

## **APPENDIX 2 – Detailed Specific Guidance**

This appendix gives specific guidance on how to control the risks from flammable atmospheres, both on a general basis (Control of Ignition Sources, Hazardous Area Classification and Safety Management Systems) and for specific examples (e.g. use of flammable gas cylinders, use of aerosols etc.) which are likely to cover 80% of situations where dangerous substances are used across the STFC sites. For the other 20% the guidance in Appendix 1 provides the framework that can be followed. Management should decide whether specialist advice is required in these cases and to call in “experts” as required.

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## A2.1 Explosion Risk Assessment Approach and Methodology

A structured assessment approach should be followed to identify the risk of an explosion occurring within either each major equipment item or process stage and to define a “Basis of Safety” for that item or stage. Remember that explosion and fire require fuel, oxygen / oxidant AND an effective ignition source. Remove one of these and the explosion is not possible. The existing control measures through which the Basis of Safety is implemented can be established and an assessment made of the residual risk to people. Where the Basis of Safety cannot be demonstrated to be sufficiently robust, and residual risks are intolerably high, additional control measures need to be recommended to secure the Basis of Safety. The assessment therefore will address the following questions:

- Can a flammable (explosive) atmosphere arise in normal or reasonably foreseeable abnormal operation and if so how extensive is it likely to be and how likely is it to occur? For example, identify materials (or groups of materials: gases / vapours, liquids and combustible dusts), which have potential to form explosive atmospheres; what makes them hazardous? (explosion hazard rather than just fire hazard); if possible for some low risk materials - rule out foreseeable risk at this stage (i.e. high flash points operating at low temperatures).
- Can ignition sources arise within the possible flammable atmosphere? How likely are they to arise in normal or reasonably foreseeable abnormal circumstances and are they likely to be sufficiently energetic to ignite the flammable atmosphere? (Refer to Section A2.2 below)
- What are the consequences in the event of ignition of the flammable atmosphere? In relation to DSEAR the concern is for the safety of people so you must consider the nature and extent of the hazard, how many people may be in the affected area and how likely they are to be present.
- What is the most appropriate Basis of Safety? (e.g. should be defined as either Explosion Prevention, or Explosion Protection – see table below) Are the existing control measures sufficient to reduce risks to tolerable levels? The residual risks should be classed as Broadly Acceptable if they are sufficiently low that no further controls need to be pursued.

It is suggested that the following Basis of Safety definitions be used, and these should cover the majority of cases on the STFC sites:

Basis of Safety	Means by Which it is achieved	Typical Example
Explosion Prevention	Avoidance of flammable atmospheres	Nitrogen padded reactor – flammable atmosphere is avoided by the elimination of oxygen / oxidant.

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	Elimination of ignition sources	Simple process vessel with no internal electrical or mechanical moving parts. Other ignition sources eliminated at source (refer to Section A2.2 below)
	Avoidance of flammable atmospheres and control of ignition sources	System normally operates below LFL (lower flammable limit), but in addition, as far as possible ignition sources are controlled at source or by appropriate equipment selection (refer to Sections A2.2 and A2.11 below)
Explosion Protection	By explosion relief	Dust filter unit or a typical powder storage silo – an explosion in the vessel will be relieved to a safe location by the bursting of a relief panel, thus preventing the vessel from rupture in the workplace
	By explosion suppression	Small powder handling vessel – explosion is quenched, and dangerous explosion over-pressures avoided, preventing rupture of the vessel by high speed injection of an inert substance (typically sodium carbonate) upon detection of pressure build-up at the start of an explosion (i.e. pressure sensor activates injection system within milli-seconds of ignition of fuel)
	By containment	Reaction vessels or gas transfer pipelines – containment systems rated for a higher pressure than the maximum explosion over-pressure of the fuel (typically >10 barg)

- If existing control measures are not considered sufficient then what additional controls are required to further reduce the residual risk? i.e. are the risks:
  - Tolerable if shown to be as low as reasonably practicable (TIFALARP) – further controls to reduce risk should be implemented unless they are shown to be grossly disproportionate (in terms of practicability and / or cost) to the resulting risk reduction.
  - Intolerable – risks are unacceptable and cannot be justified. Additional control measures must be implemented to bring the risks down to broadly acceptable or as a minimum to TIFALARP.

