

ANNEXURE-I

Technical Specification of 3KVA,110VAC	
Material Code: 6715030011	
Salient Features	
UPS Rating:	3 KVA,110VAC
Battery Back up time: 30 Mins	
Outgoing Feeders:	2 No.s Redundant
UPS Configuration: Single UPS with Stabilised Bypass(as per 5.2.1 of EIL standard specification No. 6-51-0017 Rev6)	
For Detailed Specification Refer EIL Standard specification 6-51-0017 Rev6 attached	
Battery Specification: 2V VRLA Rocket/Exide/Amararaja make battery bank suitable for 30 min backup mounted on MS Rack and inter cell connectors and with fire proof Nyvin cable UPS to battery cable 20 M	

अनइन्टरप्टेड पावर सप्लाई सिस्टम के लिए विनिर्देश

SPECIFICATION FOR UNINTERRUPTED POWER SUPPLY SYSTEM

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Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

AC	:	Alternating Current
ACDB	:	AC Distribution Board
Ah	:	Ampere-hour
Amp	:	Ampere
BS	:	British Standard
CD	:	Compact Disk
CFL	:	Compact Fluorescent Lamp
CRCA	:	Cold Rolled Cold Annealed
DC	:	Direct Current
DCS	:	Distributed Control System
DG	:	Diesel Generator
EMC	:	Electromagnetic Compatibility
Hz	:	Hertz
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IGBT	:	Insulated Gate Bipolar Transistor
IP	:	Ingress Protection
IS	:	Indian Standards
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
MCCB	:	Moulded Case Circuit Breaker
MR	:	Material Requisition
NEMA	:	National Electrical Manufacturers Association
Ni-Cd	:	Nickel Cadmium
PC	:	Personal Computer
PCB	:	Printed Circuit Board
PIV	:	Peak Inverse Voltage
PO	:	Purchase Order
P.u.	:	Per Unit
PVC	:	Poly Vinyl Chloride
RFI	:	Radio Frequency Interference
ROM	:	Read Only Memory
RS	:	Recommended Standard
SMPS	:	Switch Mode Power Supply
SPN	:	Single Phase Neutral
UPS	:	Uninterrupted Power Supply
V	:	Volt
VDE	:	Verband Deutscher Electrotechniker
VRLA	:	Valve Regulated Lead Acid

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1.0 SCOPE

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

2.0 CODES AND STANDARDS

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

IS: 5	:	Colours for ready mixed paints and enamels
IS: 1248	:	Direct acting indicating analogue electrical measuring (Part 1, 2, 4 and 9) instruments and their accessories.
IS: 7204	:	Stabilised 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 1500V DC
(Part 1, 2 & 4)		
IS: 13947	:	Low voltage switchgear and control gear specification.
(Part-5/ Sec-2)		
IEC-60146-1-1:		General requirement & line commutated inverters (specification of base requirements)
VDE-0875	:	German EMC directive for broadband interference generated by appliances.
IEEE-519	:	Recommended practices and requirements for harmonic control in electrical power systems

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

2.3 The equipment shall also conform to the provisions of 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:

- Statutory regulations
- Data sheets
- Job specification
- This specification

3.0 GENERAL REQUIREMENTS

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

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

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

- 3.4 The UPS system shall be an integrated system comprising static rectifiers, battery, static inverters, static switches, manual by pass switch, AC distribution board, voltage stabiliser 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.
- 3.5 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.
- 3.6 The inverter shall be 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.
- 3.7 The design of the UPS shall be such as to minimise the risk of short circuits and shall ensure human and operational safety.
- 3.8 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.
- 3.9 The UPS shall be single phase or three phase system as indicated in the data sheets.
- 3.10 The batteries shall meet the requirement of battery Data Sheet/ battery specifications attached with the bid document

4.0 SITE CONDITIONS

The UPS system shall be suitable for installation and satisfactory operation in a closed substation with restricted natural air ventilation in tropical, humid and corrosive atmosphere. The UPS system shall be designed to operate under site conditions as specified in the data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000m above MSL shall be considered for the UPS.

5.0 TECHNICAL REQUIREMENTS

5.1 Input Power Supply

- 5.1.1 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 $\pm$ 10%
Frequency : 50 Hz $\pm$ 5%

In addition to above variations, the input voltage may be subject to transient variations comprising voltage dip to 80% of normal voltage during motor start-up and voltage interruption during short circuit as well as frequency variations due to large motor start up. UPS system shall be designed to operate satisfactorily while deriving the input power from an emergency diesel generator set.

