Risk Control

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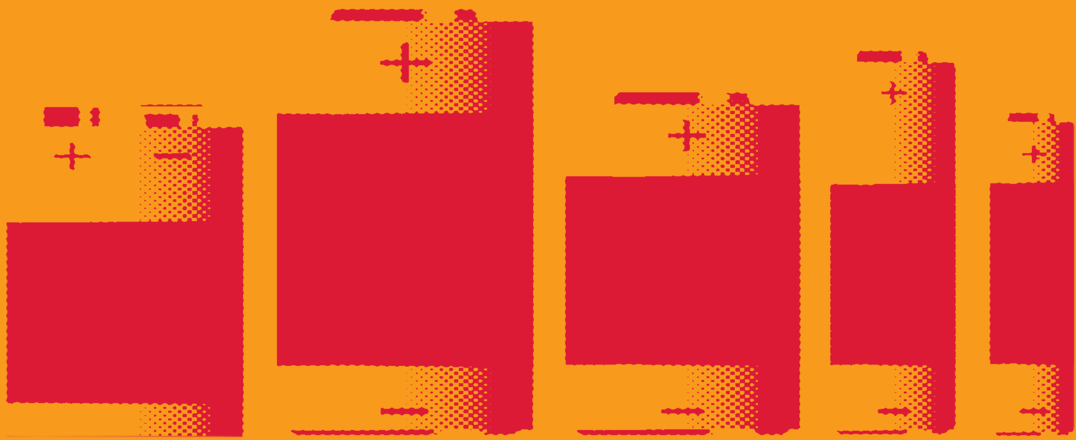
Recommendations for the storage, handling and use of batteries



RISCAuthority

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IMPORTANT NOTICE

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SCOPE

This document aims to provide practical guidance to insurers and their clients on fire hazards and appropriate control measures associated with the selection, storage, charging and use of batteries in commercial and industrial premises.

The charging of batteries in vehicles and mobility scooters is addressed in RC59: **Fire safety when charging electric vehicles** (ref 1) and is thus outside the scope of these recommendations. Similarly, recommendations for the use of fork-lift trucks (and similar items of plant which are not designed for the transport of personnel) are addressed in RC 11: (ref 2) and are also outside the scope of this document.

While this document refers to the storage of batteries on site while awaiting disposal at the end of their useful working life, it does not address the processes associated with the handling of the batteries following their removal by a licensed waste carrier.

SYNOPSIS

The recommendations are intended to provide guidance relating to the fire hazards and control measures associated with the selection, charging, storage and use of batteries. The batteries considered range from those used in small and hand-held appliances to large packs providing power for vehicles.

While primarily intended for commercial and industrial applications, the guidance is also applicable to the domestic environment.

Although not the primary focus of the document, reference is made to secondary (rechargeable) cells and the disposal of all forms of batteries following the end of their useful life.

DEFINITIONS

Electric vehicle:
The term electric vehicle is used generically in this document to relate to any form of vehicle, be it a car, mobility scooter or truck, whether powered exclusively or in part by electric power.

Mobility scooter:
In this document the term mobility scooter is used to refer to both Class 2 and Class 3 machines as defined in the Use of Invalid Carriages on Highways Regulations 1988 (ref 3). (Class 2 scooters are designed for use on the footway, travelling at speeds of up to 4mph. Class 3 scooters may be used on the footway at speeds of up to 4mph or on the road, where they may travel at up to 8mph).

Anode:
The negative terminal of a battery or cell that releases electrons during the production of an external current.

Battery:
A device that converts chemical energy into electrical energy. It consists of one or more Voltaic cells connected in series. Each cell consists of an anode or negative electrode and a cathode, or positive electrode, separated by an electrolyte. The electrodes cause negatively charged ions (anions) and positively charged ions (cations) to migrate to their respective electrodes. This leads to the build-up of electrical charge between the electrodes which may be used to power external devices.

Button cell:
A small round battery with a diameter greater than its height, which is used for special purposes such as hearing aids, watches, small portable items of equipment and back-up power supplies.

Cathode:
The positive terminal of a battery or cell that accepts electrons during the production of an electric current.

Electrolyte:
The conducting medium between the anode and the cathode in a cell.

Large battery:
In the interests of safety, reference to a large battery in this document is considered to be a battery, or number of batteries connected in series, providing more than 50Volts. (But it should be noted when considering safety, that it is the current flowing through the body, rather than voltage applied to it, that presents the danger in relation to electric shocks).

Primary battery:
A cell or battery that is not intended to be recharged and is discarded after use.

Secondary battery:
A cell or battery which may be recharged after discharge.

Rechargeable battery:
One or more secondary cells that may be repeatedly discharged and restored to full electrical capacity by the application of an electric current.

INTRODUCTION

The rapidly increasing range of items of portable electrical equipment, coupled with advances in technology and changes in social behaviour have created an increasing demand for mobile power sources. These are most conveniently provided in the form of batteries.

While primary batteries have been available in several forms for many years, there continues to be a growing demand for more powerful and durable secondary power supplies which may be recharged to provide an economical and environmentally preferable solution to this problem. Rechargeable batteries are to be found in mobile phones, laptops and tablet computers, satellite navigation equipment, radios, torches and for many other applications.

Numerous incidents worldwide have been associated with batteries causing smoke, fire, extreme heat or explosions on passenger and cargo planes (a significant number of which have been associated with lithium ion batteries). Most failures have been the result of inappropriate packaging or handling, which caused damage or electrical short circuits.

Although the technological basis of battery designs is well established, the number of units now being stored, handled and recharged in business premises also presents a potentially significant fire hazard. This document sets out guidance for fire safety managers of premises where these activities are undertaken and includes precautions that should be observed while batteries are awaiting disposal at the end of their operational life.

