




OGDCL PAKISTAN:  
OIL & GAS DEVELOPMENT  
COMPANY LIMITED

## KPD-TAY COMPRESSION PROJECT

**ISSUED FOR TENDER**

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**CLIENT : OIL & GAS DEVELOPMENT COMPANY LIMITED**

**PROJECT : KPD-TAY COMPRESSION PROJECT**

**SPECIFICATION FOR  
UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM**

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**OIL & GAS DEVELOPMENT COMPANY LIMITED**

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**SPECIFICATION FOR**

**UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM**

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## KPD-TAY COMPRESSION PROJECT

**SPECIFICATION FOR  
UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM**

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**1. PURPOSE**

This specification is intended to specify the basic requirements for designing, engineering, selection, sizing, procurement, testing, installation, pre-commissioning, commissioning and performance of static dual redundant 400V, 50 Hz 3-phase In & 230V, 50HZ, 1-phase Out A.C Uninterruptible Power Supply (UPS) unit, which deemed necessary for defining minimum requirement at FEED stage and shall not be considered comprehensive and final for procurement. This specification does not absolve the CONTRACTOR from his responsibility of supplying, installing and commissioning suitable static dual redundant UPS unit, complete in all respect. The CONTRACTOR shall develop detailed datasheets, specifications, ITP and installation details based on this specification and submit to the COMPANY/CONSULTANT for approval during detailed engineering stage.

A.C Uninterruptible Power Supply (UPS) unit comprising rectifiers, batteries, inverters, static & maintenance bypass switches and floor mounted distribution board complete with MCCB's indication lights & selector switches and main incoming for UPS from MCC room to control room and all interconnecting cables required for complete installation. The unit as specified serves as a secure (uninterruptible) alternating current source of power to vital instrumentation and safeguarding systems.

kVA rating of UPS shall cater complete essential instruments loads i.e. Compressor's UCPs, Instrument Air Compressor's control panels, fire alarm panels, etc. including of 25 % spare capacity of future loads. The CONTRACTOR/Manufacturer shall do preparation, packing, shipping and assure the AC UPS system is delivered in full compliance with this specification & provide documents as mentioned in *Section-11* for COMPANY/CONSULTANT review & approval & accordingly incorporate all the comments without offering any deviations. Any deviation from the specification shall be clearly stated and detailed described by the supplier in prequalification stage. The acceptance of any technical changes is subject to COMPANY/CONSULTANT approval.

**1.1. DEFINITION**

Where used in this specification, the following terms shall have the meanings indicated below unless otherwise clearly indicated by context of their use.

COMPANY – Oil & Gas Development Company Limited (OGDCL)

CONCESSION REQUEST - A deviation requested by the CONTRACTOR/VENDOR, usually after receiving the contract package or purchase order. Often, it refers to an authorization to use, repair, recondition, reclaim, or release materials, components or equipment already in progress

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or completely manufactured but which does not meet or comply with COMPANY/CONSULTANT requirements. A Concession Request is subject to COMPANY/CONSULTANT approval.

CONTRACTOR - The party which carries out all or part of the design engineering, procurement, construction and commissioning or management of the project.

DRAWINGS - Drawings provided by the CONTRACTOR/VENDOR.

SUPPLIER/MANUFACTURER/VENDOR - The party which manufactures and/or supplies the material/ equipment, and provides technical documents/drawings and services to perform the duties specified by the COMPANY/CONTRACTOR.

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**1.2. ERRORS & OMISSIONS:**

- The review and comment by COMPANY/CONSULTANT of any CONTRACTOR's/VENDOR's drawings, procedures or documents shall only indicate acceptance of general requirements and shall not relieve the CONTRACTOR/VENDOR of its obligations to comply with the requirements of this specification and other related parts of the Contract Documents.
- Any errors or omissions noted by the CONTRACTOR/VENDOR in this Specification shall be immediately brought to the attention of COMPANY/CONSULTANT.

**1.3. DEVIATIONS:**

- All deviations to this Specification, other related specifications or attachments shall be brought to the knowledge of COMPANY/CONSULTANT as a section in the bid. All deviations made during the procurement, design, manufacturing, testing and inspection shall be with written approval of COMPANY/CONSULTANT prior to execution of Work. Such deviations shall be shown in the documentation prepared by the CONTRACTOR/VENDOR.

**1.4. CONFLICTING REQUIREMENT:**

- In the event of any conflict, inconsistency or ambiguity between the CONTRACTOR's/VENDOR's scope of work, this Specification, National Codes and Standards, and referenced in the Project Specification or any other documents, the CONTRACTOR/VENDOR shall refer to COMPANY/CONSULTANT whose decision shall prevail.

**1.5. REPORTING PROCEDURE:**

- A reporting and documentation system shall be agreed between the CONTRACTOR/VENDOR and COMPANY/CONSULTANT for the status of procurement, design, manufacturing, inspection, testing and shipment of the equipment/material to be supplied under this
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specification. The CONTRACTOR/VENDOR shall provide reports and summaries for production performance and testing operations in conformance with a manufacturing schedule approved by COMPANY/CONSULTANT.

- Daily, weekly, monthly and run summaries of all major aspects of the production process shall be provided as reports to COMPANY/CONSULTANT.

**1.6. THIRD PARTY INSPECTION (IF REQUIRED):**

- In addition to the inspection and witnessing of tests by the inspectors to be appointed by the COMPANY/CONSULTANT during the manufacturing and shipment of the equipment/material, COMPANY/CONSULTANT may appoint a third party or its own inspector for witnessing of the inspection and tests to be carried out at VENDOR's facility under this specification.
- Information w.r.t inspection and testing purposes as per applied reference Standards and Codes shall be submitted to COMPANY/CONSULTANT.