## A2.2 Control of Ignition Sources

In some cases it is expected that safety can be based on the elimination of ignition sources, usually in cases where a flammable atmosphere is unlikely to arise and the consequences if an explosion were to occur are of limited impact. However even where safety is based on other strategies it is necessary to control ignition sources as far as is practicable and hence

ignition source controls are relevant in all cases. In particular it is recommended that the following ignition source controls are applied:

### **Control of general external ignition sources**

- Hot work should be controlled by site rules and use of a permit system
- Smoker's materials should be controlled by the STFC site policies, rules and designated smoking stations in safe areas.
- Portable equipment usage in hazardous areas should be controlled by site rules, procedures and permit to work systems.
- Fixed equipment in hazardous areas is subject to selection procedures in relation to explosion protection requirements (refer to Section A2.11).
- Other non-routine activities are controlled by permit systems.

### **Control of electrostatic ignition sources**

Electrostatic charge is generated in all processing operations. Accumulation of dangerous levels of charge on metal or conductive plant can be avoided by the earthing of all such components. In principle, a resistance to earth of less than 1 meg Ohm will prevent the accumulation of static electricity. In practice, a lower resistance target is recommended to ensure a low resistance is maintained over a period of time.

It is recommended that the resistance to earth of all metal or conductive items should be less than 10 Ohms. In general, major plant items will be earthed through their construction. Care must be taken however, to ensure that individual metal components are not insulated from earth by plastic components e.g. metal pipe connecting two sections of plastic pipe. Special earthing straps may be required for metal items insulated from earth by plastic components.

It is recommended that procedures be established at all sites to monitor the earthing of **all components** at periodic intervals during the life of the plant to ensure that the resistance to earth is maintained at an acceptably low (safe) level (i.e. less than 10 Ohms). Such checks should typically be performed at yearly intervals and after any maintenance operation where sections of plant forming the conducting path to earth may have been disconnected.

The majority of flammable materials on the STFC sites are flammable vapours (from liquids) and gases. Vapours and gases have low Minimum Ignition Energies (MIEs) (usually <1mJ) and additional safeguards / control measures are required to eliminate low energy electrostatic discharges capable of igniting vapours and gases. Particular care must be taken to control electrostatic risks associated with:

- Metallic and conductive plant components
- Personnel; should be controlled by the use of antistatic footwear and flooring,
- Processing and handling of low conductivity liquids, e.g. toluene, particularly where two phase mixtures may be present,
- The use of non-conductive (e.g. plastic) components.
- Powders
- Addition of powders to flammable vapour atmospheres,

Powders generally have MIEs that are relatively high (i.e. >10mJ) compared with those of flammable gases and vapours. Low energy discharges are generally not capable of igniting dust clouds of these materials. However, some dusts have MIEs which are <10mJ, and dust clouds of these materials can be ignited by low energy electrostatic discharges.

Generally where powders are added to flammable solvents, the MIE of the powder will be irrelevant. Electrostatic controls, which prevent ignition of flammable vapours, will also prevent ignition of flammable dust clouds. If combustible powders are to be used and are not added to flammable solvents, e.g. via a sack tip unit, the MIE should be known (or tested) to determine what control measures are likely to be required.

In order to control the electrostatic hazards identified above a range of precautions are required. The precautions listed below should be in place where applicable.

**a) Metallic and Conductive Components**

The following controls are required:

- All metal or conductive components are reliably earthed, ideally with a resistance to earth of <10Ω.
- Earthing of all mobile equipment by earthing leads,
- Any Flexible IBCs (big bags) used are Type C and are earthed at the point of use,
- All earthing systems to be tested on a regular schedule, e.g. annually.

**b) Personnel**

The following controls are required where substances are used with an MIE <30mJ (therefore all flammable vapours / gases and some powders):

- Use of antistatic (or conductive) footwear and antistatic flooring providing a resistance to earth of <10<sup>8</sup>Ω (SEE References 5, 6 and 7).
- Antistatic footwear to be tested regularly – this can be achieved either by replacing the footwear at regular intervals or via installation of test stations local to areas where personnel are working near significant quantities of solvent vapours / gases. Due to the increased risk of electric shock 240V electric tools should not be used in any area whilst wearing conductive footwear.
- Bare concrete or antistatic floors.

Where MIE is <1mJ (most gases and vapours) the following additional controls are required:

- Wear cotton, linen or viscose rayon clothing in hazardous areas e.g. cotton lab coat or one-piece boiler suit.
- Clothing should be close fitting.
- Do not remove or put on clothing in hazardous areas.

**c) Non-Conductive Components**

Non-conducting (e.g. plastic) equipment cannot be earthed. This leads to the retention of electrostatic charge on the equipment and product contained in it. However, the energy of discharges is also limited and only poses a hazard if the material MIE <10mJ.

