation.

s. The steady state output voltage and frequency (free running) variation of inverters shall not exceed ± 1% from the set value for specified input power supply conditions from no load to full load condition and load power factor variation from 0.7 lag to 1.0.

t. The UPS system shall be able to operate satisfactorily on rated loads (in KVA) with power factors in the range of 0.7 lag to 1.0. The overall efficiency of the UPS system shall not be less than 80% at rated load and 0.8 p.f.

u. The UPS shall have capacity to deliver a minimum overload of 125% for 10 minutes and 150% for 10 sec. UPS shall be provided with current limit circuit to avoid excessive loading beyond its permissible overload withstand capability.

v. The inverters shall be 'phase locked' to the stabilized bypass power supply as long as stabilized bypass supply frequency remain within ± 4% of nominal. When bypass supply frequency variation, exceeds the above limits, the inverters shall be delinked from mains. Free running frequency tolerance limit shall not exceed ± 1%. Facility shall also be provided for adjustment of range of synchronizing frequency.

w. Unless otherwise specified, the UPS system output voltage variation shall not exceed ± 10% and complete recovery to normal steady state shall be within 0.1 Sec. The above requirement shall be complied for following transient disturbances.

   i. 100% step load and unload (For single UPS and hot stand by UPS)
   ii. 50% step load (for parallel redundant UPS)
   iii. Momentary interruption in power supply
   iv. Load transfer to stabilized bypass supply
   v. Complete load transfer to other healthy inverter when one of the two parallel inverters develop a fault.

x. For 3 phase UPS system, the maximum output voltage and angle variation between the phases should not exceed 5% and 3 degrees respectively even under the condition of 100% unbalanced loading of the 3 phase output.

y. UPS system shall be suitable for floating output in case of single phase system.

z. The stabilized bypass supply shall be designed to regulate the output voltage within ±2% of the rated voltage over complete range of load from no load to full load and for specified input supply voltage variation. The type of Voltage stabilizer in stabilized bypass supply shall be as indicated in data sheet.

aa. The stabilized bypass supply shall have a continuous current rating equivalent to the rated output of the UPS unit and be capable of conducting a current ten times the rated output for the duration more than the fault clearing time of the type of fuse provided. The load transfer devices shall comprise of continuously rated static elements in both inverter and stabilized bypass supply.

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bb. Adequately rated static switches in required number & configuration shall be provided in the inverter(s) output and stabilized bypass supply to ensure positive isolation of faulty inverter section such that the other inverter and bypass circuits do not feed into the fault leading to under voltage / trip. The short time rating of all the static switches shall be at least 10 times the rated output for the duration more than the fault clearing time of the type of fuse provided.

cc. Facility shall be provided to manually and automatically initiate transfer of the load from inverters to the stabilized bypass supply and from stabilized bypass supply to the inverters. Under voltage and over voltage sensing levels to initiate transfer shall be adjustable. The maximum transfer time between inverters and bypass supply shall not exceed 4 msec and 20 msec in synchronous and asynchronous mode respectively.

dd. The criteria for load transfer:

i. Load transfer from inverter to the stabilized bypass supply shall be as follows:

- The load transfer shall only be possible when:
  - The stabilized bypass output voltage is within ± 5% of rated UPS output voltage and the mains bypass frequency is within ± 4%.
  - Auto-transfer of the load from inverter to stabilized bypass supply shall be inverted when:
  - The inverter output voltage drops below 95% of nominal output voltage under steady state condition and/or if the inverter output voltage falls below 90% of the nominal value under transient conditions.

    OR

  - The inverter output voltage exceeds 105% of the nominal output voltage under steady state condition and/or if the inverter output voltage reaches 110% of the nominal value under transient conditions.

    OR

  - The inverter output current exceeds its tolerable limits.

ii. Retransfer of load from stabilized bypass supply to the inverter shall be as follows:

- The load transfer shall be possible when:
  - The inverter output voltage is within ± 5% of nominal output voltage for more than 5 sec. and
  - Inverter output and stabilized bypass supply are synchronized.

Retransfer of load from stabilized by pass to the inverter shall be done manually only unless otherwise specified in the Data Sheet.
If automatic retransfer of load to the inverter is specified in the Data Sheet, then the retransfer of load to the inverter shall be inhibited following four automatic transfers of load to stabilize by pass within a period of 5 minutes.

ee. All breakers shall be adequately rated for continuous rating as well as breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All output isolating device shall be double pole type.

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ff. All electronic power devices including thyristors, transistors (IGBTs), diodes etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device. All other electrical components such as transformers, reactors, breakers, contactors, switches, bus bars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall be subjected to PIV greater than 50% of its rated value.

gg. All the thyristors, power transistors, diodes and other electronic devices of UPS shall be protected with high speed semiconductor fuses. I^2t co-ordination between fuse and semi-conducting power devices shall be ensured.

hh. The outgoing circuits of ACDB shall be protected by semiconductor fuses. Each inverter shall be designed to clear a fault in any of the branch circuits upto a maximum rating of 25 % of the system capacity without the assistance of the stabilized bypass supply. In case of any fault in branch circuits, the load connected to the healthy circuits shall not get affected. The fault clearing time shall be less than 4 msec.

ii All PCBs shall be provided with a transparent epoxy coating for environmental protection and tropicalisation. They shall be suitably located away from heat sources.

jj. All electronic control and monitoring printed circuit cards shall be installed in Standardized electronic equipment frames and shall be fitted with suitable means for easy removal. The frames shall incorporate guides for PCBs to facilitate correct insertion of PCB's and shall allow access to the wiring side of the connectors. All PCBs shall be placed in a manner to avoid replacement of a PCB by a wrong spare PCB. Monitoring points shall be provided on each of the PCBs and the PCB shall be firmly clamped in position so that vibration or long usage does not result in loose contacts. Failure of each PCB shall be indicated by visual alarms. Visual fault diagnostics shall preferably identify faults up to various sections in the card.

kk. Forced ventilation of panel, if provided, shall be supplemented by 100% redundant fans. In normal operation, normal & redundant fans shall run together. The power supply for the fans shall be tapped from the inverter output. However, the rating of the UPS as specified in the Data Sheet shall be the net output of UPS after deducting power consumption for fans etc. However in case of non-operation of 50% of running fans the UPS output shall not be affected. The fans shall be arranged to facilitate removal of faulty fan for maintenance without requiring system shutdown.

iii. Maximum noise level from UPS system at 1meter distance, under rated load with all normal cooling fans shall not exceed 75dBA.

