

PETRONAS TECHNICAL STANDARDS

MANUAL

Static AC Uninterruptible Power Supply (AC UPS)

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This revision of PTS **33.65.50.32 – Static AC Uninterruptible Power Supply (AC UPS) (February 2011)** has been reviewed and updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **33.65.50.32 – Static AC Uninterruptible Power Supply (AC UPS) (February 2010)** will be removed from PTS binder / e-repository from herein onwards.

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PREFACE

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1. INTRODUCTION

1.1 SCOPE

This PTS 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.

This PTS specifies requirements and gives recommendations for a static non-modular (semi-conductor) a.c. and a static modular (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.

1.2 DISTRIBUTION AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to PETRONAS companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/marketing installations.

When PTS are applied, a Management of Change (MOC) process should 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 are more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document 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 with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The **Purchaser** is the party which buys the Static UPS Unit. The Purchaser may be either the Contractor or the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

- Autonomy time

The specified time that the battery shall be capable of supplying rated current to the inverter within the specified voltage limits.

- **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.

- **C₃ battery capacity**

Nominal battery capacity based on a 3-hour discharge rate at 20 °C.

- **C₅ battery capacity**

Nominal battery capacity based on a 5-hour discharge rate in accordance with IEC 60623 (NiCd batteries)

- **C₁₀ battery capacity**

Nominal battery capacity based on a 10-hour discharge rate at 20 °C and end of battery discharge voltage of 1.8 V.

- **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.

- **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).

- **Final (or end-of-discharge) voltage**

The voltage at which the battery discharge is terminated.

- **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.

- **MTBF**

Mean Time Between Failure.

- **MTTR**

Mean Time to Repair.

- **Nickel cadmium batteries with partial gas recombination**

Nickel cadmium batteries with internal gas recombination and designed for ultra-low maintenance and which also require a controlled maximum charging voltage.

- **Non-flame-propagating material**

A material which, without any further admixture, will not, when ignited, continue to burn nor cause other material, in contact with or adjacent to it, to ignite.

- **Non-toxic substance**

A substance which causes no harm to the environment nor to a person exposed to it or ingesting it, unless that person is exposed to or ingests it under unusual conditions or in an overwhelming dose.

- **Partially discharged condition**

The condition reached when the battery has been discharged at the rate specified on the data/requisition sheet to the final voltage.

- **Power factor**

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 document, 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

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

- **UPS**

An Uninterruptible Power Supply unit consisting of a rectifier, battery, inverter, with a static switch connected to a bypass supply and maintenance bypass.

- **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.

- Modular

Made of 'plug-in units' which can be added together to make the system larger, improve the capabilities, or expand its size.

- Redundancy

Duplication of the modular rectifiers and/or inverters and/or controller with the intention of increasing reliability of the system usually in the case of a backup, with typical configuration of N+X, where X=1,2 or 3.

- Hot – swappable

The ability to remove, replace or install the rectifier, inverter and controller modules in the system while in operation.

- Scalability

The ability to expand further in power capacity to the maximum power rack capacity through addition of modules.

1.4 CROSS-REFERENCES

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

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 PTS. In the event of conflict, this PTS shall take precedence.

Additional information relating to the specific installation requirements of individual UPS systems shall be defined by the Principal on the data/requisition sheet PTS 33.65.50.94. The Vendor shall complete the data/requisition sheet 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 any instance where the equipment proposed is incapable of meeting the requirements of the data sheet as provided, this shall be clearly highlighted by the Vendor in the quotation to the Principal.

In case of conflict between documents relating to the enquiry/order the following priority of documents shall apply:

1. Purchase order;
2. Data/requisition sheet and project specification;
3. This PTS.

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 shall 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 environment for UPS equipment and batteries shall be specified to the Vendor on the data/requisition sheet. This information shall form the basis of design for critical components and in particular for associated battery systems.

Typically, the design and selection of equipment and components shall be based on achieving the following minimum lifetimes:

- 20 years for rectifier, inverter, static switch and associated auxiliaries;
- 4 years' continuous operation for rotating equipment, e.g. cooling fans;
- A minimum of 6 years for capacitors of the electrolytic type to retain the capacity needed to operate within the specified tolerances and required environment operating temperature ranges;
- 20 years for NiCd battery cells when operating in an average room ambient temperature of 25 °C;
- 10 years for Lead Acid battery cells when operating in an average room ambient temperature of 25 °C
- 12 years for VRLA battery cells when operating in an average room ambient temperature of 20 °C.

Additionally, with the exception of battery systems and ventilation, the UPS shall be designed to operate totally maintenance free for a 4 year continuous period.

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

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 and utility installations.