The technology

Batteries are now available in a vast array of shapes and sizes, leading to potential errors and confusion in their selection and use. The chemistry involved has developed from non-rechargeable carbon zinc batteries to alkaline batteries and button cells incorporating lithium, silver or zinc (mercury cells are now obsolete due to the toxicity of mercury salts).

Batteries for portable devices are readily available in five sizes:

AAA, AA, C, D and PP3 (9 Volt prismatic) and, less commonly, in a 6 Volt lantern style. In addition, batteries for cameras and specialist equipment are available in at least 14 further sizes. Many of these are available in both rechargeable and non-rechargeable formats and button cells are available in at least 27 sizes/styles.

Secondary cells originated with the ubiquitous lead acid car battery and developed to include rechargeable alkaline and lithium ion batteries. Other forms include nickel metal hydride batteries (which have replaced nickel cadmium batteries due to the toxicity of cadmium) and nickel metal hydride cells.

The technology of lithium polymer batteries allows their design to eliminate the rigid metal case, substituting this with a flexible foil like polymer laminate which may be shaped suitably for a specific application. The lack of casing results in a lighter battery and because of the denser packaging without spaces between cylindrical cells, the energy density of lithium polymer batteries may be some 20% higher than a similar lithium ion pack. Lithium polymer batteries are particularly hazardous if not stored, charged and used correctly. Not only do lithium polymer batteries burn fiercely with a very large heat output, there is the additional hazard that lithium cannot be extinguished using water or water based extinguishers.

Figure 1: Primary batteries are readily available in many styles and sizes; many of these are also available as secondary batteries.

The future may lay with fuel cells which are now finding industrial and commercial uses.

RECOMMENDATIONS

1. Compliance with fire safety legislation

1.1 In premises to which the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) (refs 4-8) applies, the fire safety management strategy should consider practical passive, active and managerial control measures. These should be applied as part of the fire risk assessment for the premises when selecting and designing areas for storing batteries and providing charging points for large capacity batteries or multiple small units. All fire risk assessments should also consider the possibility of deliberate fire setting; further information regarding the protection of premises from deliberate fire raising is set out in RISCAuthority Recommendations RC48: **Recommendations for the protection of premises from deliberate fire raising** (ref 9).

1.2 Where appropriate, an assessment in compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref 10) should be undertaken to ensure that charging areas are sufficiently remote from any hazardous materials such as flammable liquids and gases that may be stored or in use on the premises.

1.3 The response by fire and rescue services to 999/112 calls and signals routed via fire alarm monitoring organisations varies widely throughout the UK, and differs from day to night time. Fire safety managers should refer to the relevant fire and rescue service web sites to make themselves aware of the levels of response in the areas in which their premises are located and consider this information when undertaking and reviewing fire risk assessments.

1.4 Fire safety legislation is only concerned with life safety, but there are also significant benefits to be gained by extending the fire risk assessment process to consider property protection and business continuity issues.

2. Business continuity

2.1 Failure of a battery or a small fire can have a disproportionate effect on a business if occurring in a critical area. Batteries are becoming increasingly sophisticated and expensive and in many cases are becoming relied upon for the efficient functioning of a business. It is therefore important that appropriate battery technology is adopted and carefully managed to ensure efficient business operations.

2.2 In commercial premises where large capacity batteries or multiple smaller batteries may be on charge, the fire hazards and thus the threat to the business is increased if there is a need for the charging process to continue during the night or over weekends when no, or very few, staff are present. It is therefore essential that careful consideration be given to these implications when charging areas are being selected and designed.

2.3 All organisations should take steps to ensure the continued smooth running of their business by making a suitable emergency plan. Guidance for this is set out in **Business Resilience: A guide to protecting your business and its people** (ref 11). The emergency plan should address the implications of a fire, flood or other perceived disaster on all facets of the business model. It should indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of manufacturing plant or services.

2.4 When complete, the emergency plan should be rehearsed periodically by means of a table top exercise, with the results being assessed and amendments made to the plan as necessary.

2.5 Consideration may be given to applying commercially available computer programmes, such as the **ROBUST** software **(Resilient Business Software Toolkit)** that is available free of charge (ref 12), or other appropriate product, to develop and check the adequacy of the plan.

3. Fire safety management

3.1 All batteries should be stored, charged and used in accordance with the manufacturer's instructions.

3.2 No flammable or combustible material, other than that associated with the chargers, should be stored within 2m of the charging area.

3.3 Care must be taken that batteries are not damaged or pierced when in use, in storage or on charge. Any battery that has been damaged, dented or pierced should be taken out of service immediately, segregated from other batteries and stored as set out in section 7 below while awaiting safe disposal. Similarly, damaged goods containing batteries should also be segregated from other stock and stored safely to await safe disposal.

3.4 Security or other responsible staff on site who may be called to take action in an emergency should be made aware of the location of the charging area, the means for isolating the power and the action to take in an emergency.

3.5 All personnel authorised to use, change or charge batteries should be adequately trained concerning the properties of the batteries concerned and the safe use of chargers that may be involved. This is particularly important where personnel may be unfamiliar with some batteries, such as lithium polymer batteries, that are in use. A summary of the properties of some common types of batteries is set out in Figure 2.

3.6 In premises that also provide sleeping accommodation, serious consideration should be given, wherever practicable, to using timers to control socket outlets used for charging equipment such as mobility scooters, to eliminate the fire hazard during times when people may be asleep or few staff are in attendance. This precaution may be appropriate in healthcare and some forms of residential accommodation.

4. Selection and use

4.1 Careful attention should be given to the selection of the correct size and type of battery for a new application. Criteria to be considered include the availability of the batteries, the environment in which they are to be used, the characteristics of the power that they supply and the life between charges.