6.1.4 CELL BOOSTER

a. Cell booster shall be suitable for charging one to six cells within a time duration as specified. It shall be suitable for charging not only the new cells before being introduced to the battery bank but also any treatment to be given to the individual weak cells. Quantity of such boosters shall be as defined in the MR. Cell booster shall be suitable for 240 V ± 10%, 50 Hz ±3% 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:

I. For Lead Acid battery = 0.14 x Ah of cell (10 hr. Rating of the cell)

II. For VRLA battery = 0.2 x Ah of cell (10 hr. Rating of the cell)

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III. For Ni-Cd battery = 0.2 x Ah of cell (5 hr. Rating of the cell)

b. Cell booster shall have heavy duty switch fuse or MCCB on AC incomer and DC output, AC voltmeter, DC ammeter and voltmeter, indicating lamp for AC/ DC power ON. The output voltage and current of cell booster shall have manual control 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 and braided cable for AC incomer power supply and DC output connection to the battery.

6.1.5 A.C. DISTRIBUTION BOARD

a. Sheet steel enclosed AC distribution board shall be provided as part of the complete UPS package. It shall accommodate AC feeders as indicated in the Data Sheet. The distribution board shall be floor mounted fixed type with compartmentalized construction unless otherwise indicated in the Data Sheet. It shall be possible to operate the switches without opening the doors. Switches shall be provided with door interlock. Vertical cable alley of minimum 200mm width with suitable supports shall be provided for the termination of outgoing cables. Suitable supports shall be provided for supporting incoming and outgoing cables. All outgoing switches shall be air insulated load break type. Fuses on outgoing feeders shall be fast acting semiconductor type and cable entry shall be from bottom. The gland plate of the distribution board shall be non-magnetic type where single core cables are used as specified in the Data Sheet. Cable glands shall be of brass and single compression type and cable lugs shall be of tinned copper.

6.1.6 ALARM, CONTROL, INDICATION AND METERING REQUIREMENTS

If not specified otherwise in the Data Sheets, following schedule shall be followed for alarm, control, indication and annunciation. Any additional devices/features considered necessary for reliable operation and maintenance shall also be included in various panels and same shall he highlighted separately.. An illuminated one line diagram indicating operational status shall be provided on the front of the panel, metering, indications, audio-visual alarm shall be provided. Parameters/ information indicated shall be available in LCD panel or by other means directly or indirectly.

a. Metering

i. Rectifier

- Incoming line voltages (For all the three phases).
- Input line currents.(For all the three phases).
- D.C. voltage at each rectifier output.
- Battery current.

ii. Inverters

- AC voltage at each inverter output (AC voltages for 3 phase inverter).
- AC current at each inverter output (AC currents for 3 phase inverter).
- Frequency meter at each inverter output.

iii. Stabilised bypass supply

- Frequency meter for incoming supply.
- Voltmeter with selector switch for incoming supply.

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- Ammeter with selector switch for incoming supply.

iv. ACDB

Following shall be provided for each of the ACDB incomers:

- Voltmeter (voltmeter selector switch shall also be provided for 3 phase inverter).
- Ammeter (ammeter selector switch shall also be provided for 3 phase inverter).
- Power factor meter.

b. Indications

All indication lamps shall be provided with series resistors. Clustered/Jumbo LED's of minimum 10mm dia. may be provided in place of lamps subject to their having at least equal illumination.

- AC mains 'ON' - Rectifier.
- AC mains `ON' - Bypass.

i. Rectifiers (for each rectifier)

- Rectifier output 'ON'
- Battery on float charge
- Battery on rapid charge

ii. Inverters (for each inverter)

- DC input 'ON'
- Load on inverter
- Inverter synchronized with mains

iii. Load on bypass

c. Audio-Visual Alarm (separately for each circuit)

- Mains failure
- Battery charger failure
- Battery fault
- Inverter temperature high
- Low voltage from inverter
- Load on bypass
- Inverter overloaded
- All power Fuse failures

i. 2 nos. changeover contacts shall be wired to the terminal strip, 1 no for common remote alarm of 'UPS fault' in owner's panel and 1 no. for load on bypass supply annunciation.

d. Controls

- All the switches for starting, shut down and testing sequence.
- Primary input circuit breakers for feeding chargers, bypass line and dc bus from battery including backup protection.
- Inverter ON/OFF switch (to initiate inverter operation).
- Static switch transfer test Push Button.

6.1.7 RELIABILITY

All necessary care shall be taken in selection, design, manufacture, testing and commissioning of the equipment for ensuring high system reliability. Following design consideration shall be taken into account to ensure maximum availability of the system.

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a. There shall be no common device, between main and redundant units (e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.

b. It shall be possible to take out any individual power circuit for maintenance without affecting the total UPS supply.

c. Series-parallel combination of smaller devices to achieve required rating shall not be acceptable.

d. Vendors shall offer their nearest higher Standard size that will meet the requirement of the specified UPS rating.

