

# **Static Un-interruptible Power Supply System**

## **‘A Buyer’s Guide’**

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**! CAUTION !**

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## CONTENTS

<b>INTRODUCTION.....</b>	<b>3</b>
<b>STATIC UPS SYSTEMS.....</b>	<b>4</b>
<b>RATING OF UPS UNIT.....</b>	<b>5</b>
<b>BATTERY AND RECTIFIER-CHARGER .....</b>	<b>6</b>
<b>INVERTER.....</b>	<b>8</b>
<b>PARALLEL AND REDUNDANT OPERATION .....</b>	<b>9</b>
<b>LOCATION .....</b>	<b>10</b>
<b>CONCLUSION.....</b>	<b>12</b>

## INTRODUCTION

The advent of modern information technology and the rapidly increasing widespread use of computers and production processes has resulted in the need to link devices to a centralized computing system of an organization. The growth of Local Area Networks and Wide Area Networks has enabled operators throughout an organization to communicate with one another and share a variety of other computing resources using mainframe servers, routers, hubs and transceiving equipment, employed within a network to ultimately process and display information at workstations. Computer applications have been designed to address particular business functions, such as order processing, on-line banking, airline booking, and stock control.

As more and more organizations realize the need for LANs, WANs, and even standalone computer systems, they also recognize the benefits of including a basic Uninterruptible Supply System to safeguard the information they process by guaranteeing power supply. The application of a UPS System may be quite straight forward. However, it's not just a case of matching a manufactured KVA rating to a specified electrical load figure.

The following is a brief synopsis of the requirements for sizing and selecting a static UPS system to suit a particular application. Also included is a brief on the most common electrical characteristics of the UPS and supplied load which may affect the application and compatibility of both.

UPS units are applied in electrical installations where the loss of power supply can cause undesirable impacts including;

- loss of essential information, such as real-time or inter-active computer systems data;
- loss of production processes such as boiler controls, flow, level and temperature controls;
- shutdown of plant which has fail safe operation as in hydrocarbon production processes;
- loss of essential information to process operators as in a central control of a distributed control system.
- commercial/ financial loss due to disruption and damage caused by mains failures on critical loads.

Both static and dynamic UPS systems can meet the basic requirements of providing a reliable service of regulated power. The selection of either dynamic or static type will depend on the application, type of load to be supplied, environmental aspects, installation and maintenance, initial cost and life cycle costs.

## STATIC UPS SYSTEMS

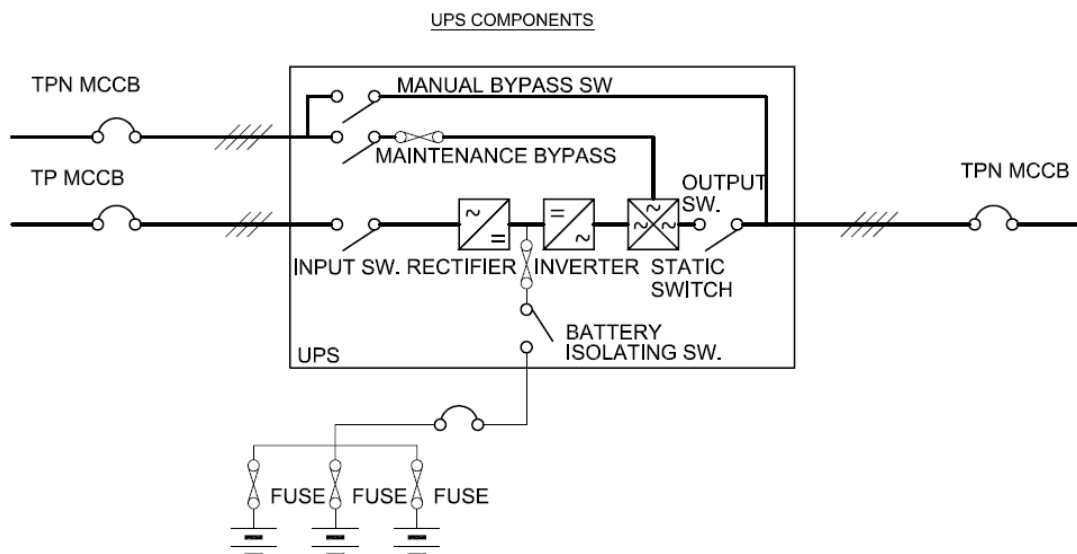
Static UPS systems are employed where a reliable high-quality power supply is necessary for sensitive loads, Static UPS systems have a high efficiency, compact dimensions, low maintenance requirements and are highly reliable. Available in single or three phase input - single phase output, and three phase input - three phase output typically from 350VA to 500KVA. Due to the modular construction of static UPS units, additional capacity, or redundancy as a means of increasing reliability can be achieved at relatively low costs.