	Crush hazard	Explosion hazard	Fire hazard	Self heating hazard	Hydrogen production	Toxic hazard	Leakage hazard	Disposal
Primary batteries								
Carbon zinc	✗	✗	✗	✗	✗	✗	✓	Recycle
Zinc chloride	✗	✗	✗	✗	✗	✗	✓	Recycle
Alkaline	✗	✗	✗	✗	✗	✗	✗[1]	Recycle
Lithium button	✓	✓	✓	✗	✗	✗	✗	Recycle
Mercury (Hg)	✓	✗	✗	✗	✗	✓	✗	Return to producer
Silver oxide	✓	✓	✗	✗	✗	✗	✗	Recycle
Zinc air	✓	✗	✗	✓	✗	✗	✗	Recycle[2]
Secondary batteries								
Lead acid	✓	✓	✗	✗	✓	✓	✓	Recycle
Alkaline rechargeable	✗	✗	✗	✗	✗	✗	✗	Recycle
Lithium ion (Li-ion)	✓	✓	✓	✓	✗	✗	✗	Return to producer
Lithium polymer (Li-Po)	✓	✓	✓	✓	✗	✗	✓	Return to producer
Nickel cadmium (NiCd)	✓	✗	✗	✗	✗	✓	✓	Return to producer
Nickel met hydride (NiMH)	✓	✗	✗	✗	✓	✗	✗	Return to producer
Fuel cells	N/A	✓[3]	✓	✗	✓	✗	✓	Seek specialist advice

Figure 2: Summary of the hazards associated with some common types of batteries

Notes:

1 In normal usage

2 Do not immerse in water

3 Depending on the type of fuel

Careful selection of appropriate rechargeable battery systems can have the additional benefits of reducing toxic materials requiring disposal and thus have environmental advantages when compared to an equivalent number of disposable batteries.

4.2 In addition to 'off the shelf' batteries, there is an enormous number of batteries available that are custom made for mobile phones, MP3 players and other tools and equipment. Because they come in so many shapes and sizes, each requiring a different charger, it is good policy, where possible, to minimise the number of types and styles of batteries in use.

4.3 A serious potential hazard is that the same styles of rechargeable and non-rechargeable cells may be present and this may lead to attempts being made to recharge primary (non-rechargeable) cells, a practice that is inherently hazardous. Another hazard would be to use the wrong type of charger for secondary cells, which can also be dangerous. Care must be taken to avoid both of these hazards.

4.4 Avoid the use of carbon zinc batteries. Although they are cheap and readily available, leaking batteries release corrosive electrolyte which will damage metallic components of electronic equipment. Alkaline batteries are a satisfactory alternative in virtually all applications and have the advantages of having a higher energy density, longer shelf life and improved high and low temperature performance.

4.5 Batteries should not be carried in pockets as coins, keys and similar metal items can cause shorting leading to overheating, burns or ignition.

4.6 All tools used in the installation and maintenance of batteries should be suitable for battery work, for example, electrically insulated and acid resistant.

4.7 Metallic items worn by operators (such as bracelets and neck chains) should be prohibited when working on large batteries to prevent short-circuiting.

4.8 Following a period of charging, batteries should be allowed to rest for a short while before use. This should be observed even when batteries have been on trickle charge.

4.9 Following use, batteries should be removed from equipment for recharging or storage in a dry, cool place. Leaving batteries in place in equipment that is infrequently used may lead to corrosion if forgotten for some time.

4.10 No attempt should be made to repair or bypass cells in large batteries in order to extend their life.

4.11 Cells in large batteries should not be subject to reverse polarity or be short circuited. (In the event of this occurring as a result of cell failure, fuses are incorporated into the design of the units to prevent the energy in one string being 'dumped' into neighbouring cells).

5. Charging

5.1 All chargers not fitted with a 13 amp plug must be installed by a competent electrician (such as those recognised by the NICEIC, the Electrical Contractors' Association (ECA), the National Association of Professional Inspectors and testers (NAPIT) or Select in Scotland).

5.2 The fixed wiring, including the connections to battery chargers, should be tested periodically by a competent electrician and in accordance with the current edition of BS 7671 (the IET Wiring Regulations) (ref 13). Inspections should be carried out on a risk assessed basis as recommended in the Periodic Inspection Report.

5.3 Where a portable charger is in use (ie one fitted with a 13 amp plug), it should be sited by a competent person so that it is positioned on a level, firm surface with leads long enough to attach to the batteries with which it is designed to be used without placing them under stress.

5.4 Portable chargers should be inspected periodically (PAT tested) at least in accordance with HS(G)107 (ref 14) and the IET Code of Practice for In-service Inspection and Testing of Electrical Equipment (ref 15) and may need to be tested more often as determined by a risk assessment.

5.5 When chargers are to be left unattended, a check should first be made to ensure that they are working satisfactorily. All foreseeable potential fire hazards should be identified and action taken to eliminate or reduce the risk to the lowest practicable level. Further information regarding unattended processes is set out in RISCAuthority Recommendations RC42 (ref 16).

Some small proprietary products such as electronic cigarettes contain lithium ion batteries. When charging, they should not be covered and it is advisable that they are not left on charge while unattended. Lithium ion batteries should not be overcharged.

5.6 The charging of vehicles and large batteries should be carried out in a separate building of non-combustible construction reserved for this purpose or in a specially designed charging area. Charging areas should preferably be located in single storey buildings and be separated from other areas by fire resisting construction, including door sets, offering at least 60 minute's fire resistance.

5.7 Charging areas should be well ventilated direct to the outside at high and low levels; this may be achieved by air bricks in an external wall. There should be no potential sources of ignition in the vicinity of the vents.