Given that the majority of substances used on the STFC sites do have an MIE  $<<10\text{mJ}$  then all plastic components used in the various areas, e.g. hoses etc. should be made of a suitable anti-static material. Materials should comply with BS2050 (Reference 4).

**d) Liquids**

The following controls are required:

- Pipeline velocities limited to 1 m/s maximum for highly resistive solvents, i.e. with conductivity  $<50\text{ pS/m}$  e.g. toluene and products based on these materials, including two-phase solutions,
- Pipeline velocities limited to 7 m/s maximum for all other solvents, i.e. with conductivity  $<50\text{ pS/m}$ , e.g. IPA, etc.
- Liquids pumped into tanks and vessels via dip-pipes or below liquid surface or directed towards wall of vessel to avoid splash filling.

**e) Powders**

Electrostatically charged powder or flake can be the source of an incendive discharge. The phenomenon is not fully understood, however it is considered that a hazard could only exist with powdered products of MIE  $<10\text{mJ}$  provided the powder is in contact with earth. However, for earthed pneumatic transfer pipe of diameter  $<1\text{m}$  there is no hazard of ignition from electrostatic discharges originating from the dust cloud within the pipe for materials with MIE  $>0.2\text{mJ}$ .

**f) Charging Powders to Flammable Solvents**

The manual addition of powders into flammable solvents has caused fires and explosions and a significant number of these have been caused by electrostatic discharges. Consideration has to be given to the potential for generating dangerous levels of electrostatic charge on the container being emptied, the charging chute and receiving vessel, the powder being charged and the operator. The following controls are required:

**Container being emptied**

- Containers should be metal, paper or other dissipative material and should be earthed before and during charging,
- High resistivity containers, e.g. plastic sacks, wax coated paper etc, should not be used near flammable atmospheres,
- High resistivity liners, e.g. polythene sack / bag inside other container, should not be used near flammable atmospheres,
- Conductive or dissipative liners may be used in conjunction with earthed metallic or conductive non-metallic containers. The liner should not be removed from the container in a flammable atmosphere unless the liner is always in contact with earth,
- Conductive or dissipative containers coated with a non-conductive coating, e.g. lacquer-lined container, may be used providing:
  - The coating is not thicker than 2mm and
  - The coating does not become detached and
  - The container is earthed

**Receiving vessel and loading chute**

- Metal or conductive non-metallic vessels and chutes should be earthed,
- Non-conductive receiving vessels and chutes should not be used.

#### **Material being handled**

- Charging chutes should not exceed 3m in length,
- High resistivity powders, e.g. polymers, synthetic resins, waxes etc. with resistivity above  $10^{10}\Omega/m$ , must be added at a controlled rate of 1 kg/s maximum,
- There is no restriction on addition rate of other powders.

#### **The Operator**

The operator should be properly earthed as detailed in b) above.

#### **g) Vapour and Nuisance Dust Extraction Systems**

It is common practice to use plastic components for vapour and dust extraction systems. The materials are light, versatile and easy to use and handle. Such materials are often non-conductive (i.e. resistance  $>10^9\Omega$ ).

The use of highly resistive materials of construction in areas where flammable atmospheres could potentially arise is undesirable. As it is not possible to earth such material dangerous levels of electrostatic charge could be produced on them. Even low energy brush discharges from such materials would be capable of igniting flammable vapours.

When considering the electrostatic ignition risk from such equipment, both the charge generation and charge dissipation mechanisms need to be taken into account.

The flow of clean vapour / air through the ducting will generate little or no electrostatic charge on the ducting. However, if condensation occurs in the ducting there is the potential to create isolated conductors (if the liquid is conductive) and these must be avoided.

Where condensation is possible, either the ducting should be of all metallic construction or, a water-cooled vent pipe should be installed on the vessel. This will restrict the condensation process to the vessel and minimise condensation in the ducting.

The flow of powder through the ducting could generate electrostatic charge. However, when on nuisance dust duty only, the passage of powder over the ducting is trivial and produces very little electrostatic charge when compared with pneumatic transfer of powders. This produces dangerously high levels of electrostatic charge.

#### **Preventative maintenance as an ignition source control measure.**

Most mechanical equipment used in processes has internal moving parts and associated drive systems such as pumps, sieves, mills, transfer system blower fans, stirrers, blenders, mixers etc. In normal operation these present little in the way of ignition risks. However in the event of a fault ignition sources can arise in the form of sparks or frictional heating from contact of internal moving parts or overheating bearings on drive systems.

A suitable preventative maintenance programme, including regular inspection and lubrication where appropriate, can be a significant ignition control measure. Similarly for electrical equipment where a fault may give rise to a spark or overheating there is a requirement for an appropriate preventative

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maintenance programme. Where explosion protected (categorised) equipment is used in hazardous areas it is essential that it be properly maintained for the degree of protection to remain in place (refer to Section A2.11).