**1.7. UNIT RESPONSIBILITY:**

- The CONTRACTOR/VENDOR shall be responsible for the complete design, manufacture, supply, delivery, inspection, installation, testing, pre-commissioning, commissioning and performance of static dual redundant 400V, 50Hz 3-phase In & 230V, 50Hz, 1-phase Out A.C Uninterruptible Power Supply (UPS) unit, including full compliance with all applicable design codes and standards listed in Section-2 of this document. The CONTRACTOR shall handle and expedite technical details/data, and supervise and coordinate all inspection and testing.
- The CONTRACTOR/VENDOR shall guarantee that all material and parts included in construction of the specified static dual redundant 400V, 50Hz 3-phase In & 230V, 50Hz, 1-phase Out A.C Uninterruptible Power Supply (UPS) unit material shall be new, unused and of the required/ specified grade.

**1.8. DOCUMENTATION:**

- Documents, technical details (confirming the design requirements of reference Standards & Codes), offered catalogues etc., to be submitted to the COMPANY/CONSULTANT for review and approval, and shall be in English Language.
  - Unless otherwise specified, the metric units shall be used by the CONTRACTOR/VENDOR.
  - Variations from or additions to this specification shall be called to the attention of the COMPANY/CONSULTANT and approved in writing by the COMPANY/CONSULTANT prior to starting manufacturing.
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- The CONTRACTOR/ VENDOR shall submit the type and quantity of drawings and documentation for COMPANY/CONSULTANT authorization or information. Mutual agreement on scheduled submittal of drawings and engineering data shall be an integral part of any formal Purchase Order.
- Comments made by COMPANY/CONSULTANT on drawing submittal shall not relieve the CONTRACTOR/ VENDOR of any responsibility in meeting the requirements of the specifications.  
Such comments shall not be construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is reached and confirmed in writing.
- Each drawing shall be provided with a title block in the bottom right-hand corner incorporating the following information:
  - Official trade name of the VENDOR
  - VENDOR'S drawing number
  - Drawing title giving the description of contents whereby the drawing can be identified
  - A symbol or letter indicating the latest issue or revision
  - P.O. number and item tag numbers
- Revisions to drawing shall be identified with symbols adjacent to the alterations, a brief description in tabular form of each revision shall be given, and if applicable, the authority and date of the revision shall be listed. The term "Latest Revision" shall not be used. Unless otherwise stated in the Purchase Order, the CONTRACTOR/VENDOR shall at least supply the documents as listed in Section-11 with the tender.

DOCUMENT PRECEDENCE:

- It shall be the VENDOR's responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.
- The CONTRACTOR/VENDOR shall notify the COMPANY/CONSULTANT of any apparent conflict between this specification, the related data sheets, the Standards & Codes and any other specification noted herein. Resolution and or interpretation precedence shall be obtained from the COMPANY/CONSULTANT in writing before proceeding with the design manufacture.

**1.9. ABBREVIATIONS**

ESD	Emergency Shut Down
JT	Joule Thomson
MMSCFD	Million Standard Cubic Feet per Day
MOC	Material of Construction



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KW	Kilowatt
HP	Horsepower
V	Voltage
F	Frequency
A	Ampere
PPM	Parts Per Million
GEG	Gas Engine Generator
EDG	Emergency Diesel Generator
LMLS	Load Management & Load Shedding System
TDMA	Time Division Multiple Access
CCR	Central Control Room
DCS	Distributive Control System

## 2. REFERENCE STANDARDS & CODES

The equipment and material selection shall strictly conform to the latest editions of the following reference Standards & Codes.

It shall be manufacturer responsibility to be or to become knowledgeable of the requirements of these reference Standards and Codes. The supply shall also include the requirements of local standards and regulations following the principles and practices detailed in this philosophy. Any changes, alteration and necessary re-certification of the equipment for compliance with the applicable Standards and Codes shall be at the expense of the Manufacturer.

STANDARD	DESCRIPTION
IEC 60038	IEC Standard Voltages
IEC 60044-1	Current Transformers
IEC 60044-2	Voltage Transformers
IEC 60051	Recommendations for Direct Acting Indicating Electrical Measuring Instruments and their accessories
IEC 60079	Electrical Apparatus for Explosive Gas Atmosphere
IEC 60146	Semiconductor converters
IEC 60158-1	Low Voltage Control Gear Part One: Contactors
IEC 60269	Low Voltage Fuses
IEC 60364	Electrical Installation of Buildings
IEC 60408	Low Voltage Air-Break switches, Air-Break Disconnectors, Air-Break Switch Disconnectors and Fuse-Combination Units





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IEC 60445	Identification of Apparatus Terminals and General Rules for a Uniform System of Terminal Marking. Using an Alpha-Numeric Notation
IEC 60478	Stabilized Power Supplies D.C. Output
IEC 60529	Classification of Degrees of Protection Provided by Enclosure
IEC 60726	Dry Type Transformers
IEC 60801-3	Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment Part 3: Radiated electromagnetic Field Requirements
IEC 60947	Low Voltage Switchgear and Control Gear
IEC 61000-3-2	Electromagnetic compatibility (EMC) Part 3 Section-2
IEEE 519	Harmonic control in Electrical Power Systems
EN 50091-2	Specification for UPS, EMC requirements
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV ( $U_m = 1,2 \text{ kV}$ ) up to 30 kV.
BS 7671	Requirements for Electrical Installation

In addition to the above, the following codes shall be considered:

- NFPA-70 / National Electric Code.
- Oil & Gas (Safety in Drilling and Production) Regulation Govt. of Pakistan
- API Recommend Practice 500 and 505.
- Relevant British Standard Specification and Codes of Practice
- CENELEC Standards
- The Institute of Petroleum – Model Code of Safety Practice Electrical
- The Institute of Electrical Engineers, Regulations for Electrical Installation.
- Institute of Electrical & Electronic Engineers ( IEEE )
- Electricity Act. 1973 (Govt. of Pakistan) – Latest edition.
- In the event of conflict between Standards, the most stringent shall prevail.

**3. SERVICE CONDITIONS****3.1. SITE CONDITIONS**

UPS and its batteries shall be stored in a conditioned room; however, following conditions shall apply: As a minimum requirement the electrical equipment selection i.e UPS, Batteries shall take into account the following extreme climate conditions:



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**SITE AND ENVIRONMENT DATA**

PARAMETERS	VALUE/UNIT
MAXIMUM AMBIENT TEMPERATURE	118 °F
MINIMUM AMBIENT TEMPERATURE	36 °F
WET BULB TEMPERATURE (DESIGN)	88 °F
MAXIMUM RELATIVE HUMIDITY	77%
MINIMUM RELATIVE HUMIDITY	20%
WIND VELOCITY	101 (Miles/Hour)
ELEVATION ABOVE MEAN SEA LEVEL (GPF)	250 ft.
SEISMIC ZONE	Zone 2A of Uniform Building Code- UBC-1997.

