

DEP SPECIFICATION

STATIC A.C. UNINTERRUPTIBLE POWER SUPPLY UNIT (STATIC A.C. UPS UNIT)

DEP 33.65.50.32-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 a static (semi-conductor) a.c. Uninterruptible Power Supply (UPS) unit comprising rectifier, battery, inverter, static bypass and maintenance bypass switch.

The unit, as specified, serves as a secure (uninterruptible) alternating current source of power to vital instrumentation and safeguarding systems.

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 February 2011; 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 its rated output in kVA at 0.8 p.f. within the specified a.c. voltage limits when the battery is the sole source of energy.
Battery design capacity	The battery power required (BDCW) as determined by the battery calculation specified in (Appendix 4).
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	The passing of an electric current through a battery by applying a constant voltage from a charger so as to maintain the battery in a state of charge.
High-rate charging	The passing of a constant electric current through a battery by applying a controlled voltage from a rectifier so as to restore the battery to a predetermined state of charge in a limited time span, usually applied after a period of deep discharge.
Inverter supply	The normal output of the UPS unit via the rectifier/battery/inverter.
Maintenance bypass switch	A manually operated switch incorporated into the UPS unit to provide a supply to the load in such a way that the main components of the UPS unit become isolated and voltage-free.
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).
Nickel cadmium batteries with partial gas recombination	Nickel cadmium batteries with internal gas recombination, designed for ultra-low maintenance and requiring a controlled maximum charging voltage.

Term	Definition
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 to the inverter when loaded at the rated kVA at 0.8 p.f.
Power factor (p.f.)	The power factor of the fundamental wave, $\cos \phi$, (sometimes referred to as the displacement factor) imposed by the combined effects of the UPS load characteristics and its harmonic content.
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.
Requisition	DEP 33.65.50.94-Gen.
Slew Rate	Rate of change of frequency, in Hz/s
Total Harmonic Distortion (THD)	Ratio of the r.m.s. value of the harmonics to the r.m.s. value of the fundamental
UPS	A static AC Uninterruptible Power Supply unit, comprising rectifier, battery, inverter, static bypass and maintenance bypass switch.
Vented or flooded batteries	Battery cells incorporating free liquid electrolyte in an enclosed container having one or more vents through which gaseous products may freely pass, and which can accept high-rate charging following a discharge (may be lead acid or NiCd).
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.
VRLA batteries	Valve regulated lead acid battery cells in containers which are sealed under normal conditions, and in which the electrolyte is absorbed in plate separator material so that oxygen evolved from the positive plates transfers to the negative plates and 'recombines' to form water. The containers incorporate a pressure relief device to permit the escape of gas if the internal pressure exceeds a certain value. The cell charging voltage on VRLA cells needs to be strictly controlled and high-rate charging is not permitted.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets (). Other documents referenced in this DEP are listed in (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2011. The following are the main, non-editorial changes.

Section/Clause	Change
2.1.1	Design life of VR NiCd battery clarified.
2.4	Added service condition for VRNiCd battery
2.6	Amended wording for option of a battery circuit breaker.
2.7	Added 3 rd sentence.
3.1.2	Deleted reference to 10 % THD.
3.2.1	Changed reference from BS 6290 to IEC 60896-22.
3.3.8	Changed fuse from gL type to gG type in the 3 rd paragraph.
3.3.8	Changed time to operate downstream protective device from 10 ms to 20 ms.
5.1	Emphasized need for displays and keypads to be adequately sized.
5.4	Changed action on AC supply failure to alarm and shutdown. Ability to re-start automatically on restoration of supply added.
5.5	Change ups from DC to AC in first sentence.
6.2.5 c)	Deleted MCB and 30 % limit.
7 e)	Added "battery capacity discharge chart".
8	Updated Reference section with DEP 00.00.05.80-Gen., DEM1 Manual and IEC 608796-22.

1.6 COMMENTS ON THIS DEP

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

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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.

2 GENERAL REQUIREMENTS

2.1 BASIC STANDARDS

The UPS unit shall comply with IEC 60146-1-1, IEC 62040-1-2, IEC 62040-2, IEC 62040-3 and this DEP.

Additional information relating to the specific installation requirements of individual UPS systems shall be defined by the Principal on the Requisition. Robust and reliable UPS supply units and distribution systems SHALL [PS] be used to supply safety critical systems e.g. process safeguarding systems.

Robust UPS systems in this context are those with an overall availability of greater than 99.95%, an overall MTBF in excess of 200,000 hrs and a MTTR of 8 hours. These figures exclude outage time for battery discharge testing and assume spare parts are available at site. Refer to (3.5).

UPS systems which are designed and manufactured in accordance with this specification are deemed to meet these requirements.

The Manufacturer shall complete the Requisition providing the necessary information to enable the Principal to assess the suitability of the proposed UPS equipment to be evaluated and confirmed during the tendering process.

In the quotation, the Manufacturer shall confirm compliance with the requirements of this DEP and the Requisition. Any deviations shall be clearly highlighted. The Manufacturer of the UPS shall be held responsible for all the equipment in the scope of supply, including the battery.

