Science and Technology Facilities Council

Controlling Explosive and Flammable Gases and Dusts

STFC Safety Code No 20

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Revisions

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1.1	Update to BS ENs in References	October 2012
1.2	Amendments to audit checklist	May 2013
1.3	Minor change to para 4.2.1	February 2014
1.4	Document Retention Policy Added	August 2014
1.5	Changes to responsibilities and action volumes	January 2015
1.6	Changes to reflect updating of DSEAR legislation, approved codes of practice, and relevant standards.	March 2018
1.7	Updates related to the launch of SHE Assure	October 2018
2.0	Major update to all parts of code	June 2024

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Controlling Explosive and Flammable Gases and Dusts

1. PURPOSE

Dangerous substances can be found in nearly all workplaces and include such things as solvents, paints, flammable gases, dusts from machining and sanding operations.

The Dangerous Substances and Explosive Atmospheres Regulations (2002 as amended) (DSEAR) require employers to assess the risks of fires and explosions that may be caused by dangerous substances in the workplace and then eliminate or reduce these risks as far as is reasonably practicable. The Regulations clarify the existing requirements to manage fire and explosion risks which are set out in the Management of Health and Safety at Work Regulations 1999.

DSEAR deals with the immediate danger to life or health from fires or explosions resulting from the ignition of dangerous substances and eliminate or reduce these risks as far as reasonably practicable. DSEAR must not be confused with COSHH which deals with the chronic and acute health effects
Gases that are under pressure (e.g. gas in a cylinder) may present a risk of explosion if not correctly handled in the workplace. Substances that can corrode metals could cause structural damage reducing integrity of structures if not suitably contained. From June 2015, DSEAR places a formal requirement to assess the risks for substances if classified for these properties and put in place suitable control and mitigation measures. The need to carry out a risk assessment and have in place procedures for the safe use of chemicals previously not covered by DSEAR are already required by the general requirements of the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999. STFC are already managing these duties within the STFC Safety Code framework and so are not considered further within this code.

2. SCOPE

The application of DSEAR in the technically complex and unique environments that exist within the STFC is beyond the capability of this code to address in full. This code does not endeavour to describe how the risks from all dangerous substances and explosive atmospheres hazards should be controlled, rather it establishes a framework upon which to carry out simple assessments or to be aware of when to involve a external consultant to carry out zoning studies for hazardous area classification (HAC). For technically complex environments the advice of competent experts is required and must be engaged in a timely manner.

The requirements of this code apply to all STFC staff, tenants, facility users and visitors and apply in any instance where dangerous substances are present, used or produced.

The requirements of this code applies to facility user / visitor equipment and experiments and they must be made aware of the code requirements.

The responsibility to undertake a risk assessment for contractor activities lies with the contractor's management, but it is the STFC responsibility to ensure that risk assessments are in place and the potential hazards are fully understood before work commences. All relevant information to enable the risk assessment to be undertaken by the contractor's management must be provided. It is also the responsibility of STFC to share any Hazardous Area Classification (HAC) zone maps with the contractor and to highlight any specific safety requirements.

This code does not address other hazardous properties associated with flammable substances. For example toxic hazards are addressed under COSHH, radiation hazards (e.g. tritium), are addressed in relevant radiation management SHE codes and by advice from SHE Group. These additional hazards should be assessed separately. Specific guidance in the handling and use of hydrogen and deuterium can be obtained by contacting the SHE Group.

Also, the use of dangerous substances in confined spaces may create further hazards. This code does not address the hazards arising from confined spaces, see STFC SHE Code 11 Work in Confined Spaces.

3. DEFINITIONS

3.1 DSEAR

DSEAR is the Dangerous Substances and Explosive Atmospheres Regulations 2002. These regulations apply in any workplace where dangerous substances are present, used or produced, with some minor exceptions (refer to Appendix 1).

3.2 ATEX

ATEX is the name commonly given to the framework for controlling explosive atmospheres and the standards of equipment and protective systems used in them. It is based on the requirements of two European Directives from which DSEAR is derived, and which are described in more detail in Appendix 1.

3.3 EPS Regulations

Equipment and Protective Systems intended for Use in Potentially Explosive Atmospheres Regulations 1996 (as amended) (EPA), which came fully into force on 30th June 2003. These regulations cover both electrical and non-electrical equipment and states that any responsible person who places equipment on the market or places equipment into service, must ensure that the essential health and safety requirements have been satisfied.

3.4 Dangerous Substances

Any substances that could, if not properly controlled, cause harm to people as a result of a fire, explosion or similar energetic event. A more detailed definition is available in Appendix 1.

3.5 Risk Assessment

A process whereby the explosion (or flammable) hazards in a particular area or of a particular activity, arising from the presence, use or production of dangerous substances, are identified and the level of fire / explosion risk estimated taking account of the effectiveness of current control measures in place. See Safety Code 06 - Risk Management.

1.6 Hazardous Area Classification (HAC)

"Hazardous Areas" in DSEAR are "any place in which an explosive atmosphere may occur in quantities such as to require special precautions to protect the safety of workers". Consequently Hazardous Area Classification is the process of assessing:

- the likelihood that an explosive atmosphere will exist;
- how voluminous it will be; and
- how long the atmosphere could exist for (time) given variables such as ventilation, rate of material production/leakage etc.

For gases and vapours the assessment process will classify the area into one of three zones:

- Zone 0: An area in which an explosive gas atmosphere is present continuously or for long periods;
- Zone 1: An area in which an explosive gas atmosphere is likely to occur in normal operation;
- Zone 2: An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time.

For dusts and powders the assessment process will classify the area into one of three zones:

- 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 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.

Additionally, thin layers (i.e. 1mm) of combustible dust can be roused to flammable concentration. Therefore, dust layers in the workplace are likely to be classified as Zone 22.

1.7 Explosive Atmosphere

In DSEAR, an explosive atmosphere is defined as a mixture of dangerous substances with air, under atmospheric conditions, in the form of gases, vapours, mist or dust in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

Atmospheric conditions are commonly referred to as ambient temperatures and pressures. That is to say temperatures of –20°C to 40°C and pressures of 0.8 to 1.1 bar.

Note this definition is used synonymously with “Flammable Atmosphere” (i.e. in these regulations they mean the same thing).

3.8 Pyrophoric materials

Pyrophoric materials (includes chemicals and gas) also fall under DSEAR as they have the ability to spontaneously ignite in air which have the potential to result in a fire and /or explosion. Also see related SHE Codes for COSHH SC37 and SC33 Pressure and Vacuum systems.

3.8.1 – Pyrophoric liquids and solids are liquids or solids that even in small quantities, are liable to ignite within 5 minutes after coming into air.

3.8.2 – Pyrophoric gas is a flammable gas that is able to ignite spontaneously in air at a temperature of 54°C or below.

3.9 Explosive Limits

Lower explosive limit (LEL): The concentration of flammable gas or vapour in air, below which the gas atmosphere is not explosive.

Upper explosive limit (UEL): The concentration if flammable gas or vapour in air, above which the gas atmosphere is not explosive.

3.10 Flammable Liquid

A liquid as defined for highly flammable liquid (see 3.1.2) but with a flashpoint up to 55°C

3.1.1 Flashpoint

The lowest liquid temperatures at which, under certain standardised conditions, a liquid gives off vapours in a quantity such as to be capable of forming an ignitable vapour/air mixture.

