

DEP SPECIFICATION

**DESIGN AND FABRICATION OF UNINTERRUPTIBLE
POWER SUPPLIES FOR NORTH AMERICAN
APPLICATIONS**

DEP 33.65.50.33-Gen.

February 2017

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE

DEM1



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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	9
1.5	SUMMARY OF MAIN CHANGES.....	9
1.6	COMMENTS ON THIS DEP	9
1.7	DUAL UNITS.....	9
1.8	NON NORMATIVE TEXT (COMMENTARY).....	9
2.	GENERAL REQUIREMENTS	10
2.1	BASIC STANDARDS	10
2.2	DESIGN BASIS.....	11
2.3	OPERATING PRINCIPLE.....	11
2.4	UNIT RATING	14
2.5	SERVICE CONDITIONS	14
2.6	PRIMARY POWER SUPPLY.....	15
2.7	TIE-IN OF UPS UNIT TO PRIMARY POWER SUPPLY SYSTEM	15
2.8	INFORMATION TO BE SUBMITTED WITH THE TENDER.....	15
3.	DESIGN REQUIREMENTS	15
3.1	UPS.....	15
3.2	RECTIFIER/CHARGER	17
3.3	DC CIRCUIT	18
3.4	INVERTER.....	21
3.5	STATIC BYPASS SWITCH (SBS).....	22
3.6	REMOTE MAINTANENCE BYPASS SWITCH (RMBS).....	23
3.7	REMOTE BATTERY DISCONNECT	23
3.8	INPUT, BYPASS AND OUTPUT TRANSFORMERS	24
3.9	RELIABILITY.....	24
3.10	EMI SUPPRESSION.....	24
3.11	NOISE LIMITS	25
3.12	DC BATTERY CHARGERS.....	25
3.13	INPUT AND OUTPUT REQUIREMENTS	25
4.	CONSTRUCTION REQUIREMENTS.....	27
4.1	ENCLOSURE, COOLING AND ACCESSIBILITY	27
4.2	ELECTRICAL COMPONENTS.....	28
4.3	WIRING AND TERMINATIONS.....	28
4.4	EXTERNAL CONNECTIONS	29
4.5	GROUNDING.....	29
4.6	TAGGING AND NAMEPLATES	29
4.7	DC BATTERY CHARGER(S) AND ASSOCIATED DISTRIBUTION SYSTEM COMPONENTS ENCLOSURE.....	31
5.	CONTROLS, MONITORING AND COMMUNICATION	33
5.1	GENERAL	33
5.2	CONTROL INDICATIONS	33
5.3	MEASUREMENT	34
5.4	AC PROTECTION AND ALARMS.....	34
5.5	CONTROL, SETPOINTS AND CALIBRATIONS.....	36
5.6	EVENT LOGGING, STATISTICS AND HISTORY	37
5.7	COMMUNICATIONS	37
5.8	DC PROTECTION AND ALARMS.....	37
5.9	DC PANEL METERS	38
6.	INSPECTION AND TESTS	39
6.1	GENERAL	39
6.2	UPS INSPECTION AND TESTING	39

6.3 BATTERY TESTING 42

7. SHIPPING 43

7.1 UPS.....43

7.2 BATTERIES 44

8. DOCUMENTS.....44

8.1 GENERAL 44

8.3 DRAWING AND DATA REQUIREMENTS 46

9. REFERENCES 47

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the material, design, fabrication, inspection, testing, and documentation for an on-line, continuous duty uninterruptible power supply (UPS) system of either pulse width modulated (PWM) design or ferroresonant type design for application in North America. Also included in this scope are the stationary batteries associated with these UPS units.

This DEP now contains the applicable requirements previously in DEP 33.65.50.33-Gen.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 - Application of Technical Standards.

