UNIVERSITY OF SUSSEX

Guidance for the safe management of Uninterruptible Power Supplies (UPS) and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)

1. Introduction

Uninterruptible power suppy (UPS) systems provide continuity of service for critical systems in the event of a power failure. Due to the risks posed by power failure in the research activities of the university, UPS are a popular solution on campus.

However, UPS can present a fire risk if they are not properly managed and the risks they present are not risk assessed and addressed. In the case of lead acid or lead crystal based systems, one significant risk being that of the production of hydrogen gas should the batteries malfunction or become overcharged. In addition, as batteries are close to being fully discharged, or when they get older, the risk of malfunction increases and overheating and fire can also be a risk.

There are several types of UPS system used on campus ranging from large fixed installations that are operated primarily by Information Technology Services and Estate and Facilities Management, and much smaller portable systems connected by 13A plugs. The latter are often used by Faculties and Professional Service Divisions. UPS systems present risks not usually associated with electrical mains equipment because they store large amounts of energy and continue to generate potentially lethal levels of electrical power even when isolated from the mains supply.

The failure of a UPS system, whether this be from a valve regulated lead acid or crystal system, or a Lithium-ion system, will release a high amount of energy and go into thermal runaway. Therefore is likely to be classed as an energetic event under the Dangerous Substances and Explosive Atmospheres Regulations 2002. With this in mind, the use of UPS needs to be considered through risk assessment.

2. Scope

This guidance document covers any UPS system which uses lead acid or lead crystal batteries to store power with the aim of providing backup power to research equipment and or buildings on campus. Some examples of UPS systems this guidance applies to can be found in Figure 1.

Figure 1: Example UPS systems this guidance covers.

3. Definitions

Uninterruptible power supply (UPS) – a system that stores back-up power, usually in valve regulated lead acid batteries.

4. Guidance on the management of UPS

4.1 Responsibilities

Faculties and Professional Service Divisions are responsible for managing and ensuring the safety of the UPS systems they purchase. It is advisable to have systems in place that:

- Control the purchase and installation of UPS systems.
- Ensure UPS that are being considered are suitable for the intended purpose, for example by engaging the supplier/manufacturer.
- Ensure UPS are recorded on an asset register, and that regular inspection and maintenance, in line with the manufacturer’s guidance, is carried out, with records kept.
- Ensure UPS at the end of their usable life are disposed of responsibly as WEEE waste.

- Ensure Estate and Facilities Management (EFM) are made aware of the intention to purchase and install a UPS where this may need be part of an EFM project or the installation may disturb the fabric of the building.

4.2 Identifying UPS type

When considering the introduction of a UPS to your work area, you need to determine which type is suitable for your needs. The three types recommended for use on campus are:

- Valve regulated lead acid systems.
- Valve regulated lead crystal systems.
- Lithium-ion systems (not covered in this guidance).

The system you intend to use will determine the risks you need to consider in your risk assessment. Some lead acid batteries need to be topped up with ionised water in order to operate. It is strongly advised that this type of battery is not considered for use on campus. If you will need to position a UPS system close to electrical items, it is advisable to explore whether a lithium-ion battery system would be suitable, as these will not release hydrogen gas that could potenitally be ignited by the surrounding electrics.

It is advisable to contact a reputable specialist company to support you in selecting the correct type of UPS for your requirements. Some companies will be able to advise on the most suitable system and provide ongoing inspection and maintenance. For larger sysems it is strongly advised that an inspection and maintenance programme is purchased alongside the selected UPS system.

4.3 Risk assessment

Where a lead acid or lead crystal UPS is selected, you will need to carry out a DSEAR risk assessment for the intended setup and use. You can use the 'Small Inventory' DSEAR risk assessment template for this purpose. The risk assessment should be carried out prior to purchase as the assessment will identify the most suitable location for the UPS and take into account any addtional measures that will need to be considered, such as establishing an EX Zone. To support you in carrying out your risk assessment, the Health and Safety Team have created a template you can use, available on our website.

- Valve regulated lead acid/crystal UPS risk assessment.

When using this template, it is important to adapt it to suit the setup and use of the UPS system/s you plan to use.

