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| Mar 2024 | 6.5.13 | 9 | Add new clause "Subject to the site constraints and conditions, the BMS shall be provided and connected to each battery cell of the UPS system for remote monitoring of the battery status, provided that :<br>i) the UPS system is three-phase with rating of 10kVA or above and adopting external battery arrangement with backup time of 30 minutes or more; and<br>ii) the UPS system is interfacing with integrated building management system (iBMS)/central control and monitoring system (CCMS)/Government-Wide Internet-of-Things Network (GWIN) to provide UPS system status for remote monitoring." |

Contents

## 1. Scope

1.1 This General Technical Specification lays down the functional requirements, performance characteristics, quality of installation and materials used, and standard of workmanship required for Uninterruptible Power Supply (UPS) system to be provided under contracts and orders administrated by the Electrical and Mechanical Services Department.

1.2 This General Technical Specification should be read in conjunction with the "General Requirements for Electronic Contracts, ESG01" and Particular Specification of the Contract or Order.

1.3 In the event of a conflict between this General Technical Specification with the Particular Specification of the Contract or Order, the Particular Specification of the Contract or Order shall prevail.

1.4 Notwithstanding the precedence specified, the Contractor shall always immediately seek advice from the Engineer in the event of conflicts between specifications.

1.5 This Specification should only be applied for the UPS system, for which the inverter is designed to operate continuously.

1.6 This Specification shall be applicable to single-phase and three-phase UPS systems.

## 2. Description of System

The UPS system shall consist of rectifier/charger, batteries, inverter, static bypass, manual bypass, protective devices and accessories that automatically provide continuous supply of electric power to its load within tolerances as set out in this General Technical Specification and/or the Particular Specification of the Contract or Order and without interruption upon the failure or deterioration of the normal a.c. supply.

## 3. Related Documents and Specifications

3.1 The following documents, references and standards shall be observed and complied with where appropriate and applicable.

(i) BS EN 62230: "Electric cables. Spark-test method"

(ii) BS 6724: "Electric cables. Thermosetting insulated, armoured cables of rated voltages of 600/1000V and 1900/3300V for fixed installations, having low emission of smoke and corrosive gases when affected by fire. Specification"

(iii) BS 7430: "Code of practice for protective earthing of electrical installations"

(iv) IEC 60228: "Conductors of insulated cable"

(v) IEC 60287-1: "Electric cables - Calculation of the current rating - Part 1: Current rating equations (100 % load factor) and calculation of losses"

(vi) IEC 60332-1: "Tests on electric and optical fibre cables under fire conditions - Part 1: Test for vertical flame propagation for a single insulated wire or cable"

(vii) IEC 60332-3: "Tests on electric and optical fibre cables under fire conditions – Part 3: Test for vertical flame spread of vertically-mounted bunched wires and cables"

(viii) IEC 60754-1: "Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content"

(ix) IEC 60896-22: "Stationary lead-acid batteries – Part 22: Valve regulated types - Requirements"

(x) IEC 60950-1: "Information technology equipment – Safety – Part 1: General requirements"

(xi) IEC 61034: "Measurement of smoke density of cables burning under defined conditions"

(xii) IEC 62040: "Uninterruptible power systems"

(xiii) IEEE 485: "Recommended practice for sizing lead-acid batteries for stationary applications"

(xiv) Code of Practice for the Electricity (Wiring) Regulations issued by Electrical & Mechanical Services Department

(xv) General Requirements for Electronic Contract ESG01 - EMSD

(xvi) Supply Rules published by local power supply companies.

3.2 The year of issue of above specifications should be the latest issue as appropriate at the time of contract placement. However, other equivalent international or national standards would be considered. Any deviation should be stated clearly in the tender submission.

## 4. Abbreviations

(a) 'BS' means British Standards published by the British Standards Institution, U.K.