- "Design temperature for rating of electrical equipment within rooms shall be based on an average temperature of 30°C-over 24-hour period and rising to a peak of 40 °C with lowering to minimum 0 °C".
- Equipment shall be installed inside an air-conditioned electrical room. However, it shall be rated and suitable for continuous operation at 40°C without any detrimental effect on any component/equipment.
- The rating of equipment/component shall take full account of all heat sources within the enclosures and must be guaranteed at the specified design temperature.
- Equipment shall be designed and built for continuous service at full load under combined variation of both voltage and frequency as specified, without exceeding the permitted temperature, with a minimum of supervision and maintenance.
- The current ratings of all components must be guaranteed at the specified design temperature.
- The Manufacturer shall use sound engineering judgment to provide a system that will perform the required functions without any operational hazards.
- Circuit breakers and Contactors shall not be used beyond 80% of their rated category.
- Pins of auxiliary circuits shall be sized for a rated current of 10 amperes minimum.
- All controls shall operate in a fail-safe mode.



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The static dual redundant A.C Uninterruptible Power Supply (UPS) unit covered by this specification shall be suitable for the following operating conditions and shall be designed and constructed accordingly.

A.C UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM	
VOLTAGE	400 V AC $\pm$ 10%, 3-PHASE 230 V AC 1-PHASE
FREQUENCY	50 Hz $\pm$ 2Hz
NEUTRAL SYSTEM	SOLIDLY GROUND SYSTEM

**4. DESIGN/ MATERIAL/ CONSTRUCTION****4.1. PARTICULAR DEFINITIONS**

Vital Service - is a service which, when failing in operation or when failing if called upon, can cause an unsafe condition of the process and/or electrical installation, jeopardize life, or cause major damage to the installation.

Rated Output - is the apparent power, expressed in kVA, which can be continuously delivered by the unit over the range of conditions of service and electrical loading specified in this document, without exceeding component ratings and any of the required output tolerances.

Power Factor - is the power factor of the fundamental wave,  $\cos \phi$  (sometimes referred to as the displacement factor).

$$\text{i.e. } \cos \phi = \frac{\text{active power of the fundamental wave}}{\text{apparent power of the fundamental wave}}$$

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 =  $\sqrt{1 - (g_1/g)^2}$  : where

$g_1$  = r.m.s. value of the fundamental component of current or voltage

$g$  = r.m.s. value of the total waveform of current or voltage

Crest Factor is the ratio of the peak value to the r.m.s. value of the total non-sinusoidal periodic waveform.

Partially Discharged Condition - of a battery is the condition reached when the battery has been discharged to the point that the inverter can no longer deliver its rated output within the permissible output tolerances.



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Float Charging - is the passing of an electric current through a battery by applying a constant voltage from a charger, such as to maintain the battery in a state of charge.

Rapid Charging - is the passing of an electric current through a battery by applying a controlled voltage from a charger, such as to restore the battery to a predetermined state of charge in a limited time span.

MTBF - Mean Time between Failures

MTTR - Mean Time to Repair

#### 4.2. GENERAL REQUIREMENTS

##### 4.2.1. BASIS OF DESIGN

The Dual redundant AC-UPS unit shall be of the electronically regulated type. Units incorporating magnetic stabilizers (e.g. constant voltage transformers) are not acceptable.

AC-UPS system shall be of transistor controlled type (not thyristors) with less noise and heat using the IGBT or MOSFET.

The design of the UPS shall be such as to minimize the risk of short circuits and shall ensure personnel and operational safety at all times.

All components shall be of a quality and reliability that satisfies the requirements of a secure A.C. source of power to vital equipment performing a controlling, monitoring and safeguarding function in continuously operating petrochemical process units & production facilities.

Components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short circuits and circuit switching operations etc. Damage arising from component failure should be confined to the component concerned.

The UPS components shall be suitably protected for operation in tropical climates.

Anti-condensation heater shall be provided if required. Components shall be moisture & fungus proof, & non-flame propagating.

Additional requirements regarding the quality and lay-out of the vital power supply for specific applications are considered to be outside the scope of this specification.

The Design & selection of equipments & components shall be based on following minimum life times.

- 20 Years for Rectifier, Inverter & static switch.



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- 20 years for Storage battery bank composed of 10 years maintenance free, sealed Lead Acid batteries

The entire battery stand should be electrically insulated.

Additionally, with the exception of battery systems and ventilation, the UPS shall be designed to operate totally maintenance free for a 6-year continuous period.

#### 4.2.2. OPERATING PRINCIPLE

##### PARALLEL STATIC UPS UNIT

In this arrangement, 100% rated UPS units operate in parallel to energize a single distribution to which the load circuits will be connected. The parallel UPS Unit shall comprise of two rectifiers, two inverters, two static switch, two bypass switch (one for available for static switch and other for maintenance switch), two isolation transformers, one by-pass transformer, two battery banks, two batteries disconnect switch, two manual bypass switches and one distribution board. Dual redundant control circuits shall be included to facilitate equal (50%) sharing of the load between the two units. Each unit shall cater complete 100 % load if any unit have in overhauling due to maintenance & troubleshooting. Each unit shall have a static switch connected to a separate bypass circuit, the rating of which shall be the same as that of each unit. The two bypass supplies shall be connected in parallel from the same mains supply bus bar.

The load sharing controls shall not be subjected to common mode failure & any failure of load sharing controls shall not result in loss of vital power.

Suitable protection shall be incorporated to safeguard against loss of synchronism during bypass supply deviations which could result in short circuiting of the UPS output.

Each unit shall effectively run at 50% duty. The output of the rectifier shall continuously supply the power requirements of the load via the inverter, while simultaneously maintaining the battery charge in the float charge mode. In the event of failure or switching-off of any one inverter shall result in uninterrupted acceptance of the complete load by the other inverter, and thereafter to the bypass circuit in the event of subsequent failure or switching-off of the second inverter.