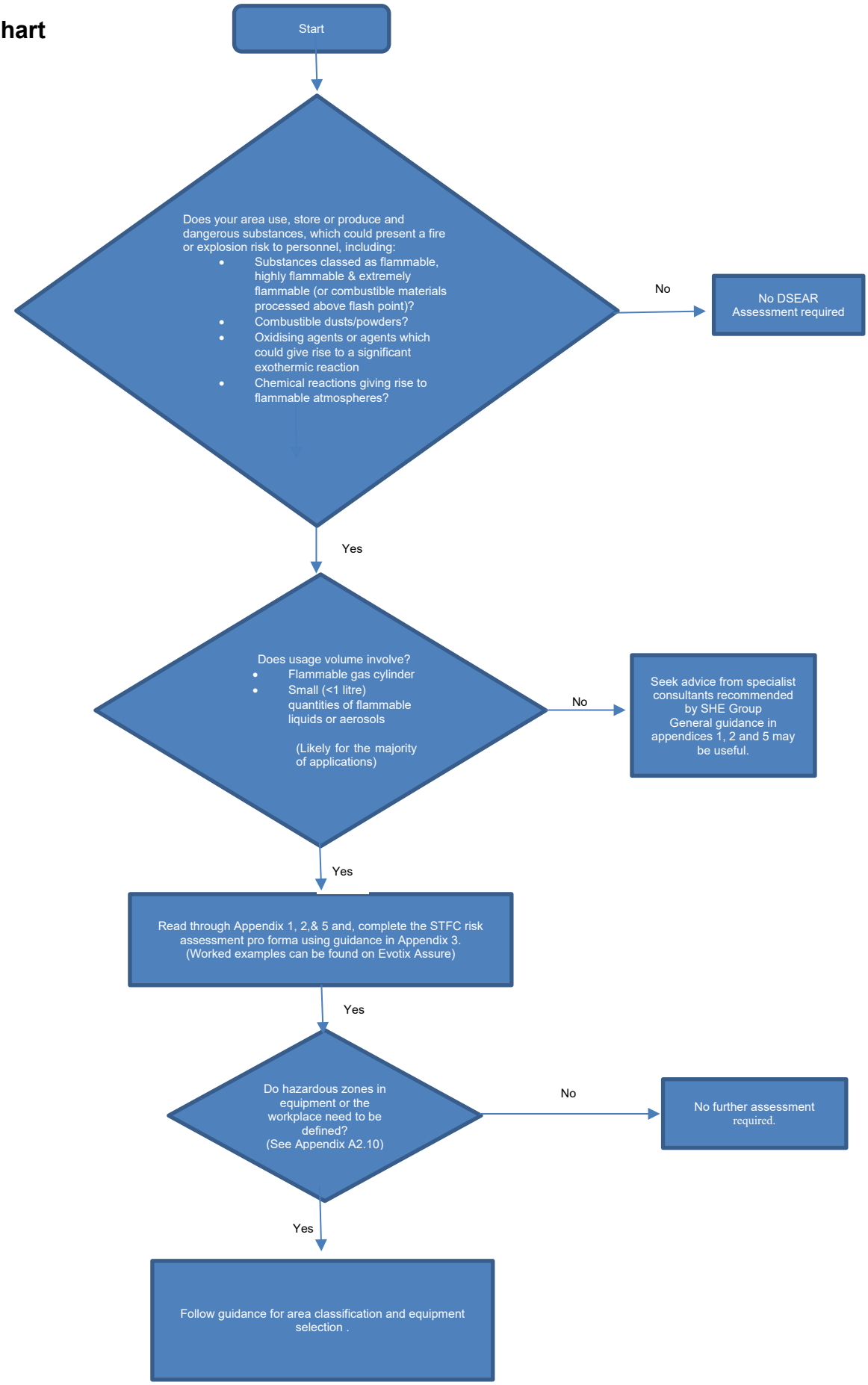
3.1.2 Highly Flammable

Highly flammable liquid means any liquid, liquid solution, emulsion or suspension other than liquid ammonia, liquified flammable gas and liquified petroleum gas which:

a) has a flash point of less than 32°C; and

b) when tested, with a heating time of 60 seconds supports combustion

Summary Flowchart



4. RESPONSIBILITIES

The majority of operations for which fire and explosion hazards exist within the STFC sites are relatively simple, mainly incorporating the use of flammable gas cylinders, laboratory style solvents and covering ancillary areas. Detailed guidance for these types of areas is provided in Appendix 1 and 4 For more complex operations that may entail extensive hazardous areas inside and outside of equipment or where unusual chemical reactions take place, this code does not give specific guidance. In these instances external / professional advice and assistance will be required in undertaking the risk assessment. The format and information in Appendices 1, 2 and 4 will act as a guide.

4.1. Group Leaders shall:

4.1.1 Ensure all dangerous substances which are to be introduced or are present or are liable to be present in the workplace; the work activities involving them; how they may fail and cause fire, explosion and similar events are risk assessed see STFC SHE Code 6, Risk Management.

4.1.2 Determine whether any activities within their responsibility involve cylinders of flammable gases, or small (<2.5 litre) quantities of highly/extremely flammable liquids or aerosols. Activities outside of these criteria should be referred to SHE Group and advice should be sought from a competent external consultant to undertake the Risk Assessment. This can be arranged through the SHE Group.

4.1.3 Decide whether their staff are competent to carry out a risk assessment in areas where fire and explosion hazards exist and if not get them trained see Training Appendix 7, or seek external advice via SHE Group,

4.1.4 Ensure that where risk assessments relating to the use of dangerous substances identify specific actions to control hazards they are undertaken promptly and to plan prior to carrying out the activity.

4.1.5 Monitor the risk assessments in order to ensure that the controls measures detailed in Risk Assessments are implemented effectively.

4.1.6 Inform SHE Group so that respective Fire Risk Assessments can be updated

4.2. Supervisors/Line Managers shall:

4.2.1 Carry out risk assessments for all activities (including maintenance activities) and equipment, existing and planned, involving dangerous substances, see SHE Code 6, Risk Management, as appropriate seeking competent external consultation, see 4.1.2. Detailed guidance on carrying out risk assessments for activities in which fire and explosion hazards exist can be found in Appendices 3 and 4 . Example Risk Assessments for the hazards arising from explosive atmospheres in a typical research environment can be found in Evotix Assure, under a side heading of DSEAR.

However, the assessment should take account of the following:

- The hazardous properties of the substances;

- The way in which they are used or stored;
- The possibility of hazardous explosive atmospheres occurring;
- All potential sources of ignition;
- The current controls, both preventive and mitigating, and their effectiveness; and
- Who might be harmed and the potential consequences (i.e. address contact burns, intoxication, asphyxiation and overpressure injuries).

As part of the risk assessment process, IF REQUIRED an Hazardous Area Classification exercise should be carried out for the area where the activity is to take place. The HAC should be documented and appropriate plan and elevation drawings produced to show the extent of the hazardous area. Drawings are not required for NON_HAZARDOUS areas with respect to DSEAR.

4.2.2 Ensure that equipment located within a hazardous area is fit for that area, see Appendix 2, section A2.11.

4.2.3 Ensure that emergency arrangements, consistent with the risk assessment and appropriate to the nature of the activity or operation are put in place

4.2.4 Report any incidents or near misses relating to dangerous substances to the SHE Group in accordance with SHE Code 5 Incident Reporting and Investigation.

4.2.5 Contract supervising officers shall ensure that all relevant information to enable the assessment to be undertaken by the contractor's management is provided, see STFC SHE Code 15 Management of Contractors. (See section 4.3)

4.3. Staff/users/tenants/contractors/visitors shall:

4.3.1 Assist as appropriate in the undertaking of DSEAR assessments by their line manager/supervisor and follow the instructions and control measures determined by these assessments.

4.3.2 Under Regulation 11 of DSEAR (Duty of Coordination) within shared workplaces effective coordination and communication is required. Shared workplaces might include two or more employers or departments sharing a building.

Employers might take the form of STFC staff, tenants, contractors (term and fixed term), visiting scientists and users etc.

It is the duty of the employer responsible for the workplace or the work that is creating the explosive atmosphere to obtain sufficient information from all employers at the workplace about their nature of work and whether any dangerous substances are likely to be present, and the likelihood of an explosive atmosphere occurring. All employers at the workplace will share any information required and assist in assessing shared risks and implementing any mitigation measures.

Coordination and communication is to:

- Alert other employers, employees and others within the workplace to the presence of hazardous places or substances used by another employer.
- Ensure that suitable control and mitigation measures are in place
- Facilitate emergency arrangements in the event of an incident.

4.4. SHE Group shall:

4.4.1 Ensure the implications of the hazards arising from flammable atmospheres are considered in Fire Risk Assessments.

4.4.2 Provide advice on DSEAR related queries and ensure involvement in any HAC.

4.5. Electrical and Mechanical Engineers shall

4.5.1 Attend a suitable CompEX course (see Appendix 7) and maintain the relevant qualification obtained.

4.5.2 Ensure that equipment located within a hazardous area is fit for that area.

4.5.3 Report back to the user/line manager/SHE Group on any defects found in the area.

4.5.4 Maintain an asset register of all ATEX relevant equipment.

4.5.5 Advise when required on the safe selection, installation, maintenance, inspection and repair of any equipment.

**** For additional responsibilities with regard to electrical engineers please see SC34****

Appendix 1. Background Information: Requirements of DSEAR

This Appendix gives background information on DSEAR, explaining what is needed from the employer / user to comply with the regulations. More detailed guidance on specific areas, including hazardous area classification and selection of equipment is available in Appendix 2 and 4 and should be suitable to ensure DSEAR compliance in 80% of cases on the STFC sites. Note that any risk assessment under the DSEAR legislation should complement other risk assessments for example asset protection, COSHH, Fire etc.

DSEAR require employers to:

- find out what dangerous substances are in their workplace and what the fire and explosion risks are;
- put control measures in place to either remove those risks or, where this is not possible, control them;
- put controls in place to reduce the effects of any incidents involving dangerous substances;
- prepare plans and procedures to deal with accidents, incidents and emergencies involving dangerous substances;
- make sure employees are properly informed about and trained to control or deal with the risks from the dangerous substances;
- identify and classify areas of the workplace where explosive atmospheres may occur and avoid ignition sources (from unprotected equipment, for example) in those areas.

A1.1 What is the Relationship between ATEX, DSEAR and EPS?

ATEX is the name commonly given to the framework for controlling explosive atmospheres and the standards of equipment and protective systems used in them. It is based on the requirements of two European Directives.