It is impractical to identify the detailed maintenance requirements for each equipment item in use on the STFC sites. These can only be defined based on manufacturers advice and the duty and environment of the unit.

### **A2.3 Use of Flammable Gas Cylinders**

Cylinders of compressed gases, including hydrogen, oxygen, acetylene, methane, propane etc, form the majority of usage of dangerous substances throughout the STFC sites. These should be stored either outside where possible or inside local to the experiments. It should be noted that liquid or two-phase leaks of flammable substances from cylinders would rapidly vaporise to form extensive flammable atmospheres.

The following controls should apply to cylinder use and storage:

- Minimise inventory wherever possible. If practical use smaller cylinders rather than the large full-sized cylinders.
- Store in a well ventilated area, preferably outside. Where this is not achievable it is good practice to use local ventilation hoods where there is a danger of flammable atmosphere or depletion of breathable oxygen in a confined space. See example below of a gas store.
- LPG cylinders should be separated by at least 3m from all other cylinders and other flammable cylinders should be separated from all other cylinders by at least 1m.
- Flammable gases and oxygen cylinders should be physically separated by at least 3m.
- Cylinders should be secured, i.e. using chains, to prevent falling over.
- Cylinders should be stored in a locked cage / area.
- Cylinder storage areas should be well protected against vehicle / impact damage.
- Storage areas should be kept clear of combustible material, e.g. packaging, vegetation, etc.
- Ensure cylinder valves are shut off when not in use (e.g. to prevent leakage from gas hoses or cutting gear).
- Careful control of gas cutting operations (e.g. removal of combustible materials from the area - only use in designated areas of the workshop).

Note that the user should still complete a risk assessment (Section A2.1), apply ignition source controls (Section A2.2), and apply hazardous area classification and appropriate equipment selection (Sections A2.10 and A2.11) as required. The above controls are best practice to avoid formation of an uncontrolled flammable atmosphere.



#### **A2.4 Small-scale Use of Laboratory Chemicals**

Handling of small quantities of combustible powders / materials in the laboratories or experimental areas has no credible means of forming a significant flammable dust cloud.

Small quantities of flammable (flash point 21-55°C) and possibly highly flammable (flash point 0-21°C) solvents are capable of forming a significantly sized flammable atmosphere. The liquids should be handled in small containers (typically <1 litre) and it is only those classed as highly flammable that present a significant risk. Provided they are stored in purpose built fire resistant steel cupboards explosion risks are easily controlled by good laboratory practices. Flammable gases are also piped to a number of laboratories, mostly from flammable gas cylinders stored outside the building. The laboratories at STFC should be operated to good laboratory practice and the following points should be noted for both laboratory and experimental areas.

- Minimise inventory insofar as possible.
- Fume cupboards should be used for handling flammable liquids and gases whenever possible.
- Solvent storage containers should be suited to the small quantities used.
- The solvents should be stored in lockable purpose built fire resistant steel cupboards.
- Flammable gas pipework routes to laboratories may run through miscellaneous areas. Such runs must be clearly identified; the integrity of the pipes checked to ensure pipes couldn't be physically damaged (e.g.

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consider guarding), and preferably use fully welded small-bore pipe (e.g. Swagelok).

Note that the user should still complete a risk assessment (Section A2.1), apply ignition source controls (Section A2.2), and apply hazardous area classification and appropriate equipment selection (Sections A2.10 and A2.11) as required. The above controls are best practice to avoid formation of an uncontrolled flammable atmosphere.

## **A2.5 Use of Aerosols**

Small quantities of flammable aerosol or liquid degreasers may be used or stored in workshop and experimental areas. They should be stored in purpose built steel cupboards and personnel should be made aware of the hazard and control measures, which include:

- Correct storage and use in small quantities
- Avoid use near naked flames or operations involving high energy such as welding, cutting, grinding
- General controls on ignition sources (refer to Section A2.2).

## **A2.6 Paint and flammable liquid storage**

Paints and flammable liquids are stored at various locations across the STFC sites. Such areas should comply with guidance on HSG 51: Storage of flammable liquids in containers. The key points of HSG 51 are summarised below.