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. Component materials shall be non-flame propagating, wherever practicable.

Capacitor electrolytes shall be non-toxic and free from 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 non-modular UPS unit

For a single static non-modular 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 as specified on the data/requisition sheet.

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 returns within the specified tolerances.

Under synchronous operating conditions, the static switch shall initiate uninterrupted transfer of the load to the bypass supply if:

1. *The inverter output voltage or frequency deviates outside the permissible tolerances specified in (3.4).*
2. *The inverter unit is switched off or faulty.*
3. *Short circuit fault.*
4. *Overload fault.*

NOTE :All the above are as a result of change in parameters at the inverter output.

NOTE: All the above shall be tested during Factory Acceptance Test.

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 whilst the UPS unit, including the static switch, is voltage-free to allow maintenance to be carried out safely without personnel being exposed to live components (assuming the battery isolation switch is also opened).

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 non-modular UPS 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.

Note: This section does not applicable for modular UPS

2.2.3 Parallel static non-modular UPS unit

Where duplicate UPS units are required to provide a single source of uninterruptible power, the parallel arrangement shown in Appendix 3A may be considered. 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:

Each unit shall effectively run at 50 % duty. 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.

Several variants of a parallel UPS design are currently available, for example, parallel systems can be installed with 2 * 50 % battery ratings that have mutual redundancy in the d.c. rectifier circuits and inverter sections. For the purposes of this PTS, 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. The Principal shall record calculations used in the assessment and approval of the change.

Note: This section does not applicable for modular UPS

2.2.4 Single static modular UPS unit

For a single static Modular UPS unit with Redundancy, the circuit arrangement shown in Appendix 3B shall apply. In this arrangement, a Modular UPS unit will comprise of Modular

rectifiers and inverters, a single Modular static transfer switch and a single Modular controller together with other functional blocks such as the bypass mains isolation transformer, battery and manual bypass switch. Redundancy can be provided for the rectifier and/or inverter and/or battery. The Modular UPS shall be of the hot-swappable type with scalability.

For standardization, the kVA rating for each module shall be as follows.

Load range	Minimum kVA per module
$\leq 20\text{KVA}$	5kVA
$20\text{KVA} < x \leq 50\text{KVA}$	10kVA
$50\text{KVA} < x \leq 100\text{KVA}$	20kVA
$100\text{KVA} < x < 150\text{KVA}$	30kVA
$150\text{KVA} < x \leq 200\text{KVA}$	40kVA
$\geq 200\text{kVA}$	50KVA

The output of "N" Modular rectifiers shall have load sharing capabilities to continuously supply the power requirements of the load via the inverter, while simultaneously maintaining the battery charge in the float charge mode. Where 1 or "X" additional rectifiers are already pre-installed for redundancy purpose, the failure or switching off of any of the rectifiers shall result in an automatic and uninterrupted transfer of the load to the remaining rectifiers so as not to affect the normal operation of the load.

Redundancy of the battery of up to "X" additional battery may be provided if required as specified in the requisition.

The output of "N" Modular inverters shall have load sharing capabilities to continuously supply the power requirements of the load, while maintaining within the voltage and frequency tolerances. Where 1 or "X" additional inverters are already pre-installed for redundancy purpose, the failure or switching off of any of the inverters shall result in an automatic and uninterrupted transfer of the load to the remaining inverters so as not to affect the normal operation of the load.

A single Modular static transfer switch shall be provided for the purpose of 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. The static transfer switch shall guarantee the synchronization of frequency and phase of the inverter with the bypass supply and a switch over from the disturbed source to the alternative source. In instances where there is no bypass supply, the use of the static transfer switch may be omitted from the UPS unit for which this will be clearly defined in the requisition.

A make before break maintenance bypass switch shall be provided to allow the load to be transferred manually to the bypass supply to allow maintenance to be carried out on the Modular UPS unit without compromising safety.

Each UPS module shall be equipped with individual control (*independent of common mode failure*) for the purpose of controlling and monitoring the status of the individual rectifiers, inverters and static transfer switch within the Modular UPS unit. *Failure on any individual control shall not affect the performance and function of the non faulty module and overall modular UPS system.* The means to achieve this shall be via a communication bus. Should such controlling and monitoring purpose not be required, the use of the *individual* controller may be omitted from the UPS unit for which this will be clearly defined in the requisition. The failure of *any individual* controller shall not in any way result in a loss of vital power so as to disrupt operation of the load.

The modular UPS panel shall preferably be one cabinet only. The sizing of the cabinet shall include empty module slot(s) for future upgrading/power expansion, if required. A minimum of 1 empty module slot shall provided by the Manufacturer for future expansion. In such a