- Directive 99/92/EC (also known as ‘ATEX 137’ or the 'ATEX Workplace Directive’) is a social directive and defines the minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres.
- Directive 94/9/EC (also known as ‘ATEX 95’ or ‘the ATEX Equipment Directive’) on the approximation of the laws of Members States concerning equipment and protective systems intended for use in potentially explosive atmospheres. The aim of this Directive is to allow the free trade of ‘ATEX’ equipment and protective systems within the EU by removing the need for separate testing and documentation for each Member State.

In Great Britain the requirements of Directive 99/92/EC were put into effect through regulations 7 and 11 of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (as amended) (DSEAR). DSEAR also incorporates parts of the old Chemical Agents Directive, in particular to assess risks associated with substances that could give rise to dangerous chemical reactions as well as those substances that may form flammable atmospheres

as defined in ATEX. Expansion of DSEAR in 2015 also requires consideration of gases under pressure and corrosive chemicals.

The requirements of Directive 94/9/EC were put into effect through the DTI's Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations 1999 (as amended) (EPS Regulations). The Regulations apply to all equipment intended for use in explosive atmospheres, whether electrical or mechanical, and also to protective systems.

Manufacturers/suppliers (or importers, if the manufacturers are outside the EU) must ensure that their products meet essential health and safety requirements and undergo appropriate conformity procedures. This usually involves testing and certification by a 'third-party' certification body (known as a Notified Body) but manufacturers/suppliers can 'self-certify' equipment intended to be used in less hazardous explosive atmospheres. Once certified, the equipment is marked by the 'EX' symbol to identify it as such.

Certification ensures that the equipment or protective system is fit for its intended purpose and that adequate information is supplied with it to ensure that it can be used safely.

A1.2 When and Where Does DSEAR Apply?

Apart from certain activities, involving Ministry of Defense DSEAR applies whenever:

- there is work being carried out by an employer (self-employed person, tenant, user, visitor);
- a dangerous substance is present (or is liable to be present) at the workplace;
- the dangerous substance could be a risk to the safety of people as a result of fires, explosions or similar energetic events.

Fires and explosions create harmful physical effects - thermal radiation, overpressure effects and oxygen depletion. These effects can also be caused by other energetic events such as runaway exothermic reactions involving chemicals or decomposition of unstable substances such as peroxides. These events are also covered by DSEAR.

The following examples illustrate the type of activities covered by DSEAR:

- use of flammable gases, such as acetylene for welding;
- handling and storage of waste dusts in a range of manufacturing industries;
- handling and storage of flammables and flammable wastes such as fuel oils;
- welding or other 'hot work' on tanks and drums that have contained flammable material;
- work that could release naturally occurring flammable substances such as methane in coalmines or at landfill sites;
- use of flammable solvents in laboratories;

- filling, storing and handling aerosols with flammable propellants such as LPG;
- transporting flammable substances in containers around a workplace;
- deliveries from road tankers, such as petrol and bulk powders;
- chemical manufacturing, processing and warehousing;
- loss of containment resulting in undesirable reaction e.g. sodium hydroxide reacting with aluminum to liberate hydrogen.

DSEAR applies to workplaces where dangerous substances are present, used, or produced. Workplaces are any premises or parts of premises used for work. This includes places such as industrial and commercial premises, mines and quarries, construction sites, vehicles and vessels, etc. Places such as the common parts of shared buildings, private roads and paths on industrial estates and road works on public roads are also premises – as are houses and other domestic premises, if people are at work there.

A1.3 What are Dangerous Substances?

Dangerous substances are substances or mixtures of substances (called 'preparations' in DSEAR) that could create risks to people's safety from fires and explosions or similar events, such as 'thermal runaway' from chemical reactions. Liquids, gases, vapours and dusts that may be found in a workplace can all be dangerous substances.

Dangerous substances include:

- substances or mixtures of substances classified as explosive, oxidising, extremely flammable, highly flammable, or flammable under the current (CLP) Regulations.
- any kind of dust that when spread in air to form a cloud (i.e. form an explosive atmosphere), can explode.
- any other substances, or mixtures of substances, which because of their physical properties and the way in which they are present in the workplace create a risk to safety from fires and explosions, but which may not be covered by CLP. For example high flashpoint liquids present in the workplace at elevated temperatures.

Many of these substances can also create health risks, for example, they may be toxic or an irritant. These kinds of risks are covered under separate legislation such as the Control of Substances Hazardous to Health Regulations (COSHH). It is important to consider both safety and health issues when looking at risks from substances in the workplace.

A1.4 How do I Comply with DSEAR?

DSEAR places duties on employers to assess and eliminate or reduce risks from dangerous substances. Complying with DSEAR involves:

Assessing risks

Before work is carried out, the fire and explosion risks that may be caused by dangerous substances must be assessed. This should be an identification and careful examination of:

- the dangerous substances in the workplace;
- the work activities involving those substances; and
- the ways in which those substances and work activities could harm people.

The purpose is to help employers to decide what they need to do to eliminate or reduce the risks from dangerous substances.

If there is no risk to safety from fires and explosions, or the risk is trivial, no further action is needed. If there are risks then employers must consider what else needs to be done to comply fully with the requirements of DSEAR. If an employer has five or more employees, the employer must record the significant findings of the risk assessment.

Preventing or controlling risks

Control measures must be put in place to eliminate risks from dangerous substances, or reduce them as far as is reasonably practicable. Where it is not possible to eliminate the risk completely measures must be taken to control risks and reduce the severity (mitigate) the effects of any fire or explosion

The best solution is to eliminate the risk completely by replacing the dangerous substance with another substance, or using a different work process. For example, replacing a low flashpoint liquid with a high flashpoint one.

Control measures

Where the risk cannot be eliminated, DSEAR requires control measures to be applied in the following priority order:

- reduce the quantity of dangerous substances to a minimum;
- avoid or minimise releases of dangerous substances e.g. via the use of fully contained systems such as welded pipework;
- control releases of dangerous substances at source;
- prevent the formation of a dangerous atmosphere e.g. operating below flashpoint of a dangerous substance;
- collect, contain and remove any releases to a safe place (for example, through ventilation);
- avoid ignition sources;
- avoid adverse conditions (for example, exceeding the limits of temperature or control settings) that could lead to danger;
- keep incompatible substances apart.

These control measures should be consistent with the risk assessment and appropriate to the nature of the activity or operation.

Mitigation

In addition to control measures DSEAR requires mitigation measures to be put in place. These measures should be consistent with the risk assessment and appropriate to the nature of the activity or operation and include:

- reducing the number of employees exposed to the risk;
- providing plant that is explosion resistant;
- providing explosion suppression or explosion relief equipment;
- taking measures to control or minimise the spread of fires or explosions;
- providing suitable personal protective equipment.

Preparing emergency plans and procedures

Arrangements must be made to deal with emergencies. These plans and procedures should cover safety drills and suitable communication and warning systems and should be in proportion to the risks. If an emergency occurs, workers tasked with carrying out repairs or other necessary work must be provided with the appropriate equipment to allow them to carry out this work safely.

The information in the emergency plans and procedures must be made available to the emergency services to allow them to develop their own plans if necessary.

Providing information, instruction and training for employees

Employees must be provided with relevant information, instructions and training. This includes:

- the dangerous substances present in the workplace and the risks they present including access to any relevant safety data sheets and information on any other legislation that applies to the dangerous substance;
- the findings of the risk assessment and the control measures put in place as a result (including their purpose and how to follow and use them);
- emergency procedures.

Information, instruction and training need only be provided to other people (non-employees/tenants) where it is required to ensure their safety. It should be in proportion to the level and type of risk.

The contents of pipes, containers, etc. must be identifiable All labeling of pipework needs to be in line with BS- 01710 to alert employees and others to the presence of dangerous substances. If the contents have already been identified in order to meet the requirements of other law, this does not need to be done again under DSEAR. For example natural gas systems for domestic purposes such as the provision of heating and hot water in offices or canteens need not be considered under DSEAR since these are covered under the

relevant (and more prescriptive) gas installation codes. (See A2.8 for further information)

Places where explosive atmospheres may occur ('ATEX' requirements)

DSEAR places additional duties on employers where potentially explosive atmospheres may occur in the workplace. These duties include:

- identifying and classifying (zoning) areas where potentially explosive atmospheres may occur (refer to Hazardous Area Classification Section in Appendix 2);
- controlling ignition sources in zoned areas, in particular those from electrical and mechanical equipment (refer to Selection of Equipment Section in Appendix 2);
- where necessary, identifying the entrances to zoned areas;
- providing appropriate anti-static clothing for employees (refer to Control of Ignition Sources section in Appendix 2);
- before they come into operation, verifying the overall explosion protection safety of areas where explosive atmospheres may occur i.e. ensure that someone competent has reviewed the DSEAR assessment.

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. It is also best practice to consider the likelihood of contact burns, intoxication, asphyxiation or blast effects.

- 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. Ignition sources need to be controlled or reduced.

	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 for staff and contractors;
- 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 for staff and contractors;
- 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 for staff and contractors.

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 combined use of antistatic footwear with static dissipative 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.