(b) 'IEC' means International Electrotechnical Commission

(c) 'IEEE' means The Institute of Electrical and Electronics Engineers, Incorporated

(d) ‘RMS’ means Root Mean Square Value

(e) ‘UPS’ means Uninterruptible Power Supply

## 5 Functional and Performance Requirements

### 5.1 General

5.1.1 The UPS system performance shall conform to IEC 62040-3.

5.1.2 The general and safety requirements of UPS system shall be complied with IEC 62040-1.

5.1.3 If the mains supply is supported by the power generator sets, the UPS system shall be designed to interface and operate with the power generators to maintain an uninterrupted electricity supply in case of city mains failure.

5.1.4 The UPS system shall be of modular design and made up of one or more physically detachable equipment modules or cabinets, preferably of the draw-out type and removable from the front of the UPS system.

5.1.5 The UPS system shall be designed to permit ready access to modules and assemblies. The placement of parts, test points and terminals shall be such that they are accessible for circuit checking, adjustment and maintenance without the removal of any adjacent module or assembly.

5.1.6 The UPS system shall be constructed in heavy duty metal enclosures and designed for floor mounting.

5.1.7 All materials and parts comprising the UPS system shall be new, of current manufacture, of a high grade and free from all defects and imperfections and shall not have been in prior service, except as required during factory testing.

5.1.8 All active electronic devices shall be solid state. All semiconductor devices shall be hermetically sealed. All relays shall be dust tight.

5.1.9 All power semiconductors in the module shall be protected by fast acting fuses so that the failure of any one power semiconductor will not cause cascading failures. Each fuse shall preferably be provided with a blown fuse indicator on the control panel.

5.1.10 The UPS module shall not incur permanent damage to itself and the

connected load under all predictable types of failure conditions within itself and the connected load.

5.1.11 Fast acting current limiting devices shall be used to protect against failures of solid state devices.

5.1.12 The total harmonic current distortion that generated by the UPS system shall conform to the Supply Rules published by local power supply companies.

5.1.13 (Optional) The Static Transfer Switch (STS) shall be provided for UPS system to supply power to the load. In the event of a UPS system fault, the STS shall automatically transfer the load from UPS output to the other source without causing any interruption.

5.1.14 (Optional) For fully modular design, the UPS system shall consist of, but not limited to, plug-in power module, battery module, bypass module, output distribution module and hot-swap module with N+1 redundancy level.

5.1.15 (Optional) For fully modular design, the UPS system shall comply with the following requirements: -

(a) All of the power module shall support hot-swap without transferring to bypass.
(b) The UPS system shall have a central bypass unit and visual display for easy maintenance.

5.1.16 (Optional) Isolation transformer is required for providing neutral terminal to the UPS system. Detailed configuration of the isolation transformer shall be referred to the Particular Specification.

## 5.2 Operation Modes

5.2.1 The UPS system shall operate in three different operating modes:

(i) Normal mode;
(ii) Discharging mode; and
(iii) Bypass mode.

### 5.2.2 Normal Mode

(a) Under normal operation, the rectifier/charger unit shall convert the incoming a.c. mains power supply to d.c. power.

(b) The rectifier/charger unit output shall feed the inverter and charge up the batteries simultaneously. The inverter shall convert the d.c. power into a.c. mains power which feeds the load.

### 5.2.3 Discharging Mode

(a) Upon failure of the incoming a.c. mains supply or the incoming a.c. mains supply voltage goes outside the tolerances as set out in the Particular Specification, the inverter and the batteries shall continue to supply power to the load without interruption or disturbance.

(b) Alarm indications shall be provided to indicate the failure of a.c. mains supply and the operation in the Discharging Mode.

(c) The UPS system shall continuously run in this Discharging Mode:

(i) for a duration as set out in the Particular Specification; or

(ii) until the incoming a.c. mains supply to return to normal at which the UPS system returns to Normal Mode. Alarm indications shall be automatically reset.

(d) "Battery low" alarm indication shall be given if the batteries reaching the cut-off voltage and the batteries are nearly drained to depletion. The UPS system shall automatically transfer to By-pass Mode.