4.4 UPS Hazardous Area Classification

As there is a risk of hydrogen release with any VRLA or lead crystal batteries if they malfunction, as part of your UPS DSEAR risk assessment you will need to establish an EX Zone 1 around the UPS system. This information should be available from the manfacturer of your selected batteries, but if not, you will need to calculate the extent of this zone by using other data about the batteries from the manufactuer, and the following calculation:

$$d = 28.8\ x\ \sqrt[3]{Igas}\ x\ \sqrt[3]{Crt}\ mm$$

In the calculation above, 'Igas' is the current producing gas (mA per Ah) and 'Crt' is the rated battery capacity (Ah). To support you in calculating the extent of your EX Zone 1, you can also use the UPS calculator on the Health and Safety A-Z.

4.4.1 I_{gas}

The value of 'Igas' is constant, depending on the features of your selected UPS. If your system has a boost function, the 'Igas' value you use should be 8mA/Ahr. If your system doesn't have a boost charge function, and can only charge in float mode, you should use the value 1mA/Ahr. If you are unsure whether your system has a boost charge mode, you should apply the 'Igas' value of 8mA/Ahr to act as a safety buffer.

4.4.2 C_{rt}

The value of 'Crt' will depend on the batteries you are using, and should be confirmed by checking the manufacturer's specifcation. If you are unsure, you should check with the supplier. The value will be in 'Ahr', for example 40Ahr, and this will apply to one battery within your UPS.

4.5 Housing type

Next you need to consider the type of system you are purchasing, as this will help you decide where the EX Zone 1 needs to be established. For example, tower UPS usually have a fan venting system that will push hydrogen out from a vent on the housing, whilst individual batteries placed on a rack with open sides will allow hydrogen to disipate in all directions from the batteries.

As an example, if you are purchasing a tower UPS which has a fan system and holds 40 batteries, you will need to calculate the total 'Ahr' capacity for the 40 batteries combined. This is because all hydrogen released by the batteries will be removed via the fan system, from one area of the tower UPS. Therefore, if your tower UPS has 40 batteries, each with a value of 40Ahr, the total Ahr capacity for the unit will be 1600Ahr, and you should use this value to calculate the EX Zone 1. The EX Zone 1 should be established on the side of the tower UPS that has the vent/s that will remove hydrogen from the system. The extent of the zone should extend the same calculated distance from the fan side of the tower UPS, in all directions (Fig.2 and 3).

If you are planning to use a set of individual static batteries, and these will be housed on open shelving or in a mesh housing, these setups will allow hydrogen to disipate in all directions from the battery units. Therefore you only need to take into account the Ahr capacity of one battery in your setup. In this instance an EX Zone 1 would need to be established around the whole setup, and extend the calculated distance in all directions

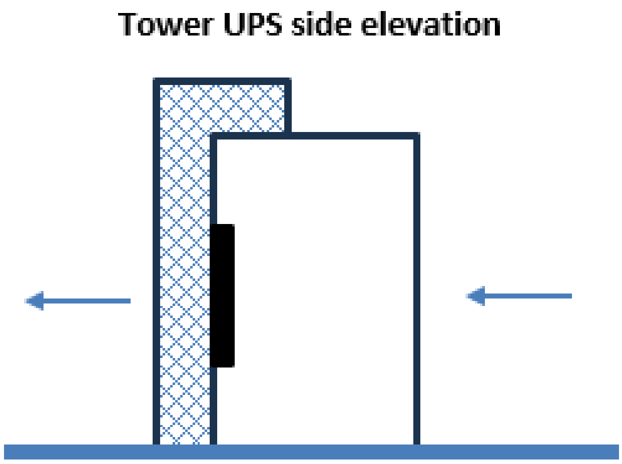

Figure 2: A side elevation of a tower UPS with a cooling fan at the rear of the system removing air and hydrogen. The arrows indicate the direction of air being drawn through the system's mechanical fan system. The EX Zone 1 therefore needs to be established around the side of the UPS where air is expelled.

from the edges of the batteries (Fig.4).

4.6 Ignition sources

Once you have established the EX Zone 1 and calculated its extent, you can then identify potenital ignition sources that may sit within the hazarous area. Where possible, position your UPS so that electrical ignition sources do not fall within the hazardous area. If this isn't possible, electrics will need to be upgraded to ATEX rated electrics. It's advisable to contact the Univeristy Health and Safety Team for advice before purchasing the UPS if this is likely to