- Powder handling, weighing, sieving, blending etc.
- Avoiding addition of powders to flammable vapour atmospheres.
- Flammable liquids are poured , pumped filtered. Agitated, stirred or flow through pipes

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**.**
If help is required to determine the MIE, please contact the SHE group for details.

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 dissipative footwear and antistatic/static dissipative flooring providing a resistance to earth of $<10^8\Omega$ (SEE References 5, 6 and 7).
- Dissipative footwear needs 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, so as not to build up a static charge
- 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 <<10mJ 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 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 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 incentive discharge. The phenomenon is not fully understood, however it is considered that a hazard could only exist with powdered products of MIE <10mJ provided the powder is in contact with earth. However, for earthed pneumatic transfer pipe of diameter <0.1m there is no hazard of ignition from electrostatic discharges originating from the dust cloud within the pipe for materials with MIE >0.2mJ.

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. Pneumatic transfer of powders produces dangerously high levels of electrostatic charge.

<u>Preventative maintenance as an ignition source control measure.</u>

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 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 (See also Appendix 4)

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 21-60ºC) and possibly highly flammable (flash point 0-21ºC) solvents are capable of forming a significantly sized flammable atmosphere. If the quantity of flammable liquid is less than 50ml then specialised equipment is unlikely to be required. The liquids should be handled in small containers (typically <2.5 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. Remember several bottles containing small amounts will sum to a much larger volume and the hazard should be considered collectively.
- 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. 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. (See also Appendix 3 & 4)

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, autonomous passenger vehicles etc.

Hydrogen will be released from batteries during charging (See HAC below). 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. STFC should ensure adequate ventilation is provided as described in INDG 139 'Using electric storage batteries safely'.
This states that adequate ventilation should maintain the average concentration of dangerous substances during normal operation to below that which could form an explosive atmosphere'. Sufficient ventilation should be provided to ensure that the concentration of hydrogen is diluted well below the LEL.

Additional guidance is as follows:

If a metal tool or other electrically conducting object short-circuits the terminals of a cell or cells, it will become hot and may cause burns. In addition, sparks and molten metal may be ejected.
Insulated tools should always be used and, before working on a battery, people should remove any metallic items from hands, wrist and neck, together with any metallic items that may fall from their
pockets.
Hydrogen and oxygen gases are emitted from a battery when it is being charged. Hydrogen/air mixtures produce violent explosions if ignited and it has to be assumed that this mixture is present in the immediate vicinity of the cell tops at all times.

To minimise the risk of explosion:

- Charging should be carried out in an area used only for that purpose which is not near any combustible materials.
- The charging area should have good natural high-level ventilation immediately above the batteries.
- Light fittings should be of a totally enclosed industrial type, e.g. bulkhead fittings, and preferably not positioned directly above the charging area
- Anything capable of causing a spark should not be used in the vicinity of the cell tops.
- A proper plug and socket arrangement should normally be used for routinely connecting the charger to the batteries – the charger should be switched off before making or breaking the connection.
- Appropriate fire-fighting equipment should be readily available. (See SC32)

Hazard Area Classification

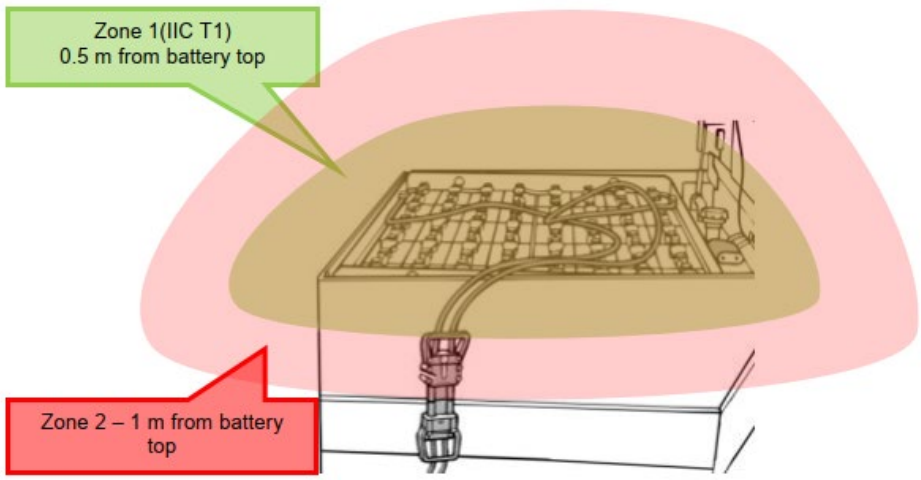
Traction batteries can be treated generically based on the following information:
- BS EN 62485-340 Clause 6.5 which states:

"In the close vicinity of the battery, the dilution of explosive gases in not always secured. Therefore a safety distance of minimum 0.5 m extending through the air without flames, electrostatic discharges, sparks, arcs or glowing devices (maximum surface temperature 300°C) must be observed."

- INDG13941 states:
“In most situations a Zone 2 hazardous area (flammable atmosphere likely to be present) should be considered to exist for up to 1 m in all directions around batteries under charge.”

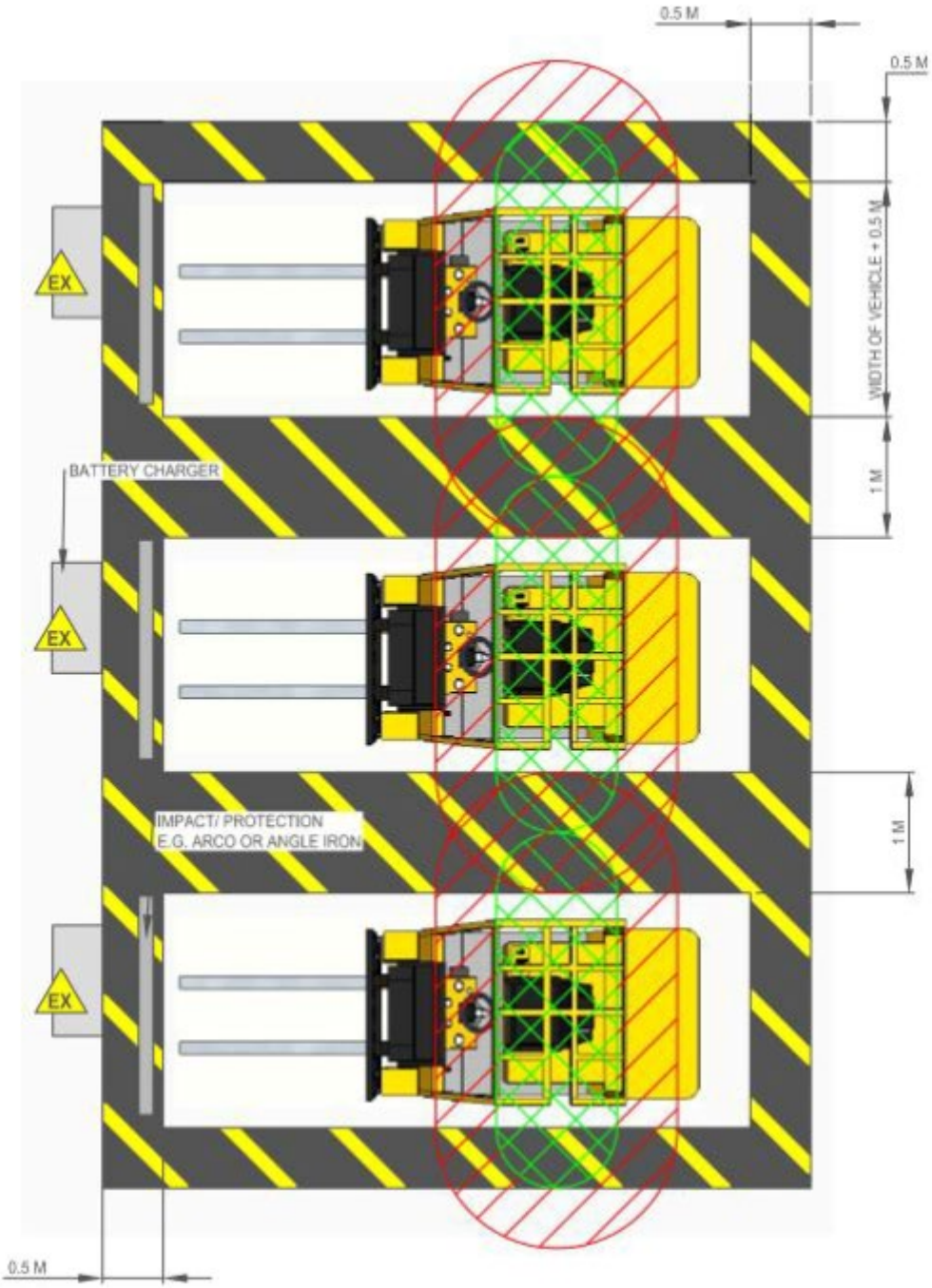
The above guidance has been used to adopt a pragmatic approach whereby a 0.5 m Zone 1 (IIC T1) and a 1 m Zone 2 (IIC T1) above the battery tops are applied based on boost / overcharge and float charge respectively.

