

DEP SPECIFICATION

**STATIC UNINTERRUPTIBLE POWER SUPPLY UNIT
(STATIC UPS UNIT)**

DEP 33.65.50.31-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for static (semi-conductor) AC and DC Uninterruptible Power Supply (UPS) units. The DC UPS comprises a rectifier and battery whereas AC UPS comprises a rectifier, battery, inverter, static bypass switch and maintenance bypass switch.

These units serve as a secure (uninterruptible) source of power to vital instrumentation, monitoring and safeguarding systems in continuously operating plants. For a battery charger used for auxiliary power supply for switchboards, refer to Annex D of DEP 33.64.10.32-Gen.

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

This is a revision of the DEP of the same number dated September 2013.

This revision combines the DEPs for AC UPS (DEP 33.65.50.32-Gen.) and for DC UPS (DEP 33.65.50.31-Gen.) into one DEP 33.65.50.31-Gen. and withdraws DEP 33.65.50.32-Gen. from publication, see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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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 could 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 regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal 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 Principal 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 authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

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

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Autonomy Time of the UPS	The time during which the UPS is able to deliver power to the load within the specified voltage limits when the battery is the sole source of energy. Autonomy time is strongly influenced by the percentage of actual load related to the nominal rating of the UPS.
Battery Design Capacity	The battery power required (BDCW) as determined by the battery calculation specified in (Appendix A).
Bypass Supply	The alternative mains supply connected directly to the static switch to provide a standby supply to the load if the inverter output is out of limits.
Conditioned Room	A ventilated room where provisions have been incorporated to minimise dust ingress and maintain an equable temperature.
Crest Factor	The ratio of the peak value to the r.m.s. value of the total periodic waveform.
Discharged Condition	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.
End-of-Discharge Voltage	The voltage at which the battery discharge is terminated.
Equalisation Charge or Commissioning/ Initial Charge	The passing of an electric current through a vented battery by applying a higher voltage to equalise and realign the voltage distribution across the battery string (normally carried out with the battery off line).
Flame Retardant Material	A material which, without any further admixture, will not continue to burn when ignited nor cause other material in contact with it, or adjacent to it, to ignite.
Float Charging	A constant voltage applied from a charger so as to maintain the battery in fully charged condition..
High Rate Charging	The application of constant potential charge from a rectifier, at a higher level than float voltage, so as to restore the battery to a predetermined state of charge in a limited time span. It is usually applied after a period of partial or deep discharge.
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.
Inverter Supply	The normal output of the UPS unit via the rectifier/battery/inverter.
Maintenance Bypass Switch	A manually operated transfer switch incorporated into the UPS unit to provide supply to the load after bypassing the major electronics in the UPS, so the UPS can be serviced without power interruption.
Mean Time Between Failure (MTBF)	Total operating period divided by number of faults that have resulted in outages (hours).
Mean Time to Repair (MTTR)	Total time to repair and return to service divided by number of faults that have resulted in outages (hours).

Partially Discharged Condition	The condition reached when the battery has been discharged to the point where it is no longer capable of delivering sufficient energy when loaded at the rated kVA.
Rated Output	The apparent power, expressed in kVA, that can be continuously delivered by the unit over the range of conditions of service and electrical loading specified in this DEP, without exceeding component ratings or any of the required output tolerances.
Relative Harmonic Content	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, as follows: $\text{relative harmonic content} = \sqrt{1 - (g_1 / g)^2}$ 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.
Slew Rate	Rate of change of frequency, in Hz/s
Switched Mode Power Supply (SMPS)	Power supply where the output DC voltage and current are pulse-width controlled by means of switching, at high frequency, an unregulated DC voltage converted from the AC mains
Safety Critical systems	Safety Critical systems are those systems, failure of which could lead to a Major Accident or Event, or systems that mitigate the consequences of a Major Accident or Event.
UPS	A static Uninterruptible Power Supply unit, with built in power reserve in case of brownout or blackout.
Vital Service	A service which, when failing in operation or when failing if called upon, may cause an unsafe condition of the process and/or electrical installation, jeopardise life, or cause major damage to the installation.