This DEP is a revision of the same number dated February 2016; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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Any authorized access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented. This is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist, in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regard to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Electrical Technical Authority of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Electrical Technical Authority may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorized to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalized term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Accredited Certification Organization (ACO)	An organization that has been accredited by the Standards Council of Canada, in accordance with specific criteria, procedures and requirements, to operate, on a continuing basis, a certification program for electrical equipment. When a reference is made to a NRTL in this DEP, this also includes the Accredited Certification Organization in Canada.
Alternate Power Source	A separate AC power supply provided to supply the load.
Backup Time (of a battery)	The duration for which the battery can supply its rated load within its specified voltage limits, following a prolonged period of battery float-charge operation.
Battery Life	The life of the battery (in years) at the time when the battery capacity is reduced to 80 % of the original design capacity at the design discharge rate and design ambient temperature.
Crest Factor	The ratio of the peak (maximum) value of a periodic function to its root-mean-square (rms) value.
Critical Service	Services that are required to ensure a safe and orderly shutdown of the facility, safety of personnel, and protection of the environment in the event that the normal power supply is lost.
DC UPS	A system containing an AC/DC battery charger, and battery that provides uninterrupted DC power to loads.
Electrical Technical Authority	The discipline engineer appointed by the Principal responsible for all technical decisions associated with the work. The Electrical Technical Authority is responsible for technical integrity.
Equalize Voltage	A high DC charging voltage applied to batteries, which has the property of equalizing the voltages of the battery cells.
Float Voltage	A low DC charging voltage applied to batteries to replace internal losses and maintain a fully charged condition.
Frequency Slew Rate	The rate of change of frequency expressed in hertz per second
Full Float Operation	Operation of a DC system with the battery charger and load cell connected in parallel and with the battery charger supplying the normal DC load, plus any self-discharge or charging current or both required by the battery. (The battery will deliver current only when the load exceeds the charger output.)
HSSE Critical Equipment	An item of equipment or structure, or a system (including software logic), that acts as a barrier to prevent the uncontrolled release of a Hazardous Substance or release of energy leading to worst case credible scenario with RAM red, yellow 5A or yellow 5B Risk, or acts as a barrier to control or mitigate the effects of such a release. HSSE critical equipment is also known as Safety Critical Equipment or SCE.

Term	Definition
Inverter	Changes DC power to AC power.
Location	The site where the new electrical facilities will be installed and operated.
Nationally Recognized Testing Laboratory (NRTL)	A part of OSHA's Directorate of Technical Support and Emergency Management in the US. The NRTL Program recognizes private sector organizations as NRTLs, and recognition signifies that an organization has met the necessary qualifications specified in the regulations for the Program. The NRTL determines that specific equipment and materials ("products") meet consensus-based standards of safety to provide the assurance, required by OSHA, that these products are safe for use in the U.S. workplace. See DEP 33.64.20.10-Gen., Appendix E for additional information on NRTLs.
Rectifier	Changes AC power to DC power. Sometimes, it is called a battery charger.
Remote Maintenance Bypass Switch (RMBS)	A three-position switch that allows the load to be connected to the bypass source and isolates the entire UPS system. The RMBS is located in a separate enclosure and mounted remotely from the UPS.
Ripple	The alternating current component from a direct current power supply arising from sources within the power supply
Static Bypass Switch (SBS)	Used to transfer automatically the load from the inverter to the alternate source and vice versa. It normally connects the load to the inverter. Under fault conditions, (e.g., an inverter failure) it transfers the load to the alternate source fast enough to prevent any significant disturbance in the power supply to the load.
Uninterruptible Power Supply (UPS)	A continuous duty solid-state on-line, uninterruptible power supply (UPS). AC power is converted to DC power by a rectifier/charger section, which provides power to operate the inverter and keep the batteries fully charged. The inverter then converts the DC power back to clean, conditioned AC power. The UPS operates in conjunction with the existing building/plant electrical systems to provide high quality power to critical loads.

1.3.3 Abbreviations

Term	Definition
AC	Alternating Current
ANSI	American National Standards Institute
CFR	Code of Federal Regulations
DC	Direct Current
DEM1	Design and Engineering Manual - to define the technical standards for design and construction that have a direct relationship to Process Safety
DEP	Design and Engineering Practice
EMI	Electro Magnetic Interference
EPROM	Erasable Programmable Read-Only Memory
ETA	Electrical Technical Authority
FCC	Federal Communications Commission
HEMP	Hazards and Effects Management Process
HMI	Human-Machine Interface
ICES	Interference-Causing Equipment Standard
IEEE	Institute of Electrical and Electronics Engineers
LEDs	Light-Emitting Diodes
MTBF	Mean Time Between Failures
MTO	Material Take Off
MTTR	Mean Time to Repair (Recovery)
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
PCBs	Printed Circuit Boards
PWM	Pulse Width Modulated
RMBS	Remote Maintenance Bypass Switch
SBS	Static Bypass Switch
SPDT	Single Pole, Double Throw
UL	Underwriters Laboratories

Term	Definition
UPS	Uninterruptable Power Supply
VLRA	Valve-Regulated Lead–Acid Battery
VPI	Vacuum Pressure Impregnation

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (9).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. The only changes are to DEP cross-references to reflect changes in the DEP library in 2017.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the “Give feedback” link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select “Submit DEP Feedback”, fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. GENERAL REQUIREMENTS

2.1 BASIC STANDARDS

2.1.1 General

1. UPS supply units and distribution systems having overall availability greater than 99.95% SHALL [PS] be used to supply HSSE critical equipment.