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

- the ratio of negative to the positive sequence components not exceeding 5% and total harmonic distortion of not more than 5%.

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.

- 5.1.2 The manufacturer shall specify the current rating of input feeder to UPS from client switchboard based on 150% overload at minimum battery voltage and including the UPS efficiency.
- 5.1.3 The UPS shall be designed to ensure that harmonic components in the input current are limited as per IEEE519. Suitable filters as required shall be provided.

5.2 UPS Configuration and Operational requirements

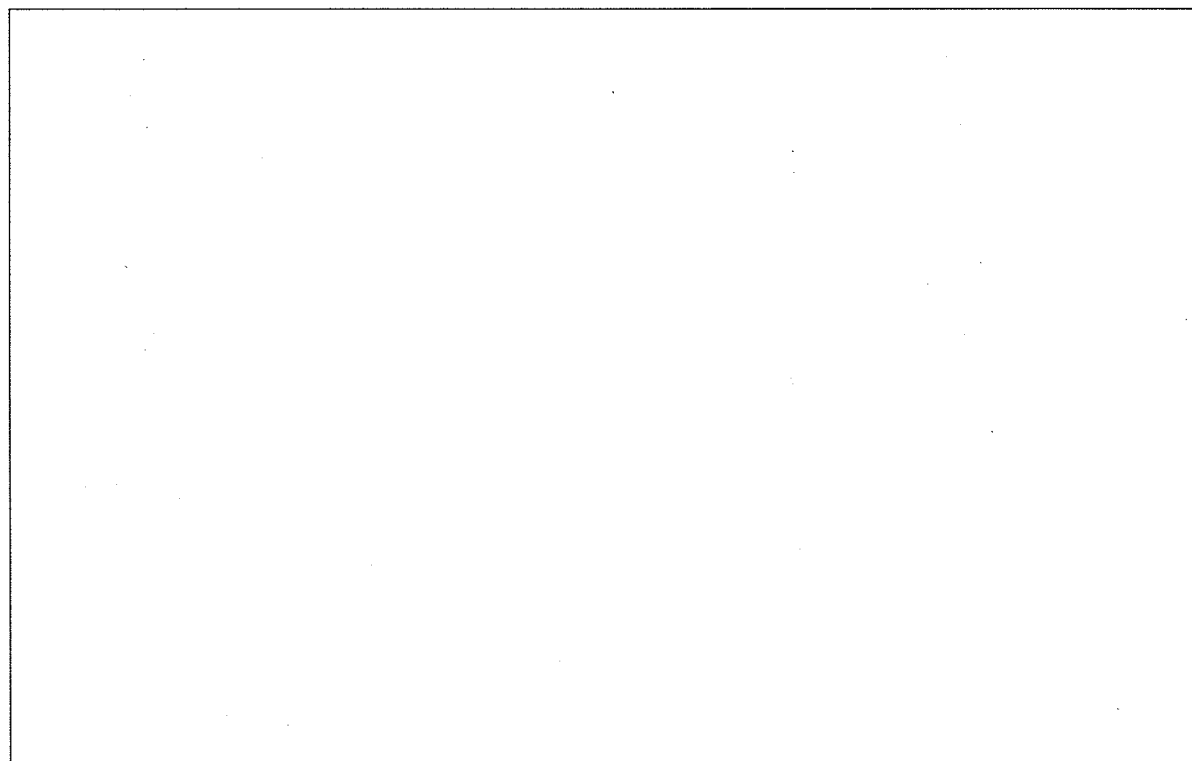
The UPS system shall have one of the following basic configurations as specified in data sheet and drawings.

5.2.1 Single UPS with Bypass (Refer Sketch 1)

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.

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.





5.3 UPS Design and Performance Requirements

- 5.3.1 Incoming AC supply shall be converted to DC through three phase 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 energising.
- 5.3.2 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 stabilised to within $\pm 1\%$ of set value during load variation between 0 to 100% of the rectifiers and specified mains input supply voltage variation.
- 5.3.3 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.