The basic UPS system consists of a battery, a rectifier-charger, an inverter and a static bypass switch (SBS). This arrangement applies to both single-phase and three-phase systems. (see fig.1) Under mains power interruption, power supply is fed by the battery to the static inverter system to facilitate continuous operation. Continuous operation implies that, with the mains supply healthy, the power is supplied continuously to the load through the rectifier and the inverter. In this mode of operation, the rectifier fulfills two functions:

- supply of power to the inverter;
- charging or float-charging of the battery.

The battery is used in the standby parallel mode - i.e. in normal operation it is in the floating condition and on failure of the mains supply it supplies the inverter without break and without any switching operation. To perform this function, it is permanently connected to a D.C. link. The static bypass is a facility whereby the frequency and voltage are the same at the input and the output terminals. It converts the mains supply to the “secure bus”, with due regard to permissible tolerances, if;

- the inverter is overloaded;
- short circuits occur in the load circuit;
- excessive inrush currents are drawn by transformers downstream of the inverter;
- switch-on peak currents occur;
- the inverter fails.



## RATING OF UPS UNIT

In selecting the size of a UPS unit, the electrical load and supply characteristics should initially be considered:

- **Steady load**  
The total load requirement, P, is the sum of the individual loads to be supplied divided by the power factor,

$$\text{Total load (P)KVA} = \frac{\text{sum of individual loads, kW}}{\text{power factor}}$$

To allow for future additions, it is advisable to apply a factor of between 1.2 to 2.0 to obtain maximum steady load,  $P_u = P_x (1.2 \text{ to } 2)$

Inrush currents should be specified for each load in peak amperes and related duration. The UPS should be capable of switching an agreed inrush current onto a steady load (e.g. 25% of the total defined load starting coincidentally on to the 75% load already operating).

- **Transient load fluctuations**  
When the UPS with its rated voltage and at no load is switched onto blocks of symmetrical loads, the voltage regulation under transient conditions should be acceptable to the loads. Otherwise, the UPS would have to be oversized to cater for such conditions. Similar considerations should be taken into account in unloading the UPS.
- **Voltage Tolerance**  
The UPS input should be between +15% and -20%; narrower limits are needed for some applications. If the input voltage strays beyond these limits, the UPS should step in with the output voltage limited to between  $\pm 1\%$  in a steady state. On connection or withdrawal of full load to/from the UPS, an output voltage deviation of up to 20% is generally acceptable provided that the voltage can recover to within typically 96% to 105% of the nominal value within 20ms.
- **Harmonics**  
Harmonics fed back to the power supply system due to the rectification of the AC quantities to the DC quantities for the purposes of inversion back to the AC quantities should be investigated. High contents of harmonics fed back to the power supply system may not be accepted by other connected loads, and will affect the sizing of any standby generator upstream of the UPS. Typical acceptable values of Harmonic Distortion Output are: 3% maximum for single harmonics, 5% maximum for total harmonic distortion.
- **Frequency Tolerance**  
Output frequency should be synchronised to the input frequency within 0.5Hz of the nominal value and at a rate of change of frequency of 0.2Hz/s.

## BATTERY AND RECTIFIER-CHARGER

The battery is an important part of UPS selection, being the source of power during a mains failure. When the AC power is restored recharging begins at approximately 125% full load rating. (CPDs must be selected on the basis of installation characteristics, breaking capacity in particular, and the current demands of the inverter and battery not just the connected load.) The charge current will remain at this level for a short duration only, determined by the amount of discharge that has occurred. The current diminishes gradually as the battery charge increases exponentially until the battery is completely (95%) replenished. Since the initial current was limited the actual charge current remains roughly constant.

The rectifier - charger can be selected to operate near 100% capacity, where it is most efficient. Usually the total inverter DC input required under full load conditions is determined and the next larger rating is specified. The table below lists common rectifier charger ratings, based on inverter rating and UPS load power factor. However a more positive method of determining the rectifier-charger rating is given in the formula:

$$lbc = \frac{A-H \times 1.1}{\text{Recharge Time}} + I_{inv}$$

Where lbc is the rectifier-charger current in amperes, A-H is the ampere hours removed during discharge; Recharge Time is in hours and  $I_{inv}$  is the inverter current under load.