Upon restoration of the A.C. mains voltage, the rectifier shall supply the power requirements of the load, via the inverter, while simultaneously recharging the battery. The rate of recharging the battery shall be such as to restore it to the required capacity within the time specified.

The output of the inverter shall be maintained within the voltage and frequency tolerances. The output voltage of the inverter shall also be controlled to maintain synchronism and phase with



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the bypass supply voltage, provided the latter is within the tolerances specified for the load transfer conditions. If the bypass supply voltage exceeds these tolerances, then the inverter shall revert to unsynchronized operation at its own internally set frequency. The inverter shall automatically resume synchronous operation with the bypass supply when the voltage and frequency of the latter returns within the specified tolerances.

Under synchronous operating conditions, the static switch shall initiate uninterrupted transfer of the load to the bypass supply in the event of deviation in the inverter output voltage or frequency outside the permissible tolerances, or the switching off of the inverter unit.

In the event of automatic transfer of the load to the bypass circuit and subsequent restoration of the inverter output quantities to within the permissible tolerances, the inverter shall automatically resume synchronous operation with the bypass supply and shall initiate uninterrupted retransfer of the load to the inverter.

A make before break maintenance by pass switch shall be provided for each unit to allow maintenance.

Facilities shall be provided with clear instructions, adequate warnings and built-in safeguards to enable manual initiation of uninterrupted transfer of the load from the inverter supply to the bypass and from the bypass to the maintenance bypass and back again.

The AC UPS shall be capable of energizing the load within the permissible tolerances and of achieving the uninterrupted load transfer requirements via the static switch, without the battery connected.

The AC UPS shall be designed with 25% spare loading capacity for future.

**4.2.3. UPS ELECTRICAL LOADS**

The electrical loads energized by the UPS shall consist principally of controlling panels, instrument field equipments, computer and/ or digital electronic equipment incorporating switched-mode power supply units.

**4.2.4. MAINS ELECTRICITY SUPPLY**

The UPS shall be capable of operating with the nominal supply system will be 400V, 3 phase, 4 wires, 50 Hz, neutral solidly earthed.

During normal system operation and under steady-state conditions, the supply system shall not deviate from the limits as specified:



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PARAMETERS	UNIT/VALUES
VOLTAGE	+/-10%
FREQUENCY	+/-2%
TRANSIENT VARIATIONS WILL OCCUR AS FOLLOWS:	
VOLTAGE	±20%
FREQUENCY	±2 Hz

In addition to the above variations, the input voltage may be subjected to transient comprising of voltage depressions up to 20% of the nominal voltage and to voltage interruptions during system short circuits, & motor starting.

#### 4.2.5. AC-UPS CONFIGURATION AND TIE-IN

The Dual Redundant AC-UPS system shall essentially comprise two UPS units, two stabilized bypass supplies, one AC distribution boards including of MCCB's, two battery banks, static switches and all necessary interconnections. The UPS switching devices shall be installed in the UPS panel.

Cables connecting the batteries to AC UPS units shall be single core, flexible, 600/1000V grade PVC insulated. These shall be sized and supplied by UPS VENDOR. The lengths of cable required will be provided by UPS VENDOR as per equipment room layout & site requirement.

The MANUFACTURER shall provide a suitable molded-case circuit breaker with the UPS unit to facilitate on-load isolation of the battery for the purpose of performing battery maintenance. The battery's switching device shall be installed adjacent to the battery, inside the battery room. Molded –case circuit breaker shall be of CAT B; In accordance with IEC-60947-2.

The manual bypass switch shall in the same operation disconnect the inverter and static changeover switch to ensure safe operating conditions for maintenance purpose.

A warning label shall be provided to warn the operator against operating the manual bypass switch if the "out of synchronization" warning indicator is showing. Isolation of the inverter shall only be possible if an alternative supply is connected to the load bus.

All indications shall be tagged in front of panel with standard colors.

The AC-Distribution board shall cater to the UPS loads, and shall be provided with 25% spare circuit breakers for future loads.



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**5. PERFORMANCE REQUIREMENTS****5.1. RECTIFIER**

Rectifier shall operate according to constant voltage, current limiting principle & shall incorporate a 'soft start' feature to gradually accept load on initial energizing. Rectifier shall restart automatically upon restoration of main power supply.

The rectifier shall be rated to simultaneously:

- Recharge the battery, within a 10 hours, from the partially discharged condition to a capacity that will enable it to fulfill the inverter input power requirements, for the duration as specified in the requisition, when the inverter is delivering rated output at 0.8 power factor lagging;
- Batteries shall be maintenance free, Sealed Lead Acid batteries with 60 minutes minimum back-up time at 100% rated load.

The above recharge performance shall be achieved irrespective of the type and method of battery recharging employed. Battery aging factor shall be provided and confirmed by the VENDOR.

For maintenance free, Sealed Lead Acid batteries, the rectifier shall perform battery charging in accordance with the operational stipulations of the battery supplier and no high rate charging shall be provided.

For maintenance free, Sealed Lead Acid batteries, the rectifier shall also be capable of delivering the battery initial equalisation charge as specified by the battery supplier.

Switched diodes or supplementary battery cells as a means of limiting D.C. voltage variations are not acceptable. The D.C. supply shall not be utilized to energize loads other than the inverter.

**5.2. RECTIFIER INPUT**

The UPS unit shall be capable of operating from the mains electricity supply as defined in (3.2.4). The rectifier shall have a mains input transformer to galvanically isolate the a.c. and d.c. systems and improve immunity against faults in the upstream circuit.

Moreover, the total harmonic voltage on the supply induced by the current harmonic contents of the rectifier input shall be calculated based on the maximum short circuit capacity at the LV switchboard bus bars as defined on the Requisition, so that the total harmonic distortion (THD) level shall not exceed 5 %.





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**5.3. RECTIFIER OUTPUT**

Under all operating conditions the voltage a.c. component ripple on the battery terminals, including any ripple from the inverter and load, shall be within the limits stated by the Manufacturer of the batteries.