### 5.2.4 Bypass Mode

The UPS system shall transfer the load to the incoming a.c. mains supply by-passing the rectifier/charger unit, batteries and inverter without any interruption under the following conditions:

(i) malfunction or failure of any modules of the UPS system

(ii) the batteries are drained to near depletion

(iii) over-temperature

(iv) overloads

(v) load current transients (inrush or fault clearing)

## 5.3 Operating Functions

5.3.1 The UPS system shall have regulating and self-protection functions against the following conditions:

(i) overvoltage

(ii) power line surges

(iii) undervoltage and overcurrent introduced by the incoming a.c. mains supply
(iv) overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching and circuit breaker operation in the distribution system
(v) sudden changes in the output load and short circuits at the output terminals

5.3.2 Ringing transients, voltage spikes and surges shall be suppressed and shall be removed from the output of the UPS system.

5.3.3 The overall efficiency of the UPS system, output to input, shall achieve the following efficiencies for UPS at 50% rated load:
i) ≥ 89% (≥ 10 to < 20 kVA UPS)
ii) ≥ 89.5% (≥ 20 to < 40 kVA UPS)
iii) ≥ 90.5% (≥ 40 to < 200 kVA UPS)
iv) ≥ 92% (≥ 200 kVA UPS)

5.3.4 The efficiency shall be measured under the following conditions:
i) The module is operating at the full rated load.
ii) The batteries are fully charged and floating on the system.
iii) The input voltage is within the Specification.
iv) The load power factor is between unity and 0.8 lagging.

5.3.5 The UPS system shall comply with IEC 62040-2 for electromagnetic compatibility requirements.

5.3.6 Temperature sensors shall be provided to monitor the temperature of UPS system and the batteries. The UPS system shall automatically transfer the load to the bypass source via the static bypass switch without power interruption in case over-temperature alarm is detected. The threshold of the over-temperature alarm shall be configurable and the alarm shall be disabled and enabled.

5.3.7 The UPS system shall be equipped with facilities to prevent backfeed to the input terminals causing hazards to the operating or maintenance personnel.

5.3.8 A maintenance bypass shall be provided to allow maintenance personnel to manually isolate the UPS system from the load for maintenance purpose and connect the load directly to the incoming a.c. mains supply.

5.3.9 A battery circuit breaker shall be provided to allow maintenance personnel to isolate the batteries from the UPS system for maintenance purpose without affecting the normal power supply to the load.

5.3.10 The UPS system shall be equipped an emergency shutdown switch.

When the emergency switch is activated, the UPS system input, output and battery circuit breakers shall be open and the UPS system shall be completely isolated from all sources of power. The emergency shutdown switch shall be protected with cover to prevent accidental shutdown.

5.3.11 (Optional) Temperature sensors shall be provided to monitor the temperature of capacitors. The UPS system shall automatically transfer the load to the bypass source via the static bypass switch without power interruption in case over-temperature alarm is detected. The threshold of the over-temperature alarm shall be configurable and the alarm shall be disabled and enabled.

## 5.4 Status and Alarm Indications

5.4.1 The UPS system shall be equipped with, either digital displays or analogue meters to display the following operation information:

i) Input voltage and current meters (with phase selection switch for 3-phase equipment)

ii) D.C. battery charge / discharge current meter

iii) D.C. battery voltage meter

iv) A.C. voltmeter with selection switch to monitor either the UPS output or the bypass supply

v) Output and bypass a.c. ammeter (load current)

vi) Frequency meter (45 - 55 Hz) with selection switch to monitor the UPS output or bypass supply

5.4.2 The UPS system shall provide at least visual indication for the following alarms:

i) Overload
ii) Overload shutdown
iii) Equipment over-temperature
iv) Battery circuit breaker open
v) Battery discharging
vi) Low battery voltage
vii) Input power failure
viii) Inverter output over-voltage / under-voltage
ix) Static bypass inhibited
x) Load on bypass

5.4.3 An audible alarm shall be triggered whenever any alarms is detected. The audible alarm shall be mutable with an acknowledgement button.

5.4.4 The UPS system shall be provided with sufficient built-in diagnostic aids to facilitate trouble-shooting, maintenance and circuit

calibration.