1.3.3 Abbreviations

Term	Definition
EMC	Electromagnetic compatibility
EODV	End of discharge voltage
HMI	Human machine interface
LCD	Liquid crystal displays
LEDs	Light-emitting diodes
MCB	Miniature circuit breaker
MCCB	Moulded case circuit breaker
PCBs	Polychlorinated biphenyls
SMPS	Switched-mode power supply
VRLA	Valve regulated lead acid battery

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 (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated September 2013. The following are the main, non-editorial changes.

Section/Clause	Change
1.1	Scope of DEP revised to combine AC and DC UPS into one DEP. DEP 33.65.50.32-Gen. is withdrawn as of V40, February 2016.
2.1	Added IEC standards IEC 60146-1-3, IEC 60623, IEC 60896, IEC 62259, IEC 62485-2.
2.1.1	Component reliability and quality requirement added
2.2	Section divided to add the requirement of AC UPS (2.2.1) and DC UPS (2.2.2)
2.3.2	New section on unit rating of DC UPS
2.6	Tie in requirement of DC US added
2.7	Information from tenderer modified seeking spare parts list and battery disposal facilities
3.1.3	Modified to add requirement of DC UPS output
3.2.1	Added selection of battery types for various applications
4.1.4	Requirement of battery installation/enclosure added
4.2	Contact rating revised
4.5	Earthing specification modified
5.2	Status indication specification modified to cover the AC and DC UPS
5.4	Revised protection and alarms combining AC and DC UPS
5.6	Modified battery diagnostics added the online battery discharge test facility
Appendix B	DC UPS sizing added to the document

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://www.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 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. The UPS unit shall comply with this DEP and IEC 60146-1-1, IEC 60146-1-3, IEC 62040-1-2, IEC 62040-2, IEC 62040-3, IEC 60623, IEC 60896, IEC 62259, IEC 62485-2.
2. Additional information relating to the specific installation requirements of individual UPS systems shall be defined by the Principal on the Requisition DEP 33.65.50.93-Gen. (DC UPS) and DEP 33.65.50.94-Gen. (AC UPS).
3. 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.

4. In the event of conflict between documents relating to the enquiry/order, the following priority of documents shall apply:
 - a. Purchase order;
 - b. Requisition;
 - c. Project specification;
 - d. This DEP.

2.1.2 Design basis

The design of the UPS aims to minimise short circuits and ensure high reliability of its components to achieve 99.95% availability at all times.

1. The UPS shall only be of the electronically regulated type.

The electrical load to be energised by the UPS comprises a high proportion of digital electronic equipment incorporating switched mode power supply units which exhibit non-linear characteristics.
2. UPS units are normally installed in conditioned rooms; however, the Requisition may specify environmental conditions different from those stated in (2.4). This information shall form the basis of design for critical components and in particular for associated battery systems.
3. The design and selection of equipment and components shall be based on achieving the following minimum lifetimes:
 - a. 20 years for rectifier, inverter, static switch and associated auxiliaries;
 - b. 6 years continuous operation for non-redundant rotating equipment, e.g., cooling fans;

- c. a minimum of 10 years for capacitors of the electrolytic type to retain the capacity needed to operate within the specified tolerances and required environment operating temperature ranges;
 - d. 20 years for NiCd battery cells (both vented type and recombination type) when operating in an indoor ambient temperature of 25 °C;
 - e. 20 years for Lead Acid Plate type and 15 years for tubular type battery cells when operating in an indoor ambient temperature of 25 °C;
 - f. 12 years for VRLA battery cells when operating in an indoor ambient temperature of 20 °C.
- 4. With the exception of battery systems and ventilation fans, the UPS shall be designed to operate totally maintenance free for a 6-year continuous period. However periodic inspections of the unit, including topping up of vented cells and high-rate charging, are permitted.
 - a. This is independent of any self-regulation features that the UPS may utilise to optimise battery performance.
 - b. The Principal may specify reduced lifetimes and maintenance intervals in the requisition for less onerous applications.
- 5. 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 should be non-flame propagating.
- 6. Capacitor electrolytes shall not be “very toxic” as defined in DEP 01.00.01.30-Gen., e.g., shall not contain polychlorinated biphenyls (PCBs).