**BATTERY FLOAT-CHARGE OPERATION**

The rectifier steady-state D.C. output voltage variations shall be controlled to within plus  $\pm 1\%$  of the set value (corresponding to the battery float-charge voltage) during load variations between zero and the rated output of the rectifier, and during steady-state input voltage and frequency variations specified.

Short-time mains supply voltage depressions of not more than 20%, which may be the result of motor starting activities, shall not result in a trip of the rectifier or the initiation of battery discharge.

The D.C. output current of the rectifier, when operating under constant current-limiting conditions, shall be controlled to within plus  $\pm 2\%$  of the set value.

Online adjustment of set value of float charge voltage shall be possible by means of a potentiometer on relevant control circuit card or by software change.

**BATTERY RAPID CHARGE OPERATION**

Facilities shall be provided to initiate battery rapid-charge operation by manual and automatic means. Automatic initiation of battery rapid charge shall occur following any period of battery discharge exceeding losses.

Battery rapid-charge operation shall be automatically controlled according to a constant current/ constant voltage characteristic.

The duration of battery rapid-charge operation shall be controlled by an adjustable timing relay. The relay shall be activated on detection of battery voltage and current conditions which indicate the restoration of the battery to an appropriate state of charge. After the elapsed time, the timing relay will reinstate the rectifier output voltage to that corresponding to continuous float-charge operation. When operating under constant current-limiting conditions, the D.C. output current of the rectifier shall be controlled to within plus  $\pm 2\%$  of the set value.

When operating under constant output voltage conditions, the voltage shall be controlled to within plus  $\pm 1\%$  of the set value.

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On-line adjustment of the set value of the final voltage applied to the battery shall be possible by means of a potentiometer on the relevant control circuit card, or by an appropriate menu driven software change.

**5.4. BATTERY AND D.C. CIRCUIT**

The battery voltage and capacity shall be such as to fulfill the inverter input power requirements when the inverter is delivering its rated kVA output at 0.8 power factor lagging, for the duration specified in the requisition.

The battery discharge performance shall be fulfilled.

- Throughout the range of service conditions specified, including that corresponding to the minimum cell temperature specified
- Repeatedly, each discharge performance being preceded by restoration of the battery to the required capacity by means of a recharge operation not exceeding eight hours
- Following a prolonged period (i.e., not less than one year) of battery float charge operation.

The nominal ampere-hour capacity of the battery supplied with the UPS shall include all necessary allowances required to compensate for aging effects that result in the progressive loss of capacity. However, the nominal ampere-hour capacity of the new battery shall be not less than 110% of the nominal ampere-hour capacity required to fulfill the performance criteria stated above.

The current ripple limits specified by the battery MANUFACTURER, for the battery supplied with the UPS, shall not be exceeded during at least normal standby operating conditions.

The MANUFACTURER shall specify the r.m.s. value of the actual, and the maximum permissible, ripple current through the battery, as a percentage of the battery nominal ampere-hour capacity, when the UPS is operating under normal standby conditions.

The D.C. circuit earthing arrangement shall be in accordance with the MANUFACTURERS standard.

**5.5. INVERTER**

The inverter shall be transistorized type PWM (Pulse Width Modulated) with microprocessor based controls using 6 or 12- pulse switching configuration. The inverter shall be of the current limiting type (short circuit proof) and have nominal output voltage and frequency as specified in specification. 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:



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- Load variations between zero and the rated output of the UPS
- Load power factors over the range 0.7 lagging to unity
- D.C. input voltage over the range corresponding to battery rapid charge and battery discharge operation during the specified discharge times.
- Inverter shall be capable of handling 'Harmonic distortion'.

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 bypass frequency exceeding these limits, the inverter shall revert to internal frequency control.

Automatic synchronizing to maintain output frequency within  $\pm 5$  degrees of the external reference signal, (provided the reference frequency stability is within  $\pm 2$ ), shall be supplied.

Upon failure of this reference, the inverter shall maintain the frequency within the tolerances quoted until the external reference returns. The inverter shall then automatically re-synchronize to the external reference.

The rate of frequency change during synchronizing shall not exceed 0.1 Hz per second when changeover is by the static switch.

Loss of synchronizing signal between the inverter and the bypass supply shall:

- Not block automatic actuated transfers from normal to bypass supply
- Not block automatic actuated transfers from bypass to normal supply

OUTPUT VOLTAGE STATIC REGULATION

The output voltage static regulation shall be maintained within plus  $\pm 1\%$  of rated output voltage.

OUTPUT VOLTAGE DYNAMIC RESPONSE

The dynamic output voltage variations shall not exceed plus  $\pm 8\%$  of rated output voltage in the event of instantaneous load changes of 100% rated output.

FREQUENCY DEVIATION

The frequency of the output voltage shall be maintained within plus  $\pm 1\%$  of rated frequency when operating on internal frequency reference.

OUTPUT VOLTAGE WAVEFORM

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The waveform of output voltage shall be sinusoidal. Inverters shall provide power from zero to full rated output without exceeding the specific 5% total harmonic distortion of the output voltage wave shape. The plant load typically includes non-linear loads which can introduce harmonics in the inverter output current. Inverters shall be capable of supplying the plant load without sustaining damage to any of their components due to such harmonics.

OUTPUT VOLTAGE SYMMETRY

For 3-phase inverters, the angular displacement of the phase voltages shall not exceed 120 deg  $\pm 1\%$  when supplying a balanced, linear load at rated output, 0.8 power factor lagging, and 120  $\pm 5\%$  when the load current in any two phases differ by 50% from the rated output current.

SHORT CIRCUIT CURRENT AND OVERLOAD

The inverter shall be capable of withstanding & delivering sufficient short circuit current as a minimum the inverter shall be capable of delivering 150 % of its rated output for one minute. For fuse clearing and excessive overloads, the unit may switch to bypass without interruption to the vital power.

**5.6. STATIC BYPASS SWITCH**CIRCUIT RATING

The load transfer switching devices may consist of either continuously rated static element in both inverter and bypass circuits, or continuously rated electro-mechanical switching devices with short time rated static elements. The bypass shall have a continuous current rating equivalent to rated output of UPS unit and be capable of conducting a current of 10 times for not less than 2 sec.