HSSE critical equipment is an item of equipment or structure, or a system (including software logic), that acts as a barrier to prevent the uncontrolled release of a Hazardous Substance or release of energy leading to worst case credible scenario with RAM red, yellow 5A or yellow 5B Risk, or acts as a barrier to control or mitigate the effects of such a release.

UPS systems are considered to be robust if they have an overall availability of greater than 99.95 %, an overall Mean Time Between Failures (MTBF) in excess of 200,000 hours and a Mean Time to Repair (MTTR) of eight (8) hours. These figures exclude outage time for battery discharge testing and assume spare parts are available at site.

UPS systems, which are designed and manufactured in accordance with this DEP, are deemed to be robust.

2. The Manufacturer/Supplier shall comply with regulatory requirements applicable to the equipment for the location in which it will be installed.
3. In the quotation, the Manufacturer/Supplier of the UPS and its ancillary equipment shall confirm that the equipment fully complies with the quotation and the whole system is manufactured in accordance with this DEP, the associated Data Sheet and is suitable for the specified duty.
 - a. Any deviations from this DEP or the Data Sheet shall be clearly highlighted.
4. If equipment proposed by the Manufacturer/Supplier cannot fully meet the requirements of this DEP, such exceptions shall be stated clearly in Manufacturer/Supplier's proposal with cross-references to the specific sections and subsections to which exceptions are taken. No exceptions shall be allowed, unless approved by the Electrical Technical Authority (ETA) in writing.
5. In the event of conflicts between and/or among documents, the Manufacturer/Supplier shall contact the Principal for resolution.
6. If deemed necessary by one of the parties involved, a pre-ordering meeting shall be arranged to define clearly the overall scope of supply, individual responsibilities and test methods.
7. If no exceptions are taken to these specifications or drawings, a specific statement to that effect shall be included.
8. If any one of the components or the whole system does not comply with the specification and any agreed amendments, the Manufacturer/Supplier shall rectify and re-test the UPS within a mutually agreed time.

2.1.2 AC UPS standards

1. The AC UPS unit shall be designed, constructed and tested in accordance with the latest revision of NEMA PE 1, this DEP and the Data Sheet.
2. The AC UPS unit shall comply with the latest revision of UL 1778 or CSA C22.2 No. 107, as applicable.

2.1.3 DC UPS standards

1. The DC UPS unit shall be designed, constructed and tested in accordance with the latest revision of NEMA PE 1, this DEP and the Data Sheet.
2. The DC UPS unit shall comply with the latest revision of UL 1778 or CSA C22.2 No. 107, as applicable.
3. For electronic system applications (e.g., control systems, communications systems monitoring systems), the DC UPS shall be designed, fabricated, and tested in accordance with NEMA PE 7.

2.1.4 Data Sheets

1. Use Data Sheet DEP 33.65.50.95-Gen. to specify the UPS.
This data sheet is applicable for both DC and AC outputs.
2. The applicable Data Sheet sections shall be completed and returned by the Manufacturer/Supplier as part of the quotation.

2.2 DESIGN BASIS

2.2.1 General design basis

The design of the UPS aims to minimize the risk of short circuits and ensure personnel and operational safety at all times.

1. The UPS shall be NRTL (Nationally Recognized Testing Laboratory) listed or ACO (Accredited Certification Organization) certified.
2. All equipment, components and materials furnished shall be new, field-proven, meet the requirements of this specification and be suitable for industrial service.
3. Obsolete components or components scheduled for discontinuation shall not be used.
4. Replacement parts and service shall be readily available.
5. UPS configuration shall be in accordance with one of the block diagrams in standard drawing S 66.236, or with the system one-line as indicated on the Data Sheet.
6. Components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short circuits and circuit switching operations.
 - a. Damage arising from component failure shall be confined to the component concerned.
 - b. Component materials shall be non-flame propagating, wherever practical.

2.3 OPERATING PRINCIPLE

2.3.1 Single UPS

1. For a single static UPS system, the circuit arrangement shall be as shown in S 66.236-001.

2.3.1.1 Normal mode operation

The rectifier/charger derives its power from the commercial AC power source and supplies DC power to the inverter while simultaneously float charging the battery.