This includes substances that are very toxic-acute, very toxic-chronic and very toxic-environment.
- 7. For tropical applications, the UPS components shall be suitably protected by conformal coating against moisture and fungus.

Conformal coating material is a thin polymeric film which ‘conforms’ to the contours of a printed circuit board to protect the board’s components

2.2 OPERATING PRINCIPLE

2.2.1 AC UPS

2.2.1.1 Single Static UPS Unit

An AC UPS provides continuous, conditioned AC secure power to vital loads. It consists of a rectifier supplied from the AC supply, battery and inverter to convert the rectifier /battery DC power to an AC output voltage suitable for the vital load. The rectifier topology can be thyristor controlled or IGBT (insulated-gate bipolar transistor) based and inverters use IGBT.

- 1. 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. If the AC mains voltage supply to the rectifier is interrupted or depressed, the battery shall supply the power requirements of the load, via the inverter, for at least the autonomy time of the UPS as specified on the Requisition.
 - a. Refer to S 66.236-001 for the circuit arrangement.

With constant output power of the inverter, the input current from the battery will increase when the battery voltage decreases during discharge.
- 2. Selective disconnecting of UPS load in steps to increase the autonomy time shall not be allowed.

3. Upon restoration of AC mains voltage, the rectifier shall supply the power requirements of the load, via inverter, while simultaneously recharging the battery.
 - a. The battery shall be recharged at such a rate as to restore it to the required capacity within the time specified in (3.1.1).
4. The output of the inverter shall be maintained within the voltage and frequency tolerances as defined in (3.3).
5. The output of the inverter shall also be controlled to maintain synchronism with the bypass supply, provided the latter is within the tolerances specified for the load transfer conditions.
 - a. If the bypass supply exceeds these tolerances, then the inverter shall revert to unsynchronised operation at its own internally set frequency.
 - b. The inverter shall automatically resume synchronous operation with the bypass supply when the voltage and frequency of the latter return within the specified tolerances.
6. Under synchronous operating conditions, the static switch shall initiate uninterrupted transfer of the load to the bypass supply if the inverter output voltage or frequency deviates outside the permissible tolerances specified in (3.4), or the inverter unit is switched off.
7. If the load is automatically transferred to the bypass circuit and the inverter output is subsequently restored 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.
8. A make-before-break maintenance bypass switch shall be provided for each unit to allow the load to be transferred manually to this maintenance bypass supply. The UPS unit, including the static switch, shall be voltage-free to allow maintenance to be carried out (assuming the battery isolation switch is also opened).
 - a. The maintenance bypass switch shall have padlock facilities to allow it to be locked in the 'on' and 'off' positions to prevent inadvertent operation.
9. 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.
10. The UPS shall be capable of energising the load within the permissible tolerances and of achieving the uninterrupted load transfer requirements via the static switch, without the battery connected.
11. Single UPS units shall be suitable for future upgrading for parallel operation or additional load.

2.2.1.2 Duplicate static UPS unit

1. 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 UPS units provide duplicate uninterruptible power supplies to systems incorporating duplicate (switched mode) DC power regulators. The arrangement is such that the AC uninterruptible supply circuits derived from the two UPS units do not operate in parallel with each other.
2. The rated output of each unit shall be greater than or equal to 100% of the maximum system load (i.e. 2x100%).
3. The two separate bypass supplies shall be derived from the mains supply bus bar.

4. With the duplicate arrangement shown in S 66.236-002, the principle of operation of each individual UPS shall be in accordance with that described in (2.2.1.1) for the single UPS arrangement shown in S 66.236-001.