In view of electronic components involved, reliability in terms of high Mean Time between Failure (MTBF) factors is essential. To achieve this objective, MANUFACTURER is required to examine the rating factors applied to all components used in manufacturing, and guarantee that the ratings for this application will be modified as necessary to ensure long term reliability. MTBF rating of UPS system shall be at least 100,000 hours.

LOAD TRANSFER CRITERIA

Facilities shall be provided to manually and automatically initiate transfer of the load from the inverter to the bypass circuit and from the bypass circuit to the inverter. The combined detection and switching time required to transfer the load from the inverter to the bypass circuit in the event of instantaneous loss of inverter output voltage shall not exceed 100 millisecs.



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When the inverter is running with its internal reference frequency and the static switch is blocked, any failure of inverter shall initiate a transfer to bypass supply after a time delay which can be adjusted from 50 to 500 milliseconds.

The criteria for load transfer shall be as follows:

- a. Transfer of the load from the inverter to the mains bypass. Load transfer shall only be possible when:
  - The mains bypass voltage is within  $\pm 10\%$  of rated UPS output voltage;
  - The mains bypass frequency is within the tolerances specified;
  - The inverter output and mains bypass voltages are synchronized.
- b. Automatic transfer of the load shall be initiated when:
  - The inverter output voltage drops below 95% of the nominal output voltage. Transfer should be accomplished before the voltage reaches 85% of the nominal value;
  - The inverter output voltage exceeds 105% of the nominal output voltage. Transfer should be accomplished before the voltage reaches 115% of the nominal value;
  - The inverter output current limit is exceeded.
- c. Retransfer of the load from the mains bypass to the inverter. Load retransfer shall only be possible when:
  - The inverter output voltage is within  $\pm 10\%$  of the nominal output voltage for more than 5 seconds;
  - The inverter output and mains bypass voltages are synchronized.

Subject to fulfilling the above criteria, retransfer of the load from mains bypass to the inverter shall be initiated automatically following automatic transfer of the load from the inverter to the mains bypass. The automatic retransfer of the load to the inverter shall be inhibited following four automatic transfers of the load to the bypass, if these take place within an interval of 5 minutes. An annunciation shall be provided under this condition.

Subject to fulfilling the above criteria, automatic retransfer of load back to the inverter(s) from the bypass transformer shall operate as follows:

- a. A two-position "AUTO-STANDBY" retransfer selector switch shall be provided for each changeover switch to control the automatic retransfer operation.
- b. When the retransfer selector switch is in the "AUTO" position, retransfer back to the inverter supply shall occur automatically whenever the conditions of Item (b) above are met.



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- c. When the retransfer selector switch is in the "STANDBY" position, retransfer back to the inverter supply shall occur automatically only if the bypass supply has been lost and normal voltage is present on the inverter supply.

All transfer switches and the actuating devices for these controls shall be so located or guarded to prevent accidental operation.

NOISE LIMIT

The sound level shall not exceed 75 dBA at 1m distance.

**5.7. CONSTRUCTION REQUIREMENTS**

**5.7.1. UNIT ENCLOSURE AND ACCESSIBILITY**

UNIT ENCLOSURE

The rectifier, inverter and static switch shall be installed in one freestanding, self supporting steel cabinet forming an enclosure. Each cabinet shall be suitable for operation and maintenance with its rear panel against a wall and with similar units located immediately on both sides. Enclosure protection shall not less than IP42 per IEC 60529, without considering floor as part of enclosure.

COOLING

Internal cooling of the unit shall be by natural or forced air ventilation. In case of fan failure, an alarm shall be triggered. Unit shall not incorporate cooling air filters that require periodic cleaning and/or replacement.

VENDOR shall provide alarm indication in case the UPS cooling fans have stopped functioning

ACCESSIBILITY

Equipment and components located within the enclosure shall not be mounted directly on the walls of the enclosure. The location and grouping of components and auxiliary equipment shall permit easy identification and access for operational, maintenance and repair purposes. Suitable partitioning between individual items shall be provided where necessary to allow adjustment and inspection to be carried out safely.

All live terminals of door-mounted equipment having a maximum (peak) voltage of greater than 24 volts shall be shrouded or otherwise protected to a degree of protection of at least IP 30.

BATTERY ENCLOSURE

Batteries shall be installed in cubical cabinet/rack separate from UPS. Battery enclosures shall be naturally ventilated to disperse gaseous products. The battery shall be positioned such that

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possible leakage of electrolyte or emission of gaseous products shall not cause damage to other equipment, components, or adjacent cells.

Separate, freestanding support racks for batteries having plastic cell containers may be steel or solid wood. The Manufacturer/Vendor shall provide battery rack/cubicle in such a way to accommodate in dedicated battery room.

**5.7.2. CONVERTER COMPONENTS**

Printed Circuit Boards (PCB) shall be installed in standardized electronic equipment frames and be fitted with handgrips for easy removal. The frames shall incorporate card guides to facilitate the correct insertion of PCB's, and allow access to the wiring side of connectors. PCB's shall include visual LED status indications and test connections on the front to facilitate fault diagnosis.

Main circuit switch shall comply with IEC-60947. Contactor shall comply with the IEC-60158-1.

**5.7.3. WIRING AND TERMINATIONS**

Vendor shall supply main incoming cables for UPS from MCC room to control room and all interconnecting cables i.e. for battery banks & distribution board to connected loads. Power supply & power cable for all the interconnected loads (DCS etc.) shall be dual redundant to attain the redundancy in case of failure in any breaker or its relevant cable. Design factors of latest editions of BS/IEC as per section 2.0 shall be considered during sizing of power cables, size of power cable shall be adequate to accommodate 25% future load too. Vendor shall share sizing to COMPANY/CONSULTANT for review & approval and consequently, proceed for procurement after incorporated COMPANY/CONSULTANT comments.