- 5.3.4 The UPS system including the stabilised by-pass shall be galvanically isolated from input power supply system by providing double wound transformers having copper winding. 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.
- 5.3.5 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 use of portable radio transmitter receiver in the vicinity of the UPS system and or UPS room.
- 5.3.6 Transient/surge protection circuit shall be provided in the input circuit to rectifiers to protect the UPS from surges & voltage spikes.
- 5.3.7 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.
- 5.3.8 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.
- 5.3.9 Facility for initial charging of batteries shall also be provided at a voltage level recommended by the battery manufacturer. The inverters may be disconnected during initial charging of the battery.
- 5.3.10 For battery sizing, the following factors shall be considered unless specified otherwise in the data sheet:
- Load Power Factor of 0.8
 - Minimum ambient temperature as specified in Data sheet.
 - Battery Current =
$$\frac{\text{Inverter rated kVA} \times \text{Rated load p. f.}}{\text{Inverter Efficiency} \times \text{End cell voltage} \times \text{No. of cells}}$$

* at 50% load on each inverter for parallel redundant UPS
 - Aging factor of 0.8
 - Back up time of 30 minutes in case of mains power failure unless specified otherwise in data sheet
 - Minimum end cell voltage for lead acid/VRLA battery 1.75 V per cell and 1.0 V per cell for Ni-Cd battery.
 - Battery state of charge factor of 0.95.
- 5.3.11 The rectifiers/chargers shall be designed to completely charge the Lead acid and Nickel cadmium batteries in a maximum time of 10 hours after complete discharge and at the same time meeting the inverter input requirements when the inverter is delivering its rated output at 0.8 p.f. 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 a duration of 24 hours and to 100% within 4 days. In addition to above, the charging shall be transferred from rapid to float mode after a preset time adjustable through 0-24 hours timer as back up protection against over charging.
- 5.3.12 The rectifiers shall be sized based on the maximum inverter input load when inverter is delivering its rated output at 0.8 rated p.f. 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:

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)

$$* \text{ where Inverter input current} = \frac{\text{Rated kVA capacity of UPS} \times \text{Rated load power factor}}{\text{Battery charging voltage} \times \text{Inverter efficiency}}$$

5.3.13 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.

5.3.14 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.

5.3.15 Battery/ DC link shall be provided with a sensitive earth leakage detection.

5.3.16 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:

- Load variations between 0-100% of the rated output of UPS
- Load power factor over the range of 0.7 lagging to unity.
- Load current waveform having a relative harmonic content varying between zero and 50%, 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	-	18% of fundamental
9th harmonic	-	7% of fundamental
11th harmonic	-	10% of fundamental

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 =

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

- DC input voltages over the range corresponding to battery rapid charge and battery discharge operation during the specified discharge times.

The UPS output voltage waveform shall be sinusoidal with a relative harmonic content not exceeding 5% for both linear and non linear loads.

5.3.17 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.

- 5.3.18 It shall be possible to vary the inverter output voltage steplessly within $\pm 5\%$ of the specified output voltage. This adjustment shall be possible to be made when the inverter is in operation.
- 5.3.19 The steady state output voltage and frequency (free running) variation of inverters shall not exceed $\pm 1\%$ 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.
- 5.3.20 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 pf.
- 5.3.21 The UPS shall have capacity to deliver a minimum overload of 125% for 10 minutes and 150% for 1 minute. UPS shall be provided with current limit circuit to avoid excessive loading beyond its permissible overload withstand capability.
- 5.3.22 The inverters shall be 'phase locked' to the stabilized bypass power supply as long as stabilized bypass supply frequency remain within $\pm 4\%$ of nominal. When bypass supply frequency variation exceeds the above limits, the inverters shall be de-linked from mains. Free running frequency tolerance limit shall not exceed $\pm 1\%$. Facility shall also be provided for adjustment of range of synchronising frequency.
- 5.3.23 Unless otherwise specified, the UPS system output voltage variation shall not exceed $\pm 10\%$ and complete recovery to normal steady state shall be within 0.1 Sec. The phase angle disturbance shall be less than $120^\circ \pm 3\%$ in case of 3 phase inverter. The above requirement shall be complied for following transient disturbances.
- a) 100% step load and unload (For single UPS and hot stand by UPS)
 - b) 50% step load (for parallel redundant UPS)
 - c) Momentary interruption in power supply
 - d) Load transfer to stabilized bypass supply
 - e) Complete load transfer to other healthy inverter when one of the two parallel inverters develop a fault.
- 5.3.24 For 3 phase UPS system, the maximum output voltage and angle variation between the phases should not exceed 6% and 3 degrees respectively even under the condition of 100% unbalanced loading of the 3 phase output.
- 5.3.25 UPS system shall be suitable both for floating output or earthing of one leg / star point in case of single phase/ three phase system respectively.
- 5.3.26 The stabilized bypass supply shall be designed to regulate the output voltage within $\pm 2\%$ 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 stabiliser in stabilized bypass supply shall be as indicated in data sheet.
- 5.3.27 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.
- 5.3.28 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.