The extents are not expected to go below the battery tops due to the buoyancy of Hydrogen. An example illustration is provided:



Electrical equipment may be located within close proximity to battery tops. If this equipment cannot be kept out of the zoned areas (i.e. within 1 m of the battery tops) then in accordance with DSEAR Schedule 3, equipment located within zoned areas should be either Category 1, 2 or 3 unless a risk assessment states otherwise.

Illustration of Hazardous Area Classification for FLT Batteries



PLAN VIEW OF MULTIPLE FORK LIFT TRUCKS ON TRICKLE/ FLOAT CHARGE WITH THE PREFERRED SEPARATION DISTANCES HIGHLIGHTED AND SUGGESTED FLOOR MARKING

A2.8 Natural Gas Supply Stations and Pipework

The pressure control / relief arrangements in the supply stations should are 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 (pipelines to be marked in accordance with BS 1710 and industry standard colour is yellow to identify pipework) and their integrity should be monitored on a regular basis.

Within STFC liquid-free Natural Gas (LNG) is usually a combined proportion of methane-plus-inserts of greater than 89% by volume, a gross calorific value not exceeding 45MJ $m^{-3,}$ molecular weight not exceeding 20 kg $kmol^{-1}$ with a lower flammability limit (LFL) of not less than 4.4%; a temp range of -20 to 50°C.

In order to determine the HAC for gas metering equipment IGEM/GM/7B – (Hazardous area classification for gas metering equipment) needs to be used. This standard is only applicable for those installations with a maximum operating pressure not exceeding 10bar.

Please contact the SHE Group for further advice.

A2.9 Diesel Storage

The flash point of diesel / gas oil is greater than 55ºC. 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.
In STFC there is a general move to Hydrogenated Vegetable Oil in Diesel generators which has a flash point of >55°C.

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 firefighting. 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 ignitions 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 60079-10-1 for gases, liquids and vapours (reference 8), BS EN 60079-10-2 for dusts (reference 9). Significant differences exist between BS EN 60079-10-1:2015 and previous editions; models for estimating zones and extents have

been overhauled. 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. Drawings do not need to be to scale but should be plan and elevation having zone types (0, 1, 2 etc.) clearly marked with an indication of the extent (e.g. 1 metre in all directions from vent). It is best if the material and temperature class are also included.

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:

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 EN60079-10-2:

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 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 ATEX 100 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 following tables. Each category requires sub-division depending on its intended duty.

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

For gases and vapours		
ZONE	**GROUP & CATEGORY**	**Equipment Protection Level**
0	Group II,1G	EPL Ga
1	Group II,1G or 2G	EPL Ga, Gb
2	Group II,1G, 2G, or 3G	EPL Ga, Gb, Gc

For dusts		
ZONE	**GROUP & CATEGORY**	**Equipment Protection Level**
20	Group II,1D	EPL Da
21	Group II,1D or 2D	EPL Da, Db
22	Group II,1D, 2D, or 3D	EPL Da, Db, Dc

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.

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

T Class	Maximum Surface Temperature (°C)
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).

Electrical Equipment; Gases & Vapours

The current standards for equipment protection are listed in the following table.

BS EN 60079-1:2014.	Electrical apparatus for explosive gas atmospheres. Flameproof enclosures 'd'
BS EN 60079-2:2014.	Explosive atmospheres. Equipment protection by pressurized enclosure "p"
BS EN 60079-5:2015.	Explosive atmospheres. Equipment protection by powder filling "q"
BS EN 60079-6:2015.	Explosive atmospheres. Equipment protection by liquid immersion “o”
BS EN 60079-7:2015.	Electrical apparatus for explosive gas atmospheres. Increased safety "e"
BS EN 60079-11:2012.	Explosive atmospheres. Equipment protection by intrinsic safety "i"
BS EN 60079-13:2017.	Explosive atmospheres. Equipment protection by pressurized room "p" and artificially ventilated room "v"
BS EN 60079-15:2010.	Explosive atmospheres. Equipment protection by type of protection "n"
BS EN 60079-18:2015 + A1:2017.	Explosive atmospheres. Equipment protection by encapsulation “m”
BS EN 60079-26:2007.	Explosive atmospheres. Equipment with equipment protection level (EPL) Ga
BS EN 60079-27:2008.	Explosive atmospheres. Fieldbus intrinsically safe concept (FISCO)

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

(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 BS EN 60079-0:2012 + A11:2013 (Reference 11).

Standards for specific protection methods for dust atmospheres are being developed. The current standards are tabulated below.

BS EN 60079-31:2014.	Explosive atmospheres. Equipment dust ignition protection by enclosure "t"
15/30277841 DC. BS EN 62784.	Particular requirements for vacuum cleaners and dust extractors providing equipment protection level Dc for the collection of combustible dusts.

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 Ω/m)	Category 1D, EPL Da Temperature limitations because of the presence of uncontrollable and excessive thickness.	Category 1D or Category 2D	Category 1D or Category 2D
Non-conductive	Category 1D, EPL Da Temperature limitations because of the presence of uncontrollable and excessive thickness.	Category 1D or Category 2D	Category 1D or Category 2D or Category 3D

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 60079-0 (Reference 11).

Existing Electrical Equipment

Existing equipment in hazardous areas must be inspected to determine whether it is suitable for use in the zone.
All users inspecting electrical equipment must have been on the appropriate CompEx training course. (See Appendix 7)

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

a) Replace with correctly categorised equipment appropriate for the zone or
b) Replace with existing spares meeting “pre ATEX” standards e.g. Ex i(a) or IP5x. As it is over a decade since DSEAR come into force this option will also need to demonstrate the aged spare is fit for purpose.

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 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^3 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
- 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 (engineered and/or procedural)

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). The system should apply to staff and contractors alike. 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 install 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.

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.

Appendix 3. Guidance for Completing a DSEAR Risk Assessment

The DSEAR form located in Appendix 4 should be used record all finding of the assessment.

This form is to be used to assess the fire and explosion risks of small scale laboratory work (e.g <50 litres solvent) .

The table below provides guidance on what might be included in each section for an assessment where DSEAR is a consideration.

When the DSEAR assessment has been completed, it must be added to Evotix Assure/Risk/Technical Risk Assessment/New Record/ (Template) Basic DSEAR.

Completed DSEAR assessments can also be viewed within Evotix Assure for help and reference when developing an assessment.

Step	Title	Notes for Completing This Step
1	**What are the hazards?**	Identify the specific **list of hazards** by identifying the dangerous substances in use (Part 2 2) and whether the manner in which they are used could give rise to a flammable atmosphere either inside equipment items or within the workplace area. Note whether hazardous area zones need to be applied either in equipment items or in the surrounding workplace and define what these will be and how far they will extend. IMPORTANT - It is recommended that if a Hazardous Area Classification is required that an external consultant is used, as there is a potential to 'over zone' an area or incorrectly zone. Seek advice from the SHE team if required. If the formation of a flammable atmosphere is very unlikely then positively state this and define the area or equipment item as non-hazardous. Note the potential ignition sources (Part 3) that may come into contact with the flammable atmosphere and if they are sufficiently energetic to cause ignition (i.e. low energy static discharges may not ignite most dusts). Limit the ignition sources to those that could credibly be present in that instance rather than listing every possible single ignition source imaginable.
2	**Who Might be Harmed and How?**	Identify groups of people. Remember: • some workers have particular needs; • people who may not be in the workplace all the time; • members of the public; • if you share your workplace think about how your work affects others present. Say how the hazard could cause harm e.g. explosion in small vessel in fume cupboard may cause vessel to rupture but unlikely to cause serious injury to personnel in the laboratory.

		Record how you think harm can be caused to affected people. Will they suffer contact burns; consider if clothing will be ignited or provide protection. Will there be poor or oxygen limited combustion that will produce harmful levels of carbon monoxide causing intoxication. Will oxygen levels be depleted so as to cause asphyxiation? If an explosion is predicted will the person suffer primary harm (blown over, damage to lungs or ears etc.) or secondary effects (falling from height etc.) Will affected people retain sufficient faculties to make a safe exit; for example ammonia releases quickly attacks eyes and lungs affecting judgement and functioning.
3	**What are you already doing?**	List what is already in place to prevent or mitigate the effects of an explosion; Are you complying with the good practice examples where applicable?
4	**What further action is necessary?**	You should decide if the residual risks of an explosion at this point are TIFALARP, and positively state the Basis of Safety as defined in Appendix 2.1. If there is a difference between your control measures and best practice, list what needs to be done to achieve a viable Basis of Safety.
5	**How will you put the assessment into action?**	Remember to prioritize. Deal with those explosion hazards that are ‘high risk’ and have serious consequences first.

Appendix 4. DSEAR Risk Assessment form

DSEAR Risk Assessment

A DSEAR risk assessment is required for work with dangerous substances, which could cause fire or explosion including source materials, products, known intermediates and by-products. **This form should be completed, approved and signed by the person responsible for the work.**

Note: The risks from the dangerous substance and explosive atmospheres identified in this risk assessment must be reduced to the lowest level reasonably practicable.