Main incoming and outgoing cable from UPS DB to loads shall be armored, 600/1000V grade XLPE insulated, and stranded copper conductors. However, interconnecting cables shall be single core, 600/1000V grade PVC insulated, and stranded copper conductors. Minimum conductor size for power circuits shall be 2.5 mm<sup>2</sup>. Wiring between terminals shall be continuous and without joints. Wires shall be held in position by means of insulating tubes, channels, cleats or plastic strips, and be routed such as to avoid mechanical damage. Wiring between fixed portions and hinged doors shall be mechanically protected against abrasion or entrapment and shall not be carried over or bent around sharp edges.

Individual wires or cables terminating in fixed (non-plug-in) components which require to be disconnected for the purpose of component testing or replacement shall be identified by means of color or by ferrules of insulating material marked in accordance with the MANUFACTURER'S drawings.



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Terminations shall be provided with 25% spare margin.

Terminals shall be provided for all external connections. External connections shall not be made directly to component terminals. Terminals shall be of the rail mounted type and have screw connectors suitable for a minimum of 2.5 mm<sup>2</sup> conductors. Only one conductor shall be terminated in each terminal. Links shall be provided where more connection required.

The UPS enclosure shall have facilities for the entry of cables from above or below, as specified in the requisition. Cable entries and terminals shall be suitable for the type and size of cables specified on the requisition. Cable glands shall be of the compression type and mounted on a removable gland plate.

The proximity of terminals and gland plates shall be such that ample space is available for terminating the cores of external cables

Distance between cable entrance and terminals shall be such that ample space is available for terminating the cores of external cables. Additional load circuit terminals shall be provided to facilitate connection of temporary load to test the UPS

#### 5.7.4. EARTHING

An earth rail, with a suitable number of earthing bolts or screws, shall be provided in a position close to the external cable glands to facilitate termination of cable earth braids or armoring.

A threaded brass earth stud of not less than 6 mm diameter, with nuts and spring washers, shall be provided within the enclosure to facilitate termination of a separate, single-core, earth cable.

Electrical conductivity between the exposed, non-current carrying conductive parts of the UPS unit components and the enclosure, and between the enclosure and the earth rail/earth stud, shall be such as to maintain effective continuity of protective circuits. Earth bonding conductors shall be utilized between enclosures and doors, and where required to achieve effective protection. The neutral of the inverter output shall be earthed by a connection to the earth rail/stud within the enclosure.

#### 5.7.5. BATTERY CELLS AND CONTAINERS

Unless otherwise specified in the requisition, storage battery bank composed of 10 years maintenance free, sealed Lead Acid batteries shall be provided along with UPS. Maintenance free Sealed Lead Acid batteries shall be designed to feed the inverter in case of power failure for an hour (60 minutes) at full load. The battery has the negative pole earthed.





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Battery cubicle shall include a DC Circuit Breaker as short-circuit protection and disconnect between the battery and the UPS Inverter unit; terminal leads to connect the battery to the UPS units is included in the scope of supply of the battery manufacturer.

**5.7.6. MARKING**

All external operating, measuring and indicating components shall be clearly identified with permanent descriptive labels that facilitate easy recognition by the operator. All components shall be identifiable by labels inscribed in accordance with the system of identification used on the MANUFACTURER'S reference drawings and documents.

Rail mounted terminals of equipment and components shall be identifiable by numerical or alphabetical markings in accordance with the MANUFACTURER'S drawings.

Terminals of input and output supply cables shall be clearly and uniquely marked to indicate the nominal system voltage and the phase/polarity of the supply.

The identification of terminals shall be in accordance with IEC-60445.

The following information shall be inscribed on a non-destructive, corrosion resistant name/rating plate attached to the unit enclosure:

- Year of manufacture.
- Name of MANUFACTURER.
- Type and serial number of unit.
- Weight of cubicle.
- Dimensions of cubicle.
- Nominal input current and voltage.
- Nominal output current, voltage and frequency.

All switches, instruments (meters), transformers, fuse holders, push buttons and indicating lamps shall have labels fixed adjacent to them. The label shall carry a functional description and all essential data including, but not limited to, the following information as applicable:

- Fuse size.
- Ratings (voltage, current, frequency).
- Accuracy.
- Switch duties.

**5.8. MEASUREMENT, PROTECTION AND CONTROL EQUIPMENT****5.8.1. GENERAL**

The UPS unit shall incorporate all the necessary equipment to enable operation, protection and control of the UPS in accordance with this specification, and to safeguard the unit and its



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components from the consequences of internal and external short circuits, over voltages and any main or control circuit malfunctions, howsoever caused.

Operating, status and diagnostic indications of light-emitting diodes (LED's) or liquid crystal displays (LCD's) shall be provided.

Each LED/alarm circuit shall have built-in test facilities. Failure of an LED/LCD shall not cause UPS mal-operation or affect the correct functioning of the remote common alarm signal. Indication by means of filament lamps is not acceptable.

Microprocessor based protection, control and metering package with serial communication shall be provided for remote control and monitoring of the UPS from the plant control system. This serial interface shall be on RS 485 Modbus RTU protocol. RS485 Port shall be provided for Remote Alarm to DCS.

#### 5.8.2. STATUS INDICATIONS

At least the following indications, in the form of LED/LCD's and/or measuring instruments, shall be provided on the front outside panel of the unit to enable verification of the operational status of the UPS. The indications shall be superimposed on a mimic diagram of the UPS unit to identify the relevant component or circuit.

- A.C. input supply available
- Alternative/bypass supply available
- Rectifier on
- Inverter on
- Load on inverter
- Load on bypass
- Inverter/bypass synchronized
- Battery on rapid charge.

#### 5.8.3. MEASUREMENT

Facilities for obtaining the following information or measurements shall be provided on the front outside panel of the unit:

- Rectifier mains (input) voltage and current, 3 Phase (AC)
  - Battery voltage and current (charge and discharge) (DC)
  - Output voltage, current and frequency (AC)
  - Inverter current (AC)
  - Bypass mains (transformer output) voltage, current and frequency (AC)
  - Total current (DC)
-



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- Output power factor
- Output peak current
- Backup Time Left (% & Minutes)

**5.8.4. PROTECTION AND ALARMS**

The status of the alarm and protection functions shall be visually verifiable by appropriate indicators with first failure feature. Alarms associated with trip functions shall be hand reset.