6.1.8 FAULT DIAGNOSTIC UNIT

a. If specified in the Data Sheet, each UPS set shall have provision for adding microprocessor based 'ON line' fault diagnostic unit. This shall supervise the UPS operation continuously. It shall identify and locate faults immediately so that corrective action can be taken. Fault Diagnostic unit shall be compatible to hook up with Owner's PC through RS232/RS485 interface. The software shall be provided on a CD ROM.

b. The fault diagnostic unit shall have provision for automatic print out facilities for time, input/output voltages, currents, frequency as a minimum under the following conditions.

- UPS power source changeover from mains to battery.
- UPS power source changeover from battery to mains.
- Changeover from inverter to stabilized bypass supply and vice versa.
- Changeover from one inverter to other inverter.
- Changeover time in case of inverter to stabilized bypass supply and from one inverter to other inverter.
- UPS failure.
- Type of failure incident along with diagnostic report.

c. In addition to the above, any other feature which vendor feels may be useful shall be provided and highlighted separately.

d. If any additional equipment (e.g. bin connector, adaptor cards etc.) are required for connecting this unit with UPS system as well as with Owner's PC. The same are also to be included in the vendor's scope.

7.0 FABRICATION

7.1 Rectifier/charger and inverter, stabilized bypass supply and static switch sections shall be suitably housed in sheet steel panels complete with all interconnections.

a. UPS panels, ACDB 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 1.6mm thick CRCA sheet steel. Wherever required suitable stiffeners shall be provided.

b. The panels shall be free standing, fitted with suitable louvers for ventilation and cooling fans as required. Hinged doors shall be provided at the front and back with dust tight gaskets. Inter panel sheet steel barriers shall be provided. The enclosure shall provide minimum IP-31 degree of protection, if not specified otherwise in the Data Sheet. The maximum and minimum operating height of the switches shall be 1800 mm and 300 mm respectively.

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7.2 Power cables shall be with aluminum / copper conductors and control cables shall be with copper conductors. All the cable connections shall be from bottom and front of the panel, if not specified otherwise in the Data Sheet. A removable bolted gland plate shall be provided along with single compression type nickel plated brass cable glands for external cable connections. Clamp type terminals shall be used for connection of all wires up to 10 mm^2. Bolted type terminals suitable for cable lugs shall be provided for wire size above this. Tinned copper lugs for all external connections shall be provided with the panels.

7.3 Bus bars shall be used in all power circuits which are rated minimum 100 Amp. Copper conductor PVC insulated cables or wires of 660V grade shall be used for power circuits rated less than 100 Amp. 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 name plate and device tag numbers as per the schematic diagram. All wires shall be ferruled and terminals shall be numbered.

7.4 MCCBs and load break power switches shall be mounted inside the panel. The control switches shall be rotary type, mounted on the door and shall be externally operable. An11 W CFL lamp controlled through a door switch shall be provided for illumination in each panel. All instruments shall be analogue/digital, switchboard type, back connected, (72x72) mm. square (Analogue type) of reputed make. Analogue instruments scale shall have red mark indicating maximum permissible operating rating. Separate test terminals shall be provided for measuring and testing of the equipment to check the performance.

7.5 A suitably sized earth bus shall be provided at the bottom of the panels including ACDB running through the panel’s line up with provision for earth connection at both ends to purchaser's main earth grid. The minimum size of earth bus shall be (25x3) mm copper (or equivalent aluminum). All potential free metallic parts of various equipment shall he earthed suitably to ensure safety.

7.6 All panels shall be of same height so as to form a panel lineup which shall have good aesthetic appearance.

7.7 Inside the panels, the controls connections shall be done with 660V grade PVC insulated wires having stranded copper conductors: 1.5 mm2 size wire shall normally be used for circuits with control fuse rating of 10 Amp. Or less. For control circuit having fuse of 16 Amps., 2.5 mm2 size wire shall be used. Control wiring for electronic circuits shall he through flat ribbon cable or through copper wire minimum of 0.5 mm dia.

7.8 All control wiring shall preferably be enclosed in plastic channels or otherwise neatly bunched together. Each wire shall be identified at both ends by PVC ferrules. Ferruling of wires shall be as per relevant IS.

7.9 All metal surfaces shall be thoroughly cleaned and de-greased 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 yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finished coat.

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7.10 After preparation of the under-surface, the panels shall be spray painted with two coats of epoxy-based final paint or shall be powder-coated. Spray painted finished panels shall be dried in stowing ovens in a dust-free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc. The vendor shall furnish the painting procedure along with the bids.

8.0 INSPECTION AND TESTING

8.1 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's/Owner's inspector. Tests shall be carried out at manufacturer's works under his care and expense.

8.2 UPS system shall be tested in accordance with applicable Standards. The following acceptance tests shall be performed on each ups system as a minimum. All tests shall be witnessed by Owner or its authorized representative and 4 weeks prior notice shall be given before the date of commencement of tests. The tests certificates indicating test results shall be furnished.

Following system acceptance tests shall be conducted on each UPS system:

8.2.1 INSULATION TESTS

a. Insulation tests shall be performed as per IEC 60146-1-1.
b. The insulation tests shall be carried out using an AC power frequency voltage or by using DC Voltage at the choice of the vendor. In 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, 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.
c. 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.

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

8.2.2 INTERCONNECTION CABLE CHECK

The interconnection cables are to be checked for correct wiring, insulation and quality of the terminations

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8.2.3 A.C. INPUT FAILURE TEST

The test is performed with the test battery and carried out by tripping a.c. incoming circuit breakers or by switching off rectifiers and bypass supply at the same time. Output voltage and frequency variations are to be checked for specified limits.

8.2.4 A.C. INPUT RETURN TEST

The test is performed by closing A.C. incoming circuit breakers or is simulated by energizing rectifiers and bypass supply. Proper operation of rectifiers starting and voltage and frequency variations of output are to be checked.