### 250V DC

Inverter Output rating	UPS load 80% PF	UPS load 100% PF
1.0KVA	6amps	6amps
2.0KVA	10amps	15amps
3.0KVA	15amps	20amps
5.0KVA	25amps	30amps
7.5KVA	35amps	50amps
10.0KVA	50amps	60amps
15.0KVA	75amps	100amps
20KVA	100amps	125amps
Additional capacity based on the battery charge rate will be required. It is usually provided by specifying a charger rated one size larger than the inverter requires.		

Battery reservoir charge time is frequently specified as 8 times the discharge time. If the battery reservoir discharge time is 1 hour, the charge time will be 8 hours. In practice the charge rate should be based on the probable frequency and duration of power outages.

The maximum current to be supplied by the battery is determined as follows:

$$\text{Max. } I_{\text{Bat}} \text{ (A)} = \frac{(\text{UPS power in kVA}) \times (\text{Power factor } 0.8) \times (\text{Rectifier efficiency} = 0.97)}{(\text{overall UPS efficiency}) \times (\text{minimum DC voltage})} \quad (1)$$

Battery tables are available which give the maximum current supplied by the selected battery in function of the requested discharge time and end voltage per cell. Discharge curves are also available. The battery type which can supply a maximum current equal or higher than the current calculated by the formula (1) is selected. If the closest battery type is higher than (1), then a higher discharging time at same end voltage or higher voltage at same discharging time will be the outcome.

$$\text{Number of cells} = \frac{\text{minimum DC voltage of UPS}}{\text{end voltage of one battery}}$$

$$\text{The maximum number of cells} = \frac{\text{maximum DC voltage of UPS}}{\text{Charging voltage of one battery cell}}$$

Nickel-cadmium batteries are the most reliable and robust but expensive. Other choices are plate type batteries and low maintenance sealed type batteries.

## **INVERTER**

The inverter determines the ultimate quality of the power that drives the critical load. A number of Inverter concepts have been developed each possessing certain characteristics which bear directly on its suitability for various applications. The purpose of the inverter is to change the DC voltage from the rectifier-charger or the battery reservoir to pulsating DC which in turn can be shaped and filtered to produce a sinusoidal voltage that meets the requirements of the critical load. This voltage must be of stable amplitude and frequency, contain a lower percentage of distortion, and be free of interruptions and transients.

The most commonly used types of inverters are the quasi square wave inverter, the pulse width inverter, the step wave inverter, and the ferroresonant inverter. Recent developments also combine the features of the step wave and pulse width modulated inverters.

Typical overload rating requirements of each inverter are 150% of the rated output for 15s maintaining its rated output voltage tolerance. On short circuit each inverter should be capable of rupturing the largest output fuse within 10ms without resorting to the AC bypass.

## PARALLEL AND REDUNDANT OPERATION

When one UPS module is not large enough to power the critical load, two or more modules are run in parallel, with their outputs feeding a common bus in a system control cabinet (Fig. 2)