The following alarm and protection functions shall be provided as a minimum:

(1 = alarm. 2 = alarm and trip rectifier. 3=alarm and trip inverter)

- A.C. input phase under voltage : 2
- Rectifier failure : 2
- D.C. Overvoltage : 3
- D.C. under voltage : 3
- Charge failure/battery discharging : 1
- Battery disconnected : 1
- D.C. earth fault (\*) : 1
- Inverter failure : 3
- Inverter overcurrent : 3
- Inverter output voltage deviation : 3
- Inverter/bypass not synchronized : 1
- Cubicle fan failure : 1
- Cubicle/inverter stack over temperature : 3
- Battery Capacity low : 1

(\*) to be provided on normally unearthed D.C. systems.

Volt free contacts for following alarms shall be wired to DCS in Main Control room:

- Common Failure Alarm
- Load on battery
- Load on bypass
- Charger failure
- UPS Healthy

The above mentioned alarm contacts shall be wired to a terminal block such as to provide one normally open and one normally closed, potential-free, contacts for remote cabling to a



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common alarm. The operation of the common alarm contacts shall have an adjustable time delay with a range of not less than 4 seconds.

An inverter over temperature alarm shall be provided to give a two-stage alarm indication. The temperature sensors shall be located by the MANUFACTURER at the highest temperature position within the equipment to ensure full protection. The operating level of the alarms shall be determined by the MANUFACTURER/VENDOR and set to ensure that adequate time is available for corrective measures on operation of the first alarm level.

Operation of the second alarm shall cause the load to be transferred to the bypass circuit and shall isolate the inverter. An alarm indicator shall be provided for both stages.

An alarm indicator shall be provided to indicate that the inverters output and the bypass circuit are out of synchronism.

In addition, a white "source synchronized" pilot light shall be provided adjacent to the operating handle of the manual bypass switch. The light shall be energized when normal and bypass sources are in synchronism.

Operation of any of the above alarms or relays shall initiate a common fault alarm relay with two sets of changeover contacts wired out to terminals for external connection.

When fault diagnostic modules are available, they shall be made visible through a transparent panel let into the front of the equipment door.

#### 5.8.5. CONTROLS

The following adjustment and control facilities shall be provided:

- Rectifier input isolation switch/MCCB;
  - Rectifier on/off control switch;
  - D.C. output voltage adjustment;
  - D.C. current limit adjustment;
  - Inverter on/off control switch;
  - A.C. output voltage adjustment;
  - Battery isolation switch;
  - Battery Diagnostic.
  - Load transfer limiting control switch.
  - Sync. Range adjustment.
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**5.8.6. BATTERY DIAGNOSTICS FACILITIES**

The AC UPS unit shall be provided with an on-line battery cell monitoring and battery discharge test facility to determine battery condition without having to disconnect the AC UPS unit from the load.

The monitoring facility shall measure voltage levels of blocks of cells within a battery by means of a permanently installed monitoring device connected to the battery control panel and wired to the battery cells.

**6. INSPECTION AND TESTING**

The UPS shall be factory tested in fully assembled conditions. Test shall be carried out in accordance with the relevant IEC 62040-3 & as per ISO standards and manufacturer's QA/QC programme.

**7. SHIPPING AND PACKING**

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

After inspection and test, equipment shall be completely free of water and dry before start of preparation for shipment.

Equipment and materials shall be protected to withstand ocean transit and extended period of storage at the jobsite. Equipment shall be protected to safeguard against all adverse environments, such as: humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray, and sea water.

**8. GUARANTEE AND PERFORMANCE**

The CONTRACTOR's Manufacturer shall guarantee, in accordance with General Terms & Conditions that the equipment shall meet the performance conditions specified in data sheets.

**9. PERFORMANCE TEST**

Only reference test are mentioned below however, the CONTRACTOR's Manufacturer shall perform the entire tests as per IEC 62040-3 & its equivalent ISO standards.

- Insulation test.
  - Load Duration test.
  - Functional test.
  - Rectifier Load test & constant output voltage.
  - Rectifier Load test at constant output current limit.
  - Static By pass switch test.
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- Battery Discharge test.
- Load sharing test

**10. SPARE PARTS**

VENDOR to provide:

- Commissioning spares.
- List of Spare parts for 2 years operation

**11. DOCUMENTATION**

Standard MANUFACTURER documentation shall be provided by the VENDOR with minimum specified in below as per mentioned stage with in cited time frame.

**WITH THE BID**

- Descriptive literature including vendor model code selection, parts and accessories with detail selection of components.
- UPS sizing calculation
- Rectifier, Inverter & Battery charger sizing calculation
- Certified type test reports of the UPS & Isolation transformer
- Data Sheet of UPS, Rectifier, inverter, isolation transformer, batteries & distribution board including of components .i.e. MCCB's, switches etc.
- Single line diagram
- Commissioning Spares with prices
- Recommended spare parts lists for two years operation with prices

**PRIOR TO MANUFACTURING**

- Document Control Register (7 days)
  - Sub vendors' document register, if have (7 days)
  - System block diagram (5 days)
  - Power and control diagrams (5 days)
  - Cable Schedule (2 days)
  - Battery arrangement & wiring diagram (5 days)
  - Overall and assembly drawings (5 days)
  - Front face arrangement (5 days)
  - Detailed component list (5 days)
  - Bill of Material (1 days)
  - General arrangement & connection drawing of UPS, Battery cubicles/Rack & distribution board (2 days)
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**SHIPMENT (BEFORE OR WITH)**

- Test reports, records and performance curves (before)
- Cable Schedule (before)
- Installation, operation and maintenance manual of UPS & Batteries (With)

On approval of preliminary drawings the Manufacturer shall develop final design drawings incorporating COMPANY/CONSULTANT's comments, if any, before proceeding with the manufacturing. All the comments shall be followed properly on comments Resolution sheet (CRS), once the documents is finalized/closed, vendor shall provide the IFC revision. Three (03) no. of sets of all the documents as per DCR including Factory As-built & test reports shall be provided with the shipment for COMPANY/CONSULTANT records.