Procedures for Uninterruptible Power Supply (UPS) Systems

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Definition: Uninterruptible power supply, UPS, systems provide continuity of service for critical systems in the event of power failure and so enable the University to deal with a number of risks associated with power failure.

1 Overview

The University has a number of UPS systems, ranging from the large fixed installations operated primarily by Digital Services and Campus Services, to small portable units connected by 13A plugs, oftenused by Schools and Services. UPS systems pose risks not normally associated with electrical mains equipment because they store large amounts of energy and continue to generate potentially lethal electrical power even when isolated from the mains supply.

If undertaking work on equipment supplied by a UPS, ensure that the equipment is disconnect from UPS (not the UPS from the supply), and prove dead using approved method.

UPS systems have a finite life, but are generally unobtrusive until they fail. Failure becomes much more likely as the units age. Due to the amount of energy involved, it is Digital Services experience thatUPS systems may fail in a potentially dangerous manner.

Since UPS systems continue to supply power when their supply is isolated they pose a risk to firefighting and electrical maintenance.

Also because UPS systems continue to supply power even when disconnected from the supply, special attention is required to maintain the protective earth.

UPS systems consume more electricity than they supply to the load and the cost of the electricity consumed will probably far exceed the initial cost of the UPS system over its lifetime.

Due to the risks and costs of operating UPS systems, the University is minded to Limit/Control and monitor the use of UPS systems and to consider their use alongside the requirements of the Provision and Use of Work Equipment Regulations (PUWER).

Battery maintained systems such as fire alarms, emergency lights etc. are excluded from these procedures as there are separate procedures coving their use. Typically these types of systems do not pose the same risks due to operating at much lower voltages, storing much less energy etc.

2 UPS Reliability

A number of UPS systems at the University have failed through overheating. Failures are typically:

- Overheating due to cascade battery failure
- Overheating due to charger failure

As UPS systems age they become noticeably less reliable, this as the batteries incorporated within the UPS lose capacity over time. At some point it is certain that the battery cells will start to fail. Some cell failure modes can cause runaway conditions.

UPS systems also have a relatively high probability of failing due to stressed, high power electrical components. This probability increases significantly over time. These failures can also lead to the UPS overheating.

Probably due to their inherent reliability issues, UPSs are expensive to maintain and the maintenance sometimes excludes key items such as batteries.

2.1 Batteries

Most UPS's will use sealed or maintenance-free batteries (VRLA). Such batteries are generally much safer to handle than the traditional (wet) lead-acid battery, but they must be treated with respect.

UPS systems use the batteries to store energy for when the mains electricity supply fails. Batteries are generally specified in two basic qualities. Typically smaller UPS systems are supplied with five year batteries. This means that the design life of the battery under ideal conditions is normally only five years and after that period they will have typically half of their original capacity remaining and the likelihood of outright failure is increasing.

UPSs are rarely operated under ideal conditions (e.g. 15 – 25°C) and so the expected battery life will be reduced.

After the nominal design life, typically 5 years, UPS systems should be disposed of and replaced if they are still required. Replacement of batteries is generally not economic. Disposal should be via the ITS department.

3 Recommendation

3.1 Roles and Responsibilities

The University's Health and Safety Policy makes it clear that each College and Department is responsible for managing and ensuring the safety of their own equipment and activities. With respect to UPS units Colleges and Services are advised to implement systems that:

a. Control the purchase and installation of UPS's
b. Ensure UPS's are suitable for purpose and can be powered via a three-pinplug
c. Ensure UPS's are recorded on a register and regular inspections, per manufacturer's instructions, are undertaken, with records kept
d. Ensure UPS units are disposed of via ITS when they come to the end of the manufacturer's advised useful life
e. Notify Campus Services of the intention to install a UPS of above 1 kVA (1000VA) prior to purchase.

3.2 Purchasing

3.2.1 Prerequisites

When considering purchasing a UPS, first establish there is a clear need. Consideration should be given that UPS systems inevitably consume additional electricity, pose additional risks and will need maintenance and replacement at the end of life.

When selecting a location for a proposed UPS system consider:

- Temperature. The recommended operating range is small, for example 15°C – 25°C
- Floor loading. UPS systems can often be heavy enough to need special consideration.
- Ventilation. Select a clean location that will not become cluttered, particularly with flammable objects such as paperwork.
- Access. There must be sufficient access to maintain the UPS safely.

Digital Services will offer assistance in purchasing UPS systems for computer and data applications, Campus Services for scientific and more general applications.

3.2.2 Supply and install

UPS systems greater than 3kVA shall be purchased with a supply and install contract.