5.8 If the recommendations in 5.6 and 5.7 are impracticable, charging of large batteries should be confined to a designated area of a building which should be kept totally clear of combustible material. A clearance of at least 2m should be established between the charging units and any adjacent combustible materials or composite panels containing combustible cores. The area should be defined by barrier rails of adequate strength. Information regarding the charging of electric vehicles and mobility scooters is set out in RC 59: **Fire safety when charging electric vehicles** (ref 1).

5.9 Whatever the choice of battery, it is imperative that the correct charger designed for use with that particular product be used. This will ensure that the battery charging commences at the right level and ceases before overcharging occurs (in some cases not observing this may be detrimental to the life of the battery or be hazardous).

5.10 Different types of batteries should not be charged together in the same charger.

5.11 Where batteries of the same type are charged together in the same charger, they should also have the same nominal capacity.

5.12 When purchasing battery chargers it should be ensured that they are capable of fully charging the product with which they are intended to be used. Some proprietary battery chargers are not capable of fully charging high capacity cells and 'smart' chargers are necessary for some forms of cell which cannot be safely or effectively charged by application of a constant voltage.

5.13 When inserting batteries in the charger, checks should be made to ensure that the polarity is correct and they are correctly located and secure before commencing charging. Poor contact with the charging pins can result in localised overheating.

5.14 Any charger reported to be faulty, have damage or chaffing of cables should be taken out of use immediately and be inspected and repaired by a competent electrician before being returned to service.

5.15 Where multiple chargers are in use, great care must be taken that the correct chargers are used for the batteries concerned. To this end, there should be a clear notice at each charging point identifying the type of battery and/or equipment for which it is suitable.

5.16 A check should be made that existing chargers are suitable before the first attempt is made to charge new batteries.

5.17 The temperature of the charging area should not be such that overheating may occur during the charging process. Battery cells should not be subject to temperatures in excess of 60°c in operation or 70°c during storage. In some instances, for example when charging some forms of lithium batteries, care should be taken that the temperature is above the minimum ambient temperature indicated by the manufacturer or supplier to ensure an efficient charging process.

5.18 Similarly, excessive temperatures should be avoided when battery operated equipment is in use; leaving equipment exposed to direct sunlight should be avoided wherever practicable.

5.19 All wiring and equipment must be suitable for its location and able to operate satisfactorily without deterioration throughout its working life. Charging points should therefore be protected from the environment during construction and use.

5.20 It is important that cells in a battery are balanced during the charging process to avoid overcharging and thus overheating individual cells; this is normally addressed automatically in the appropriate battery chargers. The manufacturer should be contacted if a large battery, or cell within the battery, appears to be overheating.

5.21 Care should be taken not to discharge batteries below 0.50V as in some cases polarity reversal of cells can occur resulting in a need for the battery to be replaced.

5.22 Where large batteries are charged, or there are multiple small chargers in use, the chargers should be fed by a dedicated electrical circuit and appropriate devices such as residual current devices (RCDs) should be in place to ensure the safe shut down of the equipment in the event of accident or failure of the mains electrical supply.

5.23 In the case of large batteries (ie greater than 50Volts) provision must be made for isolating each live conductor linked to the charging equipment manually, for use both in an emergency and for maintenance purposes. Provisions should allow the cables both from the mains supply to the charger and from the battery to be isolated.

5.24 An isolator should be easily accessible, prominently signed and as well as allowing manual isolation for maintenance, be linked so as to automatically isolate the charging circuits safely in the event of actuation of the automatic fire detection and alarm system in the building or failure of the mains power supply. Power circuits should be configured to require manual resetting of the isolator when power is restored.

5.25 Because charging of large batteries will often continue outside normal working hours, charging points should be:

- physically separated from process and storage areas, by a form of construction providing at least 60 minute's fire resistance;
- provided with suitable power supplies, control and isolation systems;
- protected by suitable fire detection and warning installations;
- subject to an emergency action plan to protect life and property and ensure the continuing functioning of the business in the case of fire; and
- carefully managed by staff trained in the safe charging of batteries and the actions to take in the event of fire, including the safe shut down of the charging process and evacuation of the premises.

5.26 Time switches may be used to operate chargers but a charging process should always be started manually and monitored for a short period before being left to operate unattended.

5.27 Lithium polymer batteries should be stored and charged in a proprietary fire safe container; they should not be left to charge outside of normal working hours. They should be charged only with a charger designed specifically for lithium polymer batteries; other forms of charger must never be used.

5.28 Care should be taken to charge batteries within the parameters set by the manufacturer. Lithium batteries in particular (such as those intended to power motorcycles), must not be overcharged.

5.29 The use of temporary extension leads and adaptors for battery chargers should be avoided. Where their use is necessary in an emergency, reeled cables should be fully unwound and extension leads should not be 'daisy chained'. Before use, a competent electrician should check that the circuit is not being overloaded.

5.30 No attempt should be made to modify charging equipment for any other use.

5.31 No attempt should be made to charge primary alkaline batteries and care should be taken not to inadvertently introduce these into chargers designed for secondary alkaline or other cells of a similar size.

5.32 If a battery on charge starts to distort or swell it should be disconnected immediately and removed to a safe area. The battery should then be kept under observation for at least 15 minutes for signs of leakage or a fire resulting from overheating or the contents coming into contact with the air. Lithium polymer batteries are particularly hazardous in this respect.

HobbyKing

A proprietary lithium polymer safety charge sack

6. Storage and handling

6.1 The shelf life of batteries being stored should be noted, and stock rotated as necessary. Old batteries of defunct styles should not be retained (for example button cells containing mercury should no longer be in storage).

6.2 Where batteries have to be transported, packaging should be designed to ensure that they are not punctured, dented or crushed as a result of any foreseeable accident.

6.3 The packaging of batteries received for forwarding may be relabeled but otherwise should not be altered in any way.

6.4 Batteries should not be unwrapped in the storage area until necessary. When they are unpackaged, the terminals of large batteries should remain covered to prevent short circuiting.