Under normal load operation, the battery bank may be disconnected from the system without affecting the inverter output. The critical load is continuously supplied by the inverter, with isolated clean AC power.

1. AC loads shall be continuously supplied by the UPS inverter.
2. The primary power source shall be connected to the input of the rectifier/charger module.

3. An alternate AC power source shall be connected to the static bypass switch and to a remote maintenance bypass switch.

Under normal conditions, the battery rectifier/charger supplies regulated DC power to a battery and to an inverter, whose power output supplies either 1 or 3-phase power to the critical loads.

2.3.1.2 Critical mode operation

Upon failure of the commercial AC power source, the critical load is supplied by the inverter without any interruption; the inverter obtains its power from the storage battery.

1. The AC load shall be continuously supplied by the UPS inverter.
2. In the event of an outage of the primary power source, DC power from the battery shall be fed automatically to the inverter without switching and without interruption of the output power from the inverter.
3. Upon restoration of the primary power source, the charger shall automatically supply, without interruption, the input to the inverter and the battery.
4. In the event of low DC voltage, the UPS shall switch to the alternate supply.

2.3.1.3 Recharge mode operation

1. Upon restoration of the commercial AC power, provided a low DC voltage had not occurred, the rectifier/charger shall recharge the batteries and simultaneously supply the DC power input to the inverter.
2. If low DC voltage has occurred, a manual closing of the inverter's DC input breaker shall be performed to recharge the batteries. The inverter shall automatically start when inverter conditions are normal.

2.3.1.4 Bypass mode operation

1. In the event of a UPS inverter malfunction, fault or overload condition, the static bypass switch shall automatically transfer the load to the alternate AC power source without an interruption of power to the load and with less than a ¼-cycle break.
 - a. Upon clearing an inverter malfunction, fault or overload condition, the following shall be met:
 - i. The static transfer switch shall Automatically transfer the UPS load from the bypass to the inverter output.
 - ii. The transfer from both directions shall be without interruption (zero-break).
 - iii. A static switch transfer shall only be accomplished when the inverter output is in sync with the bypass source, except during inverter failure.
2. All transfers and re-transfers shall be automatic unless manually overridden.

2.3.1.5 Operation without battery mode operation

1. The UPS shall be designed so that the battery source can be isolated and removed for maintenance and testing without transferring to bypass mode of operation or interrupting the load.

2.3.1.6 Remote maintenance bypass mode operation

1. The remote maintenance bypass switch (RMBS) shall be provided to enable safe maintenance or removal of the UPS for major service.
2. The RMBS shall perform a make-before-break transfer of the entire load from the UPS to the alternate AC power source and from the alternate AC power source back to the UPS.
 - a. The synchronization of the alternate AC line and the UPS shall be accomplished by the UPS, provided the alternate AC power source is within the capture range of the UPS synch circuitry.
 - b. In the bypass position, the bypass switch shall completely isolate all elements of the UPS from the output and the alternate AC power source.

2.3.2 Duplicate UPS

1. If specified on the Data Sheet, duplicate UPSs shall be provided.
2. Where two independent sources of uninterruptible power are required, the arrangement shall be as shown in S 66.236-002. In this arrangement, two identical fully segregated 100 % rated UPS units are provided.
 - a. The arrangement is such that the AC uninterruptible supply circuits derived from the two UPS units do not operate in parallel with each other.
 - b. The rated output of each unit shall not be less than the maximum load that will be transferred to it upon total failure of the other UPS.
3. With the duplicate arrangement shown in S 66.236-002, the operating principle of each individual UPS shall be in accordance with that described for the single UPS arrangement.

2.3.3 Parallel UPS

1. If specified on the Data Sheet, parallel UPSs shall be provided.
2. Where parallel UPS systems are required to provide a single source of uninterruptible power, the parallel arrangement shall be as shown in S 66.236-003.
 - a. In the standard parallel arrangement, two identical fully segregated 100 % rated UPS units operate in parallel to energize a single panel board to which the load circuits are connected.
 - b. Redundant control circuits shall be included to facilitate equal sharing of the load between the two units.
3. The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of critical power.
 - a. Each unit shall have a static bypass switch connected to a separate bypass source, the rating of which shall be the same as that of the unit.
4. Suitable protection shall be incorporated to safeguard against loss of synchronization during bypass supply deviations that could result in short-circuiting of the UPS output.
5. The operating principle of the parallel arrangement shown in S 66.236-003 is as described above for a single UPS, amended as follows:
 - a. With the two units sharing the load, each unit shall effectively run at 50 % load.
 - b. Failure or switching-off of any one UPS shall result in uninterrupted acceptance of the complete load by the other UPS.
 - c. Subsequent failure or switching-off of the second UPS shall result in the further transfer of the complete load to the bypass circuit.