5.4.5 Each module of the UPS system shall be accompanied by suitable indicators and test points allowing the current status of each module to be monitored.

5.4.6 (Optional) The UPS system shall provide local mimic panel on the equipment cabinet. The mimic shall depict a complete single line diagram of the UPS system. The status of the following circuit breakers and modules shall be indicated:

i) UPS module a.c. input circuit breaker;
ii) Battery circuit breaker;
iii) System output circuit breaker; and
iv) System bypass circuit breaker.

5.4.7 (Optional) The mimic shall display the operation mode of the UPS system and the source of power where the load is drawn.

## 5.5 Remote Monitoring

5.5.1 The UPS system shall provide voltage-free dry contacts for the summary alarm status.

5.5.2 The UPS system shall provide an output interface port for connection of workstation to allow remote monitoring the operating status of the UPS system.

5.5.3 (Optional) The workstation shall be provided for graphical display of the operating the status of the UPS system, including the alarms and status as set out in Clause 5.4.1 and 5.4.2 of this General Technical Specification.

5.5.4 (Optional) The workstation depicted in Clause 5.5.3 shall be equipped with high capacity storage device to store the event logs and alarm records for retrieval and further processing with commercially available PC applications.

5.5.5 (Optional) Remote alarm function shall be provided in the UPS system for notifying a list of pre-defined users via means, such as e-mail and SMS upon UPS system failure or change of operation mode to alert users for proper shutdown. The list of users shall be programmable.

5.5.6 (Optional) The UPS system shall be interfaced with integrated building management system (iBMS)/central control and monitoring system (CCMS)/Government-Wide Internet-of-Things Network (GWIN) to provide UPS system status for remote monitoring.

## 5.6 Ventilation

5.6.1 Adequate force air cooling by sufficient rated ventilation fans shall be installed to ensure that all components operate within their environmental ratings.

5.6.2 The power input to the ventilation fans shall be connected to the output of the UPS system, as one of the load such that continuous power supply to the ventilation fans shall be maintained all the time under different operation modes of the UPS system.

5.6.3 All ventilation fans/blowers shall be equipped with facilities for alarm status indication and remote monitoring.

5.6.4 Temperature sensors shall be provided to monitor the temperature of critical components including batteries. Upon the detection of temperatures in excess of the component manufacturers' recommended ambient working temperature, the sensors shall trigger audible and visual alarms on the control and monitoring panel.

5.6.5 (Optional) Temperature sensors shall be provided to monitor the temperature of capacitors. Upon the detection of temperatures in excess of the component manufacturers' recommended ambient working temperature, the sensors shall trigger audible and visual alarms on the control and monitoring panel.

## 5.7 Earthing Arrangement

All cabinet(s) must be solidly bonded to a good earth in accordance with BS 7430 using an adequate section of cable or busbar. The earth connection at the cabinet(s) shall be made to the frame earth terminal provided or alternatively to a substantial part of the basic frame rather than to a bolted-on panel.

# 6 Equipment and Accessories Specifications

## 6.1 General

6.1.1 The maximum working voltage, current and rate of change of current (di/dt) of all solid state power components and electronic devices shall not exceed 50% of the absolute maximum ratings established by their manufacturers. The heat dissipation capability of the solid state component cases at a certain ambient temperature

shall be such that the temperature of the cases shall not be greater than 75% of their ratings.

## 6.2 Rectifier / Charger Unit

6.2.1 The rectifier/charger unit shall be equipped with adjustable current limiting facility to limit the charging current for the batteries.

6.2.2 The output circuit of the rectifier / charger charging current shall also be voltage regulated.

6.2.3 The rectifier / charger shall be discharged such that 95% of the energy shall be replaced in ten times (10x) the discharge time.

6.2.4 The rectifier/charger unit shall have sufficient output capacity for simultaneous operation of both the rated load and charging the batteries where they have been discharged to a state of system shutdown.