- Where practicable store in a shaded open-air area.
- If not practicable to store in open air, store in separate specifically designed storerooms with good ventilation >5 air changes per hour.
- For small buildings provide airbricks or louvers at high and low level on opposite walls, ventilation area 1-3% of the total area of the walls and roof.
- Provide containment to deal with spillages and ensure containers are safely stacked.
- Locate stores well away from other processes, general storage areas or boundary fences. For storage of up to 1000 litres, a separation distance of > 2m is required or a fire wall with >30 minutes fire resistance.
- Additional requirements if storage is close to site boundary.
- Small quantities (<50 litres) can be stored in ½ hour fire resistant storage cupboards or bins at points of use (e.g. experimental areas).

## **A2.7 Battery Charging Areas**

Numerous individual small chargers may be located at strategic positions throughout the STFC sites e.g. for charging forklift trucks, delivery floats etc.

Hydrogen will be released from batteries during charging. However release rates are extremely low and hydrogen is such a light gas that it will rapidly rise away from charging stations and accumulation at low levels will not occur provided a reasonable level of general workplace ventilation is present. Accumulation at high-level roof peaks etc. may be of concern if adequate high-level ventilation is not provided.

## **A2.8 Natural Gas Supply Stations and Pipework**

The pressure control / relief arrangements in the supply stations should be maintained and serviced by the gas provider on a regular basis. They should be suitably protected within a locked building, within the site security fences and protected from vehicle / impact damage. They should be fitted with sufficient ventilation to prevent gas accumulation. The areas around gas let-down stations and pipework should be kept clear of combustible material, e.g. vegetation.

Gas supply lines should be clearly identifiable across the sites, and their integrity should be monitored on a regular basis.

## **A2.9 Diesel Storage**

The flash point of diesel / gas oil is greater than 55°C. The likelihood of forming a flammable vapour atmosphere is extremely low. Pumping pressures within storage systems is usually insufficient to form a significantly sized flammable mist or spray within the storage tanks. The risk of forming flammable mists or sprays is therefore extremely low. There is therefore generally no requirement to define a hazardous area zone within diesel storage tanks as long as pumping pressures are < 5 barg.

It should however be noted that the diesel supplies represent a significant fire hazard and systems should be put in place for controlling potential releases, controlling general ignition sources and provision of fire fighting. Bund integrity should be checked on a regular basis.

## **A2.10 Hazardous Area Classification**

The objective of area classification is to identify areas in a plant where flammable atmospheres may exist and to determine their likely extent and likelihood of occurrence. Additional controls concerning ignition risks from equipment within these zones can then be applied.

Hazardous areas inside equipment should be identified and classified during the course of the risk assessment such that any equipment within vessels can be selected appropriately. It may also be necessary to classify hazardous areas outside equipment in the various workplace areas.

Hazardous areas can be defined and classified following specific guidance e.g. BSEN 60079-10 for gases, liquids and vapours (reference 8), BS EN 61241-10: 2004 for dusts (reference 9). DSEAR requires that the extents and types of zones selected in various areas should be illustrated on suitable site drawings to aid interpretation and use on an ongoing basis.

The starting point for the assessment is to systematically, and critically, review the operations to identify credible ways in which the flammable material could be released, either inherently in normal operation or as a result of accidental circumstances. The identified sources of release can then be classified in terms of likelihood, referred to in area classification as 'Grades of Release'. Grades of release in decreasing likelihood of forming an explosive atmosphere are defined as:

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Continuous grade of release:	A release that is continuous or expected to appear for long periods. E.g. vapour space above a volatile liquid in a storage vessel.
Primary grade of release	A release which can be expected to occur periodically or occasionally during normal operation. E.g. area around a tank vent – releases occur from period tank breathing.
Secondary grade of release:	A release which is not expected to occur in normal operation and if it does occur, is likely to do so infrequently and for short periods. E.g. pipework flange leak.

European Standards and the ATEX Directive define the following zones for gases / vapours:

Zone 0:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
Zone 1:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.
Zone 2:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

For gases and vapours it is possible to calculate or predict the rates of release and the extents of hazardous zones. The size of the zone is to some extent dependent on the intrinsic properties of the material whilst other factors depend on the nature of the operation.

An explosive atmosphere can only exist where the flammable material is handled as a gas, or as a liquid at a temperature above its flash point, or if a mist of a combustible liquid can arise. For given ambient conditions a liquid of a lower flash point may give rise to a zone of larger extent. The extent of a zone will also depend on the release rate of the flammable material. As indicated above the extent of a zone will also depend on the ventilation in the area concerned, as ventilation will help dilute a release and thereby limit the zone extent.

Guidance in reference 8 should be used for determining zone extents for gases, liquids and vapours as it is far too lengthy to replicate within this code. The guidance provides common examples for a variety of typical situations, which can be used as necessary.