2.2.1.3 Parallel static UPS unit

1. Where duplicate UPS units are required to provide a single source of uninterruptible power, the parallel arrangement shall be as shown in S 66.236-003.

In the standard parallel arrangement, two identical fully segregated 100 % rated UPS units operate in parallel to energise a single switchboard to which the load circuits are connected.

2. Dual 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 vital power.

a. Each unit shall have a static switch connected to the common bypass circuit.

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

The principle of operation of the duplicate parallel arrangement shown in S 66.236-003 is as described in (2.2.1.1) for a single UPS, amended as follows:

5. With the two units sharing the load, each unit shall effectively run at 50 % load.
 - a. Failure or switching-off of any one inverter shall result in uninterrupted acceptance of the complete load by the other inverter and in the further transfer of the complete load to the bypass circuit in the event of subsequent failure or switching-off of the second inverter.
6. Variants of a parallel UPS design are available to allow optimisation of UPS and battery combinations. Any deviation from the parallel UPS arrangement as identified in S 66.236-003 shall only be permitted after the Principal has assessed the proposed arrangement and confirmed that the alternative offers an equivalent level of integrity to the standard arrangement in view of the load being supplied.

2.2.2 DC UPS

1. The rectifier shall be of one of the following types:
 - a. thyristor-controlled;
 - b. actively controlled switches (IGBTs);
 - c. switched mode power supply (SMPS).
2. The SMPS type UPS is for mainly telecom applications. Selection of SMPS type for non-telecom applications shall be subject to approval by the Principal (refer Appendix C)
3. The output of the rectifier shall, during normal operation, continuously supply the power requirements of the load while simultaneously maintaining the battery charge in the float charge mode.
4. In the event of an interruption or depression in the AC mains voltage to the rectifier, the battery shall supply the load requirements for at least the autonomy time as specified on the Requisition whilst maintaining the output voltage within the permissible limits (3.5).

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

5. Upon restoration of the AC mains voltage, the rectifier shall automatically resume supply of the load requirements while simultaneously recharging the battery in a time as specified in (3.1.2).
 - a. Where high-rate charging is necessary to fulfil this requirement, then this shall only be possible by manual initiation, providing the interlocking provisions of (3.1.5) are met.
6. The DC UPS unit shall be suitable for operation in parallel with one or more identical units that may have unsynchronized AC supplies.

2.3 UNIT RATING

2.3.1 AC UPS

1. The UPS rating and the number of output phases shall be specified by the Principal. In all cases rectifier input supply and the bypass supply shall be independent and separate.
 - a. Input shall be 3-phase/3-wire
 - b. Bypass shall be 3-phase/4-wire or 1-phase/2-wire.
2. The UPS shall be rated to continuously energise 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 satisfying the operational requirements specified in this document.
3. The unit shall be capable of energising loads between 0.7 lagging and unity power factor within the specified tolerances, provided these falls within its kW/kVA rating.
4. The UPS unit shall be capable of supplying a load consisting of principally computer and/or digital electronic equipment incorporating switched-mode power supply units that may have a crest factor of up to 3.

2.3.2 DC UPS

1. The rated output of the DC UPS unit shall be based on standard duty Class I of IEC 60146-1-3.
2. Unless otherwise specified on the Requisition, DC UPS units having rated outputs up to and including 1.8 kW shall have single-phase and neutral inputs and units having rated outputs in excess of 1.8 kW shall have 3-phase and neutral inputs.
3. The nominal DC output voltage shall be as indicated on the Requisition as one of the following standard DC voltages 24 V, 48 V, 110 V and 220 V.

2.4 SERVICE CONDITIONS

1. Unless otherwise specified on the Requisition, the UPS and its batteries shall be located inside a freely ventilated, conditioned room or module for which the conditions in Table 1 apply:

Table 1 Service Conditions

Maximum ambient air temperature	40 °C
Air temperature in the room or module	20 °C to 25 °C
Minimum air temperature	5 °C
Relative humidity not exceeding	90 %
Altitude not exceeding	1 000 m