6.5 Prolonged storage of batteries causes them to age, thus the number retained in storage should be the minimum consistent with anticipated day to day business operations. (Nevertheless, in general, primary batteries store well; alkaline and primary lithium batteries can be stored for 10 years with moderate loss of capacity.)

6.6 Bulk supplies of batteries should be stored in a location designed with this purpose in mind. The area should be subject to a fire risk assessment in compliance with the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) (refs 4-8) and in compliance with the DSEAR Regulations (ref 10) to ensure that it is remote from identified hazard zones.

6.7 Storage areas should provide at least 60 minutes fire resistance between the stored batteries and any other part of the premises. Where there is a door allowing access to the premises from the store, the doorset should provide the same degree of fire resistance.

6.8 Charging should not be permitted within an area intended for the bulk storage of batteries.

6.9 Batteries should be stored in a dry environment at about 15°C; under no circumstances should the temperature be lower than –40°C or above 50°C. Extremes of temperature should be avoided as low temperatures may lead to freezing of the electrolyte and high temperatures to rupture of cells. Freezing of batteries occurs more easily when they are discharged.

6.10 Care should be taken to ensure that large batteries are stored in areas where they will not be exposed to water or other liquids. They should be kept in good condition; any damaged batteries should be removed and isolated in an area away from buildings and combustible materials and be protected from the environment while awaiting collection for safe disposal.

6.11 Large batteries should not be stored on metal shelving because of the risk of short circuits if terminals are exposed.

Temperature	Lead acid at full charge	Nickel based at any charge	Lithium-ion (Li-cobalt)	
			40% charge	100% charge
0°C	97%	99%	98%	94%
25°C	90%	97%	96%	80%
40°C	62%	95%	85%	65%
60°C	38% (after 6 months)	70%	75%	60% (after 3 months)

Figure 3: Estimated recoverable capacity when storing a battery for one year

6.12 To minimise age-related capacity loss during storage, lead acid batteries should be maintained at full charge during storage. When in long term storage, the voltage or specific gravity of the electrolyte should be monitored frequently and recharging be undertaken if the voltage drops below 2.10V/cell or the specific gravity of the electrolyte falls below 1.225.

6.13 In contrast, nickel and lithium based batteries should be stored at about 40% of their full charge.

7. Collection and safe disposal

The manufacture and safe disposal of batteries is subject to Directive 2006/66/EC of the European Parliament Concerning Batteries and Accumulators and Waste Batteries and Accumulators (ref 17). The requirements of this directive, which has been amended several times since its adoption, have been applied in the UK through the Waste Batteries and Accumulators Regulations 2009 (ref 18).

These regulations came into force because in the 1980s batteries commonly contained hazardous elements such as mercury, cadmium, and lead, which, when incinerated or disposed of in landfill, presented a risk to the environment and human health. The 'Battery Directive' explicitly bans certain chemicals and metals in batteries. It sets maximum quantities of chemicals and metals in batteries and requires proper waste management, including recycling, collections and 'take-back' initiatives.

7.1 At the end of their working life, batteries should be recycled and not sent to landfill. Although there are only trace amounts of heavy metals in most batteries and lithium has little scrap value, the recovery of copper, nickel and cobalt makes the recycling process economic.

7.2 Small non-combustible receptacles should be used to collect waste batteries in the workplace with the contents

Figure 4: Facilities for the disposal of car batteries are now widely available

being periodically transferred to a larger container outside the premises. This may need to be undertaken daily to prevent large numbers of batteries from accumulating. Collection points for batteries should not be sited on escape routes.

7.3 The receptacles should be made of a non-combustible, non-metallic (ie non-conductive) material with a high melting point, such as a thermosetting plastic. Care should be taken to ensure that extraneous metallic items such as silver foil, wire wool and paper clips are not introduced into the container to prevent shorting of battery terminals and fires.

7.4 Containers for the bulk storage of waste batteries outside the premises should be constructed from non-combustible, non-metallic material and be sited away from the buildings. Waste batteries should be protected from the effects of the weather while awaiting disposal by a specialist contractor or the supplier in accordance with the requirements of EU Directive 2006/66/EC (ref 17).

7.5 Waste lithium polymer batteries should be packaged individually in a proprietary fire safe container and be removed from the premises as soon as they are identified as no longer being required. They should not be stored, even temporarily, in waste battery receptacles.

7.6 Outside the premises lithium polymer batteries should be segregated from other batteries and be stored in a closed metal container to await safe disposal.

8. Fire protection

8.1 Fire protection measures for battery storage areas should be proportionate to the risk and be based on the findings of the fire risk assessment.

8.2 Battery charging and storage areas should be protected by automatic fire detection and alarm (AFD) installations designed, installed and maintained by an engineer with accreditation by an independent UKAS accredited third party certification body. The installation should be to a recognised category of installation in accordance with BS 5839-1 (ref 19) as determined by a risk assessment.

8.3 The automatic fire detection and alarm system should be monitored either on-site or by an off-site alarm receiving

Case histories

- Although often thought of as very minor components and not given great consideration, battery failure can have a severe impact on business continuity. One of the most serious arose as a result of at least four occasions of electrical system problems on Boeing 787 Dreamliners. These led to the Federal Aviation Authority (FAA) ordering a review of the design and manufacture of the airliner as a result of which the problem was traced to overheating of lithium ion batteries.

  The problem was so serious that at least one airliner had to execute an emergency landing, with the evacuation of passengers down the emergency chutes. The subsequent grounding of the entire fleet of these aircraft during the FAA enquiry led to a serious disruption of business for several airlines, as well as a loss of reputation of the manufacturers of the aircraft.