8.2.5 SIMULATION OF PARALLEL REDUNDANT UPS FAULT

The test is applicable for UPS with parallel redundant configuration. Fault of rectifier or inverter are to be simulated and output transients are to be recorded.

8.2.6 TRANSFER TEST

Transients shall be measured during load transfer from inverter to bypass supply caused by simulated fault and load retransfer after clearing the fault.

8.2.7 REGULATION TEST

a. This test shall be carried out by measuring input voltage, input current, output voltage, output current, DC link voltage, output distortion, input active power, output active power and frequency at no load, 50% load and 100% load at 0.7 and 0.8 p.f.

b. Following parameters of rectifiers and inverters are to measured:

   i. Measurement shall be carried out in the rectifier float charge mode and in rapid charge mode. Measurement shall be at nominal A.C. voltage and at no load, 50% load and 100% of rectifier full load. Rectifier measurement shall comprise of:-

      - Input voltage, frequency, phase current and input power. D.C. output voltage and current.
      - Ripple current at the DC link bus shall be recorded after isolating the test battery.

   ii. Inverter measurement shall also be at no load, 50% load and 100% load of inverter rated output current and shall be repeated for inverter D.C. input voltages corresponding to battery float charge operation as well as rated inverter maximum and minimum input D.C. voltage. Measurement shall comprise of:

      - Input voltage, input current.
      - Output voltage, frequency and waveform distortion, output power and current.

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8.2.8 UPS EFFICIENCY

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

8.2.9 CURRENT DIVISION IN PARALLEL UPS

Load sharing between UPS units shall be measured with a dummy load under parallel redundant UPS configuration.

8.2.10 LIGHT LOAD TEST

The test is to verify that all functions of the UPS system operate properly. The load applied is limited to some percentage of rated loads. The following points are to be checked.

a. Output voltage and frequency and correct operation of meters.
b. Operation of all control switches and other means to put UPS system into operation.
c. Functioning of protective and warning devices

8.2.11 BURN-IN TEST FOR PRINTED CIRCUIT BOARDS

PCB's and other electronic components sub assemblies 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.

8.2.12 CONTINUOUS FULL LOAD TEST AT 0.8 POWER FACTOR WITH TEMPERATURE RISE MEASUREMENT

a. The test is required to be performed by connecting resistive load or resistive and inductive load to the UPS system output. The load shall be placed outside the test room to avoid influences of its heat upon UPS ventilation.
b. UPS system in this test shall undergo a complete full load test for 32 hours at 0.8 power factor. Out of these 32 hours, each inverter section shall be subjected to full load test for 8 hours. Both invertors sections operating in parallel shall be subjected to full load test for 8 hours and the for remaining 8 hours, the bypass section shall be subjected to full load test. Steady state temperature of rectifier transformer, Rectifier set, D.C. choke, inverter set, static switch etc. shall be recorded during the test. The temperature of all UPS panels is also to be recorded.

8.2.13 AUXILIARY EQUIPMENT AND CONTROL CIRCUIT TESTS

The correct functioning of all measuring instruments, alarms, indications, protection devices and controls are to be verified. The functioning of auxiliary devices such as lighting, cooling fans, annunciation etc. should be checked.

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8.2.14 SYNCHRONIZATION TEST

Frequency variation limits of inverter are to be tested by feeding bypass supply incoming line by variable frequency generator and inverter synchronization limit is to be checked as specified.

8.2.15 UNBALANCED LOAD TEST (FOR 3 PHASE UPS ONLY)

Unbalance load at specified limits is applied to the UPS system. The specified voltage and phase angle variation may be checked for compliance with specified values.

8.2.16 OUTPUT VOLTAGE UNBALANCE (FOR 3 PHASE UPS ONLY)

Output voltage unbalance shall be checked under symmetrical load conditions and unbalance load conditions. Phase to phase and phase to neutral output voltage are to he observed. The voltage unbalance is the ratio of highest phase voltage minus lowest phase voltage to the average value. Phase angle variation may be measured for phase to phase and phase to neutral voltages

8.2.17 OVERLOAD CAPABILITY TEST

Specified values of short time overload are to be applied for specified time interval. Values of output voltage and output current are to be recorded.

8.2.18 SHORT CIRCUIT CURRENT CAPABILITY TEST

Specified short circuit current capability is to be tested by application of a short circuit to UPS output if necessary via a suitable fuse. Short circuit current is to be recorded.

8.2.19 SHORT CIRCUIT FUSE TEST

Fuse tripping capability of the UPS system is to be tested by short circuiting the UPS system output via a specified rating of fuse. The test is carried out at an appropriate UPS load under normal operation.

8.2.20 RESTART

Manual restart to be tested after complete shutdown of UPS system.

8.2.21 OUTPUT OVER VOLTAGE

Operation of output over voltage protection is to be checked.

8.2.22 DYNAMIC RESPONSE TEST

Output recording at different loads and operating condition to be done.

8.2.23 HARMONIC COMPONENTS

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Harmonic components of output voltage are to be recorded at no load, 50% load and 100% load conditions. Harmonic voltages caused by UPS system components in the A.C. incomer side shall be recorded at site.

8.2.24 EARTH FAULT TEST

An earth fault is to be applied to the output terminal of UPS system. UPS output transients are to be measured. An earth fault is also to be applied to the battery terminal and UPS system output transient shall be measured.

8.2.25 AUDIBLE NOISE TEST

a. The audible noise is required to be measured at 1meter distance from UPS system in at least 4 to 5 locations and its value shall be within permissible limit.
b. The detailed test schedule and test procedure shall be formulated in line with above. Before giving call for the witness of the tests, vendor shall get Consultant approval on the test procedures. Vendor shall also indicate the max. Allowable tolerance for each test result along with the test procedures.
c. If tests show that certain requirements of the specifications are not met, 'Vendor' shall make necessary corrections to the equipment so that it satisfies all the requirements before acceptance is made.