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.

2.1.1 Design basis

The UPS shall be of the electronically regulated type. Units incorporating magnetic stabilisers (e.g. constant voltage transformers) are not acceptable.

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

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.

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.

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 average indoor ambient temperature of 25 °C;
- e) 20 years for Lead Acid (Planté) battery cells when operating in an average indoor ambient temperature of 25 °C and 10 years for other vented lead acid battery types;
- f) 12 years for VRLA battery cells when operating in an average indoor ambient temperature of 20 °C.

Additionally, 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.

NOTE: This is independent of any self-regulation features that the UPS may utilise to optimise battery performance.

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 shall be confined to the component concerned. Component materials shall be non-flame propagating, wherever practicable.

Capacitor electrolytes shall be not highly toxic (see DEP 01.00.01.30-Gen.), e.g., shall not contain polychlorinated biphenyls (PCBs).

For tropical applications, the UPS components shall be suitably protected against moisture and fungus

2.2 OPERATING PRINCIPLE

2.2.1 Single static UPS unit

For a single static UPS unit, the circuit arrangement shall be as shown in (Appendix 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 a.c. mains voltage supply to the rectifier is interrupted or depressed, the battery shall supply the power requirements of the load, via the inverter, for not less than the autonomy time of the UPS as specified on the Requisition.

- NOTES:
1. 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.

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 battery shall be recharged at such a rate as to restore it to the required capacity within the time specified in (3.1.1).

The output of the inverter shall be maintained within the voltage and frequency tolerances as defined in (3.3). 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. If the bypass supply exceeds these tolerances, then the inverter shall revert to unsynchronised 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 return within the specified tolerances.

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.

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.

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, is to be voltage-free to allow maintenance to be carried out

(assuming the battery isolation switch is also opened). The maintenance bypass switch shall have padlock facilities to allow locking in on and off position to prevent inadvertent operation.

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 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.

Single UPS units shall also be suitable for future upgrading for parallel operation or additional load.

2.2.2 Duplicate static UPS unit

Where two independent sources of uninterruptible power are required, the arrangement shall be as shown in (Appendix 2). In this arrangement, two identical fully segregated 100 % rated UPS units provide duplicate uninterruptible power supplies to systems incorporating duplicate (switched mode) d.c. power regulators. The arrangement is such that the a.c. uninterruptible supply circuits derived from the two UPS units do not operate in parallel with each other. 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.

With the duplicate arrangement shown in (Appendix 2), the principle of operation of each individual UPS shall be in accordance with that described for the single UPS arrangement shown in (Appendix 1).

2.2.3 Parallel static UPS unit

Where duplicate UPS units are required to provide a single source of uninterruptible power, the parallel arrangement shall be as shown in (Appendix 3). 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. Dual redundant control circuits shall be included to facilitate equal sharing of the load between the two units.

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. 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 and only one maintenance bypass switch shall be provided.

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 (Appendix 3) is as described above for a single UPS, amended as follows:

With the two units sharing the load, each unit shall effectively run at 50 % load. 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.

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 (Appendix 3) 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.

2.3 UNIT RATING

The UPS rating and the number of output phases shall be specified by the Principal. In all cases the rectifier input supply shall be 3-phase/3-wire and the separate bypass supply shall be 3-phase/4-wire or 1-phase/2-wire, as appropriate.

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. The unit shall also be capable of energising loads between 0.7 lagging and unity power factor within the specified tolerances, providing these fall within its kW/kVA rating.

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.

2.4 SERVICE CONDITIONS

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 following conditions apply:

- 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

Where relevant, the Manufacturer shall apply de-rating and ageing factors to take account of temperature.

VRLA batteries shall be designed for operation in a nominal ambient temperature of 20 °C, but shall be capable of operating for limited periods in the temperature range of 10 °C to 30 °C, unless specified otherwise. VRNiCd batteries shall be designed for operation in a nominal ambient temperature of 20 °C, but shall be capable of operating in the temperature range of -40°C to 60 °C, unless specified otherwise.

Vented batteries shall be designed for operation in a nominal ambient temperature of 25 °C, but shall be capable of operating for limited periods in the temperature range of 5 °C to 40 °C, unless otherwise specified.

The Requisition shall specify any special conditions (tropical/moderate climate, land or offshore location). Where relevant the Principal may specify additional requirements.

2.5 MAINS ELECTRICITY SUPPLY

The UPS shall be capable of operating with the nominal voltage and frequency as indicated on the Requisition and on the basis of the following:

During normal system operation and under steady-state conditions, the supply voltage shall not deviate from the rated voltage by more than 5 % and the system frequency shall not deviate from the rated frequency by more than 2 %.

Deviation from the supply characteristics, if any, shall be stated on the Requisition.

The a.c. power supply to the UPS will be symmetrical and sinusoidal within the limits defined by IEC 60146-1-1, Immunity Class B, 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. Transient high frequency voltages of up to 2 kV may also be superimposed on the input voltage as a consequence of system switching operations.