- Other incidents involving lithium ion batteries resulted in 4.2 million batteries being recalled following a number of fires in Apple laptop computers. A problem was identified in that some of a batch of Sony batteries had incorporated metal particles during the manufacturing process that could puncture the polymer layers separating cathodes and anodes, triggering short circuits. A Dell laptop caught fire at a conference in Osaka, Japan, and footage of the incident was widely viewed on the Internet, damaging the reputation of the manufacturers of the equipment.

Figure 5: Laptop computer catches fire at a conference as a result of battery failure.

In July 2007 Toshiba announced a recall of 10,000 lithium ion batteries which had also been installed in Dell and Hewlett Packard laptop computers or supplied as service replacements. This followed 19 reports of the batteries overheating, including 17 reports of flames or fire with 10 of these resulting in minor property damage. Two consumers experienced minor burns.

The battery for a radio controlled helicopter was placed on a workbench on charge at 09:00; just 50 minutes later the fire alarm sounded and intense flames and smoke were seen coming from area of the battery pack. An investigation after the fire had been extinguished by the fire and rescue service revealed that the battery had been totally discharged and had suffered impact damage during use prior to charging.

centre with accreditation by an independent UKAS accredited third party certification body and operating in accordance with BS 5979 (ref 20).

8.4 The installation should be periodically serviced and maintained by a competent engineer with accreditation by an independent UKAS accredited third party certification body in accordance with BS 5839-1 (ref 19).

8.5 The AFD installation should be interfaced so as to isolate the power supply to charging circuits in the event of the fire alarm actuating.

8.6 The installation of automatic fixed fire suppression systems is strongly recommended in areas where where batteries, especially lithium ion and lithium polymer batteries, are stored in bulk and where chargers are to run outside of normal working hours.

8.7 The most effective extinguishing agent for the particular application should be selected following a risk assessment and taking into consideration the effectiveness of the agent as well as toxicity, asphyxiation potential, environmental and contamination issues in the context of the application of the system. The principal alternatives are dry powder (which can cause contamination of electrical control systems), carbon dioxide and other gaseous flooding systems.

8.8 Where the fire risk assessment indicates that fire suppression systems should be provided such systems should be installed in accordance with a recognised standard by engineers certificated by an independent UKAS accredited third party certification body.

8.9 Where the fire risk assessment determines that the provision of a water sprinkler installation is appropriate, the system should be designed, commissioned commissioned and maintained in accordance with the LPC Sprinkler Rules incorporating BS EN 12845 (ref 21)

8.10 Suppression systems should be tested and maintained according to the requirements of the relevant British Standard and/or the installer's recommendations by an engineer with certification from an independent UKAS accredited third party certification body. Suitable records should be kept.

8.11 A suitable number of carbon dioxide and dry powder fire extinguishers should be available and immediately accessible in the case of a fire. Such portable extinguishers should be approved and certified by an independent, third party certification body and be installed in accordance with BS 5306: Part 8 (ref 22) and inspected and maintained in compliance with BS 5306: Part 3 (ref 23).

8.12 Where batteries are stored in a relatively small enclosed environment consideration may be given to installing a proprietary in-cabinet system to automatically detect and suppress a fire in its incipient stages. Where such a system is installed it should be monitored to allow the fire and rescue service to be alerted without delay.