2.3.4 DC UPS operating principle

This section defines the operating principles of the DC UPS unit that are the basis of the performance requirements.

Standard drawing S 67.080 shows a typical arrangement.

1. The output of the battery charger, during normal operation, continuously supplies the power requirements of the load while simultaneously maintaining the battery charge in the float charge mode.
2. In the event of an interruption or depression in the AC supply voltage to the battery charger, the battery shall supply the load requirements for at least the autonomy time as specified on the Data Sheet while maintaining the output voltage within the permissible limits.

The battery capacity selected by the Manufacturer in order to achieve this will henceforth be referred to as its 100 % nominal capacity.

3. Upon restoration of the AC supply voltage, the battery charger automatically resumes supply of the load requirements while simultaneously recharging the battery.
 - a. Where high rate charging is necessary to fulfil this requirement, then it shall only be possible by manual initiation.
4. If specified on the Data Sheet, parallel chargers should have communication between units to insure that each takes 50 % of the load.

2.4 UNIT RATING

1. The UPS input supply, rating and the number of output phases shall be specified on the Data Sheet.
 - a. DC UPS input supply and DC nominal voltage shall be specified on the data sheet.
2. The UPS shall be rated to continuously energize the load at a load power factor of 0.8 lagging while maintaining an output voltage within the permissible tolerances as defined in (3), and satisfy the operational requirements specified in this DEP.
3. The unit shall be capable of energizing loads between 0.4 lagging to 0.9 leading within the specified tolerances.
 - a. No power de-rating should be accepted for this power factor range.
4. The UPS shall be capable of carrying 100 % unbalanced loads.
5. The UPS shall be capable of operating with a load step change of 0 % to 100 %, without transferring to the bypass source.

2.5 SERVICE CONDITIONS

1. Site conditions shall be as specified on the Data Sheet.
2. The UPS shall be located inside a freely ventilated, conditioned room or module.
3. Where relevant, the Manufacturer/Supplier shall apply de-rating and ageing factors to take account of temperature.

2.6 PRIMARY POWER SUPPLY

1. The UPS shall be capable of operating with the nominal voltage and frequency as specified on the Data Sheet and based on the following:
 - a. During normal system operation and under steady-state conditions the supply voltage shall not deviate from the rated voltage by more than +/- 10 % and the system frequency shall not deviate from the rated frequency by more than +/- 6 %.
 - b. Deviation from the supply characteristics, if any, shall be stated on the Requisition.
 - c. The primary power supply to the UPS shall be symmetrical and sinusoidal to within the limits as indicated on the Data Sheet, although the input voltage may be subject to transients comprising short-term voltage depressions of up to 20 % of nominal during motor starting, and to voltage interruptions during system short circuits.
 - d. Transient high frequency voltages of up to 2 kV may also be superimposed on the input voltage because of system switching operations.

2.7 TIE-IN OF UPS UNIT TO PRIMARY POWER SUPPLY SYSTEM

1. The Principal shall provide all the interconnecting cables between the UPS and external equipment such as the primary and alternate power sources and battery.
2. The Manufacturer/Supplier shall specify the size of the conductor required for the battery cables, based on a cable length not exceeding 65 ft (20 m).
3. For the parallel redundant configuration as shown in S 66.236-003, the Manufacturer/Supplier shall supply all control bus cabling/wiring.
4. If specified on the data sheet that the UPS will be connected to a bypass transformer, the bypass transformer shall match the inverter and bypass supply voltages and provide galvanic isolation between the upstream system and the UPS output.

2.8 INFORMATION TO BE SUBMITTED WITH THE TENDER

1. See (8) for documentation to be submitted with the tender

3. DESIGN REQUIREMENTS

3.1 UPS

3.1.1 General

1. UPS configuration shall be an on-line type system of the type indicated and rated to supply the full load as specified on the Data Sheet.

3.1.2 UPS types

1. A PWM-type UPS system shall include a rectifier/charger, inverter, static bypass switch, remote maintenance bypass switch, transformers and accessories.
2. A ferroresonant-type UPS shall include a rectifier/charger, inverter, ferroresonant transformer, static bypass switch, remote maintenance bypass switches, transformers and accessories.

3.1.3 UPS electrical characteristics

1. The electrical performance characteristics for the UPS shall be in accordance with Table 1.