For Combustible Dusts the zones are as defined in EN61241-10:

Zone 20:	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.
Zone 21:	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation

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	occasionally.
Zone 22:	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation, but if it does occur, will persist for a short period only.

Whilst for gases and vapours it is possible to calculate or predict the rates of release and the extents of hazardous zone, this is not practicable for dusts. Historically EN standards suggested:

Zone 20:	Within process equipment enclosures.
Zone 21:	Normally of only small extent, typically up to 1 metre from nearest point of the source of release extending vertically downwards to the ground or level of a solid floor.
Zone 22:	In most circumstances extending up to 1 metre around the source of release and vertically downwards to the ground or level of a solid floor.

It is worth noting that a combustible dust cloud will be clearly visible as a dense cloud. The extents of Zone 22 will sometimes be more than the guidance above and is impacted by the standard of housekeeping. Practically it is best to define the extent of Zone 22 by comparison with powder spread in similar area. Physical inspection by a person experienced in the technique and familiar with dust / powder handling operations is an essential part of area classification for combustible dusts.

The properties of the dust, e.g. particle size, moisture content etc and the workplace environment, e.g. dry, still, inside workplace or wet, windy, outside workplace will all affect the Zone extents. Therefore the guidance in reference 9 should be followed should area classification for dust handling be required.

### **A2.11 Selection of equipment for use in hazardous areas**

The guidance presented below should be used for selecting both electrical and non-electrical equipment for use in the hazardous area zones and summarises the key requirements of the ATEX100 Equipment Directive (94/9EC).

It should be noted that simple items of non-electrical equipment with no “own sources” of ignition i.e. manual valves, chutes, pipework do not fall within the scope of the ATEX 100 Directive and therefore do not require categorisation. It should also be noted that where the only source of ignition is electrostatic, due to the movement of powder etc. through an items of equipment, it is not deemed as an “own source”.

#### **Equipment Groups & Categories**

Equipment for use in hazardous areas should carry the CE and specific explosion marks.



Equipment is grouped based on the location of its intended use and then categorised according to the level of “ignition protection” provided. This is illustrated below.

Group (Location)	Level of Ignition Protection		
	Very High	High	N/A
I (Mines)	Category M1	Category M2	N/A
II (Other)	Category 1	Category 2	Category 3

The level of protection required for each of the Group II categories is summarized below:

LEVEL OF PROTECTION	CATEGORY GROUP II	PERFORMANCE OF PROTECTION
Very High	1	Two independent means of protection or safe even when two faults occur independently of each other.
High	2	Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account
Normal	3	Suitable for normal operation

There is a clear link between Group II categories and hazardous areas (zones) as defined by ATEX. This relationship is shown in the table below. Each category requires sub-division depending on its intended duty.

- ‘G’; gas, vapour or mist duty
- ‘D’; dust duty

Gases, Vapours	Dusts
Zone 0 • Category 1 G	Zone 20 • Category 1D
Zone 1 • Category 1G or 2G	Zone 21 • Category 1D or 2D
Zone 2 • Category 1G, 2G or 3G	Zone 22 • Category 1D, 2D or 3D

### **Temperature Classification**

Hot surfaces represent potential ignition sources and the maximum surface temperature of equipment should be considered. A common approach is to use the T class system discussed below.

When selecting apparatus according to temperature classification, the maximum surface temperature or the T class of the apparatus (or, where the apparatus is marked with a particular temperature, that temperature) should be specified to avoid ignition of the potential flammable atmospheres.

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The T class is normally assigned to apparatus on the basis of temperature rise tests assuming a local ambient temperature not exceeding 40°C. In special cases, apparatus may be designed on request to operate in a local ambient temperature of more than 40°C. In this case the maximum permitted local ambient temperature will be clearly marked on the apparatus. The T class will have been assigned on the basis of temperature rise tests and the assumption that the apparatus may operate at temperatures up to the maximum permitted local ambient temperature.

When apparatus which has a T class assigned assuming a 40°C maximum ambient temperature is to be used at a higher local temperature, for example because it is mounted on a hot surface, it is important to check with the manufacturer on the suitability of the apparatus to operate at these higher temperatures. For example, when apparatus is to be mounted under pipe-lagging, it is virtually unaffected by the air temperature, but may fail due to heat from the pipe.

The permitted maximum surface temperatures classified according to T Class are given below.

**Temperature Classes**

<b>T Class</b>	<b>Maximum Surface Temperature (°C)</b>
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

**Vapour & Gases:** The maximum surface temperature should not exceed the auto-ignition temperature of the flammable mixture concerned.

**Dusts:** The maximum surface temperature shall not exceed two thirds of the minimum (dust cloud) ignition temperature in °C of the dust air mixture concerned.