8.2.26 SITE ACCEPTANCE TESTS

Vendor shall furnish Site Acceptance Tests procedure to be followed. Final acceptance testing along with the batteries shall be done at site. It shall be Vendor's responsibility to arrange necessary instruments and tools as required by their commissioning engineer for these tests.

9.0 MARKING, PACKING AND SHIPMENT

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling Special notations such as Fragile', 'This side up', ' center of gravity', `weight', 'Owner's particulars', `PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order. The equipment may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed.

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Energising Quality

VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION
FOR
SOLAR ELECTRIC POWER SYSTEM

VCS – SS – EL - 4012

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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
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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
VRLA	Value Regulated Lead Acid
Ni-Cd	Nickel Cadmium
AH	Amphere hour
MCCB	Moulded case circuit breaker
SCR	Silicon Controlled Rectifier

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1.0 SCOPE

1.1 This Specification provides the minimum requirements for the design, manufacture, testing and supply of the Solar Electric Power System to be installed. The Solar Electric Power System shall independently meet the power requirement of continuous loads as defined in Data Sheet.

1.2 The exact number of solar electric power systems along with loads connected to each system and the load rating of each system shall be as indicated in the equipment Data Sheet.

1.3 Each solar electric power system when installed in accordance with Vendor's instructions shall form self-sufficient power system to meet the power requirements of continuous loads.

2.0 REFERENCE DOCUMENTS

2.1 The equipment supplied shall comply with the requirements of the latest revision of the relevant standards of

NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
API	American Petroleum Institute
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
IEC	International Electro-technical Commission

2.2 Any other recognized international codes or standards may be used in lieu of the above, subject to the approval of the Company.

3.0 DEFINITION

3.1 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.

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4.0 DESIGN

4.1 POWER SYSTEM

4.1.1 Power system shall include the following equipment. Photovoltaic solar cell array (solar panels). Battery bank solar power controller the solar power system shall be self sustained type. The photo voltaic solar cell array (solar panels) and the solar controller shall be sized to meet through battery back-up, the load cycle requirements of the connected loads with the solar energy availability at site under worst weather conditions the load requirement per day shall be determined on the basis of load data specified in the Data Sheet.

4.2 SOLAR PANELS

4.2.1 The photovoltaic solar panel array shall consist of required number of individual solar panels. The individual photovoltaic elements shall be connected in suitable series-parallel combinations to obtain the required voltage and current rating of a solar module. Individual solar modules shall be connected in suitable series parallel combinations to obtain the required voltage and current rating of a solar panel. Solar panel array shall consist of required number of panels in series-parallel combination to meet the System requirements.

4.2.2 The Solar panels will be mounted on steel support structure of suitable height on the control room roof top.

4.2.3 The solar panel array shall be designed based upon isolation data (to be gathered by contractor from metrological department) and following design conditions:

A. Output current to be considered at operating point based on following operating conditions:

I. Cell temperature while delivering current corresponding to P max point on the I-V curve at specified ambient temperature.

II. Operating voltage considering:

- Charging voltage of the battery.
- Voltage drop sin cables between solar array and solar, controller and solar controller and battery.
- Voltage losses in solar controller.
- Negative tolerance, if any, on the output voltage at solar controller.

4.2.4 After working out the output current at operating point, the following de-rating factors shall be applied:

a. Deterioration factors over life span or 15% whichever is higher.
b. Losses due to dust deposit or 1% whichever is higher.
c. Losses due to module/branch mismatch or 2% whichever is higher.
d. Losses due to line resistance cables (panel to controller).

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e. Losses in field wiring and array wiring. Losses in solar controller.
f. Battery charge/discharge efficiency or 93% whichever is lower.
g. Any other de-rating factor considered essential for satisfactory and guaranteed performance of Solar Power System (e.g. negative tolerance on nominal rating of solar panels)
h. De rating factor of 2% or as applicable (whichever is higher) to account for panel orientation other than the specified one as per insulation data.
i. The solar panels shall be able to fully charge the battery bank after "3 NO SUN DAYS" cycle from the surplus power available from the solar panel in next 14 days with 70% Depth of Discharge of battery.

4.3 BATTERYBANK

4.3.1 Battery Cells

a. The battery bank shall be charged from the surplus power available from the solar panel when the sunlight is available and will supply/supplement the solar electric power from the solar panel when the sunlight is inadequate under cloudy condition and during nights. The battery cells shall be low self discharge (up to 3% at 27°C per month) Ni-Cd suitable for photovoltaic application. The battery cells shall be provided with flame arresting type catalytic caps or ceramic plugs. The type of battery cells shall be as specified in equipment Data Sheet.
b. The battery shall incorporate the following features:
   i. High charging efficiency.
   ii. Good cycle life even for deep discharge.
   iii. Extended life expectancy.
   iv. Long maintenance interval Maintenance free for VRLA battery cell.
   v. Large electrolyte reservoir.
c. The type, AH capacity and no. of cells in the battery bank shall be decided on the following basis:
   i. Geographical and climatic conditions prevalent at site.
   ii. Back-up during low insulation periods considering the de-rated solar panel output and insulation data.
   iii. Unless specified otherwise, the system voltage shall be 12 V (Nominal).
   iv. Battery suitable for4000or more charge-discharge cycle for 10%depthof discharge and for 1600ormore charge dischargecyclefor70% depth of discharge.
   v. 70%Depth of Discharge.
   vi. Minimum3 days back up to independently feed the load, plus, losses, if, any.
   vii. Design ambient temperature minimum and maximum site temperatures as given in Specification-"Site Conditions and Climate".
   viii. Deterioration-factor over the life span (Actualor20% whichever is higher).
   ix. Weight of individual cell shall be of the order of 55 Kg
   x. Self discharge during low insulation periods considering average ambient temperature of 30°C.