This assessment will only be used for simple low risk tasks e.g. for quantities below 50 litres of materials. If you are unsure, please contact your local SHE Group.

Part 1 - Information

Ref:	Title:
Assessment Date:	Rm/Building/STFC Site:
Main Assessor name and position:	Department:
Assessment team involved:	
Activity/ Task being assessed (this must be filled in with as much information as possible). **DO NOT LEAVE BLANK.**	

Part 2 – List of Hazards

Compressed gas description	Hazard Phrases (SDS)	Precautionary Phrases (SDS)	Flammable (Y/N)	Highly Flammable (Y/N)	Extremely Flammable (Y/N)	Oxidisers	Explosive	Lower Explosive Limit %	Upper Explosive Limit %	Flash Point °C	Auto-Ignition Temp °C	Boiling or melting point °C	Vapour Density (Air = 1)

Liquids Description	Hazard Phrases (SDS)	Precautionary Phrases (SDS)	Flammable (Y/N)	Highly Flammable (Y/N)	Extremely Flammable (Y/N)	Oxidisers	Explosive	Lower Explosive Limit %	Upper Explosive Limit %	Flash Point °C	Auto-Ignition Temp °C	Boiling or melting point °C	Specific Gravity

Other Chemicals of note in the area.	Hazard and Precautionary Phrases (SDS)	Pyrophoric Chemicals	Flammable (Y/N)	Highly Flammable (Y/N)	Extremely Flammable (Y/N)	Oxidisers	Explosive	Lower Explosive Limit %	Upper Explosive Limit %	Flash Point °C	Auto-Ignition Temp °C	Boiling or melting point °C	Specific Gravity

Frequency of use of substances
Indicate if Daily, Weekly, Monthly, Other?
Additional Comments

Part 3 – Potential Ignition Sources

Type	Applicable (Y/N)	Item (please list)	Control Measure
Heat Energy			
Choose an item.			
Choose an item.			
Choose an item.			
Choose an item.			
Choose an item.			
Other (please list)			
Electrical Energy			
Choose an item.			

Choose an item.			
Choose an item.			
Choose an item.			
Choose an item.			
Other (please list)			
Mechanical Energy			
Choose an item.			
Choose an item.			
Choose an item.			
Other (please list)			

Part 4 – Workplace

Workplace or management systems appropriate to nature of activity or task	Please indicate **Yes No N/A**
Is the workplace designed, constructed and maintained so as to provide adequate fire-resistance and or explosion relief	
When was the last Fire Risk Assessment carried out on the Workplace?	
Is there is adequate fire detection in the area?	
Are there any gas alarm systems in the area?	
Is any assembly, construction, installation, rig, plant, equipment, protection system designed in such a way as to minimise risk of fire and/or explosion	
Is any assembly, construction, installation, rig, plant, equipment, protection system used in such a way as to minimise risk of fire and/or explosion	
Have appropriate safe systems of work, or other required procedural systems or organising work, been developed and communicated to all other person who might need to know?	
Is a permit to work scheme required for working with substances in the work area and is this strictly enforced?	

Part 5 Monitoring

Use the space below to detail what monitoring, type and safe systems are in place

Part 6 - Identification of Risk and Controls

Step 1 Hazard Description	**Step 2** Affected persons	How might they be harmed	**Step 3** Existing controls/defences (Pick control from drop down or add in)	Expand on control measure **(do not leave blank)**	**Initial risk?** (See risk assessment matrix below)			Further control measures (if required)	**Step 4** Who will take these actions forward and completed by when?		
					H Harm	L Likelihood	R Risk		Action by whom	When	Completed
	E.g., Contractors, visitors, students, security guards, cleaners, etc. present in the area.	*They are likely to be un-trained and may not appreciate the full range of hazards present.*	Choose an item.								
			Choose an item.								
			Choose an item.								
			Choose an item.								
			Choose an item.								
			Choose an item.								
			Choose an item.								
			Choose an item.								

			Choose an item.								
			Choose an item.								
			Choose an item.								
			Choose an item.								

Part 7 – Distribution List

Distribution List	Signature	Date

Has the assessment been entered into the Evotix Assure system under the DSEAR tab? YES/NO Evotix Assure (list above as well) ref no:

Step 5 Review Date:

- Review your assessment to make sure you are always improving the identification of hazards and control measures
- If there is a significant change in your workplace, remember to check your risk assessment and where necessary amend it
- Review your assessment after any incident and amend as appropriate

What is the level of risk? For each hazard, choose the 'Harm' and 'Likelihood'. Choose 'the most likely reasonably foreseeable injury' and **not** just the worst-case outcome. For example, it is very unlikely that someone would be killed from falling from a footstool, the most common injury is likely to be a minor injury which may or may not require attention from a First-Aider.

E.g. if Harm was 'Moderate' and Likelihood 'Unlikely' the Risk would be 'Medium'

		If control measures are not adhered to potential harm is likely to be:				
HARM	**Major**	Fatality	High	High	V High	V High
	High	Fatality or life changing injuries or serious health effects	Med	Med	High	V High
	Moderate	Time off work, e.g. broken bones, stress or musculoskeletal injury	Low	Med	Med	Med
	Slight	Minor injury which may or may not require First-aid treatment	Low	Low	Low	Low
			Very Unlikely	**Unlikely**	**Likely**	**Very Likely**
			Conceivable but difficult to realise. Would require a combination of several failures	Can be envisaged but is unlikely. Never previously happened in STFC	Can be anticipated to happen. Has previously been known to happen in STFC	Can be anticipated to happen. Has previously been known to happen on site
			LIKELIHOOD			

Low Risk	No additional controls are necessary unless they can be implemented at very low cost (in terms of time, money and effort) or there is a mandatory requirement within legislation. Actions to further reduce these risks can be assigned low priority.
Medium Risk	Consideration should be given as to whether the risks can be lowered, where applicable, to a low risk level, but the costs of additional risk reduction measures should be take into account. The risk reduction measures should be implemented within a defined time period.
High Risk	The controls put in place are critical and it is imperative that they are monitored by a line manager (or equivalent) on a regular basis to ensure they are in place. Risk reduction measures should be contemplated as per the hierarchy and favor engineering controls over administrative controls and PPE. Additional controls may require extra resources and these would be justifiable.
Very High Risk	Additional control measures **must** be implemented to reduce the risk, regardless of cost, or a decision taken to terminate the activity until the risk level can be reduced.

Appendix 5. Safe Storage and Handling of Flammable Liquids and Gases

1.0 Background

There are many operations within STFC that involve the use and storage of flammable materials which present potential fire and explosion risks. This guidance document addresses fire and explosion prevention and protection requirements to ensure that risks from flammable liquids are adequately controlled.

Fires or explosions can occur when vapours or liquids are released from a controlled environment to areas where there may be an ignition source, or, alternatively, when an ignition source is introduced into a controlled environment.

Common causes of such incidents include:

- Lack of training and awareness of the properties of flammable liquids
- Inadequate design of equipment
- Failure and malfunction of equipment
- Inadequate maintenance and installation
- Hot work on or close to a flammable liquid container.

1.1 Purpose and Scope

This policy covers design features for typical flammable liquid installations, however it is essential that the detailed design is established using a comprehensive risk assessment specific to the local design.

This guidance is applicable to all sites and it is recommended that this guidance is shared with all tenants and contractors.

The standard does not cover the risks of flammable mists / sprays and/or combustible liquids under vacuum. These could be ignitable at temperatures well below their flash point.

Expert advice should be sought if any condition could give rise to mists or sprays of flammable liquids, or if involves the use of vacuum. In addition, expert advice must be sought for the storage or handling of non-conducting flammable liquids at temperature above flashpoint.