In addition, where dust layers may be present, up to 5mm in thickness the maximum surface temperature of the apparatus shall not exceed a value of 75°C below the minimum ignition temperature for a 5mm layer of the dust concerned. Where dust layers may exceed 5mm in thickness the maximum surface temperature should be reduced accordingly.

For equipment where layer thicknesses are not controlled or limited (e.g. within process containment), or where apparatus can be submerged in dust, special precautions are necessary. The use of electrical apparatus (such as motors, luminaries, plugs and sockets) should be avoided in these areas. Apparatus for measurement or control techniques (e.g. instrumentation, sensors, controls) should be provided with a system of power limitation or be “non-heat dissipating”. In “non-heat dissipating” apparatus the hottest part of the enclosure does not exceed 5°C above ambient when measured in free air (e.g. pocket or thermowell apparatus).

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### **Electrical Equipment; Gases & Vapours**

The EN 50014 series has been available since the 1970s and the standards are currently being updated to form the EN 60079 series to support ATEX Directive 94/9/EC, with no technical alterations.

- EN 50015: Oil immersion ‘o’
- EN 50016: Pressurized apparatus ‘p’
- EN 50017 Powder filling ‘q’
- EN 50018 Flameproof enclosure ‘d’
- EN 50019 Increased safety ‘e’
- EN 50020 Intrinsic safety apparatus ‘i’
- EN 50021 Type ‘n’ apparatus
- EN 50028 Encapsulated apparatus ‘m’
- EN 50039 Intrinsically safe systems ‘ia’ and ‘ib’

The above standards can be used in conjunction with a Technical Interface document to ensure ATEX compliance.

Zone 0	Group II, Category 1G, EN 50284 ‘i’ EN 50020, ‘ia’ EN 50039
Zone 1	Group II, Category 2G ‘o’, ‘p’, ‘q’, ‘d’, ‘e’, ‘m’, ‘ia’, ‘ib’ plus Category 1G (above)
Zone 2	Group II, Category 3G ‘n’ EN 50021 plus Category 1G or 1G (above)

Group II apparatus with type of protection “i”, “d” or “q” may be sub-divided into three explosion groups depending on the nature of the potentially explosive atmosphere for which it is intended.

- Group IIA:** Apparatus tested in propane / air (260mJ).
- Group IIB:** Apparatus tested in ethylene / air (86mJ).
- Group IIC:** Apparatus tested in hydrogen / air (19mJ).

A number of the above standards have been, or will soon be, replaced by equivalent standards in the EN 60079 series:

- EN 60079-0: General Requirements
- EN 60079-1: Flameproof enclosure ‘d’
- EN 60079-2: Pressurised enclosure ‘p’
- EN 60079-7: Increased safety ‘e’
- EN 60079-15: Type of protection ‘n’
- EN 60079-18: Encapsulated apparatus ‘m’
- EN 60079-25 Intrinsically safe systems

### **Electrical Equipment; Dusts**

The protection of electrical apparatus for use in the presence of combustible dusts is based on a number of safeguarding methods:

- (a) Enclosing the apparatus so as to limit the amount of dust, which may enter the enclosure and come into contact with sources of ignition.

and

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- (b) Restricting the maximum surface temperature of the apparatus to prevent it acting as a source of ignition for dust clouds and dust layers.

Construction and testing requirements and requirements for selection and installation are given in BSEN 61241-0 (reference 11).

Note: Additional figures, such as submersible depth, may be used to clarify the basic categories.

Guidance on selection is given below with the terminology in alignment with the ATEX Directives. Special considerations are required for apparatus in Zone 20 and for surface temperature requirements.

Type of Dust	Zone 20	Zone 21	Zone 22
Conductive (Electrical resistivity $<10^3$ $\Omega/m$ )	Category 1D Temperature limitations because of the presence of uncontrollable and excessive thickness.	Category 1D or Category 2D (e.g. IP6X)	Category 1D or Category 2D (e.g. IP6X)
Non-conductive	Category 1D Temperature limitations because of the presence of uncontrollable and excessive thickness.	Category 1D or Category 2D (e.g. IP6X)	Category 1D or Category 2D or Category 3D (e.g. IP6X or IP5X)

N.B. For Zones 21 and 22 a maximum surface temperature (T Class) must be defined.

### **Inspection and Maintenance**

Correct installation, inspection and maintenance are critical for electrical equipment and systems should be in place to manage the use of electrical equipment in hazardous areas. Guidance presented in the following standards should be followed:

- gas / vapour hazardous areas; BS EN 60079-14 (reference 10)
- dust hazardous areas; BS EN 61241-0 (reference 11).