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4.3.2 The battery shall be able to fully charge after"3 no sun days" cycle from surplus power available from the solar panel in next 14, days with 70%depthof discharge.

4.3.3 General requirements and performance for Ni-Cd batteries shall be as per manufacturer data available in market.

4.4 SOLAR POWER-CONTROLLER

4.4.1 Technical requirements

a. The solar power controller shall regulate the charge of the battery and shall monitor the charging current from the solar array power from the battery set shall be routed through the solar controller.

b. The controller shall be provided with low loss type, high efficiency, test eland tropicalized components with overall loss of the solar controller not exceeding 10%ofthe rated load. MCCBs and MCBs shall be used for the circuit or device protection in place of fuses. However, semiconductor grade fuses shall be used for diodes, SCRs etc.

c. Unless specified otherwise, the solar controller shall be wall mounted type with hinged and gasket door in the front .The cable entry shall be from top or bottom (to be decided at the time of detailed engineering.) through glands and access to all inside equipment shall be from the front only.

d. The supply system shall be suitable for both negative earthed and unearthed system as required. The provision of negative earthing shall be through an isolating link.

e. Apart from required control elements, the following components/ features shall be provided in the controller as minimum requirements:

i. A 2-Pole MCCB with shunt trip to isolate the solar panel from the solar controller/battery on receipt of 60% LEL signal from the gas detection panel. (The signal will be in the form of a normally open potential-free contact).
ii. The battery bank shall be automatically disconnected from the solar panels when the state of charge of the battery reaches 110% or maximum permissible charge level (as indicated by the battery manufacturer) and from the load when the depth of discharge reaches 70%. The battery bank shall be automatically reconnected to the Solar Panel when the state of charge of the battery drops to 100%.
iii. Ammeters to measure load current and solar array current.
iv. An array fault indicator to indicate solar array failure.
v. Voltmeter to indicate system output voltage and Battery voltage.
vi. Charge-discharge Ammeter.
vii. Battery deep discharge alarm and indication.
viii. Control circuit fail alarm and indication.
ix. Switches mounted on the front to disconnect all alarms and indications.
x. Necessary transducers for providing two wire 4-20 mA signals for the following parameters :
   - Battery voltage
   - Solar array current

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- Battery charging current
- Load current
- Solar panel fault indicators

xi. Current limiting features with active elements.

xii. Voltage regulator shall be switching mode type.

xiii. Digital Ampere hour meter.

f. Protection features to take care of faults in DCDB bus, solar controller, solar panel, battery circuit etc.

4.5 General requirements

4.5.1 Bus Bars

Bus bars shall be sufficiently sized and adequately braced for the supply conditions specified in data sheet. The bus bars shall be electrolytic copper and shall be sleeved with 1100V grade flame retardant PVC. Bus joints shall be bolted type and insulated by flame-retardant insulation tape.

4.5.2 Earthing

An earth bus bar made of electrolytic copper shall be provided, running the complete length of the solar controller. All non-current carrying parts shall be bonded with flexible copper wires with the earth bus. The earth bus shall have provisions at both ends for connecting it to earth grid conductor.

4.5.3 Segregation

All electrical devices and live parts in the solar controller panel shall be segregated by means of metallic screens. All power connections in case of solar controller shall be segregated from one another and from the electronic circuits

4.5.4 Cabling

All interconnecting cables between various solar panels and main JBs, included in scope of supply, shall be Flame Retardant Low Smoke (FRLS) type. Cables of sizes, as specified, connecting JBs to solar controller, solar controller to battery shall be supplied by contractor.

Adequate space shall be provided for termination of external cables. All required Nickel Chromium plated brass double compression cable glands and tinned copper lugs shall be included in the scope of supply.

4.5.5 MATERIALS AND FINISH

All materials shall be selected and finished to resist the site conditions and climate specified.

All electronic circuit boards shall be tropicalized to prevent corrosion and fungus growth. Painting shall be suitable for the requirements specified in Specification.

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4.5.6 IDENTIFICATION

All solar panels, batteries, solar controller and related devices and materials shall have permanent tags in contrasting colors affixed on them and lettering of at least 12 mm size. The tag inscription shall be in line with the equipment number list.

5.0 FABRICATION

5.1 Panel Construction

5.1.1 The Solar modules shall have suitable encapsulation and sealing arrangements to protect the Silicon elements (Cells) from the environment. The arrangement and material of encapsulation shall be compatible with the thermal expansion properties of the silicon cells and the module framing arrangement/material. The encapsulation arrangement shall ensure complete moisture proofing for the entire life of the solar modules.

5.1.2 The solar panel shall have suitable supporting arrangement complete with adjustable mounts, solar module fixing accessories, inter-module connections, cable termination arrangement, double compression, nickel/chromium plated, brass cable glands and all other necessary equipment and hardware. The supporting arrangement shall be such as to utilize minimum space on the control room roof top. Unless specified otherwise width of the walkway is 1600mm. The panel dimension and its supporting structure shall be so sized as to leave a clear walking space of minimum 750mm. Materials used in the construction of panel frame to support the solar modules, supporting structure and all other accessories shall be suitable for location in extremely corrosive, dusty environment to be encountered. The solar module framing shall be copper free aluminum alloy. Arrangement, such as, vertical stainless steel rods or flexible rods shall be provided to prevent bird landing on the panels. Each panel shall be provided with a weatherproof Junction box with minimum IP 55 enclosure with removable gasket front cover for termination of external cables. The electrical terminals in the junction box shall be corrosion proof and anti-loosening type. Suitable bypass diodes shall be provided for partial shadowing of modules, if recommended by manufacturer.

6.0 INSPECTION AND TESTING

6.1 All tests shall be carried out as per relevant Standards at Vendor's works.

6.2 The Consultant/Owner reserves the right to have a representative to witness the final testing and inspection. Prior intimation of at least 20 days shall be given to enable the Consultant/Owner depute its representative to witness the tests.