9. Checklist

		Yes	No	N/A	Action required	Due date	Sign on completion
9.1	**Compliance with fire safey legislation (section 1)**						
9.1.1	Does the fire risk assessment undertaken in compliance with the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) consider practical passive, active and managerial control measures relating to battery charging? (1.1)						
9.1.2	Does the fire risk assessment also consider the possibility of deliberate fire setting? (1.1)						
9.1.3	Where appropriate, has an assessment in compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) been undertaken to ensure that charging areas are sufficiently remote from any hazardous materials such as flammable liquids and gases that may be stored or in use on the premises? (1.2)						
9.1.4	As the response by fire and rescue services to 999/112 calls and signals routed via fire alarm monitoring organisations varies widely throughout the UK, and differs from day to night time has reference been made to the relevant fire and rescue service web sites to determine their level of response in the areas in which the premises are located? (1.3)						
9.1.5	Has the fire fire risk assessment process been extended to address property protection and business continuity issues? (1.4)						
9.2	**Business continuity (section 2)**						
9.2.1	Has careful consideration been given to the appropriate battery technology to be adopted and is it carefully managed to ensure efficient business operations? (2.1)						
9.2.2	Has careful consideration been given to the selection and design of charging areas where there is a need for the charging process to continue during the night or over weekends when no, or very few, staff are present? (2.2)						
9.2.3	Have steps been taken to ensure the continued smooth running of the business by making a suitable emergency plan? (2.3)						
9.2.4	Has the emergency plan been rehearsed by means of a table top exercise, with the results being assessed and amendments made to the plan as necessary? (2.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.2.5	Has consideration been given to applying commercially available computer programmes, such as the **ROBUST** software (**Resilient Business Software Toolkit**) or other appropriate product, to develop and check the adequacy of the plan? (2.5)						
9.3	**Fire safety management (section 3)**						
9.3.1	Are all batteries stored, charged and used in accordance with the manufacturer's instructions? (3.1)						
9.3.2	Is the charging area free of flammable and combustible materials, other than those associated with the chargers? (3.2)						
9.3.3	Is care taken that batteries are not damaged or pierced when in use, in storage or on charge? Is any battery that has been damaged segregated from other batteries while awaiting safe disposal? (3.3)						
9.3.4	Have security or other responsible staff on site who may be called to take action in an emergency been made aware of the location of the charging area, the means for isolating the power and the action to take in an emergency? (3.4)						
9.3.5	Have all personnel authorised to use, change or charge batteries been adequately trained concerning the properties of the batteries concerned and the safe use of chargers that may be involved? (3.5)						
9.3.6	In premises that also provide sleeping accommodation, has serious consideration been given to using timers to control socket outlets used for charging equipment such as mobility scooters, to eliminate the fire hazard during times when people may be asleep or few staff are in attendance? (3.6)						
9.4	**Selection and use (section 4)**						
9.4.1	Is careful attention given to the selection of the correct size and type of battery for new applications? (4.1)						
9.4.2	Has consideration been given to minimising the number of types and styles of batteries in use? (4.2)						
9.4.3	Is care taken to avoid having the same styles of rechargeable and non-rechargeable cells present and are the correct chargers in use for the types of secondary cells in use? (4.3)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.4.4	Is the use of carbon zinc batteries avoided? (4.4)						
9.4.5	Are staff aware that batteries should not be carried in pockets with coins, keys and similar metal items? (4.5)						
9.4.6	Are all tools used in the installation and maintenance of batteries suitable for battery work, for example, electrically insulated and acid resistant? (4.6)						
9.4.7	Is the wearing of metallic items by operators (such as bracelets and neck chains) prohibited when working on large batteries to prevent short-circuiting? (4.7)						
9.4.8	Following a period of charging, are batteries allowed to rest for a short while before use? (4.8)						
9.4.9	Following use, are batteries removed from equipment for recharging or storage in a dry, cool place? (4.9)						
9.4.10	Are staff aware that no attempt should be made to repair or bypass cells in large batteries in order to extend their life? (4.10)						
9.4.11	Are measures taken to ensure that cells in large batteries are not subject to reverse polarity or short circuiting? (4.11)						
9.5	**Charging (section 5)**						
9.5.1	Are all chargers not fitted with a 13 amp plug installed by a competent electrician? (5.1)						
9.5.2	Is the fixed wiring, including the connections to battery chargers, tested periodically by a competent electrician and in accordance with the current edition of BS 7671? (5.2)						
9.5.3	Where a portable charger is in use, has it been sited by a competent person so that it is positioned on a level, firm surface with leads long enough to attach to the batteries with which it is designed to be used without placing them under stress? (5.3)						
9.5.4	Are all portable chargers inspected periodically (PAT tested) at least in accordance with HS(G)107 and the IET Code of Practice for In-service Inspection and Testing of Electrical Equipment? (5.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.5.5	When chargers are to be left unattended, is a check made to ensure that they are working satisfactorily? (5.5)						
9.5.6	Is the charging of vehicles and large batteries carried out in a separate building of non-combustible construction reserved for this purpose or in a specially designed charging area? (5.6)						
9.5.7	Are charging areas well ventilated direct to the outside at high and low levels with no potential sources of ignition in the vicinity of the vents? (5.7)						
9.5.8	If the recommendations in sections 5.6 and 5.7 are impracticable, is charging of large batteries confined to a designated area of a building which is kept totally clear of combustible material? (5.8)						
9.5.9	Are the correct chargers in use for the particular batteries on site? (5.9)						
9.5.10	Is care taken not to charge different types of batteries together in the same charger? (5.10)						
9.5.11	Where batteries of the same type are charged together in the same charger, do they also have the same nominal capacity? (5.11)						
9.5.12	When purchasing battery chargers is it ensured that they are capable of fully charging the product with which they are intended to be used? (5.12)						
9.5.13	When inserting batteries in the charger, are checks made to ensure that the polarity is correct and they are correctly located and secure before commencing charging? (5.13)						
9.5.14	Is any charger reported to be faulty, have damage or chaffing of cables taken out of use immediately and inspected and repaired by a competent electrician before being returned to service? (5.14)						
9.5.15	Where multiple chargers are in use, is great care taken that the correct chargers are used for the batteries concerned? (5.15)						
9.5.16	Is a check made that existing chargers are suitable before the first attempt is made to charge new batteries? (5.16)						
9.5.17	Is the temperature of the charging area not such that overheating may occur during the charging process? (5.17)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.5.18	Are excessive temperatures avoided when battery operated equipment is in use? (5.18)						
9.5.19	Is all wiring and equipment suitable for its location and able to operate satisfactorily without deterioration throughout its working life? (5.19)						
9.5.20	Do the battery chargers automatically ensure that cells in a battery are balanced during the charging process to avoid overcharging and thus overheating individual cells? (5.20)						
9.5.21	Is care taken not to discharge batteries below 0.50V as in some cases polarity reversal of cells can occur resulting in a need for the battery to be replaced? (5.21)						
9.5.22	Are containers for the bulk storage of waste batteries constructed from non-combustible, non-metallic material and stored outside, away from the buildings? (5.24)						