6.2.5 The rectifier/charger unit shall maintain the batteries at full charge until the next discharge operation.

6.2.6 The rectifier/charger unit shall provide features whereby when the a.c. power is returned to the a.c. input bus after the UPS system has been operating on battery power or has been de-energised, the total initial current requirement at the input terminals will not exceed 20% of the rated output current, and the current will gradually increase to 100% of full rating over a 15-second time interval.

## 6.3 Inverter Unit

6.3.1 The output voltage shall be adjustable to +3% of the nominal voltage as stipulated in the Particular Specification.

6.3.2 The inverter shall be able to sustain an overload across its output terminals without shut off. It shall continue to operate at 125% of its rated power for 10 minutes, and shall maintain full output voltage for at least 10 second, when supplying up to 150% of its rated current.

6.3.3 The inverter shall be capable of providing at least 300% over-current under short circuit conditions. The tenderer shall state the period that the UPS system will continue to operate under the 300% overload condition before the inverter is shut down and disconnected automatically from the load bus.

6.3.4 The output frequency of the inverter shall be maintained in a

phase-locked condition with the frequency of the bypass source for as long as it is within +2% of the nominal value.

6.3.5 In the event of the bypass line frequency being out of the tolerance, the inverter shall phase lock to a built-in temperature compensated oscillator. In such case, the total frequency deviation, including short term fluctuations and long terms drifts, shall not exceed ±0.25% from the nominal frequency.

6.3.6 The inverter shall have fault sensing facilities, a static interrupter and output circuit breaker for the removal of the inverter output from the load, without exceeding the limits stated in this Specification.

6.3.7 When feeding a linear load, the total harmonic distortion generated by the inverter shall be less than 5% RMS and any single harmonic shall be less than 3% RMS over the entire load range.

6.3.8 The steady-state (static) output voltage regulation of the inverter shall not deviate by more than ±3% under the following conditions:

i) 0 to 100% load application;
ii) ambient temperature variations;
iii) minimum to maximum DC bus voltage.

6.3.9 The dynamic (transient) output voltage regulation of the inverter shall be better than ±10% under the following conditions:

i) 50% step load application and rejection with zero initial load and 50% initial loads;
ii) transfer of the rated load from the inverter to the bypass source or vice versa;
iii) loss or return of the a.c. input. The output voltage shall return to 95% of the steady-state value within 50 milliseconds.

## 6.4 Static Bypass Switch

6.4.1 A static bypass switch shall be equipped to provide uninterrupted transfer of the load to the bypass source automatically when a malfunction or overload occurs in the UPS system.

6.4.2 The transfer shall be performed on a “make-before-break” basis such that the static bypass switch is closed before the static interrupter and/or the output circuit breaker is tripped open.

6.4.3 The static bypass switch shall preferably be connected in parallel with a circuit breaker which is activated together with the static switch and subsequently replaces the static switch.

6.4.4 If the transfer of load to the bypass source is the result of an overload, then when the overload is removed, the load shall be transferred back to the inverter either automatically or manually depending on the setting of a selection switch.

## 6.5 Batteries

6.5.1 The batteries shall be of maintenance-free and sealed type conforming to IEC 60896-22.

6.5.2 The batteries shall be of heavy-duty industrial type design. The housing of the battery shall be corrosive resistant.

6.5.3 The batteries shall be equipped with safety vent caps to prevent internal cell explosions caused by internal pressure developed during battery discharge or recharge.

6.5.4 The batteries shall have sufficient voltage and ampere-hour rating to maintain the UPS output at the rated output capacity for the duration as set out in the Particular Specification.

6.5.5 The discharge ratings of the batteries shall be determined at 25$^{o}$C conforming to IEEE 485.

6.5.6 The batteries shall be housed in either racks or cubicles with good ventilation, as set out in Particular Specification. The rack or cubicle shall be protected with electrolyte resistant paint.

6.5.7 Inter-cell connectors shall be protected with anti-corrosion plastic or non-metallic covers.

6.5.8 Circuit breakers shall be provided to isolate the batteries from the rectifier/charger unit and the inverter unit of the UPS system. The circuit breakers shall be automatically opened to disconnect the batteries when the discharge limit of volts per cell of the batteries is reached.