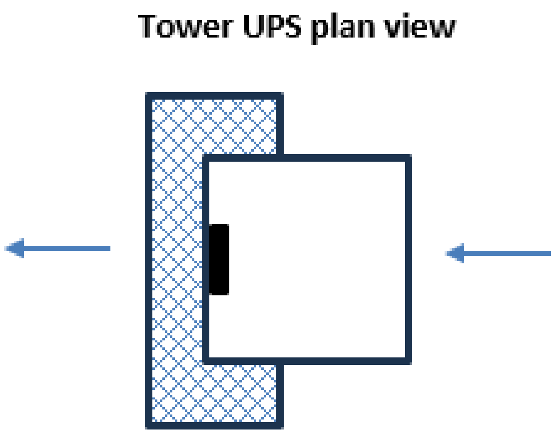

Figure 3: A plan view of the same tower UPS with a cooling fan at the rear of the system removing air and hydrogen. The arrows indicate the direction of air being drawn through the system's mechanical fan system. The EX Zone 1 therefore needs to be established around the side of the UPS where air is expelled.

be the case, as the EX zone will need to be recorded on the university's building management system.

For more information on identifying and removing ignition sources from the work area, please see the Dangerous Substances and Explosive Atmospheres guidance.

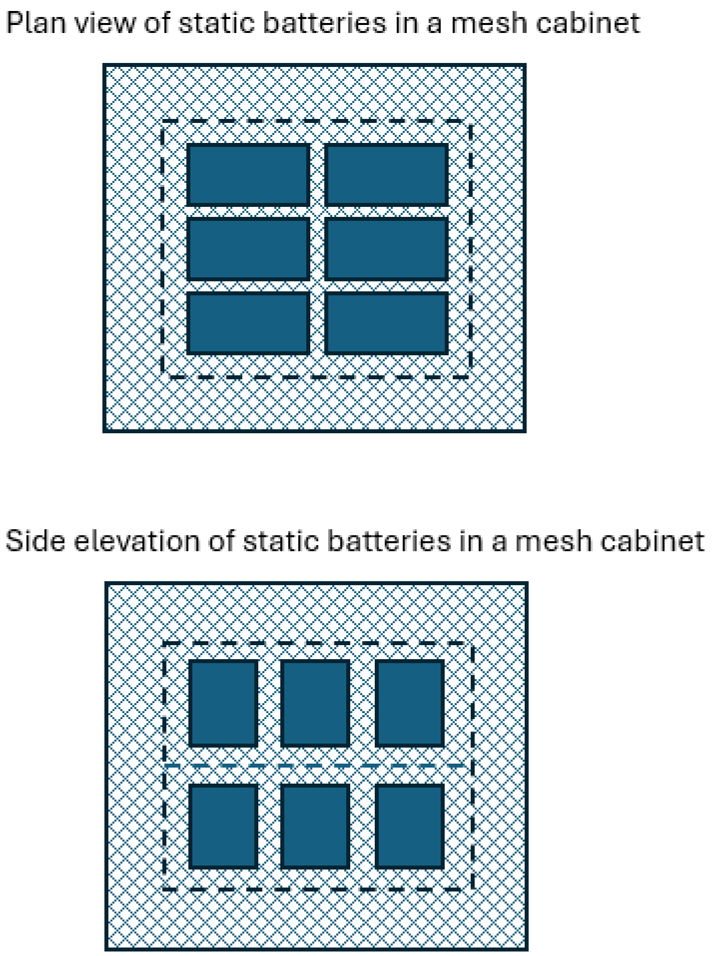

Figure 4: A mesh shelving rack holding 12 static batteries (i.e. 2 shelves, each holding 6 batteries). As the mesh shelving rack allows hydrogen to dissipate outwards from the batteries in all directions and does not have a mechanical fan to draw hydrogen to one location, the EX Zone 1 is established around the entire setup, from the edge of the batteries.

4.7 Ventilation

Wherever possible it is advisable to locate your UPS in an area where natural ventilation is freely available. However, bear in mind this may also mean the UPS will be exposed to extreme weather conditions. This should be considered when looking at potential locations for your proposed UPS. Ensure you check the manufacturer's guidance and engage your supplier in this process.

Where natural ventilation is to be relied upon, you should calculate the size of the openings required in opposing walls at both low and high levels to allow for enough free air movement. This should be based on the specification of your proposed UPS. To calculate the size of the openings required, you can use the formula below or the UPS calculator (please see Appendix 1 for the formula's key). If louvred panelling will be used on natural ventilation openings, 88% of the value calculated by this formula should be added on to account for the louvres blocking an area of the open space. For example, if the formula calculates that you need an opening at high and low level in opposing walls, each being 10cm^2 in size, each opening would need to be at least 18.8cm^2 if the openings will be louvred. If you are not able to add openings to opposing walls, for example, because part of the room is built into a hillside, you can contact the University Health and Safety Team for advice.