9.5.23	Where large batteries are charged, or there are multiple small chargers in use, are the chargers fed by a dedicated electrical circuit and are appropriate devices such as residual current devices (RCDs) in place to ensure the safe shut down of the equipment in the event of an accident or failure of the mains electrical supply? (5.25)						
9.5.24	In the case of large batteries is provision made for isolating each live conductor linked to the charging equipment manually, for use both in an emergency and for maintenance purposes? (5.26)						
9.5.25	Is an isolator easily accessible, prominently signed and as well as allowing manual isolation for maintenance, linked so as to automatically isolate the charging circuits safely in the event of actuation of the automatic fire detection and alarm system in the building or failure of the mains power supply? (5.27)						
9.5.26	Because charging of large batteries will often continue outside of normal working hours, are charging points: • physically separated from process and storage areas, by a form of construction providing at least 60 minute's fire resistance; • provided with suitable power supplies, control and isolation systems; • protected by suitable fire detection and warning installations; • subject to an emergency action plan to protect life and property and ensure the continuing functioning of the business in the case of fire; and • carefully managed by staff trained in the safe charging of batteries and the actions to take in the event of fire. (5.28)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.5.27	When time switches are used to operate chargers is the charging process always started manually and monitored for a short period before being left to operate unattended? (5.29)						
9.5.28	Are lithium polymer batteries stored and charged in a fire safe container, only charged with a charger specifically designed for this purpose and never left to charge outside of normal working hours? (5.30)						
9.5.29	Is care taken to charge batteries, especially lithium batteries, within the parameters set by the manufacturer? (5.31)						
9.5.30	Is the use of temporary extension leads and adaptors for battery chargers avoided? (5.32)						
9.5.31	Are no attempts made to modify charging equipment for any other use? (5.33)						
9.5.32	Is care taken not to charge primary alkaline batteries or to inadvertently introduce these into chargers designed for secondary alkaline or other cells of a similar size? (5.34)						
9.5.33	Are staff aware that if a battery on charge starts to distort or swell it should be disconnected immediately, removed to a safe area and kept under observation for at least 15 minutes? (5.35)						
9.6	**Storage and handling (section 6)**						
9.6.1	Is the shelf life of batteries being stored noted, and stock rotated as necessary? (6.1)						
9.6.2	Where batteries have to be transported, is packaging designed to ensure that they are not punctured, dented or crushed as a result of any foreseeable accident? (6.2)						
9.6.3	Is the packaging of batteries received for forwarding relabeled but otherwise not altered in any way? (6.3)						
9.6.4	Are batteries not unwrapped in the storage area until necessary, and when they are unwrapped are the terminals of large batteries left covered to prevent short circuiting? (6.4)						
9.6.5	Is the number of batteries retained in storage the minimum consistent with anticipated day to day business operations? (6.5)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.6.6	Are bulk supplies of batteries stored in a location designed with this purpose in mind that is subject to a fire risk assessment in compliance with the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) (refs 4-8) and in compliance with the DSEAR Regulations to ensure that it is remote from identified hazard zones? (6.6)						
9.6.7	Do storage areas provide at least 60 minutes fire resistance between the stored batteries and any other part of the premises? (6.7)						
9.6.8	Is charging prohibited within areas intended for the bulk storage of batteries? (6.8)						
9.6.9	Are batteries stored in a dry environment at about 15°C (and under no circumstances lower than –40°C or above 50°C? (6.9)						
9.6.10	Is care taken to ensure that large batteries are stored in areas where they will not be exposed to water or other liquids? (6.10)						
9.6.11	Are provisions available so that large batteries are not stored on metal shelving because of the risk of short circuits with some forms of batteries? (6.11)						
9.6.12	Are lead acid batteries maintained at full charge during storage? (6.12)						
9.6.13	Are nickel and lithium based batteries stored at about 40% of their full charge? (6.13)						
9.7	**Collection and safe disposal (section 7)**						
9.7.1	Are used batteries recycled at the end of their working life rather than being sent to landfill? (7.1)						
9.7.2	Are small non-combustible receptacles used to collect waste batteries in the workplace with the contents being periodically transferred to a larger container outside the premises? (7.2)						
9.7.3	Are collection points for batteries sited away from escape routes? (7.2)						
9.7.4	Are the receptacles made of a non-combustible, non-metallic (i.e. non-conductive) material with a high melting point, such as a thermosetting plastic? (7.3)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.7.5	Is care taken to ensure that extraneous metallic items such as silver foil, wire wool and paper clips are not introduced into the container to prevent shorting of battery terminals and fires? (7.3)						
9.7.6	Are containers for the bulk storage of waste batteries outside the premises constructed from non-combustible, non-metallic material, sheltered from the effects of weather and sited away from the buildings? (7.4)						
9.7.7	Are waste lithium polymer batteries packaged individually in a proprietary fire safe container and removed from the premises as soon as they are identified as no longer being required? (7.5)						
9.7.8	Outside the premises are lithium polymer batteries segregated from other batteries and stored in a closed metal container to await safe disposal? (7.6)						
9.8	**Fire Protection (section 8)**						
9.8.1	Are the fire protection measures for battery storage areas proportional to the risk as determined by the fire risk assessment? (8.1)						
9.8.2	Are battery charging and storage areas protected by automatic fire detection and alarm (AFD) installations designed, installed and maintained by an engineer with accreditation by an independent UKAS accredited third party certification body? (8.2)						
9.8.3	Is the automatic fire detection and alarm system monitored either on-site or by an off-site alarm receiving centre? (8.3)						
9.8.4	Is the installation periodically serviced and maintained by a competent engineer? (8.4)						
9.8.5	Is the AFD installation interfaced so as to isolate the power supply to charging circuits in the event of the fire alarm actuating? (8.5)						
9.8.6	Are automatic fixed fire suppression systems installed in areas where batteries, especially lithium ion and lithium polymer batteries, are stored in bulk and where chargers are to run outside normal working hours? (8.6)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.8.7	Has the most effective extinguishing agent for the particular application been selected following a risk assessment and taking into consideration the effectiveness of the agent as well as toxicity, asphyxiation potential, environmental and contamination issues? (8.7)						
9.8.8	Where the fire risk assessment indicates that a fire suppression system should be provided has such a system been installed in accordance with a recognised standard by engineers certificated by an independent UKAS accredited third party certification body? (8.8)						
9.8.9	Where the electrical installations comprise a small number of battery chargers and there is not a significant hazard in the form of flammable liquids, has consideration been given to installing a water sprinkler installation? (8.9)						
9.8.10	Are suppression systems tested and maintained according to the requirements of the relevant British Standard and/or the installer's recommendations by an engineer with certification from an independent UKAS accredited third party certification body? (8.10)						
9.8.11	Is a suitable number of carbon dioxide and dry powder extinguishers available and immediately accessible in case of fire? (8.11)						
9.8.12	Where batteries are stored in a relatively small enclosure has consideration been given to installing a propietary in-cabinet fire suppression system? Where a system has been installed is it monitored? (8.12)						

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