1.2 Definition and Classification of Flammable Liquids
For the purposes of this guidance document, a flammable liquid is defined as:

- Any liquid with a flashpoint lower than 60°C (140°F) (i.e. Global Harmonised System definition).
- Materials stored /processed above their flashpoint, even if the flashpoint is greater than 60°C:

Category 1: flashpoint <23°C and initial boiling point < 35°C

Category 2: flashpoint <23°C and initial boiling point > 35°C

Category 3: flashpoint >23°C and < 60°C; and

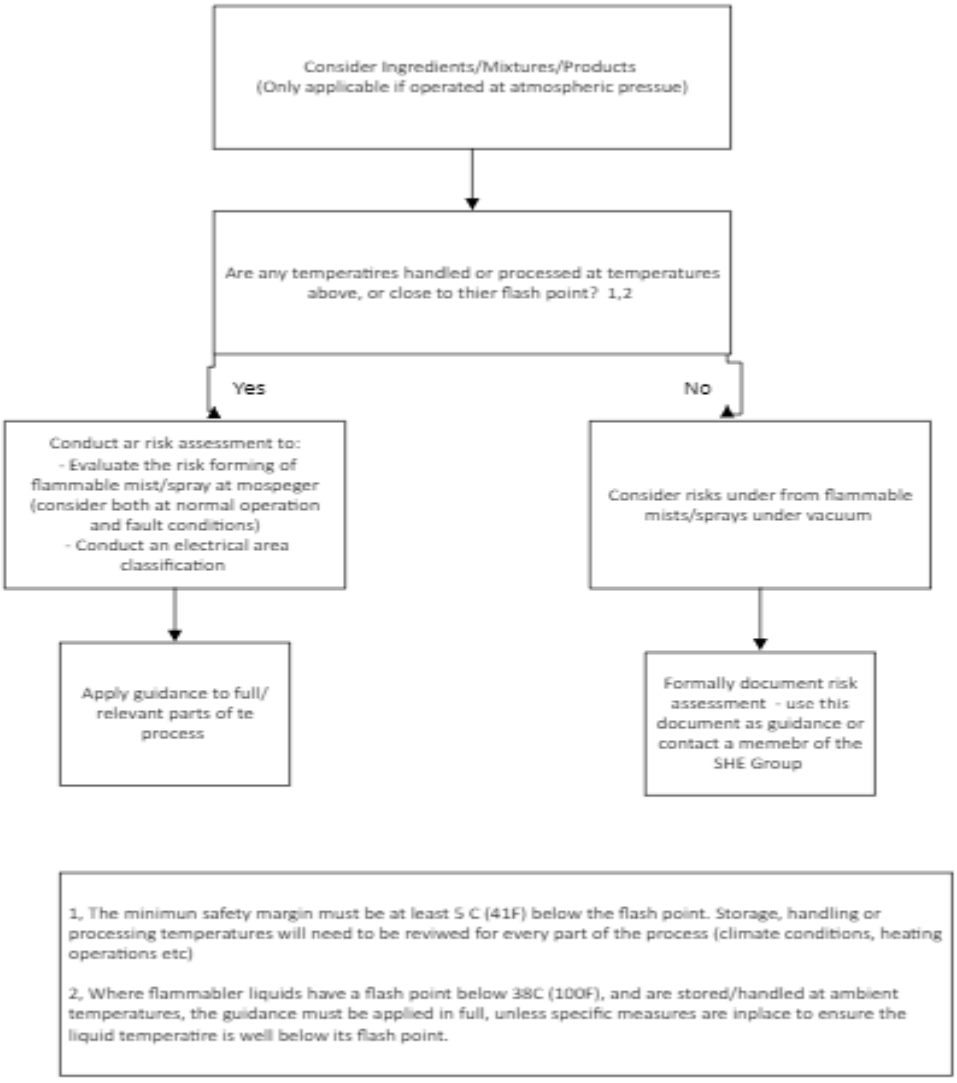
Combustible liquids with a flashpoint above 60°C

All elements of the document must be applied where there is potential for flammable vapour to be formed. Where an area classification / risk assessment concludes that there is no potential for flammable vapours to form (for example, ambient temperatures are always at least 5°C (9°F) below the flashpoint), a review of the required elements of the standard must be applied, as indicated in the chart below. The assessment must be documented and consider the potential for liquid to create flammable atmospheres through contact with hot surfaces (i.e. increasing the temperature above the flashpoint), or through formation of flammable mists or sprays or use of vacuum (i.e. reducing flashpoint).

1.3 Control of potential ignition sources

Under Regulation 7 of DSEAR, it is STFC's responsibility to determine the potential extent of a flammable atmosphere that could result from the leaks of flammable liquids stored above their flashpoint (or where this might be anticipated) and ensure that all potential ignition sources are excluded from the area.

See below for further information.



2. General requirements (minimum)

All the requirements of section 2 are applicable to all activities involving storage and /or handling of flammable liquids. Where national legislation requires a higher standard of protection than described in this document, then the higher national standard has precedence.

2.1 Safety Requirements

Item	Requirement
2.1.1	Each individual STFC site must establish if any liquids onsite fall within the requirements of this standard.

2.1.2	Safety Data Sheets (SDS's) showing the flashpoint of the liquid (Section 9) concerned must be collated and retained on site for all flammable liquids stored and handled within each department.
2.1.3	Training must have been undertaken for the managers and employees who are responsible for the design and/or operation of flammable liquid installations/operations. Individuals who are directly involved in the operation must: • Have knowledge of the properties of flammable liquids. • Be able to explain how the installation's operating procedures, practices and operational criteria ensure process safety and • Be familiar with their role in the installation's emergency shutdown procedures.

2.2 Control of Ignition Sources

Item	Requirement
2.2.1	If required, an area classification study must be performed for any activity involving the storage and handling of flammable liquids to confirm the locations, extents and classification of hazardous areas. Area classification studies must follow the guidance of an internationally recognised code of practice (e.g. EN, IEC or NFPA codes). Appropriate control of ignition sources must be implemented based on the classification**.**
2.2.2	A formal record of the findings of the area classification study for each operation / area must be prepared and reviewed / updated whenever modifications are made and at least every **three years.**
2.2.3	Area classification drawings illustrating the locations, extents and classification of hazardous areas must be prepared and updated as appropriate when operations / processes are modified and displayed at or near the zone entrance.
2.2.4	All electrical apparatus located within hazardous areas defined by the area classification study must be suitable certified and maintained for safe operation in the classification of hazardous area in which it is installed (e.g. Ex certified or certified to the correct US Class and Division).
2.2.5	Where portable equipment must be taken into hazardous areas it must be suitably certified for the classification of hazardous area in which it is to be used. Alternatively, the area must be declassified (under permit control) when (non-certified) portable equipment is in use.
2.2.6	All who must enter hazardous areas must wear antistatic footwear and high cotton content/static dissipative clothing.
2.2.7	If required, formal records of earthing inspection and testing must be retained, with any failures or non-compliances identified by the procedures listed, along with requirements for remedial action, assignment of responsibility and target dates for completion.

2.2.8	All storage of flammable liquids must be clearly marked to indicate their contents. Appropriate warning signs must identify storage areas containing significant quantities of flammable liquids.
2.2.9	All Hot Work must be covered with a permit – see SC32

2.3 Ventilation for indoor locations

Item	Requirement
2.3.1	Good continuous extract ventilation is required (minimum of 3 air changes per hour), if this cannot be achieved then forced ventilation should be considered.
2.3.2	Ventilation systems must be capable of ensuring that the amount of vapour in a work area is not only diluted to well below flammable limit, but also reduced to a level below the relevant exposure limit.

3.0 Storage of Flammable Material in Tanks – Above ground

The requirements apply to all tanks storing liquids (including fuels) with flashpoint below 60°C (140°F)

Item	Requirement
3.1	Bulk storage tanks must be adequately supported on concrete, masonry or steel and be strong enough to support the weight of the liquid if the tank fails
3.2	There must be manual isolation valves on all pipe connections to tanks
3.3	Tanks must be fitted with an independent high-level alarm / overflow protection system with a safety interlock provided to close inlet valves / stop feed pumps and avoid overfilling. If tanks are not fitted with alarms/overflow systems they need to be subjected to a risk assessment and relevant mitigation measures introduced.
3.4	Bunding and spill control: Bunds must be sized to contain at least 110% of the volume. There must facilities to remove rainwater from the bund, but without directing it to the main drainage system. Materials not compatible with the flammable liquid must not be stored within the bund. Bunds must not be used as storage areas. Bunds must be checked periodically for growth of vegetation. If found the vegetation must be removed and the bund checked for integrity.
3.5	Tanks should be situated in a well-ventilated position separated from the site boundary, occupied buildings and sources of ignition.
3.6	Tank layout should always take into account the accessibility needs for the emergency services.
3.7	Storage of flammable liquid in tanks within buildings should be avoided and if necessary, only the minimum amount required should be stored.

3.8	If gauging of the amount is done by dip rods, a suitable dip tube should be provided. Note: Dip rods are potential ignition sources as they may produce frictional heating or sparking, or static electricity. Therefore, they will need to be made of non-sparking material and earthed.

4. Storage of Flammable Liquids in Containers, Drums and Individual Bulk Containers (IBC's). See Section 5 for Laboratories

The requirements of this section apply to storage of any raw material products which are classified as flammable liquids (i.e. flashpoint below 60°C) in containers (e.g. Plastic, metal or glass), in a designated storage area. Containers include lab size containers, small drums/polys, full size drums and IBC's. The requirements in this section apply to storage areas only.

Item	Requirements
4.1	Metal drums and IBC's must be used for storing liquids with flashpoints below 21°C (70°F). For liquids with a flashpoint above 21°C (70°F) the use of non-dissipative material may be permitted subject to justification by a suitable risk assessment, but metal is preferred where it is economically viable.
4.2	Where containers must be stored within a room, quantities in containers should be limited to no more than **50 litres** of extremely, highly flammable material (13.2 gallons), unless storage is within fire cabinets rated for storage of flammable liquids, and arrangements are justified by a suitable risk assessment. Ideally, the fire cabinets should be rates to 90 minutes and located external to the building. (British Standard for Fire Safety storage cabinets BS EN 14470-1) All fire cabinets/COSHH cabinets will need to have relevant signage in place and located on more than one side. (Add in ISO Standard) Amounts no more than 2.5 litres located on any single bench, fume cupboard etc., within any single room. The above quantity is to include flammable waste.
4.3	Flammable liquids must not be stored in the same room/COSHH/Flammable cabinet as oxidising agents or flammable liquids not at atmospheric pressure. Steve to send over documentation - separation vs segregation
4.4	Storage of IBCs must be at ground floor level (i.e. not in upper floors or basements of buildings)
4.5	Portable containers must be sealed when they are being moved, held securely and transported along authorised routes. The use of a portable spill kit is useful when transporting any chemicals.
4.6	When dispensing liquids, an earthed metal funnel must be used.