6.5.9 The circuit breakers shall also be manually operated and shall be able to be remotely controlled.

6.5.10 (Optional) The Battery Management System (BMS) shall be provided to monitor the real time status and performance of each battery cell and provide alert on any identified abnormality of individual battery cell.

6.5.11 (Optional) The BMS shall continuously capture and securely transmit battery performance data to the workstation. Monitored battery parameters shall include, but not limited to, individual

battery terminal voltage, battery internal impedance, ambient temperature, internal battery temperature, status of charge and float current. The BMS shall also provide trend analysis of the captured battery performance data.

6.5.12 The Contractor shall provide battery sizing calculation for the required battery backup time at the rated load.

6.5.13 Subject to the site constraints and conditions, the BMS shall be provided and connected to each battery cell of the UPS system for remote monitoring of the battery status, provided that :

i) the UPS system is three-phase with rating of 10kVA or above and adopting external battery arrangement with backup time of 30 minutes or more; and

ii) the UPS system is interfacing with integrated building management system (iBMS)/central control and monitoring system (CCMS)/Government-Wide Internet-of-Things Network (GWIN) to provide UPS system status for remote monitoring.

## 6.6 Power Cable & Earthing Cable

6.6.1 The conductors shall be of high conductivity annealed copper wire complying with IEC 60228.

6.6.2 The maximum continuous current carrying capacity and the factors for determining such ratings for the cable shall be based on IEC 60287 and on the conditions obtained on Site.

6.6.3 The nominal thickness of the insulation shall be as specified in BS 6724.

6.6.4 The insulation shall not break down when spark tested in accordance with BS EN 62230.

6.6.5 The cables shall be flame retardant and shall comply with the requirements of IEC 60332-1 & 60332-3.

6.6.6 The emission level of hydrochloric acid of the insulation and sheath of the cables under combustion shall not be greater than 0.5% when tested in accordance with IEC 60754-1.

6.6.7 The level of smoke density of all cables under burning shall comply with the requirement of IEC 61034.

6.6.8 Appropriated grommets or insulated bushes should be used to protect the non-armoured cables passing through metal box or any other metal work.

## 7 Reliability and Availability

7.1 The UPS system shall be designed for continuous reliable operation. All the system components including the rectifier/charger unit, inverter unit, bypass switch, batteries and cables shall have a design serviceable life of at least 10 years.

7.2 The inability to perform a required function, the occurrence of unexpected action by the equipment, or the degradation of performance to below the required specifications shall be considered as a failure.

7.3 Mean-Time-Between-Failure (MTBF) shall be the average operating time accumulated by the total population of identical items in the UPS system between failures.

7.4 The MTBF for the following equipment shall not be less than 50,000 hours or as set out in the Particular Specification:

a) rectifier/charger unit;
b) inverter unit;
c) bypass static switch; and
d) batteries.

7.5 The availability of the UPS system shall be defined as the probability the UPS system is providing the normal operation and functions with the required performance. The availability shall be determined mathematically as follows:

$$\text{Availability} = \frac{\text{Total operation time between failure}}{\text{Total operation time between failure} + \text{Time to restore to normal}}$$

$$\text{or Availability} = \frac{\text{MTBF}}{\text{MTBF+MTTR}} \text{x } 100\%$$

where MTTR is the Mean-Time-To-Restore figure of the UPS system.

7.6 The availability of the UPS system shall be better than 99.99% or as set out in the Particular Specification.

7.7 The tenderer shall submit calculations with reliability block diagrams for the UPS system to demonstrate compliance with the required availability and predicted MTBF figure for the whole UPS system.

7.8 The MTTR of the UPS system shall not exceed 1 hour. The MTTR shall be the time, excluding travelling time, required to diagnose the fault and restore the UPS system to normal working condition by means of module replacement on site. The Tenderer shall provide a statement on the MTTR of the supplied UPS system.

- End -