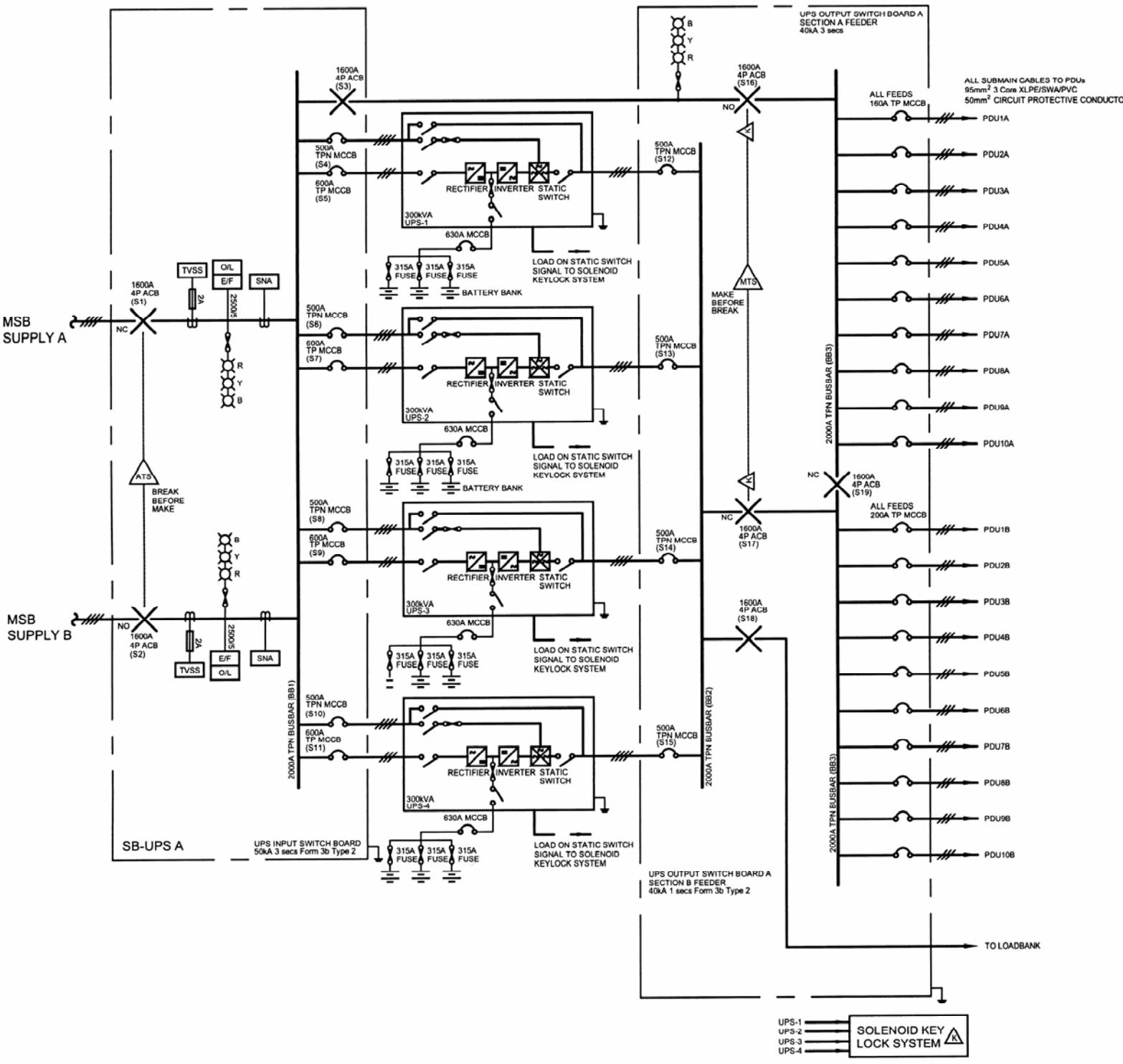
In the parallel configuration, the static transfer switch and utility bypass input are located in the system control cabinet. Logic circuits are designed so that each module powers its share of the load (each of two modules in parallel carries on-half the load).

It is desirable to use as few modules as possible. It makes more sense to power a 600kVA load by two 300kVA modules rather than by three 200kVA modules. Two modules offer greater reliability by having fewer components that can fail.

A “redundant” UPS system employs one more module than is required to power the critical load. A 300kVA redundant UPS would thus consist of two 300kVA modules feeding a system control cabinet, one of which is required to power the load and the other which is a backup. A 600kVA redundant UPS would consist of three 300kVA UPS modules feeding a system control cabinet, one being a backup.

As in normal parallel operation, the on-line modules share the critical load evenly where three 300kVA modules feed a common bus with a 600kVA load, each of the three modules would carry one-third of the load, or 200kVA. If one of the modules should malfunction, an isolating device called “static interruption” would disconnect the faulted module from the common bus without affecting the critical load. The two remaining 300kVA modules would share the 600kVA load until the faulted module was repaired and put back on line, making the system redundant once again.

TYPICAL UPS SYSTEM SCHEMATIC  
(3+1 CONFIGURATION)