5. Working within Laboratories or engineering workshops

Note: The aim is always be to minimise releases into the general atmosphere of the laboratory. Primary sources (e.g. vapour released when pouring from one container to another) should normally be so small they can easily be controlled by adequate ventilation, and the extent of any explosive atmosphere is negligible. The risk assessment will take into account all secondary sources (e.g. container fractures or is knocked off the bench to the floor)

The volatility of any flammable liquid must be considered in the context of the temperature at which it will be used. If pouring a solvent from one open container to another at a temperature below its flash point, there should be no hazardous area, because too little vapour is present. Distilling the same solvent and the condenser cooling fails, vapour will be released, and the risk is much greater. Consequently, the comments on flammable liquids apply whenever they are used or stored above their flash point (See Section 1.2 of this document)

Item	Requirement
5.1	Rooms will be limited to 50 litres of **extremely**, **highly** flammable (Definition see section 3.10 above) liquids and those liquids with a flashpoint below the maximum ambient temperatures of the workroom/working area. All must be stored in a COSHH/Flammable cabinet. Anything over 50 litres may require an in depth DSEAR assessment.
5.2	Minimum quantities will always be used.
5.3	Restrictions of Quantity: 2.5 litres located on any single bench, fume cupboard (this includes Flammable Waste) 10 litres in use at any given time in any single room
5.4	Spill kit locations will be known before starting work with flammable materials. Spill kits must be checked periodically to ensure contents are still intact and available.
5.5	Material will be decanted into labelled wide neck wash bottles when smaller quantities are required.
5.6	Oxidising materials or strong acids will NOT be stored in the same location as flammable materials. Strict separation distance of 3 meters must be observed from flammable materials in metal cabinets.
5.7	Consider separately releases which occur suddenly, but where the maximum release quantity can be specified, e.g. the fracture of a glass flask. Secondary containers may be required, or additional mitigation measures.
5.8	Spill kits must be easily located and know to all operational staff.

6. Storage of Gas Cylinders.

Item	Requirement
6.1	Gas cylinders will always have a clear means of identification through labelling or colour coding.

6.2	Separation distances must be observed
6.3	Signage must be displayed on the perimeter of the storage area (as defined by the risk assessment, such as: No Smoking (mandatory) No Naked Lights, No sources of ignition etc
6.4	Part and Full cylinders must have specific signage indicating contents and hazard.
6.5	Oil, Grease or Combustible materials will not be stored within the areas

7.0 Pipework and transfer requirements

Item	Requirement
7.1	Piping and insulation must be designed, constructed, and tested in accordance with international standards (e.g. ASME Standard B31.3).
7.2	All pipework must be assessed and designed to consider thermal expansion (i.e. expansion of liquid isolated between consecutive isolation valves). Pressure relief must be provided where necessary.
7.3	Route flammable liquid piping outside (above or below ground) of important buildings and structures. Do not pipe flammable liquids through or under buildings or process structures that do not use the liquids.
7.4	Transfer pumps will be configured to automatically stop in the event of fire detection.
7.5	Outdoor transfer pumps must be located within a bunded area for spill containment. Where pumps are located near outdoor flammable liquid storage tanks, place the pump in a different bund to the one used for the storage tank.
7.6	Consideration must be given to pressure-volume combination characteristics (e.g. very low-pressure large volume to small volume >100bar)

8.0 Outdoor storage tanks - specific requirements

Item	Requirement
8.1	Piping and insulation must be designed, constructed, and tested in accordance with international standards (e.g. ASME Standard B31.3).
8.2	All pipework must be assessed and designed to consider thermal expansion (i.e. expansion of liquid isolated between consecutive isolation valves). Pressure relief must be provided where necessary.
8.3	Route flammable liquid piping outside (above or below ground) of important buildings and structures. Do not pipe flammable liquids through or under buildings or process structures that do not use the liquids.
8.4	Transfer pumps must be configured to automatically stop in the event of fire detection.
8.5	Outdoor transfer pumps must be located within a bunded area for spill containment. Where pumps are located near outdoor flammable liquid storage tanks, place the pump in a different bund to the one used for the storage tank.

Appendix 6. Audit Checklist

Ref	Item	Rating	Comments
1 (Section 4.1.1)	Have Group leaders ensured that all hazards that have the potential to create an explosive atmosphere have been identified within their area of responsibility and have been subjected to risk assessments?		
2 (Section 4.2.1)	Have DSEAR risk assessments and if required Hazardous area classification assessments been conducted for all activities in the area involving the use of dangerous substances that have the potential to harm people, or are such assessments incorporated into the generic risk assessments for the areas?		
3	Are the DSEAR risk assessments documented in the Evotix Assure?		
4 (Section 4.1.4)	Have actions arising from DSEAR risk assessments been implemented to plan?		
5 (Appendix 7)	Have all supervisors/managers/Group leaders been trained in this DSEAR code, risk assessment and the STFC Risk Assessment database? Has refresher training been undertaken?		
6	Have all DSEAR risk assessments been reviewed at least on a 2 yearly basis?		

Appendix 7. Training

Role	Initial Training	Refresher	Frequency
Group Leader	Objectives for DSEAR training include: Attend ½ day DSEAR awareness course. In house/RPS Safety	To address the same objectives	Every 3 years or when there is a significant change to legislation.
Supervisors / Line Managers	As above, or attend the below HSE courses if a more in-depth knowledge is required.	As above	As above
Staff working in DSEAR areas	Attend ½ day DSEAR awareness course. In house/RPS Safety DSEAR : Gases and Liquids. https://solutions.hse.gov.uk/health-and-safety-training-courses/dsear-gases-and-liquids?cg=25138 HSE, Buxton DSEAR: Hazardous Area Classification for Gases and Liquids https://www.hsl.gov.uk/health-and-safety-training-courses/dsear-hazardous-area-classification-for-gases-and-liquids HSE, Buxton	As above	As above
Electrical and Mechanical Engineers	CompEX Certification Courses: **See SC34 for definitive course per role.** https://www.exveritas.com/training-and-competence-certification/ https://www.intertek.com/hazardous-locations/compex/chester-uk/	As above	As above

Appendix 8. References

1. The Dangerous Substances and Explosive Atmospheres Regulations 2002. More information can be found on the HSE's website: http://www.hse.gov.uk/fireandexplosion/dsear.htm

2. The Equipment and Protective Systems intended for use in potentially explosive atmospheres Regulations 1996 (as amended). More information can be found via the following link: http://www.dti.gov.uk/files/file11278.pdf

3. PD CLC/TR 60079-32-1:2015 Explosive atmospheres. Electrostatic hazards, guidance

4. BS 2050 (1978) Electrical resistance of conductive and anti-static products made from flexible polymeric materials.

5. BS EN ISO 20345:2011 Personal Protective Equipment – Safety Footwear

6. BS EN 1081:1998 Resilient floor coverings – Determination of the electrical resistance.

7. BS ISO 2878:2005 Antistatic and conductive products. Determination of electrical resistance.

8. BS EN 60079-10-1:2015 Electrical apparatus for explosive gas atmospheres Part 10. Classification of hazardous areas.

9. BS EN 60079-10-2:2015 Electrical apparatus for use in the presence of combustible dusts. Classification of areas where combustible dusts are or may be present.

10. BS EN 60079-14: 2014 Explosive atmospheres. Electrical installations design, selection and erection

11. BS EN 60079-0:2012 + A11:2013 Explosive Atmospheres. General Requirements

12. BCGA Code of Practice CP33 The Bulk Storage of Gaseous Hydrogen at Users' Premises 2012

13. HSG 51: Storage of Flammable Liquids in Containers

14. The following link provides access to information about fire and explosion on the HSE website: http://www.hse.gov.uk/fireandexplosion/information.htm

15. STFC Guidance in the handling of hydrogen and deuterium, see STFC SHE Group

16. HSG140 – Safe use and handling of flammable liquids. This is free to download on: https://www.hse.gov.uk/pubns/priced/hsg140.pdf

17. HSG176 – Storage of flammable liquids in tanks. This is free to download on: https://www.hse.gov.uk/pubns/books/hsg176.htm

18. IGEM/GM/78 Edition 2 – Hazardous area classification for gas metering equipment.

Appendix 9. Document Retention Policy

Records established	Minimum retention period	Responsible record keeper	Location of records	Comments and Justification
DSEAR Assessments	Current + 5 Years	Line Management	Evotix Assure	SHE Group Maintain Evotix Assure Facility