6.3 Testing and inspection shall include but not necessarily limited to the following:

6.3.1 GENERAL (FOR ALL ITEMS)

a. A quantitative check to ensure that all items in specified quantity are present.
b. A visual inspection to check workmanship and compliance with submitted drawings.
c. Dimensional checks.

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6.3.2 SOLAR PANELS

a. Following environmental tests shall be carried out on photovoltaic modules on sampling basis. Minimum 2% of ordered modules or 1 no. Module, whichever is higher, shall be subjected to following tests and performance of module before and after each test shall be tabulated and furnished. The tests shall be carried out sequentially on each module selected for testing and the tested module shall be discarded after tests.

b. In case on account of testing:

i. The overall deterioration in the performance of the tested modules after test exceed 5% of rated performance, or
ii. The tested module exhibits any open circuits and or ground faults, or
iii. The tested module develops cracks or mechanical damage, or
iv. The tested module fails to pass the electrical isolation tests

c. The entire ordered lot of modules shall be rejected.

S. No.	Test	Test Details
1.	Cold	Temp. : (-) 40°C Duration : 16 Hrs.
2.	Rapid Change of Temperature	Low Temp.: (-)40°C High Temp:+ 85°C No. of cycles :10 Duration of Exposure:30 Min.
3.	Dry heat	Temp. : 85°C Duration : 16 Hrs.
4.	Salt mist	Temp. : + 35°C Duration : 48 hrs.
5.	Wind	Pressure equivalent to an air velocity of
6.	Rain	Test as required in the mentioned Standards
7.	Dust	Test as required in the mentioned Standards
8.	Composite /Humidity Test	Test as required in the mentioned Standards.
9*	Mould Growth	84 days
10*	Hail Storm test	Test as required in the mentioned Standard
11 *	Shock Test	Peak Acceleration : 490m/sec 2 Duration : 11

* Vendor shall submit the test procedure for Owner's review. Vendor shall indicate test conditions like temperature limits and duration etc. and also mention the name of the applicable standards.

d. The following design qualification tests shall also be conducted:

i. Earth continuity test.
ii. Electrical isolation test.
iii. * Hot spot endurance test.

NOTE: Type test certificate can be accepted for the tests marked with asterisks (*).

6.3.3 SOLAR CONTROLLER

Tests in the following order shall be conducted for the panel :

a. General
b. Earth Continuity Test

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c. Functional Tests
d. Insulation Resistance Measurement
e. Heat Run Test
f. Insulation Resistance Measurement
g. Functional Test

6.3.4 Burn out tests for 120 hrs. On the complete system in one assembly.

7.0 MARKING, PACKING AND SHIPMENT

The offered equipment's along with accessories shall be shipped to site packed in wooden crates. They shall be wrapped with polythene sheets, before being placed in the crates to prevent damage to finish. Crates shall have skid bottom for handling.

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Energising Quality

VCS Quality Services Pvt Ltd

STANDARD SPECIFICATION
FOR
FLAME PROOF LIGHTING AND POWER PANELS

VCS – SS – EL - 4013

02	05.03.2022	SP	RD	AA	HK
01	16.10.2019	MG	VV	AD	SK
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Rev. No	Date	Prepared By	Checked By	Approved By	Authorized By

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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	05.03.2022	SP	RD	AA	HK	New revision system updated

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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
TPN	Triple Pole Neutral
SPN	Single Pole Neutral
FRP	Fiber Reinforced Concrete
SS	Stainless Steel
GI	Galvanized Iron

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1.0 SCOPE

This Specification covers the requirements of design, manufacture, testing, packing and supply of flameproof Lighting and Power panels/ accessories suitable for installation in locations handling flammable liquids and gases.

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:	Colors for ready mixed paints and enamels.
IS-1248 (Parts 1 & 2):	Direct acting indicating analogue measuring instruments and their accessories.
IS-2148:	Flameproof enclosures for electrical apparatus.
IS-5571:	Guide for selection of electrical equipment for hazardous areas
IS-8828:	Specifications for Circuit breakers for Over current protection for household and-similar installations
IS-12640:	Residual current operated circuit breakers.
IS-13346:	General requirements for electrical apparatus for explosive gas atmosphere.
IS-13408 (Part-1):	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosives processing and manufacture).
IS-13947 (Parts 1 & 5):	L.V. Switchgear and Control gear.

2.2 Imported equipment shall conform to the International Standards such as IEC/ BS/ VDE/ NEMA or equivalent.

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/ NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred Standards/ Specifications/ at a Sheet and statutory regulations, the following order of decreasing priority shall govern:

a. Statutory Regulations
b. Data Sheets
c. Job Specification
d. Standard Specification

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e. Codes and Standards.

3.0 DEFINITIONS

3.1 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 enclosures of the lighting and power panels shall be made of cast light metal alloy and shall be free from frictional sparking hazard. The magnesium content in the alloy shall be as per IS-13346.

5.0 DESIGN

5.1 GENERAL REQUIREMENTS

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

5.2 POWER SUPPLY

5.2.1 Unless otherwise specified, lighting and power panels shall be suitable for 415V, 50Hz, three phase and neutral (TPN) incoming supply and outgoing circuits for 240V, single phase and neutral (SPN).

5.2.2 For lighting and power panels falling under the jurisdiction of DGMS, the following additional requirements shall apply:

a. The phase-to-phase voltage shall not exceed 250 volts.
b. The panels shall have 415V, three phase, 4-wire system.
c. Earth leakage protection shall be provided for all outgoing circuits, which shall isolate both poles.