5.3.29 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.

5.3.30 The criteria for load transfer:

A) Load transfer from inverter to the stabilized bypass supply shall be as follows:

(i) The load transfer shall only be possible when:

- The stabilised bypass output voltage is within $\pm 5\%$ of rated UPS output voltage and
- The mains bypass frequency is within $\pm 4\%$.

(ii) Auto-transfer of the load from inverter to stabilized bypass supply shall be initiated 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.

B) Retransfer of load from stabilized bypass supply to the inverter shall be as follows:

(i) The load transfer shall be possible when-

- The inverter output voltage is within $\pm 5\%$ of nominal output voltage for more than 5 sec. and inverter output and stabilised bypass supply are synchronised

Retransfer of load from stabilised 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 stabilised by pass within a period of 5 minutes.

5.3.31 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.

5.3.32 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.

- 5.3.33 All the thyristors, power transistors, diodes and other electronic devices of UPS shall be protected with high speed semiconductor fuses. It co-ordination between fuse and semi-conducting power devices shall be ensured.
- 5.3.34 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 up to a minimum 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.
- 5.3.35 All PCBs shall be provided with a transparent epoxy coating for environmental protection and tropicalisation. They shall be suitably located away from heat sources.
- 5.3.36 All electronic control and monitoring printed circuit cards shall be installed in standardised electronic equipment frames and shall be fitted with suitable means for easy removal. The frames shall incorporate guides for PCB's 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 PCB's and the PCB shall be firmly clamped in position so that vibration or long usage do 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.
- 5.3.37 Forced ventilation of panel, if provided, shall be supplemented by 100% redundant fan. 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. All fans shall be equipped with monitoring facilities to provide an alarm in the event of fan failure.
- 5.3.38 Maximum noise level from UPS system at 1 metre distance, under rated load with all normal cooling fans shall not exceed 75 dBA

5.4 Construction

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

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 1.6 mm thick CRCA sheet steel. Wherever, required suitable stiffeners shall be provided.

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.

- 5.4.2 Power cables shall be with aluminium / 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 mm². 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. Terminals shall be provided for all external

connections. Interconnection cables for cubicles located side to side shall be supplied. All interconnecting cables, as required between UPS system and ACDB, UPS system and batteries shall be in the scope of vendor.

- 5.4.3 Bus bars shall be used in all power circuits which are rated above 100 Amp. Copper conductors PVC/XLPE 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.
- 5.4.4 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. An 11W 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, 72 x 72 mm. square (for Analogue type). Analogue instruments shall be preferred. 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.
- 5.4.5 A suitably sized earth bus shall be provided at the bottom of the panels including ACDB running through the panels line up with provision for earth connection at both ends to purchaser's main earth grid. The minimum size of earth bus shall be 25 x 3 mm² copper (or equivalent aluminium). All potential free metallic parts of various equipments shall be earthed suitably to ensure safety.
- 5.4.6 All panels shall be of same height so as to form a panel line up which shall have good aesthetic appearance. ACDB can be of different height.
- 5.4.7 Inside the panels, the controls connections shall be done with 660V grade PVC/XLPE insulated wires having stranded copper conductors. 1.5 mm² size wires 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 wires shall be used. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire minimum of 0.5 mm dia.
- 5.4.8 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.
- 5.4.9 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 under-surface 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.
- 5.4.10 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 stoving ovens in a dust-free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.5 Cell Booster

- 5.5.1 Cell booster 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 $\pm$ 10%, 50 Hz $\pm$ 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 current rating shall be as under:

For Lead Acid battery = $0.14 \times \text{Ah of cell (10 hr. Rating of the cell)}$

For VRLA battery = $0.2 \times \text{Ah of cell (10 hr. Rating of the cell)}$

For Ni-Cd battery = $0.2 \times \text{Ah of cell (5 hr. Rating of the cell)}$

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.

5.6 A.C. Distribution Board

Sheet steel enclosed AC distribution board shall be provided. It shall accommodate AC feeders as indicated in the data sheet. The distribution board shall be floor mounted, fixed type with compartmentalised construction unless otherwise indicated in the data sheet. The switchboard shall be provided with 2 I/Cs (one from UPS & another from Bypass supply) with adequately rated Switch/MCCB/ACB. 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. Isolation transformers (if required) shall be mounted inside ACDB. HRC fuses shall be provided for isolation transformer feeders. 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.