### **Existing Electrical Equipment**

Existing equipment in hazardous areas must be inspected to determine what whether it is suitable for use in the zone.

For unsuitable electrical equipment located in hazardous zones then two options are available.

- Replace with correctly categorised equipment appropriate for the zone or
- Replace with existing spares meeting “pre ATEX” standards e.g. Ex i(a) or IP5x.

T Class and apparatus group should be as recommended for new equipment.

For retrospective assessment of equipment, enclosures are rated according to the protection that they provide against the ingress of solid objects and

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water. Sources of protection are indicated by the characteristic letters IP followed by two numerals (e.g. IP 54). The first number indicates protection against solid ingress, the second against water ingress. Relevant parts of the IP code are summarised below.

IP6X enclosures are dust tight enclosures.

IP5X are dust-protected enclosures. Such enclosures prevent dust entering in sufficient quantity to interfere with satisfactory operation or exceed 10 g/m<sup>3</sup> in concentration within the enclosure.

First Digit Number	Degree of protection against particulate matter	Second Digit Number	Degree of protection against liquids
4	Protection against ingress of solid particles or objects greater than 1.0mm.	4	Protection against splashing. Liquid splashed from any direction shall have no harmful effects.
5	Protection against the ingress of dust in an amount sufficient to interfere with the satisfactory operation of the equipment enclosed. (This is Dust Protected).	5	Protection against water projected by nozzle from any direction. (Hose proof).
6	Complete protection against the ingress of dust. (This is Dust Tight).	6	Protection against conditions on ships deck in heavy seas.

### **Existing Non-Electrical Equipment**

Ignition sources presented by mechanical process equipment should have been assessed as a fundamental part of the explosion risk assessment. Most equipment if well designed, correctly installed and well maintained and does not present ignition sources in normal operation e.g. equivalent to Category 3, suitable for use in Zone 2 or 22 areas. In addition management systems relating to installation, inspection and maintenance of such equipment should be audited against the original equipment manufacturer's instructions.

### **A2.12 Safety Management Systems**

The following elements of a good safety management system are recommended in order to fully support DSEAR compliance. These should already be in place across the STFC sites. It is worth reviewing these systems when conducting DSEAR assessments in order to ensure that these are in place within the local area.

#### **General Safety Management Elements**

Key elements include:

- The definition and publication of health and safety policies

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- A clearly defined organisational structure with responsibilities assigned
- Accident / near miss investigation
- Consultation arrangements
- Identification of potential training requirements
- Identification of potential hazard types and processes for risk assessments
- Emergency procedures

### **Training**

Training covering the following topics should be considered:

- Outline of explosion hazards (e.g. what is an explosion? and how does an explosion occur?)
- Potential consequences of explosions
- Potential ignition sources
- Control measures

Some of the above training requirements may be "generic" across most of the site and others may form part of specific training for certain areas.

### **Operating Instructions**

General operating instructions should be in place to ensure all procedural safety requirements are reliably implemented. Such instructions should also be used as the basis for local operation training. Consider updating start-up and shutdown check sheets etc. to include signed checks for completion of key stages.

### **Permit to Work Systems**

Appropriate Permit to Work and Hot Work Permit systems should ideally be in place for all areas, particularly those in which there are potential explosion hazards (i.e. in hazardous zoned areas). Systems should also be in place to identify any non-routine operations or any operations, which may have become "custom and practice". Such operations should be subjected to formal, documented risk assessments if they are not covered by the permit to work system or by operating instructions.

### **Management of Change**

Formal systems or procedures should be in place to assess risks introduced as a result of changes to operations, equipment or personnel. Such systems should be developed and implemented to ensure the Explosion Risk Assessment and Hazardous Area Classification Documents are reviewed before changes are implemented.

### **Identification of Hazardous Areas**

DSEAR requires that operators of facilities may wish to consider installation of warning signs at strategic locations. For example:

- a) 'Ex' warning triangles, as defined by the DSEAR Regulations, at strategic points where they give benefit, e.g. at the entrance to rooms, or work areas which contain large hazardous areas.
- b) Identification of localised hazardous areas outside or within a room which is largely "safe", is more difficult and may be better implemented by installation of local signs on equipment or floor warning markings, or by provision of site plans showing the extent of zones at entrances or other suitable locations.

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Note that the use of signage is best limited to locations such as major entrances or where there are particular risks. Over use of signage results in it losing its prominence at locations where it does offer benefit.

No smoking signs at entrance points to the site and at the exits from designated smoking areas within the site are recommended.