5.3 TECHNICAL REQUIREMENTS

5.3.1 COMPOUND SPECIFICATION

a. Busbars in the lighting and power panels shall be made of high-conductivity copper and shall be supported by non-hygroscopic insulators. Busbars shall be color coded for identification of phases and neutral.

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b. Unless otherwise specified, the incomer shall have one no. 4 pole 32A MCB isolator (without overload and short-circuit release) and one no. 4 pole ELCB. ELCB's shall have a maximum sensitivity of 30mA.

c. Unless otherwise specified, the outgoing feeders shall be provided with double pole 10A MCBs having overload and short-circuit releases.

d. Unless otherwise specified, all MCBs (except isolators) and ELCBs shall be with 9kA (M9. category) interrupting capacity.

e. The ELCB. shall be hand reset type one no. door mounted reset push button shall be provided.

f. The operating knobs (ON/ OFF/ RESET) shall be. provided with a suitable rack and pinion arrangement for operating them smoothly from outside.

5.3.2 TERMINAL & WIRING

a. The panels shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Unless otherwise specified, the terminals for termination of incoming and outgoing external cables shall be suitable for termination of up to 70 mm² and 6 mm²copper conductors respectively. Terminals shall be suitable for termination of solid conductors upto 6 mm² and stranded conductors above 6 mm². Wherever lugs are required for cable termination, tinned copper type lugs shall be provided.

b. All internal wiring in lighting and power panels shall employ adequately sized, 660V grade, PVC insulated copper conductor wires, color coded for phase, neutral and earth, with minimum conductor sizes as below:

i. Incomer 16 mm²

ii. Outgoing 2.5 mm²

6.0 FABRICATION

6.1 The enclosures of the lighting and power panels shall be made of cast light metal alloy and shall be free from frictional sparking hazard. The magnesium content in the alloy shall be as per IS-13346. The temperature of external surfaces shall be limited to 200°C, unless otherwise specified. The enclosures shall be sized to facilitate easy maintenance and heat dissipation.

6.2 The panels shall be suitable for use in outdoor open locations and shall have IP-55 degree (minimum) of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 14 SWG (2mm) galvanised sheet steel or FRP. The canopy shall be suitable for providing protection against rain from top and two sides.

6.3 The lighting and power panels shall be provided with gaskets made of non-inflammable and self-extinguishing material.

6.4 The enclosures shall be treated and prepared for painting with two coats of epoxy paint with final colour shade (both internal and external) as below:

Flame proof (Gas group IIA/IIB) : Dark admiralty grey shade 632 of IS-5

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Flame proof (Gas group IIC) : Light yellow shade 355 of IS-5

6.5 A warning inscription "Isolate power supply elsewhere before opening" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning shall be of nickel plated brass or stainless steel. accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

6.6 All the non-current carrying metallic parts of the panel shall be inherently bonded together. Each lighting and power panel shall be provided with two earthing studs with lugs on the exterior of the panel enclosure suitable for termination of 10 mm diameter GI wire rope.

6.7 Each outgoing feeder shall be provided with distinct terminals for phase, neutral and earth. The terminal block enclosures shall be adequately sized to properly terminate the cables by taking into account the required bending radii of cable cores and shall have the following minimum gland to terminal distances.

Conductor size	Up to 2.5mm²	Above 2.5mm² & up to 10mm²	Above 10mm² & up to 35mm²	Above 35mm² & up to 70mm²
Distance	40 mm	60 mm	100 mm	150

6.8 The panels shall be provided with suitably sized cable entries at the bottom/ sides, for incoming and outgoing cables. Panels shall be complete with double compression type nickel plated brass flameproof cable glands. Flameproof nickel plated brass sealing plugs shall be supplied, for plugging the unused cable entries. The quantity of sealing plugs shall be equal to 20% of the total number of outgoing cable entries.

6.9 The panels shall have external fixing lugs for mounting on wall or column. The holes, provided on these lugs shall be of oblong type.

6.10 A nameplate indicating TAG No. shall be provided on each panel Nameplates shall also be provided for each incoming and outgoing feeder Separate nameplate shall also be provided to indicate the details of testing agency (PESO or equivalent), test certificate no. with date, statutory approval no. with date and agency (PESO/ OISD/ DGFASLI/ DGMS), BIS license number and date, applicable gas group etc. The nameplates shall be engraved on 3 ply. black white black lami cold Sheds using square cutters. Black engraved per spex sheet nameplate shall also be acceptable. Nameplates shall be fixed by screws and shall not be pasted. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

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, if specified/ agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to Consultant

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/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense. .

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

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

7.4 All equipment shall be subjected to various acceptance tests as per standards but not limited to the following:

a. General visual inspection
b. Dimensional inspection
c. Verification of electrical operations
d. Dielectric tests
e. Routine pressure test as per IS-2148
f. Any other routine and acceptance test as per applicable Standards.

7.5 Type tests shall be carried out if specified in Data Sheet/ job Specification.

7.6 CERTIFICATION

7.6.1 The equipment shall have test certificates issued by recognized independent test house (PESO/OISD/ CPRI/ ERTL/ Baseefa/ LCIE/ UL/ FM or equivalent). All indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and parking as required by statutory authorities.

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 the selected mode of transportation, i.e. by ship/ rail-or trailer and shall be wrapped in air bubble polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as `Fragile', This side up, `Center of gravity', `Weight', `Owner's particulars', `PO no.' etc, shall be clearly marked on the packages together with other details as per Purchase Order.

8.2 The equipment may be stored in a covered shed for long periods before installation. The packing should be suitable for such storage.

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STANDARD SPECIFICATION
FOR
LIGHTING FITTINGS FOR HAZARDOUS LOCATION

VCS – SS – EL - 4014

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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
CIMFR	Central Institute of Mines and Fuel Research
MSL	Mean Sea Level
BIS/IS	Bureau of Indian standards
IEC	International Electro-Technical Commission
BS	British Standards

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