3.2.3 Maintenance and monitoring

It is recommended that Colleges and Services consider purchasing an extended warranty if available and financially viable.

To address the reliability and potential fire risk, it is recommended that the entire system is replaced at the end of the expected battery life.

Fixed installations above 10 kVA should be covered by a maintenance contract that delivers the manufacturer's recommended maintenance plan.

3.3 Installation

3.3.1 Earthing

Some UPS systems greater than 1kVA must be separately earthed and should be discussed with Campus Services.

3.3.2 Ventilation

Batteries should be stored and charged in well ventilated areas in accordance with manufacturer's instructions and away from combustible materials and potential ignition sources (see Charging below).

Specific calculations may also be required to reduce the risk from fire and explosion during charging. This is based on the maximum charging current, which when known, the rate at which hydrogen is released during charging can be calculated. With this information it is possible to determine the airflow needed to provide effective ventilation and avoid a flammable atmosphere forming in the charging area. Basically, as long as the velocity of the airflow through these ventilation openings is at least 0.1 m/s, the minimum area of both the inlet and the outlet necessary to achieve the required airflow is given by the following equation (*taken from HSE Using Electric Storage Batteries Safely*):

Minimum area of inlet/outlet needed = $0.3 \times N \times I \times S$ cm^2

Where:

N = number of cells in the battery(ies)

I = the overcharging current (amps)

S = the appropriate dilution factor; 10 for workrooms, 4 for enclosures

Effective dilution depends on several factors. These include the rate of hydrogen production; the location of the battery within the area; the shape and size of the area; and anything that would impede the natural circulation of air. However, in relatively uncongested areas natural ventilation is often sufficient to provide effective dilution. Good housekeeping is essential.

3.3.3 Risks to Firefighting and Electrical Maintenance

All UPS systems greater than 1kVA should be notified to Campus Services who will then ensure they are considered in the fire risk assessment. Each college or department must also consider the fire risk

from UPS in their own risk assessment.

3.4 Charging batteries

Explosive gases are given off when batteries are charged. The risk of an explosion is great if the gases are allowed to collect. When charging batteries:

Getting ready

- Make sure you understand the battery manufacturer's instructions on charging.
- Always use a dedicated, well-ventilated charging area.
- Do not smoke, carry out hot work (eg welding, brazing, grinding), or use a mobile phone in the charging area.
- Do not charge batteries below electric lights or other equipment that could be an ignition source.
- Check that the charging equipment is suitable for the battery, eg correct voltage and charging rate.

Basic Charging Advice (always following manufacturer's instructions)

- Make sure the charger is switched off before connecting the charging leads to the battery (unless the charger manufacturer specifies a different procedure).
- Check that the charging leads are securely clamped in position before switching on the charger.
- Never charge the battery faster than the battery manufacturer's specified maximum charging rate.
- Do not remove or adjust the charging leads while the charger is switched on. Always switch it off first.
- Switch off the charger before disconnecting the charging leads from the battery (unless the manufacturer's instructions specify otherwise).
- Allow a vented battery to stand for at least 20 minutes after disconnecting it from the charger.

3.5 Inspection and Performance Monitoring

It is recommended that all UPS systems are recorded on a register which holds the following data:

- UPS specifications
  - Asset number
  - Description
  - Location
  - Manufacturer
  - Model
  - Serial number
  - Power rating
  - Design Autonomy (Backup time)
- Maintenance information
  - Date of purchase
  - Expected design life
  - Preventative maintenance interval (if applicable)
  - Date of last PAT test and visual inspection
  - PAT test and Visual inspection interval
- Purpose
  - Description of equipment protected

- Departmental contact

The maintenance schedule shall be according to the following table:

Power rating	Frequency	Maintenance & Test Action	Responsible
0 – 1 kVA (portable)	Annual	PAT test and visual inspection	Departmental
	End expected life [1]	Recorded WEE disposal via IT Services	Departmental
1 – 10 kVA (stationary)	Annual	Visual inspection	Departmental
	After three years	Manufacturers preventative maintenance visit	Departmental
	End expected life [1]	Decommission & WEE disposal	Departmental[2]
10 kVA + (fixed)	Annual	Manufacturer's preventative maintenance	Campus Services
	End Expected life [1]	Decommission & WEE disposal	Campus Services

[1] Consult UPS manufacturer, typically 5 years at <20°C, 4 years at < 25°C
[2] Campus Services would do the actual work.

3.6 Maintenance of UPS systems

Any maintenance of UPS systems shall be carried out by competent engineers.

3.7 Disposal

UPS systems at the end of their design battery life must be disposed of as WEE waste though Digital Services.