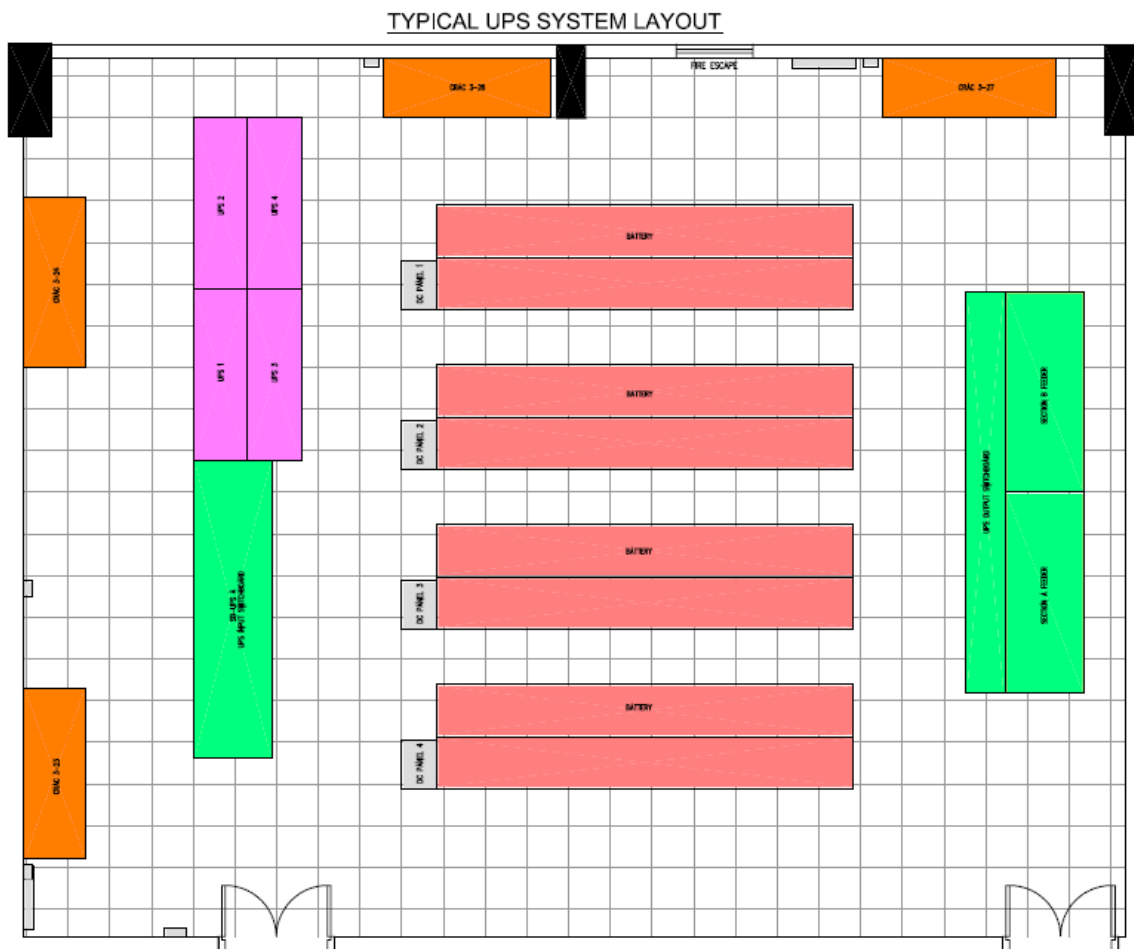


## LOCATION

Distances between UPS components should be kept short to minimize voltage drop. Distances of 10m between the module and the battery and 30m between the module and the critical load are generally considered safe. If measurements show excessive voltage drop, oversized conductors and/or step up, step-down transformers may be required.

Floor loading should be considered, since UPS equipment is quite heavy, as well as battery cubicles. A typical 75kVA module weighs 2000kg distributed over 1.66m<sup>2</sup> (1205kg/m<sup>2</sup>), and a 500kVA module weighs 6818kg distributed over 4.23m<sup>2</sup> (1612kg/m<sup>2</sup>).

Heat rejection of UPS is generally high. The efficiency of the UPS is typically 87% for a 10kVA unit upto 93% for a 120kVA unit. Few rooms are large enough or sufficiently ventilated to disperse heat dissipated; therefore, air conditioning is usually required.



## CONCLUSION

It is not possible to convey all aspects of design and installation of Static UPS units in this short article. Other requirements should be addressed such as; Electromagnetic Compatibility, Noise Filtering, Earthing, Shielding, Surge protection, Selection of Circuit Protective Devices and Degree of Protection for Enclosures. As well as the possibility of UPS Power Management and Diagnostic Software, and utilisation of Manual Bypass Facility. This brief insight should direct you into avoiding some of the common pitfalls encountered and provide awareness on issues that must be examined.

Compliance with the relevant standards of the following documents must also be achieved;

- BS EN 50091-1 Uninterruptible Power Systems Part 1 General and Safety Requirements.
- BS EN 50091-2 Uninterruptible Power Systems Part 2 Performance Requirements.
- BS EN 55022, BS EN 50082-1 Electromagnetic Compatibility.
- BS 5420, BS 5490 Degree of Protection Provided by Enclosures.
- BS 6290 Requirements for Nickel Cadmium and Lead Acid Stationary Rechargeable Cells.
- BS 7671 Requirements for Electrical Installations.
- IEC 950 Safety of Electrical Energised Office Machines, Data Processing Machines.