$$A = 28 \times Q(\text{cm}^2)$$

Where natural ventilation is not available, mechanical ventilation will need to be used. You should calculate how many metres cubed of air needs to be removed and replaced every hour. You can use the formula below for this purpose, or you can use the UPS calculator. The values you use for this calculation must be specific to the system you are planning to use.

$$Q = v \times q \times s \times n \times I_{gas} \times C_{rt} \times 10^{-3}(\text{m}^3/\text{h})$$

It is strongly advised that unless the calculation indicates that more that 10 air changes per hour will be required, you should arrange for there to at least 5-10 air changes per hour in the room your UPS will be located. A minimum of 5-10 air changes per hour equates to 'good ventilation' in COSHH guidance. If the calculation indicates that more than 10 air chages per hour will be required, you should arrange for the mechanical ventilation in the room to meet this higher value.

Where work is required to create additional natural ventilation openings in walls, or if additional mechanical ventilation needs to be installed, Estate and Facilities Management (EFM) should be consulted.

5. Other Considerations

5.1 Additional risk assessment considerations

As with all DSEAR risk assessments where an EX Zone is established, your completed draft risk assessment must include:

- Supporting images of the planned UPS.
- Schematic plan and side elevation images of the UPS detailing the extent of the EX Zone 1.
- Details of the emergency procedure to follow should something go wrong with the UPS.
- List of Equipment for Hazarous Area Classification (where electrics have been

upgraded to ATEX).

Your final draft risk assessment must also be verified by the Health and Safety Team, Fire Safety Team and Senior Technical Services Manager for the area it is to be located.

For more information on these elements of the DSEAR risk assessment process, please see the DSEAR guidance. For more information on Li-ion UPS, please see our lithium battery guidance.

If you will be handling the batteries within your UPS setup, you should also carry out a COSHH risk assessment, covering arrangements for safe handling, for example, if the batteries were to become damaged or leak.

5.2 Service, inspection and maintenance

Where available, it is recommended that you purchase a service, inspection and maintenance programme from your UPS supplier/manufacturer. This will ensure your UPS remains in a suitable condition for use and will be maintained inline with the manufacturer's guidance. You should follow established arrangements for service contractors attending campus for this work.

If you have not purchased a service, inspection and maintenance programme with your UPS you will need to ensure that this work is arranged and carried out by competent contractors. The frequency of such service, inspection and maintenance should be checked with the UPS supplier or manufacturer.

Where an EX Zone 1 has been established around a UPS system, this needs to be communicated to the service contractors as measures will need to be taken by them to ensure their safety. Maintenance personnel should also wear antistatic footwear and use antisparking tools, to reduce the risk of igniting any hydrogen that may be present. This should be detailed in their risk assessments and method statements.

5.3 Small lead acid batteries

Some equipment used at the university will include VRLA batteries to run it, for example, a portable handheld smoke machine used to identify air movement in fume cupboards. These batteries are likely to be very small, and although may still release hydrogen if they malfunction, this is likely to be in small amounts. Any EX Zone 1 associated with these batteries is likely to be of negligible extent and no action would need to be taken to remove ignition sources. This would also likely be impractical due to the portable nature of the equipment they power.

However, other things to consider when purchasing and using these smaller batteries include:

- Purchasing a recognised brand from a reputable supplier.
- Visually inspecting the battery before each use.
- Following the manufacturer's guidance regarding storage, use and disposal.

- Disposing of the battery responsibly if it is damaged or at the end of its usable life.

See also:

- **DSEAR Health and Safety Webpage for:**
- **Guidance on Completing DSEAR Assessments.**
- **Guidance on using of lithium batteries.**
- **DSEAR risk assessment template for lead acid batteries.**
- **UPS EX Zone and ventilation calculator.**

Appendix 1 – Formula Key

$$A = 28 \times Q (\text{cm}^2)$$

A = free area of opening in air inlet and outlet (cm^2)

Q = Ventilation air flow in m^3/hr

$$Q = v \times q \times s \times n \times I_{gas} \times C_{rt} \times 10^{-3} (\text{m}^3/\text{h})$$

v = necessary dilution of hydrogen (100% - 4%)/4% = 24

q = amount of hydrogen generated per Ahr of battery capacity

s = general safety factor = 5

n = number of battery cells

Igas = current producing hydrogen (1mA/Ahr in float mode or 8mA/Ahr in boost mode for VRLA cells)

Crt = capacity of each battery (Ahr)

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