5.7 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 be 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 by menu driven LCD display or by other means directly or indirectly.

5.7.1 Metering

5.7.1.1 Rectifier

- a) Incoming line voltages (For all the three phases).
- b) Input line currents.(For all the three phases)
- c) DC voltage at each rectifier output.
- d) Battery current.

5.7.1.2 Inverters

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

5.7.1.3 Stabilised bypass supply

- a) Frequency meter for incoming supply.
- b) Voltmeter with selector switch for incoming supply.
- c) Ammeter with selector switch for incoming supply.

5.7.1.4 ACDB

Following shall be provided for each of the ACDB incomers:

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

5.7.2 Indications

All indicating lamps shall be LED type. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. LEDs shall be provided for following:-

- 5.7.2.1 a) AC mains 'ON' - Rectifier.
- b) AC mains 'ON' - Bypass.

5.7.2.2 Rectifiers (for each rectifier)

- a) Rectifier output 'ON'
- b) Battery on float charge
- c) Battery on rapid charge

5.7.2.3 Inverters (for each inverter)

- a) DC input 'ON'
- b) Load on inverter.
- c) Inverter synchronised with mains.

5.7.2.4 Load on bypass.

5.7.3 Audio-Visual Alarm (separately for each circuit)

- 5.7.3.1 a) Mains failure
- b) Battery charger failure
- c) Battery fault
- d) Inverter temperature high
- e) Low voltage from inverter
- f) Load on bypass
- g) Inverter overloaded
- h) All power Fuse failures
- i) DC earth fault

5.7.3.2 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.

5.7.4 UPS shall also be provided with provision to hook up all indication and audio visual alarm, as specified in clause no.: 5.7.2 and 5.7.3 above, with owner's PC through RS232/RS485 / fibre optic port through serial interface.

5.7.5 Controls

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

5.8 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.

- 5.8.1 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.
- 5.8.2 It shall be possible to take out any individual power circuit for maintenance without affecting the total UPS supply.
- 5.8.3 Series-parallel combination of smaller devices to achieve required rating shall not be acceptable.
- 5.8.4 Vendors shall offer their nearest higher standard size that will meet the requirement of the specified UPS rating.

5.9 Fault Diagnostic Unit

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.

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.

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

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.

6.0 INSPECTION, TESTING AND ACCEPTANCE

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

6.2 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 authorised 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:

6.2.1 Insulation tests

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

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 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, 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.

$V_p / \sqrt{2}$ (V_p 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

6.2.2 Interconnection cable check

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

6.2.3 AC input failure test

The test is performed with the test battery and carried out by tripping AC 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.

6.2.4 AC input return test

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

6.2.5 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.

6.2.6 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.

6.2.7 Regulation test

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.

Following parameters of rectifiers and inverters are to be measured:

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.
- DC output voltage and current.
- Ripple current at the DC link bus shall be recorded after isolating the test battery.

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

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

6.2.8 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.

6.2.9 Current division in parallel UPS

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

6.2.10 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 load. 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

6.2.11 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. Supplier's test certificates are also acceptable for this test.

6.2.12 Continuous full load test at 0.8 power factor with temperature rise measurement

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. Supplier's test certificates are also acceptable for this test.

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 by pass 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 temperatures of all UPS panels are also to be recorded.

6.2.13 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.

6.2.14 Synchronisation test

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

6.2.15 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 shall be checked for compliance with specified values.

6.2.16 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 be 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

6.2.17 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.

6.2.18 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.

6.2.19 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.

6.2.20 Restart

Manual restart to be tested after complete shut down of UPS system.

6.2.21 Output over voltage

Operation of output over voltage protection is to be checked.

6.2.22 Dynamic Response test

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

6.2.23 Harmonic components

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 AC incomer side shall be recorded at site.

6.2.24 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.

6.2.25 Audible noise test

The audible noise is required to be measured at 1 meter distance from UPS system in at least 4 to 5 locations and its value shall be within permissible limit.

6.3 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 EIL's approval on the test procedures. Vendor shall also indicate the max. allowable tolerance for each test result, along with the test procedures.

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.

7.0 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.

8.0 PACKING AND DESPATCH

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', 'centre of gravity', 'weight', 'Owner's particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order. 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.

